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FOREWORD

Presented number of Silesian University of Technology. Scientific Papers. Organization and Management Series. Presented papers contain result of researches conducted by various universities. The number consists of 44 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: leadership, energy management, environmental management, ethics in management, smart cities, healthcare management, renewable resources, democracy, the implementation of artificial intelligence in management, social media usage, public participation, economics, critical thinking, lean manufacturing, strategic planning, life cycle, impact of COVID-19 pandemic on management, production management, organizational culture, medical marketing, human capital, digital competences, logistics, crisis analysis, technology management, city promotion, human resources management, internationalization, Industry 5.0 and quality management

Radosław Wolniak

THE INFLUENCE OF LEADERSHIP STYLE ON TEAM PSYCHOLOGICAL CLIMATE AND EMPLOYEE PRODUCTIVITY

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The purpose of this article is to investigate the impact of different leadership styles, including network, global and e-leadership, on the psychological climate in teams and the employees' productivity. The research seeks to determine how each of these styles facilitates or hinders effective interaction between team members and the achievement of organizational goals.

Design/methodology/approach: a qualitative research methodology was used, including literature analysis and comparative analysis of different approaches to leadership. The article examines the main theoretical models and concepts describing network, global, and e-leadership and their impact on various aspects of team management and organizational culture. Data collection also included analyzing real cases and examples from modern practice.

Findings: were found that each leadership style has similar features, such as an emphasis on communication and flexibility, and differences, particularly in the approach to communication management, the integration of cultural differences, and the use of digital technologies. The study results emphasize the importance of adapting the leadership style depending on the specific conditions and requirements of the team, which contributes to increasing work efficiency and a positive psychological climate.

Research limitations/implications: One of the study's limitations is the use of mainly theoretical sources and examples, which may limit the generalization of the results to other contexts. Future research should conduct empirical studies to confirm the trends identified and determine the most effective strategies for applying different leadership styles in practice.

Practical implications: The obtained results can be helpful for leaders and managers who seek to improve the management of their teams and increase their productivity. Practical application of the recommendations given in the article can lead to improved communication, reduced conflict, and increased employee job satisfaction, which positively impacts the organization's overall effectiveness.

Social implications: Research can impact public perceptions of leadership, contributing to more flexible and adaptive approaches to management. This can affect corporate social responsibility, improve working conditions, and improve employees' quality of life in various organizations.

Originality/value: The article offers a new perspective on the relationship between different leadership styles and their impact on team psychological climate and performance. The work

will be helpful for scholars who research leadership issues and practitioners involved in personnel management and organizational development.

Keywords: leadership, network leadership, global leadership, e-leadership.

Category of the paper: Research paper.

Introduction

In the contemporary organizational environment, leadership styles are critical in shaping the psychological climate and enhancing employee productivity. Leadership practices determine the effectiveness of organizational processes and significantly impact staff morale, motivation, and overall job satisfaction. Given the rapid changes in the business environment, such as globalization, intensified competition, and the rapid development of information technology, organizations face new challenges and demands. These changes require leaders to be flexible and innovative in management, making effective leadership even more crucial (Gardner, 2020; Luedi, 2022).

Leadership is critically important for creating a favorable psychological climate within a team, which, in turn, affects organizational productivity and performance outcomes. Different leadership styles can substantially alter the internal atmosphere of a team and determine how effectively organizational goals are achieved. Leaders who can adapt their approaches to the specific conditions and needs of the organization can significantly enhance team effectiveness, foster motivation, and provide a harmonious environment for productive activity (Saputra et al., 2022; Alheet, 2021; Kuzior et al., 2022, 2023).

Among contemporary leadership styles actively integrated into management practices are network leadership, global leadership, and e-leadership. Network leadership focuses on developing and utilizing communication networks and connections to achieve organizational goals, ensuring effective communication and collaboration among team members (Schreiber et al., 2008; Shvindina et al., 2022). Global leadership is oriented toward managing conditions of cultural diversity, requiring leaders to account for and integrate various cultural approaches and management practices (Morrison et al., 2020; Rickley et al., 2022). E-leadership, in turn, emphasizes the use of digital technologies to manage virtual teams, which has become particularly relevant in the context of the rise of remote work (DasGupta, 2011; Van Wart et al., 2019).

Understanding the impact of these leadership styles on psychological climate and work productivity is crucial for developing and implementing effective management strategies. Adapting management practices to new realities helps organizations maintain high productivity levels and create a conducive work environment that fosters growth and achievement of goals. Studying contemporary leadership styles allows for identifying the most effective management approaches critical to ensuring organizational competitiveness and success in a rapidly changing environment.

Results

Network Leadership

Network leadership, as a management concept, differs from traditional leadership models by focusing on creating and maintaining a network of interactions between leaders and subordinates. In this approach, the leader is not the sole authority but rather an agent who creates an environment for the development of other leaders and establishes interpersonal connections that contribute to the entire organization's success.

The core idea of network leadership is that the leader manages and activates interaction processes among team members, creating a platform for their development. This approach fosters the formation of a shared vision and provides feedback among all participants, which, in turn, can positively impact the team's psychological climate and productivity (Liou et al., 2019; Zehrer et al., 2014).

Network leadership has a significant impact on the psychological climate within a team. A leader who creates and maintains a network of interactions fosters trust and collaboration. Network leadership also positively affects work productivity by creating conditions for greater work efficiency.

Figure 1 illustrates the critical aspects of the impact of network leadership on the psychological climate and employee productivity.

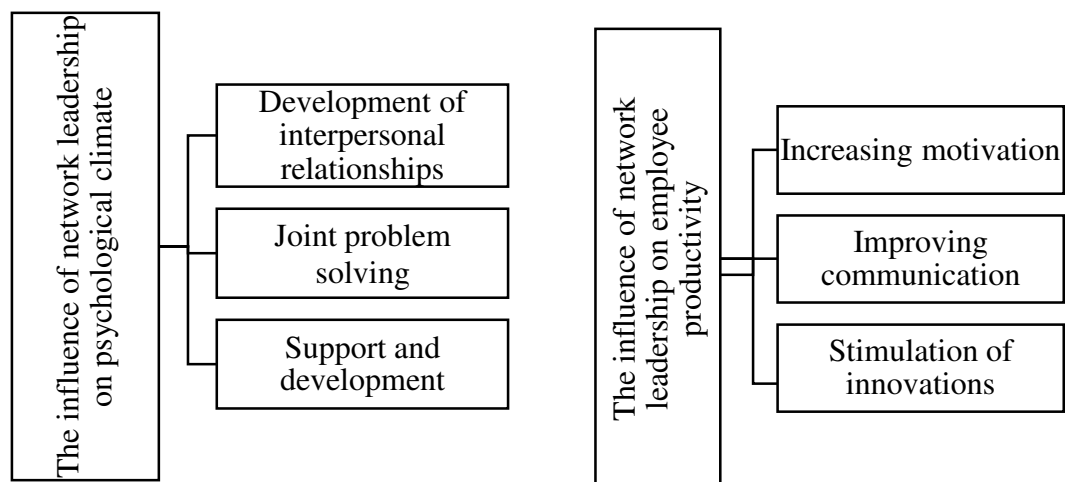


Figure 1. The influence of network leadership on the psychological climate and employee productivity.

Developing interpersonal connections within network leadership fosters deep interpersonal relationships among employees, helping to avoid conflicts and improve mutual understanding. A leader who ensures open dialogue and promotes collaboration helps the team solve problems more effectively, reducing stress and enhancing morale. Network leaders support the development of each employee's potential by creating a positive environment for personal and professional growth. With the support and feedback from a network leader, employees experience increased motivation to achieve high results. Established connections and clear

communication channels enable employees to exchange information more quickly and accurately, contributing to more effective task execution. Leaders who actively support exchanging ideas and creative approaches stimulate innovation and improve productivity through new solutions and process improvements (Mandell et al., 2009; Friedrich et al., 2016). Thus, network leadership plays a crucial role in fostering a healthy psychological climate and enhancing organizational work productivity. By creating and maintaining effective interpersonal connections, the leader promotes individual employee potential and collective effectiveness.

Examples of successful implementation of network leadership include Cisco Systems, which uses network leadership to support innovation and effective team performance. They have created a networked structure where employees can easily exchange knowledge and experience (Chatman et al., 2005; Mazur, 2014). Procter & Gamble (P&G) also applies network leadership to stimulate innovation through its "Connect + Develop" program, which encourages employees to collaborate with external partners (Ozkan, 2015; Chesbrough, 2003).

E-leadership

E-leadership is a management practice conducted within a digital environment involving information technologies for managing and interacting with a team. This approach encompasses various practices, from email and video conferencing to social media and specialized collaboration platforms. The core idea of e-leadership is to effectively manage a team through digital channels to achieve organizational goals (Avolio et al., 2000; Liu et al., 2018).

E-leadership significantly impacts the psychological climate within a team, and this impact can be both positive and negative, depending on the effectiveness of technology use and the management style. E-leadership can greatly influence work productivity because it can optimize work processes and improve coordination among team members.

Figure 2 illustrates the impact of e-leadership on the psychological climate and employee productivity.

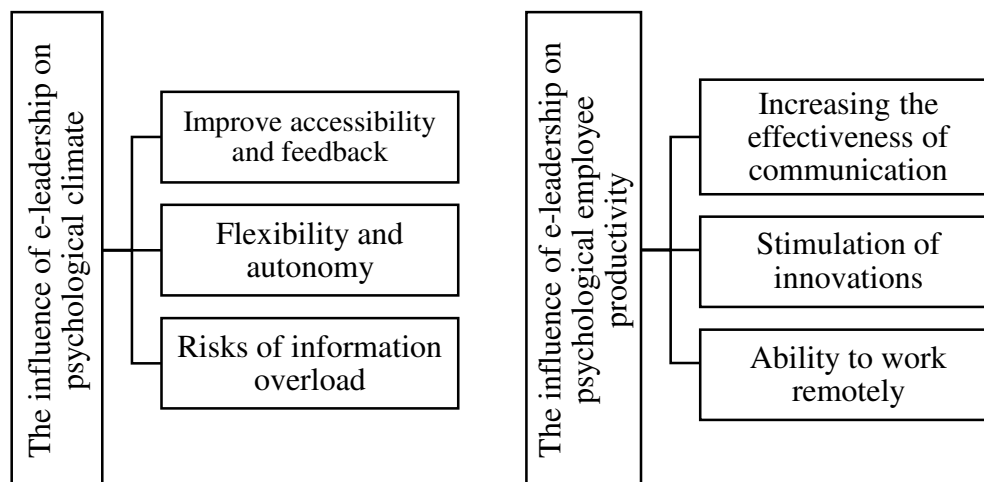


Figure 2. The influence of network leadership on the psychological climate and employee productivity.

The impact of e-leadership on the psychological climate includes improvements in accessibility and feedback, as e-leadership enables leaders to be more accessible to employees, regardless of their location. Quick and regular feedback can help maintain motivation and trust between the leader and the team. Digital tools allow employees to work at convenient times and from any location, which increases autonomy and job satisfaction, positively affecting the psychological climate. However, constant access to information and communication can lead to information overload and stress among employees, so the e-leader must balance providing access to information and protecting employees from excessive workloads.

The impact of e-leadership on work productivity can significantly improve workflows and coordination among team members. Digital tools ensure fast information exchange and document management, which contributes to more efficient task execution, avoiding delays and reducing task completion time. Modern technologies and collaboration platforms stimulate innovation, as employees can exchange ideas more quickly and receive feedback. E-leadership also enables the organization of remote work, which can improve productivity through flexibility and the ability to work in a comfortable environment.

E-leadership can enhance both the psychological climate and work productivity (Garcia, 2020; Darics, 2017). However, to achieve positive results, using digital tools correctly is essential, ensuring effective communication and maintaining a balance between technology and personal interactions.

Examples of successful implementation of e-leadership include IBM's practice of extensively using e-leadership to manage virtual teams worldwide. The company has implemented numerous technological solutions to support remote work and effective communication (Lynn Pulley et al., 2001; Avolio et al., 2014). Automattic also uses e-leadership to manage a fully remote team. The company has no centralized office, and all work is conducted through online platforms (Mullenweg, 2014; Romo, 2023).

Global leadership

Global leadership is defined as a concept that encompasses the skills and strategies necessary for effectively managing teams and organizations in the context of globalization. This concept includes management practices aimed at integrating different cultures, adapting to global markets, and managing distributed teams. Global leaders must be able to work in a multicultural environment, understand various cultural norms, and effectively communicate with people from different countries (Jokinen, 2005; Mendenhall et al., 2013).

Global leadership significantly impacts the psychological climate within the team, which can be positive and negative depending on the leader's ability to manage cultural differences and create an inclusive environment. Additionally, global leadership can positively influence work productivity by effectively managing distributed teams and implementing best practices from various cultures. Figure 3 illustrates global leadership's impact on the on the psychological climate and employee productivity.

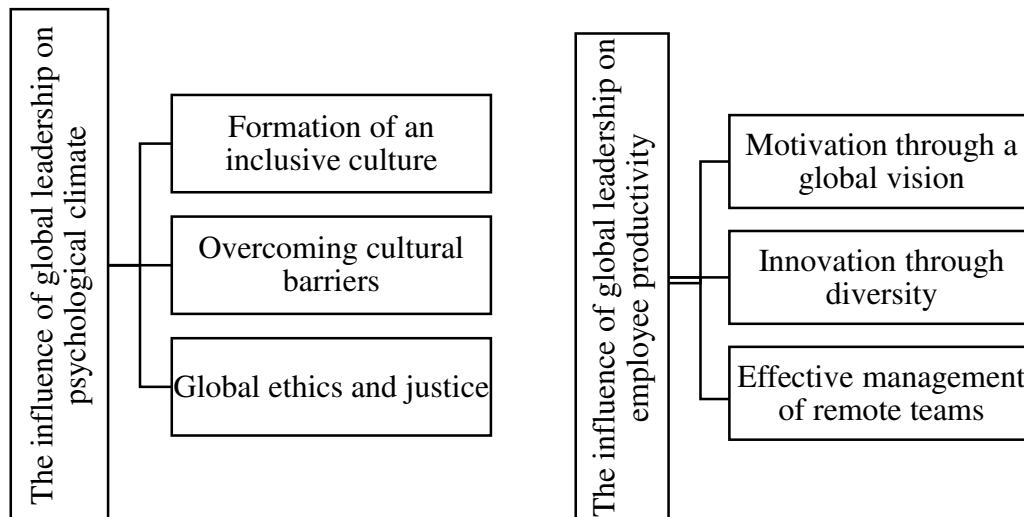


Figure 3. The influence of global leadership on the psychological climate and employee productivity.

The impact of global leadership on the psychological climate includes fostering an inclusive culture, where the global leader actively works on integrating various cultural perspectives and ensures respect for cultural differences. This approach reduces stress and conflicts within the team, enhancing the overall psychological climate. An effective global leader employs strategies to overcome cultural barriers and ensures clear communication among team members, which improves mutual understanding and trust. A global leader must demonstrate ethical behavior and fair treatment of all team members, which can enhance trust and satisfaction among employees.

The impact of global leadership on work productivity occurs through motivating employees by creating a shared purpose and global vision, helping to engage the team in achieving high results. Thanks to diverse cultural perspectives, global leaders can stimulate innovation and creativity, positively affecting work productivity and contributing to the development of new ideas and solutions. Global leadership also includes effective management of remote teams, which can reduce costs and improve work outcomes through the use of modern communication and management tools. Therefore, global leadership has significant potential to improve the psychological climate and work productivity within an organization (Mendenhall et al., 2012; Youssef et al., 2012). It is important for global leaders to leverage their knowledge of cultural differences and best practices to create a positive and productive environment for all team members.

Unilever is an example of global leadership, as the company effectively manages its operations in various countries, taking into account cultural differences and global trends (Whitfield et al., 2008; Stahl et al., 2017). The case of General Electric demonstrates global leadership through its global leadership development program, which includes rotating executives around the world to gain cross-cultural experience (Goldsmith et al., 2003; Osland et al., 2017).

Conclusions

The article examines the influence of different leadership styles on the team's psychological climate and employees' productivity. The analysis showed that effective leadership is essential in creating a positive atmosphere in the workplace, which contributes to increased motivation, job satisfaction, and overall productivity.

Such modern approaches as network, global, and e-leadership are considered. It was found that these leadership styles have several standard features. First, all of them are aimed at effective communication and interaction between team members, which is achieved by creating an open and trusting environment that stimulates the exchange of information and coordination of actions. Second, these approaches promote adaptability and flexibility, allowing organizations to respond quickly to changes in the external environment and internal challenges.

However, along with similar traits, each leadership style has unique differences. Networked leadership manages communication networks that enable close collaboration between different teams and departments. This approach emphasizes horizontal connections and interaction, allowing for quick resource allocation and solving problems in real-time.

Global leadership emphasizes integrating cultural differences and the global scale of management. Such leadership involves understanding and considering the various cultural and economic contexts influencing decision-making. Leaders practicing global leadership focus on adapting their strategies to the specifics of different regions, ensuring harmonious coexistence and cooperation.

E-leadership focused on using digital technologies to lead remote teams. E-leadership differs from other styles in its ability to effectively manage a team that may be geographically distributed, using virtual platforms to support communication and productivity. This leadership style requires the leader to have high technical competence and the ability to create digital spaces that facilitate effective interaction.

Thus, the right choice and adaptation of the leadership style, considering both similar and different elements of approaches, is critical for improving the effectiveness of teams in today's business environment (Kuzior et al., 2021, 2022, 2023). Leaders who can flexibly respond to challenges and changes ensure the achievement of organizational goals and contribute to the harmonious development of personnel.

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ANALYSIS OF THE ENVIRONMENTAL IMPACT OF TRAINING SERVICES FROM THE ORGANIZER'S PERSPECTIVE – A CASE STUDY BASED ON SECONDARY DATA

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Purpose: The purpose of this paper is to analyze the life cycle assessment (LCA) of training services and compare the environmental impacts of online and on-site training.

Design/methodology/approach: The research uses a life cycle assessment methodology to evaluate and compare the environmental impacts of online and on-site training across various categories. The analysis focuses on key areas such as acidification, climate change, freshwater ecotoxicity, resource depletion, and ozone layer depletion.

Findings: The study found that online training generates a lower environmental impact across all analyzed categories. For acidification, online training shows a 23% lower impact compared to on-site training, where 63% of emissions originate from energy production and 15% from participant transportation. Regarding climate change, online training results in 21% fewer greenhouse gas emissions due to the absence of transport and catering-related impacts. Freshwater ecotoxicity for online training is 60% lower, primarily due to the lack of emissions related to food preparation. Resource depletion for online training accounts for 73% of the impact of on-site training, with electricity being the main contributor. For ozone layer depletion, online training generates only 19% of the impact compared to on-site training.

Research limitations/implications: The study highlights the need for further research into the environmental impact of meals consumed during online training and standardizing perspectives for both training models.

Practical implications: The findings demonstrate the importance of online training as a more sustainable option, particularly in reducing the environmental impact associated with transportation and catering. Organizations can implement online training to minimize their environmental footprint. However, it is essential to consider specific quantitative assumptions and varying parameters resulting from the particular training practices, which may differ from those described in this study.

Social implications: This research contributes to the estimation of an organization's carbon footprint, particularly in Scope 3, within the category of purchased goods and services. It highlights the need for further studies to enhance understanding and provide detailed insights into this aspect.

Originality/value: This paper provides a novel comparison of the environmental impacts of online versus on-site training, offering valuable insights for organizations, policymakers, and educators seeking to implement more sustainable training practices.

Keywords: life cycle assessment, on-line training, on-site training, environmental impact, sustainable.

Category of the paper: Research paper, case study.

1. Introduction

Managing environmental impacts has become one of the key challenges for contemporary organizations, particularly in the context of global actions towards sustainable development. As ecological awareness grows, an increasing number of organizations are striving to analyze the environmental impact of various aspects of their operations, including services such as training. The impact of purchased training on climate change is often considered in the carbon footprint assessment of many organizations, particularly within Scope 3, Category 1: "Purchased goods and services".

A comprehensive analysis of the environmental impacts of a given product or service across all stages of its lifecycle—from raw material acquisition to implementation processes—is achievable through the application of Life Cycle Assessment (LCA). This methodology is recognized as a robust tool (Neramballi et al., 2020). In recent years, as organizations increasingly recognize the importance of sustainable development, LCA has gained popularity in the context of services. This highlights the necessity of adapting assessment methods to the unique characteristics of the service sector (Lindgreen et al., 2022).

Training services, as a significant element of the educational and development sector, pose unique challenges in the context of environmental assessment. Their intangible nature requires identifying and quantifying factors such as emissions associated with participant transportation, energy consumption in training facilities, and the use of office materials (Martín-Garín et al., 2021). Research indicates that different forms of training delivery—on-site, remote, and hybrid—can vary significantly in their environmental impact, making LCA particularly relevant in this context (Chaudhary, Dey, 2020).

Promoting sustainable development within organizations requires not only appropriate strategies but also the involvement of all stakeholders, which is crucial for achieving positive environmental and social outcomes (Marciszewska, 2024). Therefore, analyzing the impact of services, including training services, becomes essential for understanding their environmental implications and making informed decisions in project management in the context of sustainability.

This article aims to conduct a Life Cycle Assessment (LCA) of training services, considering the specific stages of their delivery and identifying key sources of environmental impact. It focuses on a comparative analysis of on-site and remote training to determine which format has a lower environmental footprint. Applying the LCA approach to training services provides valuable insights for both organizers and participants, supporting decision-making aligned with sustainable development principles. In this way, the article contributes to advancing knowledge about the environmental dimension of the service sector and represents a step toward systematically incorporating LCA into analyses of intangible products (Akyol et al., 2018).

2. Context and research problem

Training services, both on-site and online, are a significant component of educational and business activities, yet their environmental consequences are often underestimated or entirely overlooked. The growing prominence of online training, perceived as more environmentally sustainable, raises questions about the actual differences in their environmental impact compared to traditional on-site training. The key research problem, therefore, lies in estimating the differences in environmental impact between these two training formats and identifying the most significant factors contributing to their ecological footprint.

Research in this area is relatively limited, but existing findings suggest that online training may have a significantly lower environmental impact, primarily due to the elimination of participant travel and reduced consumption of physical resources such as paper or catering. For example, Rath et al. (2020) indicate that transitioning to remote education can lead to a reduction in greenhouse gas emissions from transportation by over 80% compared to traditional teaching methods. Similarly, research by Laurent et al. (2012) emphasizes that the environmental impact of on-site education is highly dependent on local conditions, such as the energy sources used in training facility infrastructure.

Key aspects of the research problem

To accurately assess the environmental impact of both forms of training, it is essential to collect and analyze data covering all stages of their life cycle. Particular attention should be given to the following aspects:

- Preparation stage (production): Organizing training involves activities such as sending emails, making phone calls, and preparing training materials (printed or digital). These actions can vary in terms of emissions depending on the training format.

- Duration of the training: Differences in the length of training sessions can affect energy consumption, both in physical training rooms and in the devices used for online training.
- Participant travel: For on-site training, greenhouse gas emissions associated with participant transportation are a key component of environmental impact. Different modes of transportation (trains, combustion-engine cars, hybrid vehicles) generate varying levels of emissions.
- Training resources: Organizing on-site training necessitates the provision of printed materials, catering, and maintaining suitable conditions in the training room (e.g., heating, lighting). In online training, these resources are replaced with digital materials, which also have their own environmental footprint.
- Infrastructure and technology: Online training relies on digital platforms and devices, which generate additional energy consumption, though to a lesser extent than the infrastructure required for on-site training.

Research challenges

The analysis of the environmental impact of training services faces several significant challenges:

- Data incompleteness: Information regarding individual emissions, particularly related to participant travel, is often imprecise or difficult to estimate.
- Variability of local conditions: Differences in energy sources, climatic conditions, and transportation infrastructure can significantly affect the results.
- Systemic complexity: Comparing two distinct training models requires a detailed Life Cycle Assessment (LCA) that accounts for all stages of impact.
- Participant diversity: Participants may use various modes of transportation and have different habits regarding infrastructure usage, making data standardization challenging.

This study addresses an existing gap in the literature on the environmental impact of training services by focusing on a comprehensive comparison of on-site and online formats using the LCA methodology.

3. Research methodology

The research methodology is based on the application of Life Cycle Assessment (LCA) to compare the environmental impact of two types of training: on-site and online.

The declared functional unit for the study is the provision of on-site and online training for 20 participants, taking into account the assumptions outlined in Chapter 4.

The analysis process was divided into the following steps:

1. Defining system boundaries.

Within the analysis, the following were considered:

- Preparation stage (organization, communication, printing of materials).
- Participant transport in the case of on-site training.
- Resource and energy consumption during training delivery (e.g., electricity, catering).
- Digital distribution of materials and certificates for online training.

2. Data collection.

Data on key environmental parameters were obtained from:

- Actual operational data (e.g., kilometers traveled, energy consumption).
- Assumptions based on market standards (e.g., transport emissions per kilometer).
- Available environmental databases, such as Ecoinvent and Agribalyse.

3. Modeling and calculations.

- Models and estimates were applied to energy consumption during office work, email correspondence, and phone calls.
- Models and estimates were also applied to participant travel, preparation and distribution of training materials, and the delivery of on-site and online training.
- Process modeling in SimaPro was based on indicators from Ecoinvent and Agribalyse. The indicator for electricity consumption reflects the energy mix in Poland (location-based).

4. Results analysis.

The results are presented in a comparative format, highlighting key differences in the environmental impact between on-site and online training. The analysis includes indicators such as acidification, climate change (including biogenic, fossil fuel, and land use change sources), freshwater ecotoxicity (divided into inorganic, organic, and other factors), eutrophication (marine, freshwater, and terrestrial environments), ionizing radiation, land use, photochemical ozone formation, resource use (fossil fuels), and water use.

This methodology allows for a comprehensive comparison of both training models, identifying areas with the highest environmental impact and providing recommendations for their optimization.

4. Description of data and assumptions

4.1. Training preparation

Firstly, the electricity consumption in an office room over 10 hours was analyzed. The total energy consumption for this period amounted to 10.9 kWh, with the dominant components being electric heating (10 kWh) and lighting, which required 0.4 kWh of energy, assuming the use of four LED bulbs for 10 hours. Energy consumption by a computer operating at 50 W for 10 hours accounted for 0.5 kWh (Latif, 2015; Han et al., 2013).

It was assumed that as part of the preparatory activities for training, 25,000 emails needed to be sent. The total energy consumption associated with this activity was 629.25 kWh. This includes three main components: data transmission, data storage in the cloud, and energy consumption during email reading and writing. Data transmission for an average 2 MB email, assuming that transferring 1 GB of data consumes 5 kWh, amounted to 245 kWh. Storing the same data in the cloud, with an average annual consumption of 7 kWh/GB, added another 342.5 kWh. Energy consumption during laptop use (2 minutes for writing and reading an email) amounted to 41.75 kWh (Tayari, Burman, 2018; Lessard et al., 2017).

The energy consumption associated with making 50 phone calls was 8.975 kWh. This includes 8.35 kWh of energy consumed by smartphones during the calls and 0.625 kWh attributed to the operation of network infrastructure, assuming a data transfer rate of 0.5 MB/min and average network energy consumption of 5 kWh/GB (Carvalho et al., 2020; Kim et al., 2021).

These analyses provide a detailed overview of the energy costs of office and communication activities and can serve as a basis for further research into energy efficiency and carbon footprint reduction in office and remote work.

4.2. Participants' travel to the training venue

The analysis considered the distribution of participants in on-site training: 10 participants travel by private car, and another 10 use rail transport. The total number of participants is 20, and the total distance traveled by participants in both scenarios was estimated accordingly.

For private car travel, it was assumed that 10 participants each travel an average of 10 km. This results in a total distance of 100 km (10 participants \times 10 km). Car travel is associated with shorter distances, corresponding to local commutes.

In the train travel scenario, it was assumed that 10 participants each travel an average of 300 km, resulting in a total distance of 3000 km (10 participants \times 300 km). This mode of transport is associated with longer commutes.

The total distance traveled by 20 participants is therefore 3100 km, of which 100 km involves cars (assumed to use diesel fuel) and 3000 km involves trains (Coutaz et al., 2018; Bano, Sehgal, 2020).

4.3. Training materials

The process of preparing and distributing training materials was divided into several stages: presentation preparation, printing materials, and sending files in PDF format. Preparing the presentation required 8.5 hours of work on a laptop, including content creation and saving the document in two formats: PowerPoint and PDF. The laptop's energy consumption amounted to 0.425 kWh, while data exchange involving 200 MB added another 1 kWh, resulting in a total of 1.425 kWh (Pano, 2017; Phillips et al., 2011).

For printing the presentation, it was assumed that each of the 20 participants in the on-site training would receive a 100-page presentation, totaling 2000 pages.

The distribution of training materials involved sending a 10 MB PDF file. The data transmission process via the Internet, consuming 5 kWh per GB, required 0.0488 kWh per file, amounting to 0.976 kWh for sending the file to 20 participants. Storing the same file in the cloud for one year, with an energy consumption of 7 kWh/GB, required 0.0684 kWh per file, totaling 1.368 kWh for 20 files. Additionally, preparing and reviewing materials before the training, which took 5 minutes of laptop use, consumed 0.0042 kWh per user, resulting in a total consumption of 0.084 kWh.

The total energy consumption for the preparation, distribution, and handling of training materials amounted to 2.428 kWh, including data exchange and long-term cloud storage of files. This analysis highlights the energy costs of remote work and digital content distribution (Al-Ghamdi, Bilec, 2015; Muñoz-González et al., 2021).

4.4. Conducting training on-site

The analysis of energy consumption during an 8-hour on-site training session in a 35 m² room included all key elements requiring electricity. The total energy consumption was estimated at 55.6 kWh, based on standard equipment and training conditions.

Lighting the room with LED bulbs at 10 W/m² for a total area of 35 m² consumed 2.8 kWh over the 8-hour session. Electric heating, operating at 100 W/m² to maintain a comfortable temperature, accounted for 28 kWh. The projector, operating at 300 W, consumed 2.4 kWh, while air conditioning, with a power of 1500 W, consumed 12 kWh (Cassola et al., 2022; Heddeghem et al., 2014).

Computer equipment included laptops for the trainer and coordinator, each operating at 50 W, consuming 0.4 kWh each. Additionally, 20 participant laptops, running throughout the session, consumed 8 kWh. The room's sound system, including a microphone and speakers at 200 W, consumed 1.6 kWh. These findings highlight key areas of energy consumption during

on-site training sessions, showing that air conditioning, heating systems, and participant equipment represent the largest shares. This analysis can serve as a basis for optimizing energy use in similar scenarios (Zhang et al., 2010; Ferdous, 2023).

The analysis also evaluated the demand for coffee and related energy consumption, considering two scenarios: serving coffee with milk and coffee without milk. In both cases, 25 cups of coffee, each 200 ml, were considered. Each cup required 7 g of ground coffee, totaling 175 g for the entire event. In the scenario with milk, each cup contained 100 ml of coffee and 100 ml of milk, requiring 2.5 liters of milk for the event. The scenario without milk involved serving only black coffee, increasing the water demand to 5 liters.

The energy consumption of the coffee machine, assuming 0.1 kWh per liter of coffee prepared, was 0.25 kWh for coffee with milk and 0.5 kWh for black coffee, proportional to the required water quantity (Menezes et al., 2012; Shan, Cao, 2017).

4.5. Conducting online training

An analysis of energy consumption was conducted for an 8-hour online training session involving 20 participants and one trainer. The assessment considered all key elements related to the use of electronic devices and data transmission via a video conferencing platform. The total energy consumption was estimated at 219.24 kWh.

The main sources of energy use included the operation of laptops, cameras, microphones, and data transfer. A total of 21 laptops (20 participants and 1 trainer), each operating at 50 W for the entire training duration, consumed 8.4 kWh. Cameras and microphones, essential for interaction during the training, consumed 0.84 kWh, assuming a power requirement of 5 W per person.

The largest share of energy consumption was attributed to the video conferencing platform, related to data transmission. It was assumed that each participant used an average of 2 GB of data over 8 hours, resulting in a total data transfer of 42 GB for all participants. With an energy consumption rate of 5 kWh per GB of data transfer, the platform's operation accounted for 210 kWh (Zhang et al., 2011; Vartholomaios et al., 2023).

This analysis highlights the significant impact of data transmission on energy consumption in online training sessions, emphasizing the critical role of internet infrastructure in the energy balance of such events. These findings can be used to optimize resources and plan effective and environmentally friendly solutions for organizing virtual meetings (Kim et al., 2020; Yuan, Yan, 2012).

5. Analysis of LCA results of the training service

The results of the Life Cycle Assessment (LCA) analysis compared two training service delivery variants: online training and on-site training. The results encompass environmental impact categories consistent with the Environmental Footprint 3.1 methodology. The analyzed impacts pertain to the life cycle stages associated with energy production and materials used during the organization of the training sessions.

Table 1.
LCA results for online and on-site training services

Impact category	Unit	Szkolenie on-line	Szkolenie on-site
Acidification	mol H ⁺ eq	5,47E+00	7,07E+00
Climate change	kg CO ₂ eq	7,72E+02	9,73E+02
Climate change - Biogenic	kg CO ₂ eq	3,68E-01	1,38E+01
Climate change - Fossil	kg CO ₂ eq	7,71E+02	9,23E+02
Climate change - Land use and LU change	kg CO ₂ eq	2,46E-01	3,66E+01
Ecotoxicity, freshwater - part 1	CTUe	8,87E+02	2,23E+03
Ecotoxicity, freshwater - part 2	CTUe	1,11E+03	1,79E+03
Ecotoxicity, freshwater - inorganics	CTUe	1,94E+03	2,47E+03
Ecotoxicity, freshwater - organics - p.1	CTUe	5,72E+01	1,07E+03
Ecotoxicity, freshwater - organics - p.2	CTUe	3,60E+00	4,72E+02
Particulate matter	disease inc.	7,51E-06	2,93E-05
Eutrophication, marine	kg N eq	5,91E-01	1,24E+00
Eutrophication, freshwater	kg P eq	1,01E-01	1,04E-01
Eutrophication, terrestrial	mol N eq	6,65E+00	1,48E+01
Human toxicity, cancer	CTUh	3,44E-07	4,61E-07
Human toxicity, cancer - inorganics	CTUh	9,86E-08	1,43E-07
Human toxicity, cancer - organics	CTUh	2,46E-07	3,18E-07
Human toxicity, non-cancer	CTUh	8,67E-06	9,82E-06
Human toxicity, non-cancer - inorganics	CTUh	8,60E-06	9,33E-06
Human toxicity, non-cancer - organics	CTUh	7,47E-08	4,90E-07
Ionising radiation	kBq U-235 eq	9,60E+00	3,10E+01
Land use	Pt	1,66E+03	8,08E+03
Ozone depletion	kg CFC11 eq	2,86E-06	1,48E-05
Photochemical ozone formation	kg NMVOC eq	1,92E+00	2,91E+00
Resource use, fossils	MJ	8,88E+03	1,21E+04
Resource use, minerals and metals	kg Sb eq	1,62E-05	4,44E-04
Water use	m ³ depriv.	1,03E+02	3,34E+02

5.1. Acidification

Acidification refers to the emission of gases such as sulfur oxides (SO_x) and nitrogen oxides (NO_x), which react with water in the atmosphere to form "acid rain", leading to soil and water acidification and negatively impacting ecosystems.

Online training generates 5.47 mol H⁺ eq, which is lower compared to 7.07 mol H⁺ eq for on-site training. For on-site training, electricity production accounts for 63% of this impact, rail transport of participants contributes 15%, and food preparation accounts for 22%. In the case

of online training, 100% of the impact in this category is associated with electricity consumption.

The higher level of acidification in on-site training is primarily due to the intensive use of electricity and emissions related to participant transport and food preparation. Sustainable practices in energy use and catering could significantly reduce this impact.

5.2. Climate change

Climate change refers to the emission of greenhouse gases, such as carbon dioxide (CO₂) and methane (CH₄), which contribute to global warming, leading to rising sea levels, desertification, and climate changes that affect ecosystems and humans.

Online training generates 7.72×10^2 kg CO₂ eq, which is lower compared to 9.73×10^2 kg CO₂ eq for on-site training. For on-site training, electricity production accounts for 65% of this impact, participant transport generates 20%, and food preparation contributes 15%. In the case of online training, 100% of the impact in this category is associated with electricity consumption.

The higher level of greenhouse gas emissions in on-site training is primarily due to the reliance on electricity with a high carbon footprint, as well as emissions from participant transport and food preparation. Adopting more sustainable practices in energy sourcing and catering could significantly reduce this impact.

5.3. Ecotoxicity of freshwater

Freshwater ecotoxicity measures the potential risk of harmful effects of chemical substances on organisms living in freshwater ecosystems.

For online training, the total impact is 8.87×10^2 CTUe, approximately 40% of the impact compared to 2.23×10^3 CTUe for on-site training. In the case of on-site training, electricity production accounts for 32% of the total impact, participant transport for 10%, and food preparation for 58%. Among the food-related impacts, lunch contributes the largest share (30%), followed by dried fruits (6%), cake (6%), sandwiches (7%), and juice (5%).

For online training, 100% of the impact on freshwater ecotoxicity is associated with electricity consumption.

The high level of freshwater ecotoxicity for on-site training is primarily due to emissions from electricity production and food preparation processes. Online training, with a significantly lower contribution to this category, is a more sustainable option, particularly in the context of reducing food- and transport-related emissions.

5.4. Resource consumption

Resource use refers to the exploitation of non-renewable materials such as fossil fuels, minerals, metals, and water, which can lead to their depletion.

For online training, the total resource consumption is 8.88×10^3 MJ, approximately 73% of the impact compared to 1.21×10^4 MJ for on-site training. In on-site training, the largest share of resource use comes from electricity production, accounting for about 60% of the total impact. Rail transport contributes 20% (also related to energy use), while the remaining 20% is primarily associated with food preparation, including meat production, processing, and product transport. For online training, 100% of the impact in this category is associated with electricity consumption.

The higher level of resource consumption in on-site training is primarily due to greater energy demands and the intensive use of natural resources in catering-related processes. Online training, with a lower contribution to this category, offers a more sustainable alternative in terms of reducing resource exploitation. However, it is important to note that this analysis, from the organizer's perspective, does not account for meals and beverages consumed during online training. Considering different perspectives would provide a more comprehensive understanding of this impact.

5.5. Ozone layer depletion

Ozone layer depletion is associated with the emission of gases, such as chlorofluorocarbons (CFCs), that destroy ozone in the stratosphere. A thinner ozone layer allows harmful UVB radiation to penetrate, increasing the risk of health issues such as skin cancer.

The impact on the ozone layer for online training is 2.86×10^{-6} kg CFC11 eq, approximately 19% of the impact compared to 1.48×10^{-5} kg CFC11 eq for on-site training. For on-site training, electricity consumption accounts for about 16% of the total impact, while the remaining impact is primarily due to emissions from food preparation processes and transportation. For online training, 100% of the impact in this category is linked to electricity consumption.

The significantly higher emissions from on-site training are due to the use of energy with a large environmental footprint and emissions from catering processes. Online training, with about five times less impact, represents a more sustainable solution in this category.

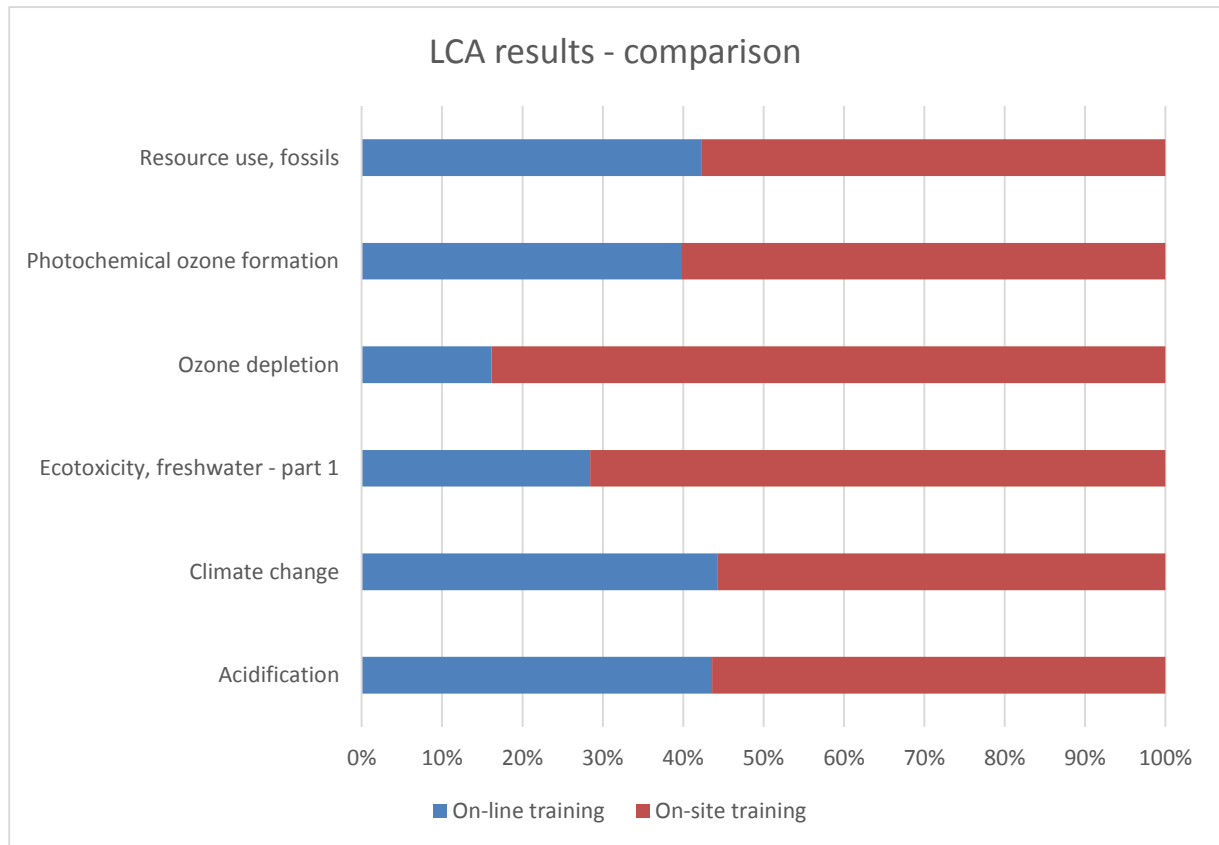


Figure 1. LCA Results - Comparison of online and on-site training services across selected impact categories.

6. Summary

In the tested analytical model, online training generates a lower impact on acidification, climate change, freshwater ecotoxicity, resource use, and ozone layer depletion compared to on-site training. This highlights the potential for implementing more sustainable practices in energy management and catering. Examples of such practices include using renewable energy sources, optimizing participant transportation (e.g., selecting training locations closer to participants' residences), and choosing local and seasonal food products, which can significantly reduce their environmental impact.

Additionally, it is important to consider various perspectives in environmental impact analyses to obtain a more comprehensive understanding, including the consideration of meals and beverages consumed during online training. References for further exploration of this topic may include studies on sustainable development in education, the environmental impact of training, and best practices for energy and resource management in the context of event organization.

Future research should account for the full scope of consumption, including the potential impact of meals consumed during online training, to provide a more holistic view of the environmental effects of both models. Implementing the recommended practices can significantly improve the sustainability of training sessions, regardless of their format.

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ANALYSIS OF THE CHANGE IN DIRECTIONALITY OF A GUNSHOT NOISE AFTER APPLYING A GUN SILENCER

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Purpose: The purpose of the article is to present the results of research conducted by the author on the effectiveness of gunshot noise reduction and changes in the directionality of the sound source after applying selected models of acoustic silencers for different firearm calibers and types of ammunition. Based on the conducted research, a trend was identified for changes in the directional characteristics and frequency spectrum of the sound, and positive environmental effects associated with these changes were highlighted.

Design/methodology/approach: To determine the changes in directionality and the spectral characteristics of sound generated during a gunshot after applying a firearm silencer, a field research experiment was planned and conducted. Measurements were taken of acoustic pressure levels as a function of octave frequencies during test shots with firearms of various calibers, both with and without silencers. The obtained results were subjected to detailed analysis.

Findings: The conclusions and findings from the conducted research may be used in modeling the acoustic impact of shooting ranges. With knowledge of the directional characteristics of the sound source and by incorporating it into simulation models, the accuracy of noise prediction across the entire computational area is significantly improved.

Practical implications: The obtained research results allow for more accurate modeling of noise emissions to the environment from gunshots in places such as sports shooting ranges, hunting ranges, and military training grounds. Modeling that incorporates the directionality and spectral characteristics of the sound source allows for the inclusion of phenomena like sound absorption and reflection, thus increasing the accuracy of acoustic calculations. Another very important aspect is the potential use of these research findings in the design and improvement of new silencer constructions.

Originality/value: The author's original achievement was the planning and conducting of a research experiment involving the recording of transient sound level changes at designated control points and based upon this determining the directional characteristics of noise emitted during gunfire with the use of silencers. The research was conducted for three typical types of firearms in common civilian and military calibers.

Keywords: noise, gunshot noise, gun silencer, noise directionality, noise reduction, environmental protection, silencer design.

Category of the paper: Research paper, Technical paper.

1. Introduction

In recent times the number of military and civilian shooting ranges in Poland has been growing rapidly. This is partly due to high civilian interest in shooting sports and partly due to the geopolitical situation and the need for intense shooting training for uniformed services, the military, and local units of the Territorial Defense Forces (WOT). Existing shooting ranges are typically used extensively, which leads to significant acoustic disturbance for residents living nearby.

The impulsive noise generated during a gunshot poses a serious risk not only to the health of shooters but also significantly impacts the environment. Its particular disturbance and effect on the acoustic climate is most noticeable in residential areas located close to military, sports, and hunting shooting ranges.

One of the most effective ways to reduce gunshot noise is to use silencers, which lower the overall energy of the acoustic wave emerging from the barrel, thereby reducing both noise and firearm recoil. The use of a silencer also changes the directionality and frequency characteristics of the sound that propagates after a shot. Though this information is generally known, silencer manufacturers do not provide any quantitative or even qualitative information describing these changes. Why? Because they do not have it. They do not conduct this type of research, as it is costly and to the average silencer user this information is simply unnecessary. Therefore, they limit themselves to specifying sound attenuation by indicating noise reduction in dB(C), which further misleads the average user, as they equate this value with the perceived (by ear) difference expressed in dB(A), and these are two different values.

Understanding the change in the directionality characteristics of the sound after using acoustic silencers is especially important for environmental acousticians, who can use this information to model the propagation of impulsive noise associated with shooting at firing positions, and thus estimate or predict the impact of this noise on the surrounding environment. With this knowledge they can design more effective noise protections, such as by appropriately shaping acoustic barriers or improving the construction of the silencers themselves.

2. Review of existing research

The literature contains many publications on the use of firearm silencers and their effect on reducing noise emitted to the environment. These studies primarily focus on silencer effectiveness, defined as the decrease in sound level in the area around the shooter's head (or at other points in the environment) before and after using the silencer.

These studies provide information on the potential to mitigate the negative impact of gunshot noise on shooters' hearing by using silencers and other items such as specialized subsonic ammunition (Murphy et al., 2017). A great deal of attention is given to analyzing the effectiveness of hearing protection for shooters using silencers and demonstrating their significantly greater effectiveness compared to individual hearing protectors (Branch, 2011) and (Boczkowski et al., 2020). Research results are often used to design and improve internal silencer constructions, such as by using fluid dynamics simulation tools (Kilikevičius et al., 2023), or numerical analysis of various internal baffle constructions and determining their effect on sound level reduction with distance (Gurdamar et al., 2023; Huerta-Torres et al., 2021).

The analysis of firearm shot recordings for forensic use, such as identifying the direction of the shot or the type of firearm, also receives significant attention in the literature (Maher, Shaw, 2010). Many resources are also available on the theoretical basics of silencer construction, design, and application (Rusiecki, 2013), as well as reviews of available market solutions along with analyses of their advantages and disadvantages (Sweeney, 2016).

Significantly less attention in the literature is devoted to analyzing the impact of silencers on noise emitted to the environment, specifically regarding the change in the directional characteristics of sound emitted during gunfire. Yet it is precisely this change in the directionality of the sound source that makes the resulting noise considerably less audible from behind and to the side of the shooter. Additionally, the effectiveness of noise reduction is influenced by changes in the sound's spectral characteristics after using a silencer. This area of research is not yet sufficiently explored, and it is precisely this niche that the author's research seeks to fill. Knowledge of the change in the sound source's directionality after using a silencer can be used in acoustic modeling of shooting range impacts on the external environment, as well as in designing silencers with increasingly directional noise characteristics.

3. Description of conducted research

A research experiment was conducted to determine the effectiveness of gunshot noise reduction, the changes in directionality and the changes in the frequency characteristics of the sound source after applying a silencer. The experiment consisted of determining the maximum and average sound level at the shooter's ear (point U) before and after applying the silencer, as well as the average sound level at 8 measurement points (P1-P8) evenly distributed around the shooter at a distance of 10 m and at a height of 1.5 m. The placement of measurement points is shown in Figure 1.

The noise measurements were conducted at the HUBERTECH shooting range in Jaworzno in December 2020 under conditions of free-field acoustic environment, that is in open terrain with negligible influence of reflections from buildings.

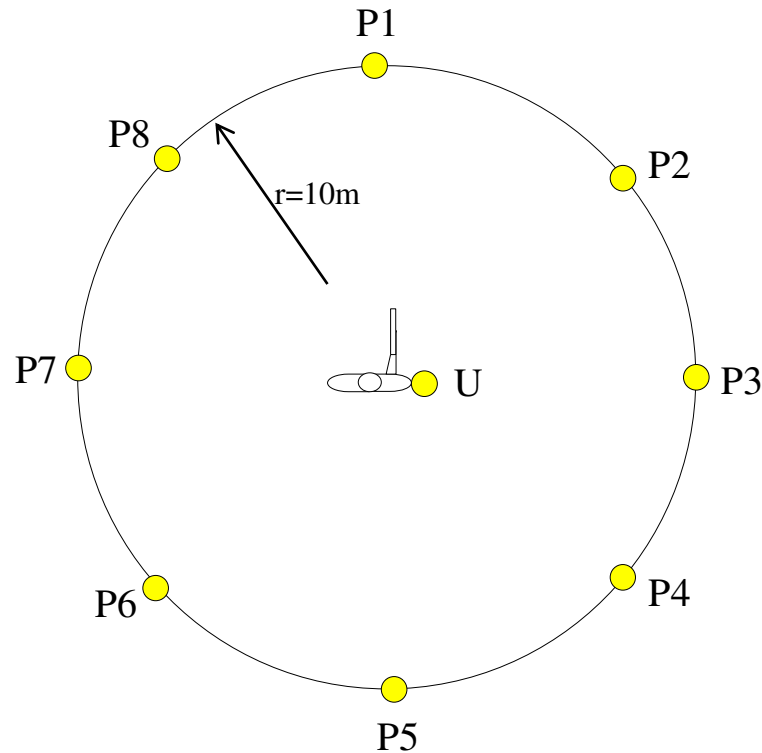


Figure 1. Placement of measurement points in relation to the shooter firing a gun.

The tests were conducted during target shooting with the following types of firearms (Figure 2), calibers, and silencers:

1. Ruger American Predator bolt-action rifle in .308 Win caliber using GGG FMJ ammunition weighing 9.55 grams (147 grains), with an initial velocity of 842 m/s, initial energy of 3375 J and an A-Tec H2 0.3 acoustic silencer with a nominal effectiveness of 33 dB(C).
2. AR-15 DPMS Panther Arms carbine in .223 Rem (5.56x45 NATO) caliber using GGG ammunition weighing 4.99 grams (77 grains) with Sierra HPBT projectile and an initial velocity of 855 m/s, initial energy of 1825 J, and an A-Tec AR 40-3 acoustic silencer with a nominal effectiveness of 28 dB(C).
3. Glock 45 pistol in 9x19 mm caliber using Selier&Bellot Luger FMJ ammunition weighing 8.0 grams (124 grains), with an initial velocity of 360 m/s, initial energy of 518 J, and an A-Tec PMM-6 M13.5x1 LH acoustic silencer, for which the manufacturer specifies effectiveness at 36 dB(C) for a wet silencer and 28 dB(C) for a dry silencer.



Figure 2. Guns used during noise measurements: a) Ruger American Predator bolt-action rifle, b) AR-15 DPMS Panther Arms carbine, c) Glock 45 pistol, d) A-Tec H2 0.3 silencer, e) A-Tec PMM-6 silencer.

To ensure the appropriate bandwidth of the measurement apparatus a measurement set was used consisting of a 1/8-inch Brüel & Kjær type 4138 microphone with a sensitivity of 1 mV/Pa, a frequency range from 6.5 to 140 kHz, a dynamic range from 52.2 to 168 dB, and a polarization voltage of 200V, a Svantek SVAN 945A sound level meter and a UA-0036 adapter which allowed for connecting the two devices. The configured measurement set is shown in Figure 3.



Figure 3. Measurement set for recording impulse signals.

During field noise measurements for each of the 3 types of firearms described above (bolt-action rifle, carbine, pistol), the transient changes in acoustic pressure were recorded with a time resolution of 2 ms (0.002 s). The recordings were made at each of the 8 measurement points (P1-P8) and additionally at the shooter's ear. The following sound levels were recorded in real time, parallel to each other: L_A , L_{Amax} , L_{Amin} , L_C , L_{Cpeak} , along with changes in their frequency spectra in octave bands. The recorded acoustic waveforms served as the basis for processing the results using SvanPC software and determining the relevant indicators describing the recorded sound. An exemplary course of changes of the transient sound level A at the shooter's ear during a 0.30" caliber bolt-action rifle shot without a silencer and with an A-Tec H2 silencer is shown in Figure 4.

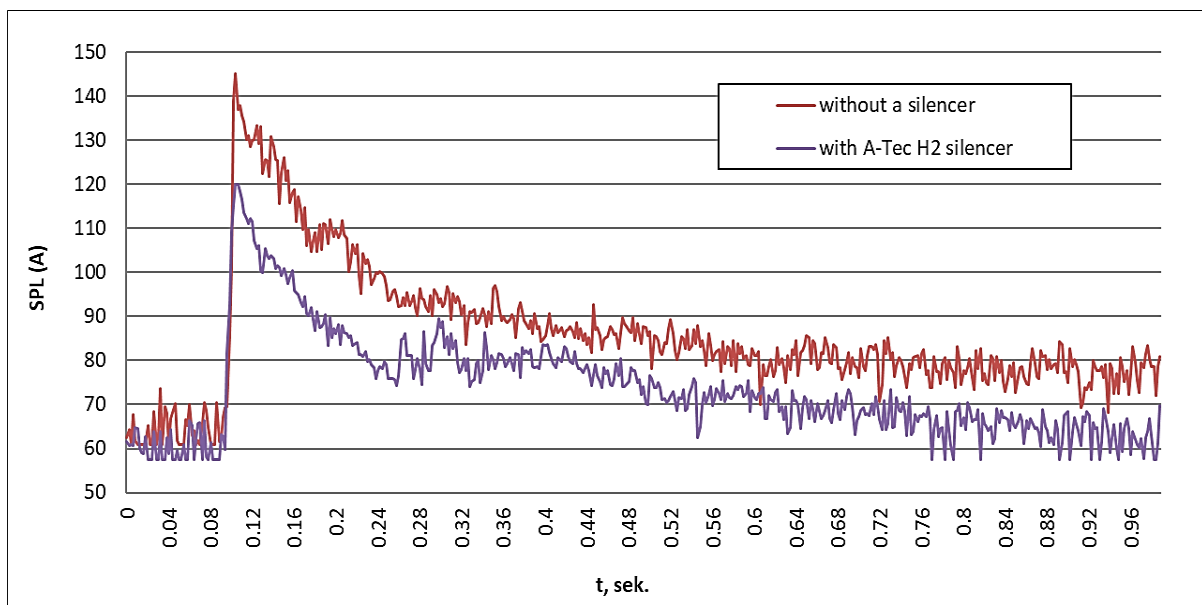


Figure 4. Change in sound pressure level corrected by A characteristics.

4. Achieved test results

The compilation of measurement results and acoustic level calculations at the shooter's ear and at the 8 measurement points P1-P8 during shots fired with and without acoustic silencers for each of the three types of firearms (bolt-action rifle, carbine, pistol) is presented in Table 1. The symbols in the table represent:

- $L_{Aeq,1s}$ – the average sound level A measured from 10 ms before the shot until 1 second after the shot, that is until the complete sound attenuation,
- L_{Amax} – the maximum sound level A reached at the moment of the shot,
- L_{Cpeak} – the maximum peak sound level C reached at the moment of the shot.

Table 1.

Compilation of measurement results and calculations of sound levels obtained during the conducted test shots

Ruger American Predator bolt-action rifle, cal. 308 Win, silencer A-Tec H2 0.3							
ID point	without silencer			with silencer			Silencer effectiveness in point U
	$L_{Aeq,1s}$	L_{Amax}	$L_{C,peak}$	$L_{Aeq,1s}$	L_{Amax}	$L_{C,peak}$	
U	121.9	144.5	155.3	101.3	120.2	130.7	$L_{Aeq,1s}$ 20.6 dB(A) L_{Amax} 24.3 dB(A) L_{Cpeak} 24.6 dB(C)
P1	116.4	137.6	150.2	110.8	136.7	148.7	
P2	116.3	136.5	147.4	102.0	125.2	136.3	
P3	111.9	133.7	143.8	86.3	107.1	115.5	
P4	102.8	123.3	132.6	82.9	101.1	109.2	
P5	100.7	121.1	128.2	80.0	96.1	102.7	
P6	103.0	125.2	135.6	82.6	102.3	111.6	
P7	113.0	131.9	142.7	86.2	106.6	116.2	
P8	116.1	136.4	146.6	102.2	126.5	137.7	

AR-15 DPMS Panther Arms carbine, cal. 223 Rem, silencer A-Tec AR 40-3							
ID point	without silencer			with silencer			Silencer effectiveness in point U
	$L_{Aeq,1s}$	L_{Amax}	$L_{C,peak}$	$L_{Aeq,1s}$	L_{Amax}	$L_{C,peak}$	
U	121.6	144.1	152.3	105.7	128.8	138.1	$L_{Aeq,1s}$ 15.9 dB(A) L_{Amax} 15.3 dB(A) L_{Cpeak} 14.2 dB(C)
P1	120.7	139.3	147.3	107.0	133.3	145.5	
P2	119.5	140.4	145.9	97.9	122.8	134.6	
P3	113.8	134.5	141.6	87.2	106.2	115.9	
P4	106.1	125.6	133.6	82.5	102.2	109.2	
P5	102.6	120.1	128.3	80.6	99.3	105.8	
P6	105.3	124.6	132.8	82.9	102.8	110.0	
P7	111.0	130.3	139.9	89.4	107.4	114.9	
P8	117.8	137.9	144.4	98.4	122.9	134.5	

Glock 45 pistol, cal. 9x19 Luger, silencer A-Tec PMM-6 M13.5x1 LH							
ID point	without silencer			with silencer			Silencer effectiveness in point U
	$L_{Aeq,1s}$	L_{Amax}	$L_{C,peak}$	$L_{Aeq,1s}$	L_{Amax}	$L_{C,peak}$	
U	121.4	145.9	153.9	100.8	122.2	129.9	$L_{Aeq,1s}$ 20.6 dB(A) L_{Amax} 23.7 dB(A) L_{Cpeak} 24.0 dB(C)
P1	118.9	141.1	152.9	115.9	141.1	152.3	
P2	110.9	130.6	140.1	97.8	115.5	121.0	
P3	108.2	127.1	137.2	80.9	101.1	111.6	
P4	106.1	124.1	129.4	80.8	95.5	106.1	
P5	103.8	121.0	125.7	76.0	94.2	105.2	
P6	106.2	124.3	131.2	80.5	94.0	105.3	
P7	108.5	127.5	137.0	80.3	100.6	110.9	
P8	112.2	130.4	139.9	96.9	114.7	120.7	

The analysis of the presented results (at point U) has shown that the use of silencers allows for a reduction in the noise level at the shooter's ear, significantly reducing the shooter's exposure to harmful noise. In the case of silencers used on the bolt-action rifle and the pistol, a reduction of approximately 24 dB in the maximum transient sound level A and peak sound level C was achieved, along with a reduction of the average sound level A in 1 second by 20 dB. In both cases, this result is lower than the manufacturer's specified silencer

performance, but it is entirely satisfactory for the shooter and allows for a clearly noticeable difference in the gunshot loudness. For the AR carbine silencer, a reduction in the average sound level of about 15 dB was achieved, however it is mainly due to the small size of the silencer used and the construction of the carbine itself.

During the conducted test shots, it was possible to notice that the spectral characteristics of the noise changed after using the silencer. The gunshot noise without a silencer contains many low and mid-frequency components (the noise itself is very unpleasant and penetrates the entire body), while after using the silencer, the mid and high-frequency characteristics clearly dominate, and the shot is softer and more ear-friendly. An example of the spectral characteristics of the noise is shown in Figure 5.

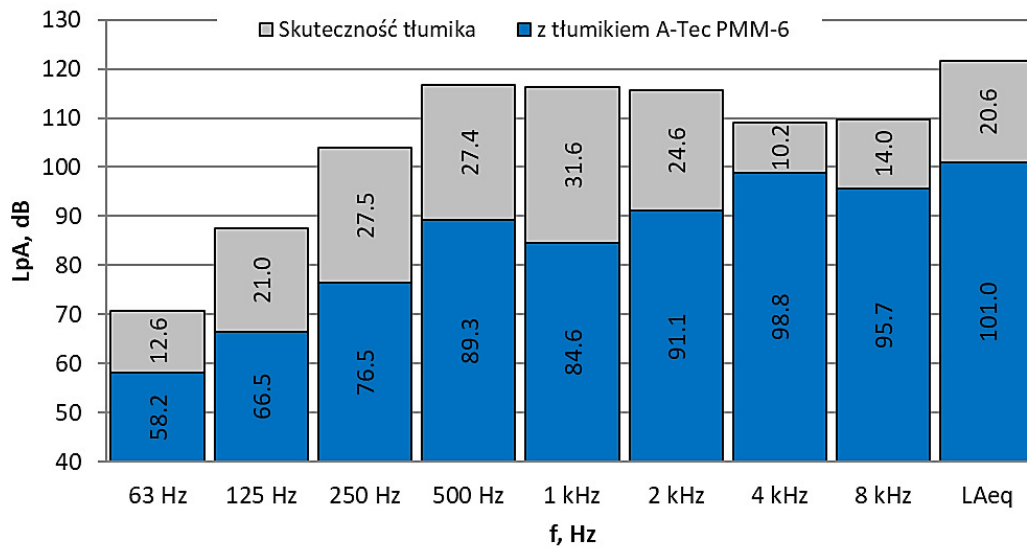


Figure 5. Spectral characteristics of noise while shooting a Glock 45 pistol.

A very important aspect of using silencers is that they also change the directional characteristics of the sound source from omnidirectional to highly directional, with the dominant direction being determined by the shooting direction. The decrease in sound level in the shooting direction is minimal, while in the opposite and perpendicular directions it is significant. An example of the directional characteristics obtained when shooting with the Ruger American Predator bolt-action rifle is shown in Figure 6, with the AR-15 carbine in Figure 7, and with the Glock 45 pistol in Figure 8.

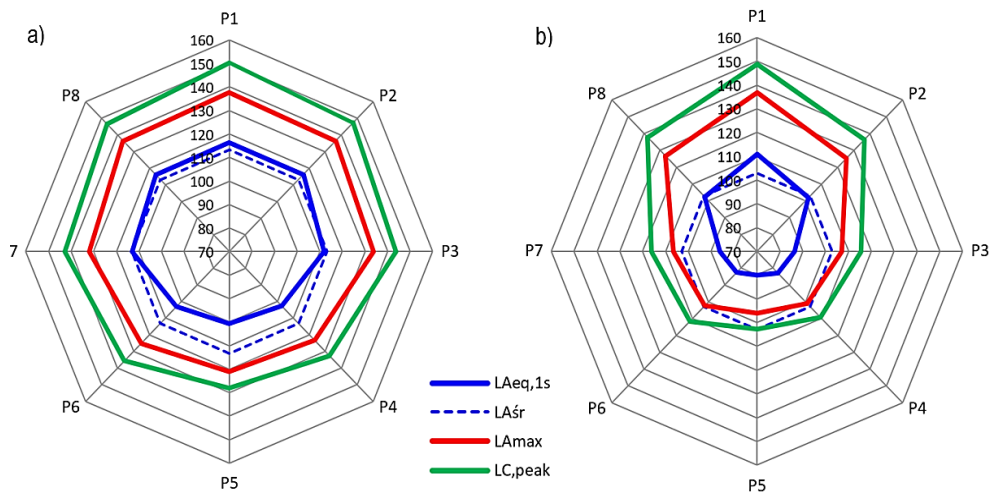


Figure 6. Directional characteristics of noise while shooting a Ruger bolt-action rifle (.308 Win): a) without a silencer, b) with an A-Tec H2 silencer.

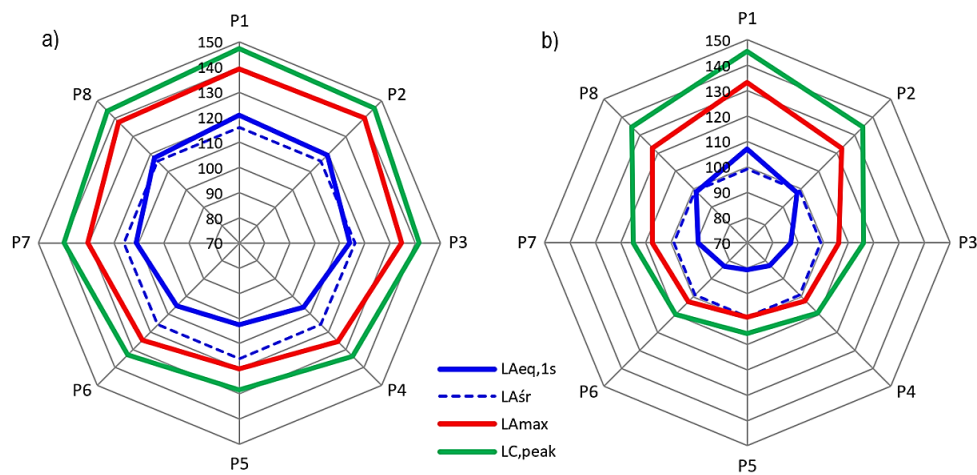


Figure 7. Directional characteristics of noise while shooting an AR-15 carbine (.223 Rem): a) without a silencer, b) with an A-Tec AR 40-3 silencer.

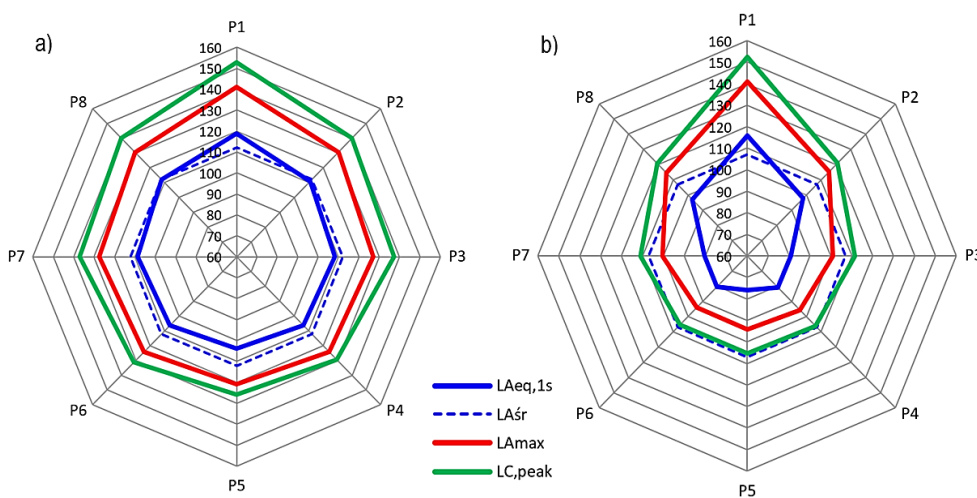


Figure 8. Directional characteristics of noise while shooting a Glock 45 pistol (9x19): a) without a silencer, b) with an A-Tec PMM-6 silencer.

A comparison of the obtained results of the change in sound source directionality during shots fired with different types of guns, with and without a silencer, is presented in Figure 9.

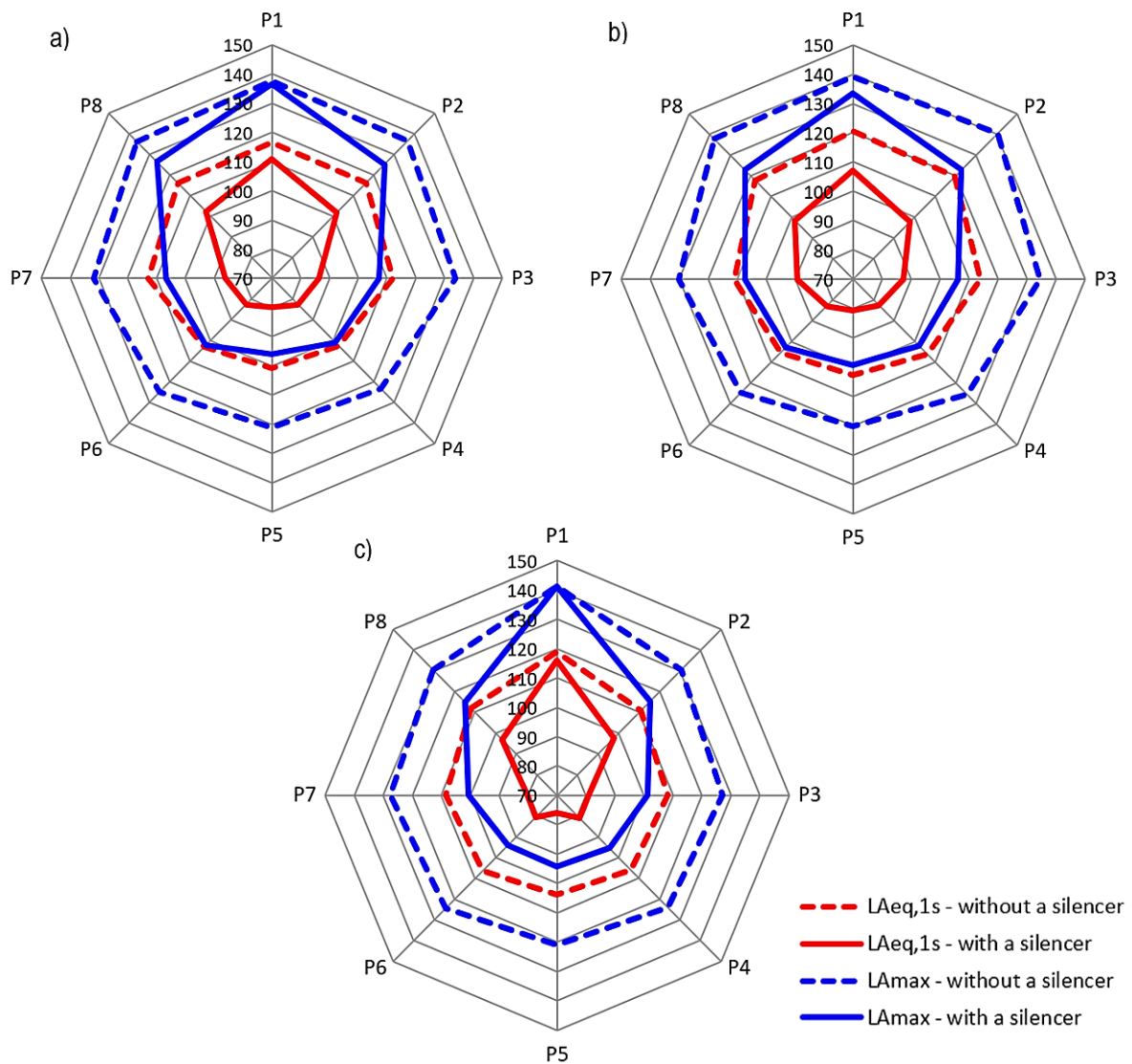


Figure 9. Comparison of directional noise characteristics while shooting with and without a silencer: a) Ruger American Predator bolt-action rifle in .308 Win caliber, b) AR-15 carbine in .223 Rem caliber, c) Glock 45 pistol in 9x19mm caliber.

In each of the analyzed and presented cases, a clear change in the directionality of sound propagation during the shot with the silencer was observed. A shot fired without a silencer has characteristics similar to a circular pattern shifted towards the shooting direction. In general it can be stated that in directions perpendicular to the shooting direction the sound level reduction is on average 10 dB, and in the opposite direction, it is 20 dB. After using a silencer, the gunshot noise propagates in a much more directional manner. In directions perpendicular to the shooting direction, the noise level is lower than the highest level by an average of 30-35 dB, and in the opposite direction, by 40-45 dB.

5. Conclusions

The obtained test results have allowed for determining the change in the directionality of gunshot noise after using a silencer and have provided a justification for using silencers during sports and hunting shooting. Due to the protection of the shooter's hearing and the protection of the external environment, especially the population residing in the immediate vicinity of shooting ranges, the use of such solutions should be required.

Unfortunately, the current Polish legislation, except for a few cases such as sanitary culling of animals to combat infectious diseases, does not permit the use of silencers, considering guns with silencers as particularly dangerous weapons. Among the public, there is often a belief that a shot with a silencer is inaudible, which is clearly untrue. Perhaps in subsonic calibers or sporting calibers like .22LR, significant noise reduction during a shot can be achieved, but it does not mean that it will be inaudible.

Understanding the directionality of the source during a shot is of paramount importance due to the possibility of a more precise assessment of the impact of noise on the external environment, especially using computational methods for noise propagation in the environment. This allows for a more accurate modeling of noise emission from shooting ranges, taking into account the placement of firing axis as well as the type and intensity of shooting.

Another critical aspect of knowing the directionality characteristics during a gunshot with a silencer is the potential for improving silencer construction. Currently, focus should be placed on reducing noise emission from the silencer in the direction of the shot, as there is a clear pattern of minimal attenuation in this area, with practically zero or very slight sound reduction. In contrast, highly satisfactory noise reduction results are achieved in the lateral and rearward directions relative to the shooter.

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ANALYSIS OF THE SIMILARITY AMONG EUROPEAN UNION COUNTRIES IN TERMS OF SUSTAINABLE ENERGY DEVELOPMENT

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Purpose: The primary purpose of the study was to empirically analyze the similarity among EU countries concerning their energy sustainability.

Methodology: The research methodology developed and applied includes a taxonomic approach based on the k-means method. This method was used to cluster European Union countries into homogeneous groups, based on selected indicators, to identify countries with similar levels of energy sustainability in 2013 and 2022. The indicators represented various aspects of energy sustainability, such as greenhouse gas emissions, the development of renewable energy sources (RES), energy consumption per capita, and energy productivity in terms of euros per kilogram of oil equivalent.

Findings: The study results indicate considerable variation among EU countries in energy sustainability. Scandinavian countries consistently achieve the best results, characterized by a high share of renewable energy in the energy mix and low greenhouse gas emissions, reflecting the successful integration of their energy policies with sustainability goals. In contrast, some Central and Eastern European countries exhibit weaker records of energy sustainability due to economic and political historical contexts and related social challenges. This group is marked by higher GHG emissions, a lower share of renewable energy, and lower energy efficiency.

Practical Implications: The methodology used allows for the grouping of EU countries based on their achievements in energy sustainability and facilitates comparisons between them. It also identifies leaders and outliers from the average, particularly highlighting the need for diagnosing the reasons behind the status of the outlier group and identifying actions to improve the current state. Achieving energy neutrality is now a priority of EU economic policy. The results indicate significant variation in the energy development of EU countries, suggesting the need for more tailored EU financial and technological support.

Originality: The paper presents a holistic approach, utilizing a taxonomic method to analyze the similarity among a group of EU countries in terms of sustainable energy development. This broad and multidimensional approach integrates various aspects of energy sustainability, enabling a comprehensive assessment of energy policy implementation between 2012 and 2022 at the level of EU countries.

Keywords: sustainable energy development, goal 7 - clean and accessible energy, energy policy, European Union, taxonomic method, holistic approach.

Category of the paper: Research paper.

1. Introduction

Sustainable energy development is one of the fundamental challenges of the modern world, particularly in the context of growing environmental awareness and the urgent need to reduce greenhouse gas emissions (Gunnarsdottir et al., 2021; Marti, Puertas, 2022; Tutak et al., 2020). It should be understood as the use of energy sources that meet three basic requirements: they do not deplete as a result of their use, their use does not cause emissions or other environmental risks to humans and/or ecological and climatic systems on a significant scale, and they are not associated with the perpetuation of significant social injustices (Jaiswal et al., 2022).

As part of global sustainable development initiatives, specifically Sustainable Development Goal 7 (SDG 7) adopted by the United Nations, countries are committed to providing universal access to affordable, reliable, and clean energy sources (United Nations, 2021). Within the European Union, which comprises 27 member states with diverse economic and energy profiles, achieving this goal requires coordinated action and effective policies at both the national and EU levels. As one of the world's leading economic and political communities, the European Union plays a key role in achieving these global goals while simultaneously striving to meet its own ambitious domestic targets for environmental protection, energy security, energy efficiency, and greenhouse gas emission reductions. To meet these objectives, numerous directives, regulations, and initiatives have been implemented, such as the European Green Deal, which aims to achieve climate neutrality by 2050. Promoting renewable energy sources (RES), improving energy efficiency, and reducing CO₂ emissions are critical components of this strategy (Council of the European Union, 2021; European Commission, 2019, 2020, 2021).

However, the implementation of these goals is not uniform across the EU. Member states vary significantly in terms of natural resource availability, technological development, economic structure, and energy policy. Social aspects, which are also diverse across the EU, play an important role in these processes. For instance, Scandinavian countries such as Sweden and Denmark are leaders in the field of RES, while Central and Eastern European countries such as Poland and Bulgaria still rely heavily on fossil fuels, resulting in a low share of RES in their energy mix and high GHG emissions.

In this context, studying the EU-27 countries in terms of energy sustainability, both individually and in terms of their similarity, is fully justified. An important tool for analyzing the similarity of EU countries in terms of sustainable energy development is the use of indicators that identify the problem under study and allow for comparisons of individual countries across various aspects of this process.

The purpose of the research presented in this paper is to analyze the similarity among EU countries concerning sustainable energy development, specifically in the context of achieving Goal 7 of Agenda 2030: "Ensure access to affordable, reliable, sustainable,

and modern energy for all". This analysis was conducted using a set of nine key indicators to monitor progress toward this goal, with the k-means method (a taxonomic method) employed for the analysis. The first part of the paper presents the research methodology, including the characteristics of the indicators used and a discussion of the k-means method. This was followed by a comparative analysis of EU countries, including key indicators of energy sustainability. The next part of the work included the identification of groups of countries with similar characteristics and achievements in energy transition. Finally, based on the conclusions of the study, recommendations were made for energy policies in the context of further integration and cooperation within the EU.

2. Key indicators of sustainable energy development

Energy sustainability is the foundation of the energy transition, which seeks to meet the growing demand for energy while minimizing environmental impacts. In the context of accelerating climate change and global efforts to decarbonize economies, key indicators of energy sustainability are essential tools for evaluating the progress and effectiveness of energy strategies (Neves et al., 2010; Neves, Leal, 2010; Pan et al., 2023; Vera, Langlois, 2007).

These indicators provide a comprehensive assessment of various aspects of the energy system, such as energy efficiency, reliance on energy imports, diversification of energy sources, and greenhouse gas emissions. They enable the monitoring, analysis, and optimization of energy policies in a way that promotes both economic development and environmental protection. Additionally, these indicators help identify areas requiring intervention and measure the effectiveness of implemented actions.

The existing literature employs various indicators to assess countries' progress in achieving energy sustainability. Table 1 presents and characterizes the most significant of these indicators.

Table 1.
Sustainable energy development indicators

Indicator	Characteristics
Total primary energy supply per capita (TPES per capita), tonnes of oil equivalent (TOE)	This indicator measures the amount of primary energy available per capita. Primary energy refers to energy obtained directly from natural sources, such as coal, oil, natural gas, nuclear power, and renewable energy sources. This indicator serves as a measure of the availability of energy resources within a country.
Primary energy consumption per capita, tonnes of oil equivalent	This indicator measures actual primary energy consumption per capita. It is important because it reflects the amount of energy used for economic, industrial, and domestic needs, making it crucial for assessing a country's energy efficiency.
Energy Import Dependency, %	This indicator measures the percentage of energy consumed in a country that is sourced from imports. A high level of import dependence indicates vulnerability to external energy shocks, such as fluctuations in commodity prices or supply disruptions.

Cont. table 1.

Energy Productivity, Euro per kilogram of oil equivalent (KGOE)	This indicator measures the efficiency of energy use in the economy, expressed as the economic value (e.g., GDP) generated per unit of energy consumed. High energy productivity indicates efficient use of energy in economic processes, benefiting both the economy and the environment.
Share of renewable energy in gross final consumption, %	This indicator measures the percentage of energy derived from renewable sources (such as solar, wind, hydroelectric, biomass, and geothermal) within a country's or region's total final energy consumption.
Share of renewable energy consumption in transport, %	This indicator measures the percentage of energy used in the transportation sector that comes from renewable energy sources. It is important because the transportation sector is a major source of greenhouse gas emissions, and increasing the share of renewable energy sources in this sector can significantly contribute to reducing emissions.
Share of renewable energy consumption in electricity, %	This indicator measures the percentage of electricity generated from renewable energy sources. It is crucial for assessing progress in the energy transition toward more sustainable energy sources, which is important for reducing CO ₂ emissions and protecting the environment.
Share of renewable energy consumption in heating and cooling, %	This indicator measures the percentage of energy used for heating and cooling that comes from renewable energy sources. The heating and cooling sector is a significant energy consumer, and its decarbonization is crucial for achieving climate goals.
GHG emissions from energy sector per capita, t CO ₂ eq./capita	This indicator measures the amount of greenhouse gases emitted by the energy sector on a per capita basis. It is crucial for assessing the sector's impact on climate change and the effectiveness of emission reduction policies.
Population unable to keep home adequately warm by poverty status, %	This indicator determines the percentage of the population unable to adequately heat their homes due to poverty. It is important for evaluating the social aspects of energy policies.
Energy prices, euro/kilowatt	This indicator refers to the costs associated with purchasing various forms of energy, such as electricity, natural gas, fuel oil, and renewable fuels. These prices are a key factor affecting national economies, households, and the industrial sector.
Energy Intensity, kilograms of oil equivalent (KGOE) per thousand euro	This indicator determines the amount of energy required to produce a unit of economic output or value added in the economy. It is a key parameter for assessing the energy efficiency and economic sustainability of a country. This indicator is typically expressed as the amount of energy (usually in kilograms of oil equivalent, KGOE) per unit of economic value (usually in thousands of euros).

These indicators are used by researchers and international institutions to monitor and evaluate the effectiveness of energy policies, assess the environmental and social impact of energy systems, and plan measures to achieve sustainable development in the energy sector.

3. Materials and methods

The analysis of the similarity of EU countries in terms of their energy sustainability was based on data from the Eurostat database. This database contains comprehensive and reliable statistical data on various aspects of energy sustainability. A total of 9 indicators were used for the study, which characterized the studied EU countries in terms of:

- Total primary energy supply per capita, tons of oil equivalent.
- Primary energy consumption per capita; tons of oil equivalent.
- Energy import dependency, %.
- Energy productivity, Euro per kilogram of oil equivalent.
- Share of renewable energy consumption in transportation, %.
- Share of renewable energy consumption in electricity, %.
- Share of renewable energy consumption in heating and cooling, %.
- GHG emissions from energy sector per capita, t CO₂ eq./capita.
- Population unable to keep home adequately warm by poverty status, %.

The data covered the years 2013 and 2022 and served as the basis for the analysis conducted using the k -means method.

The k -means method is a clustering technique employed in the analysis of large multidimensional datasets. It divides a dataset into a specified number of clusters (k), such that objects (in this case, EU countries) within the same cluster are more similar to each other than to objects in other clusters. The method iteratively minimizes the sum of squared distances between data points and the centroid of their respective clusters (Dol, Jawandhiya, 2023; Ikotun et al., 2023).

The k -means algorithm includes the following steps:

- 1) To create a calculation matrix with dimensions $N \times M$, where N is the number of objects and M is the number of variables:

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1M} \\ x_{21} & x_{22} & \dots & x_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ x_{N1} & x_{N2} & \vdots & x_{NM} \end{bmatrix} \quad (1)$$

- 2) To standardize computational data:

$$z_{ji} = \frac{x_{ij} - \mu_i}{\sigma_i} \quad (2)$$

where:

z_{ji} - the standardized value of the j -th point for the i -th variable,
 μ is the mean value, and σ is the standard deviation.

- 3) To select initial centroids:

$$\mu_1, \mu_2, \dots, \mu_k \quad (3)$$

where μ_i are the initial centroids.

A matrix of centroids:

$$\mu^{(t)} = \begin{bmatrix} \mu_{11}^{(t)} & \mu_{12}^{(t)} & \dots & \mu_{1M}^{(t)} \\ \mu_{21}^{(t)} & \mu_{22}^{(t)} & \ddots & \mu_{2M}^{(t)} \\ \vdots & \vdots & \ddots & \vdots \\ \mu_{k1}^{(t)} & \mu_{k2}^{(t)} & \vdots & \mu_{kM}^{(t)} \end{bmatrix} \quad (3)$$

- 4) To assess points to nearest centroids. For each point x_j in the dataset, it is assigned to a cluster C_i with the nearest centroid μ_i :

$$C_i = \{x_j: \|x_j - \mu_i\|^2 \leq \|x_j - \mu_l\|^2 \forall l = 1, \dots, k\} \quad (4)$$

where $\|x_j - \mu_i\|$ is the Euclidean distance between the point x_j and the centroid μ_i .

The Euclidean distance between the point $x_j = (x_{j1}, x_{j2}, \dots, x_{jn})$ and the centroid of the $\mu_i = (\mu_{i1}, \mu_{i2}, \dots, \mu_{in})$ is determined from this equation:

$$\|x_j - \mu_i\| = \sqrt{\sum_{m=1}^n (x_{jm} - \mu_{im})^2} \quad (5)$$

- 5) Centroid update. To calculate a new centroid for each cluster C_i .

$$\mu_i = \frac{1}{|C_i|} \sum_{x_j \in C_i} x_j \quad (6)$$

where:

$|C_i|$ is the number of points in cluster C_i ,

the sum is run over all points x_j assigned to cluster C_i .

- 6) Steps 2 and 3 are repeated until the centroids no longer change significantly (change less than a preset threshold ϵ) or the maximum number of iterations T is reached.

The k -means method requires a priori specification of the number of clusters. The determination of the optimal number of clusters was carried out using the Elbow Method. This method aims to find the optimal number of clusters by analyzing the Within-Cluster Sum of Squares (WCSS) graph (Shi et al., 2021). The formula for calculating WCSS for a given number of clusters k is given by:

$$WSSC = \sum_{i=1}^k \sum_{x \in C_i} \|x_j - \mu_i\|^2 \quad (7)$$

where:

k is the number of clusters;

C_i is the i -th cluster;

x is the data point assigned to cluster C_i ;

μ_i is the center of *the* i -th cluster (centroid).

4. Results and discussions

In the first stage of the analysis, the optimal number of clusters was determined to which the EU-27 countries were assigned. Calculations using the WCSS method indicated that the optimal number of clusters was 4 (Figure 1).

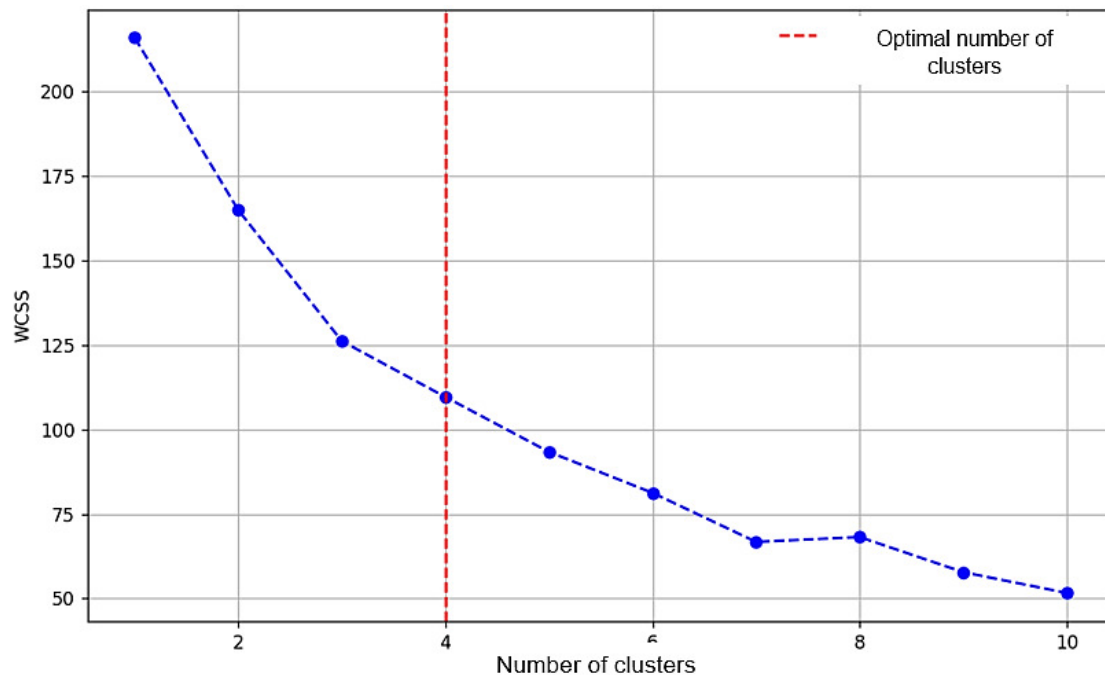


Figure 1. Determination of the optimal cluster count from the WCSS method.

Source: Own elaboration.

Next, the compositions of the clusters of similar countries in terms of energy sustainability for the years 2013 and 2022 were determined. This grouping was based on the 9 indicators of energy sustainability adopted for the study.

The initial analysis focused on clustering EU countries based on data from 2013. In the first step, the cluster compositions for that year were established, as shown in Table 2, along with the distance of each country from the center of its respective cluster.

Table 2.

Cluster compositions of similar countries in energy sustainability in 2013

Cluster 1		Cluster 2		Cluster 3		Cluster 4	
Country	Distances from Centre of Cluster 1	Country	Distances from Centre of Cluster 2	Country	Distances from Centre of Cluster 3	Country	Distances from Centre of Cluster 4
Denmark	0.916	Belgium	0.558	Bulgaria	0.869	Luxembourg	0,00
Austria	0.558	Bohemia	0.438	Greece	0.424		
Finland	0.787	Germany	0.424	Spain	0.686		
Sweden	0.730	Estonia	1.159	Croatia	0.582		
		Ireland	1.052	Italy	0.618		
		France	0.455	Cyprus	0.704		
		Netherlands	0.502	Latvia	0.684		
		Poland	0.592	Lithuania	0.453		

Slovenia	0.570	Hungary	0.589
Slovakia	0.497	Malta	0.785
		Portugal	0.601
		Romania	0.747

A *k*-means clustering analysis identified four main clusters of EU countries based on 2013 data. Within each cluster, countries are the most similar in terms of energy sustainability, while being significantly different from countries in other clusters. Countries located closer to the center of a cluster exhibit the greatest similarity to each other. The farther a country is from the center of its cluster, the less similar it is to the countries closer to the center. Assigning such a country to a different cluster would be unwarranted due to insufficient similarity to countries in that cluster.

Cluster 1 includes Denmark, Sweden, Finland, and Austria. These countries are moderately distant from the center of their cluster, indicating similar characteristics in terms of energy sustainability despite some differences. On average, these countries have high per capita energy consumption, ranging from 3.17 to 5.88 tons of oil equivalent (TOE). The total primary energy supply (TPES) per capita ratios also remain at an average level, ranging from 3.11 to 6.08. Dependence on energy imports is relatively low, ranging from 12.31% to 61.26%. High energy productivity, with values ranging from 5.59 to 13.19, is another distinguishing feature of these countries. The share of renewable energy sources in transportation ranges from 6.46% to 10.67%, in electricity from 30.54% to 68.91%, and in heating and cooling from 33.22% to 50.77%. Per capita greenhouse gas emissions are average, ranging from 6.51 to 8.86 tons. The proportion of the population experiencing difficulty maintaining an adequate temperature at home due to energy poverty is low, ranging from 1.2% to 3.8%.

Cluster 2 includes Belgium, Czechia, Germany, Estonia, Ireland, France, Netherlands, Poland, Slovenia, and Slovakia. With the exception of Ireland, these countries are relatively close to the center of the cluster, indicating they share many common characteristics in terms of energy development. They exhibit average to high per capita energy consumption, ranging from 2.27 to 4.36 tons of oil equivalent (TOE). TPES per capita ratios are also average, ranging from 2.35 to 4.96. Dependence on energy imports varies significantly, from 14.52% to 91.55%. Energy productivity ranges from 3.67 to 12.74. The share of renewable energy sources in transportation ranges from 4.90% to 7.30%, in electricity from 9.91% to 25.28%, and in heating and cooling from 4.00% to 43.11%. Per capita greenhouse gas emissions are medium to high, ranging from 5.18 to 14.36 tons. The proportion of the population experiencing difficulty heating their homes due to energy poverty is relatively low, ranging from 2.9% to 10%.

Cluster 3 comprises Bulgaria, Greece, Spain, Croatia, Italy, Cyprus, Latvia, Lithuania, Hungary, Malta, Portugal, and Romania. These countries also share similarities but exhibit greater variability in energy characteristics within the group, with some countries being slightly further from the cluster center. They have low per capita energy consumption, ranging from 1.52 to 2.52 TOE. TPES per capita ratios are low to average, ranging from 1.58 to 2.58. Dependence on energy imports is variable, ranging from 18.32% to 104.14%. Energy productivity ranges from 2.28 to 7.29. The share of renewable energy sources in transportation ranges from 0.95% to 6.67%, in electricity from 1.57% to 49.10%, and in heating and cooling from 13.97% to 37.31%. Per capita greenhouse gas emissions are low to average, ranging from 3.93 to 7.09 tons. The proportion of the population experiencing difficulty heating their homes due to energy poverty is high, ranging from 8% (Spain) to 44.9% (Bulgaria).

Cluster 4 consists solely of Luxembourg. This unique case indicates that Luxembourg's energy characteristics are so distinct that it does not fit into any of the other clusters, showing insufficient similarity to the other EU countries. Luxembourg is characterized by very high per capita energy consumption, at 7.91 TOE, and a very high TPES per capita value of 7.385. Dependence on energy imports is also very high, at 97.1%. Energy productivity is notably high, at 10.35 euros per kilogram of oil equivalent. The share of renewable energy sources in transportation is only 4.07%, in electricity is 5.33%, and in heating and cooling is 5.33%. As a result, per capita greenhouse gas emissions are very high, at 18.5 tons. Conversely, the proportion of the population experiencing difficulty maintaining an adequate temperature at home due to energy poverty is very low, at 1.6%.

Table 3 presents the basic descriptive statistics for each cluster created.

Table 3.

Basic descriptive statistics of the formed clusters for 2013 data

Cluster	Variable	Mean	Min	Max	Variance	Median
Cluster 1 (4 objects)	Primary energy consumption per capita, TOE	4.418	3.17	5.88	1.157	4.31
	TPES per capita, TOE	4.572	3.11	6.08	1.597	4.55
	Energy import dependency, %	38.49	12.31	61.26	355.46	46.46
	Energy productivity, euro per kilogram of oil equivalent	8.48	5.59	13.19	10.52	8.27
	Share of renewable energy consumption in transport, %	8.964	6.456	15.315	15.74	8.081
	Share of renewable energy consumption in electricity, %	51.818	30.543	68.909	212.13	52.411
	Share of renewable energy consumption in heating and cooling, %	45.58	33.222	61.708	139.48	41.199
	Greenhouse gas emissions from energy sector per capita, t CO ₂ eq.	6.719	4.15	8.86	3.74	6.93
	Population unable to keep home adequately warm by poverty status, %	2.15	0.9	3.8	1.64	2.35

Cont. table 3.

Cluster 2 (10 objects)	Primary energy consumption per capita, TOE	3.48	2.46	4.34	0.34	3.81
	TPES per capita, TOE	3.65	2.57	4.51	0.45	3.98
	Energy import dependency, %	44.43	14.52	91.55	521.96	47.46
	Energy productivity, euro per kilogram of oil equivalent	6.10	2.63	12.74	8.73	5.16
	Share of renewable energy consumption in transport, %	5.41	0.45	7.60	4.36	6.21
	Share of renewable energy consumption in electricity, %	18.16	9.91	33.08	52.19	16.98
	Share of renewable energy consumption in heating and cooling, %	17.59	4.00	43.11	157.78	14.27
	Greenhouse gas emissions from energy sector per capita, t CO ₂ eq.	8.63	5.18	14.36	6.70	8.70
	Population unable to keep home adequately warm by poverty status, %	6.18	2.90	11.40	7.40	5.40
Cluster 3 (12 objects)	Primary energy consumption per capita, TOE,	2.14	1.52	2.53	0.09	2.14
	TPES per capita, TOE	2.16	1.58	2.58	0.08	2.15
	Energy import dependency, %	66.30	18.32	104.14	511.38	70.00
	Energy productivity, euro per kilogram of oil equivalent	5.93	3.64	9.62	3.48	5.22
	Share of renewable energy consumption in transport, %	3.29	0.93	6.34	3.89	3.48
	Share of renewable energy consumption in electricity, %	26.72	1.57	49.10	281.59	31.30
	Share of renewable energy consumption in heating and cooling, %	27.80	13.97	49.65	107.58	26.20
	Greenhouse gas emissions from energy sector per capita, t CO ₂ eq.	5.00	3.59	7.09	1.38	4.28
	Population unable to keep home adequately warm by poverty status, %	20.74	8.00	30.50	60.25	21.10
Cluster 4 (1 object)	Primary energy consumption per capita, TOE,	7.91	N/A	N/A	N/A	N/A
	TPES per capita, TOE	7.39	N/A	N/A	N/A	N/A
	Energy import dependency, %	97.10	N/A	N/A	N/A	N/A
	Energy productivity, euro per kilogram of oil equivalent	10.35	N/A	N/A	N/A	N/A
	Share of renewable energy consumption in transport, %	4.07	N/A	N/A	N/A	N/A
	Share of renewable energy consumption in electricity, %	5.329	N/A	N/A	N/A	N/A
	Share of renewable energy consumption in heating and cooling, %	5.33	N/A	N/A	N/A	N/A
	Greenhouse gas emissions from energy sector per capita, t CO ₂ eq.	18.46	N/A	N/A	N/A	N/A
Population unable to keep home adequately warm by poverty status, %	1.6	N/A	N/A	N/A	N/A	

Cluster 1 is characterized by a high share of renewable energy sources, high energy productivity, and low dependence on energy imports. Cluster 2 includes countries with medium energy productivity, varying shares of renewable energy sources, and medium greenhouse gas emissions. Cluster 3 consists of countries with low energy productivity, variable shares of renewable energy sources, and a high proportion of the population having difficulty heating

their homes. Cluster 4 (Luxembourg) is distinguished by very high energy consumption, high dependence on energy imports, and very high greenhouse gas emissions.

These findings are supported by the analysis of variance (ANOVA) presented in Table 4. The results indicate that many of the variables studied, such as primary energy consumption per capita, TPES per capita, the share of renewable energy in various sectors, and the proportion of the population unable to maintain adequate home temperatures, exhibit statistically significant differences between clusters. This confirms that the groups formed in the cluster analysis are distinct in terms of these indicators. Conversely, variables such as dependence on energy imports and energy productivity do not show significant differences between groups, suggesting relative homogeneity in these aspects among the clusters.

Table 4.
Analysis of variance (ANOVA) for variable

Variable	Between SS	df	Inside SS	df	F	Significance <i>p</i>
Primary energy consumption per capita, TOE	21.466	3	4.534	23	36.298	0.000
TPES per capita, TOE	20.210	3	5.790	23	26.762	0.000
Energy import dependency, %	6.291	3	19.709	23	2.447	0.089
Energy productivity, euro per kilogram of oil equivalent	5.916	3	20.084	23	2.258	0.109
Share of renewable energy consumption in transport, %	13.979	3	12.021	23	8.916	0.000
Share of renewable energy consumption in electricity, %	11.536	3	14.464	23	6.115	0.003
Share of renewable energy consumption in heating and cooling, %	12.044	3	13.956	23	6.616	0.002
Greenhouse gas emissions from energy sector per capita, t CO ₂ eq.	18.091	3	7.909	23	17.536	0.000
Population unable to keep home adequately warm by poverty status, %	16.513	3	9.487	23	13.344	0.000

The next stage of the analysis involved grouping EU countries by similarity in terms of their energy sustainability in 2022. The determined cluster compositions are shown in Table 5, and in Table 6 the basic descriptive statistics for each cluster formed.

Table 5.*Cluster compositions of similar countries for sustainable energy development in 2022*

Cluster 1		Cluster 2		Cluster 3		Cluster 4	
Country	Distances from Centre of Cluster 1	Country	Distances from Centre of Cluster 2	Country	Distances from Centre of Cluster 3	Country	Distances from Centre of Cluster 4
Denmark	0.869	Bulgaria	0.877	Bohemia	0.615	Belgium	0.495
Finland	0.647	Greece	0.504	Estonia	0.875	Germany	0.346
Sweden	0.783	Spain	0.534	Poland	1.172	Ireland	1.037
		France	0.500			Luxembourg	1.175
		Croatia	0.587			Netherlands	0.414
		Italy	0.560			Austria	0.775
		Cyprus	0.758				
		Latvia	0.868				
		Lithuania	0.516				
		Hungary	0.593				
		Malta	0.791				
		Portugal	0.635				
		Romania	0.809				
		Slovenia	0.610				
		Slovakia	0.476				

Denmark, Finland, and Sweden are located in Cluster 1. The distances from the center of the cluster for these countries are 0.869, 0.647, and 0.783, respectively, indicating moderate differences between them. These distance values suggest that the countries in this cluster are fairly homogeneous, though some variation exists. Compared to 2013, the composition of Cluster 1 has changed, as Austria is no longer included. The countries in Cluster 1 are characterized by high per capita energy consumption, typical of nations with high living standards and developed economies. TPES per capita is also high, reflecting intensive energy consumption. Dependence on energy imports varies, indicating different strategies for managing energy resources. These countries have high energy productivity, signifying efficient energy use in the economy. A significant share of renewable energy sources, especially in electricity and heating, underscores a strong commitment to sustainable development. Low per capita greenhouse gas emissions reflect effective emission reduction policies (see Table 6).

Cluster 2 includes 15 countries, with distances from the center of the cluster ranging from 0.476 for Slovakia to 0.877 for Bulgaria. This indicates that the countries in this cluster have a moderate level of cohesion, with some differences. Countries in Cluster 2 have lower per capita energy consumption and TPES per capita compared to those in Cluster 1. Dependence on energy imports is medium, reflecting moderate risk from external energy suppliers. Energy productivity is lower than in Cluster 1, suggesting less efficient energy use. The share of renewable energy sources is variable but generally lower than in Cluster 1. Per capita greenhouse gas emissions are higher than in Cluster 1, indicating greater challenges in emission reduction (see Table 6).

Cluster 3 consists of Czechia, Estonia, and Poland. The analysis of distances from the cluster center reveals significant internal variation among these countries, as they are all notably far from the center. This indicates substantial differences in their energy characteristics. These countries exhibit average per capita energy consumption and TPES per capita. Dependence on energy imports is low, suggesting greater energy autonomy. Energy productivity is at an average level, and the share of renewable energy sources varies. Per capita greenhouse gas emissions are relatively high, reflecting a reliance on more carbon-intensive energy sources, such as coal, particularly in Poland (see Table 6).

Cluster 4 includes Belgium, Germany, Netherlands, Ireland, Luxembourg, and Austria. Belgium, the Netherlands, and Germany have the shortest distances from the cluster center, indicating they are very homogeneous and central to this cluster. In contrast, Luxembourg, Ireland, and Austria are farther from the center, highlighting differences compared to the more central countries. The countries in Cluster 4 have high per capita energy consumption and TPES per capita, similar to Cluster 1. They also have high dependence on energy imports, making them vulnerable to external energy suppliers. Energy productivity is high, reflecting efficient energy use. The share of renewable energy sources is moderate, and per capita greenhouse gas emissions are high, due to a significant reliance on emitting fuels in the energy mix, especially in Germany, Ireland, and Luxembourg. This suggests challenges in reducing emissions and transitioning to more sustainable energy sources (see Table 6).

Table 7.

Basic descriptive statistics characterizing the created clusters for 2022 data

Cluster	Variable	Mean	Min	Max	Variance	Median
Cluster 1 (3 objects)	Primary energy consumption per capita, TOE	4.75	3.17	6.09	2.65	4.98
	TPES per capita, TOE	2.69	0.87	4.36	2.60	2.84
	Energy import dependency, %	36.85	26.82	42.87	125.45	40.88
	Energy productivity, euro per kilogram of oil equivalent	11.41	6.36	17.75	22.21	10.11
	Share of renewable energy consumption in transport, %	19.74	10.24	29.16	91.56	18.83
	Share of renewable energy consumption in electricity, %	69.15	47.93	83.34	280.24	69.15
	Share of renewable energy consumption in heating and cooling, %	59.02	50.11	69.39	108.46	58.55
	Greenhouse gas emissions from energy sector per capita, t CO ₂ eq.	4.51	2.95	5.92	2.29	4.67
	Population unable to keep home adequately warm by poverty status, %	3.26	1.40	5.10	2.13	3.30

Cont. table 2.

Cluster 2 (15 objects)	Primary energy consumption per capita, TOE	2.68	1.66	3.81	0.33	2.63
	TPES per capita, TOE	9.32	0.09	60.606	659.2	2.188
	Energy import dependency, %	58.08	32.412	99.009	1010.04	58.4
	Energy productivity, euro per kilogram of oil equivalent	7.69	2.53	26.77	58.43	6.76
	Share of renewable energy consumption in transport, %	9.19	2.395	29.158	72.86	8.54
	Share of renewable energy consumption in electricity, %	38.14	15.936	83.34	519.53	37.005
	Share of renewable energy consumption in heating and cooling, %	39.93	15.411	69.393	463.55	37.005
	Greenhouse gas emissions from energy sector per capita, t CO ₂ eq.	4.55	3.422	8.837	3.55	4.368
	Population unable to keep home adequately warm by poverty status, %	10.87	2.6	22.5	54.85	7
Cluster 3 (3 objects)	Primary energy consumption per capita, TOE	3.25	2.44	4.98	2.09	3.02
	TPES per capita, TOE	2.7	0.413	160.645	4358.62	2.24
	Energy import dependency, %	48.6	6.159	160.645	4689.36	46.029
	Energy productivity, euro per kilogram of oil equivalent	10.38	4.19	26.77	55.23	5.29
	Share of renewable energy consumption in transport, %	7.5	5.793	10.467	1.25	7.197
	Share of renewable energy consumption in electricity, %	37.58	15.499	65.442	118.94	37.58
	Share of renewable energy consumption in heating and cooling, %	24.53	15.936	60.959	274.25	25.802
	Greenhouse gas emissions from energy sector per capita, t CO ₂ eq.	7.02	4.497	8.656	3.65	8.358
	Population unable to keep home adequately warm by poverty status, %	4.73	2.9	8.8	6.73	4.9
Cluster 4 (6 objects)	Primary energy consumption per capita, TOE	3.59	2.44	8.32	5.41	3.74
	TPES per capita, TOE	10.07	0.823	34.108	114.83	6.35
	Energy import dependency, %	60.45	40.884	92.018	169.98	51.917
	Energy productivity, euro per kilogram of oil equivalent	10.16	7.22	26.77	41.67	10.28
	Share of renewable energy consumption in transport, %	8.91	5.512	10.811	7.04	10.241
	Share of renewable energy consumption in electricity, %	41.19	15.936	77.22	257.95	47.637
	Share of renewable energy consumption in heating and cooling, %	35.76	15.411	77.22	272.69	30.579
	Greenhouse gas emissions from energy sector per capita, t CO ₂ eq.	6.11	4.066	10.702	6.55	6.575
	Population unable to keep home adequately warm by poverty status, %	4.54	2.1	6.8	5.29	5.3

In the next stage of the study, an analysis of variance was conducted for individual variables to identify whether there are statistically significant differences between groups of countries (clusters) in terms of energy sustainability in 2022 (Table 7).

Table 7.
Analysis of variance (ANOVA) for variable

Variable	Between SS	df	Inside SS	df	F	Significance <i>p</i>
Primary energy consumption per capita, TOE	11.988	3	14.012	23	6.560	0.002
TPES per capita, TOE	5.680	3	20.320	23	2.143	0.122
Energy import dependency, %	12.605	3	13.395	23	7.215	0.001
Energy productivity, euro per kilogram of oil equivalent	9.851	3	16.149	23	4.676	0.011
Share of renewable energy consumption in transport, %	14.667	3	11.333	23	9.923	0.000
Share of renewable energy consumption in electricity, %	9.913	3	16.087	23	4.724	0.010
Share of renewable energy consumption in heating and cooling, %	13.479	3	12.521	23	8.253	0.001
Greenhouse gas emissions from energy sector per capita, t CO ₂ eq.	15.501	3	10.499	23	11.320	0.000
Population unable to keep home adequately warm by poverty status, %	11.247	3	14.753	23	5.844	0.004

The variable "Primary energy consumption per capita" had an *F-value* of 36.298 and a *p-value* less than 0.000, indicating that the differences between clusters are statistically significant. Similarly, "TPES per capita" had an *F-value* of 26.762 and a *p-value* of 0.000, also showing significant differences between clusters. The variable "Energy import dependency, %" had an *F-value* of 2.447 and a *p-value* of 0.089, suggesting that differences between clusters for this variable are not statistically significant at the 0.05 level. "Energy productivity" had an *F-value* of 2.258 and a *p-value* of 0.109, also indicating no significant differences between clusters.

An *F-value* of 8.916 and a *p-value* of 0.000 were obtained for "Share of renewable energy consumption in transportation," indicating significant differences between clusters. Significant differences were also found for "Share of renewable energy consumption in electricity" and "Share of renewable energy consumption in heating and cooling." The variable "Greenhouse gas emissions from the energy sector per capita, tons" had an *F-value* of 17.536 and a *p-value* less than 0.000, indicating significant differences between clusters. Lastly, "Population unable to keep home adequately warm by poverty status" had an *F-value* of 13.344 and a *p-value* less than 0.000, suggesting significant differences between clusters.

In summary, most variables showed significant differences between clusters, highlighting diversity in energy sustainability among the analyzed countries. Only "Energy import dependency" and "Energy productivity" did not show statistically significant differences between clusters.

A comparison of the 2013 and 2022 analyses reveals changes in the distribution of countries across different clusters. While Cluster 1 remained relatively stable in terms of its main characteristics, other clusters experienced shifts in composition. These changes reflect the

evolving implementation of EU energy policies and progress towards SDG Goal 7. The results underscore the importance of continuous monitoring of trends in energy consumption, energy efficiency, the share of renewable energy sources, and greenhouse gas emissions. The dynamic nature of cluster compositions highlights the need for ongoing evaluation of energy strategies at both national and EU levels. Countries should prioritize enhancing energy efficiency, increasing the share of renewables, and reducing greenhouse gas emissions to achieve sustainability and climate change goals. This is particularly crucial for countries that still rely heavily on traditional energy sources, including those in Central and Eastern Europe (CEE). These nations should focus on expanding the use of RES, such as wind, solar, and biomass, and improving energy efficiency. Such measures will facilitate more effective resource use and help reduce dependence on conventional energy sources, which are associated with high greenhouse gas emissions.

5. Conclusions

This paper presents a comparative study of the energy sustainability of EU countries for the years 2013 and 2022, utilizing nine key indicators aligned with the European Union's energy policy and SDG Goal 7 of the 2030 Agenda. The analysis was conducted using the k-means clustering method, which identified four distinct clusters of countries based on their energy sustainability characteristics.

Based on the research conducted for 2013, the following conclusions were made:

- Countries in Cluster 1, i.e., Denmark, Sweden, Austria, and Finland, stood out for their high energy productivity, low dependence on energy imports, and high share of renewable energy sources. These countries have, on average, high energy consumption and greenhouse gas emissions, and the population with heating difficulties is low.
- Countries in Cluster 2, i.e., Belgium, Czechia, Germany, among others, were characterized by average energy consumption and varying shares of renewable energy sources. Energy productivity and greenhouse gas emissions varied.
- Countries in Cluster 3, such as Bulgaria, Greece, and Spain, had low energy consumption, variable import dependence, and low energy productivity. Greenhouse gas emissions are low to average, and heating problems are significant.
- Luxembourg, forming a stand-alone Cluster 4, is unique because of its very high energy consumption, high dependence on imports, and very high greenhouse gas emissions relative to other EU countries.

In turn, the main conclusions of the analysis for 2022 are as follows:

- Cluster 1 is made up of Denmark, Finland, and Sweden, characterized by consistently high energy consumption per capita and TPES per capita, low dependence on energy imports, and high energy productivity. A high share of renewable energy sources results in low greenhouse gas emissions from the energy sector.
- In Cluster 2 (15 countries), moderate consistency is noted with differences in energy consumption and TPES per capita. These countries have lower values for energy consumption and energy productivity than in Cluster 1. The share of renewable energy sources is lower, and GHG emissions are higher, indicating greater challenges in reducing emissions. Dependence on energy imports is medium, indicating a moderate risk to these countries' energy security.
- Cluster 3 included Poland, Czechia, and Estonia, countries of considerable diversity, with marked differences in energy consumption and TPES per capita. These countries have low dependence on energy imports, which means greater energy autonomy. Energy productivity is average, and the share of renewable energy sources varies. High per capita GHG emissions indicate a high share of coal (Poland, Czechia) and other emitting energy sources (Estonia - shale).
- Belgium, Germany, Ireland, Luxembourg, Netherlands, and Austria, which make up Cluster 4, are characterized by high per capita energy consumption and TPES, as are the countries in Cluster 1 (Denmark, Sweden, and Finland). These countries have high dependence on energy imports and high energy productivity. The share of renewables is moderate, but per capita GHG emissions are high, especially in Germany and Ireland, indicating major challenges in transitioning to more sustainable energy sources.

In terms of specific clusters, countries in Cluster 1 should continue their approach to sustainability, investing in renewable energy sources and efficiency-enhancing technologies. Countries in clusters 2 and 3, on the other hand, should focus on increasing energy efficiency and reducing greenhouse gas emissions by developing infrastructure for renewable energy sources. These countries' policies should be tailored to local needs and conditions. Countries in Cluster 4 should consider preparing a new strategy to reduce emissions and transition to more sustainable energy sources, given their high energy consumption and high emissions.

In these activities, cooperation with other EU countries in technological innovation and exchange of best practices is particularly advisable. In general, it can be concluded that European solidarity and cooperation between countries should be the way to achieve the adopted goals. The results also show that the EU-27 countries have different approaches to energy policy and sustainable development. It is therefore advisable to make greater use of the results presented and included in other research works in the process.

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THE USE OF THE NEW ECOLOGICAL PARADIGM SCALE TO MONITOR THE ENVIRONMENTAL ATTITUDES OF POLISH STUDENTS BEFORE AND AFTER THE IPCC SPECIAL REPORT ON GLOBAL WARMING OF 1.5°C

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Purpose: In October 2018, the IPCC Special Report on Global Warming of 1.5°C was published. The Youth Climate Strike took place in many Polish cities. Over the last few years, there has been a noticeable change in the approach to environmental protection in Poland, which has been observed both in the media and in everyday life. The aim of the article is to present how the environmental awareness of Polish students has changed following specific events and changes in the general approach to environmental protection in Poland.

Design/methodology/approach: The study was conducted using the New Ecological Paradigm Scale questionnaire and a questionnaire checking the state of knowledge about the natural environment as well as about the causes and consequences of its pollution. The study was conducted in 2016 on a group of 624 students of various faculties and universities in several Polish cities, repeated in 2021 on a group of 700 students.

Findings: After 5 years, the results were similar, especially concerning the environmental knowledge. The only significant change concerned beliefs about the reality of a serious ecological crisis and the negative impact of human activity on the environment. An increase of the level of knowledge was observed mainly regarding current and widely discussed issues such as smog.

Practical implications: According to the results, the increase in awareness of the harmfulness of human activity is not accompanied by significant increase in environmental knowledge, therefore it is worth to improve environmental education.

Social implications: Polish students are more aware of the harmfulness of human activity and the perspective of environmental crisis than before, therefore they are presumably more interested in environmental issues and willing to learn about the natural environment and its protection.

Originality/value: The article provides a comparison of results of research conducted before and after important events and significant changes in the country.

Keywords: New Ecological Paradigm Scale, environmental awareness of students, environmental attitudes, environmental knowledge, fear of environmental crisis.

Category of the paper: Research paper.

1. Introduction

In the second half of the 20th century, when the foundations of modern environmental awareness were being formed in the Western Europe and in United States of America, Poland, for various reasons, remained outside the mainstream of this process. Environmental issues did not garner much interest and were most often identified with protection of the natural environment understood in a very traditional sense.

New issues brought on by the anthropogenic nature of the growing global environmental crisis (Jonas, 1996) did not arouse much interest. The sustainable development strategy promoted by the UN (Our Common Future, 1987) and the European Union was treated as a problem of the distant future, affecting future generations rather than those currently living (Pastusiak, 1999).

Public attention was mainly drawn to the spectacular activities of radical supporters of "deep ecology" (Devall, Sessions, 1995; Dziubek-Hovland, 2004; Gliński, 1988, 1996; Żuk, 2001; Through environmentalism to freedom, 2014). Protests against the construction of the Czorsztyńska Dam in the Pieniny Mountains, the nuclear power plant in Żarnowiec, and the bypass in the Rospuda Valley were often met with opposition and suspicion as to the intentions of the protesters (Tomasiewicz, 2004; Leszczyński, 2007; Feliksiak, 2007; Niedbał, 2014), due to the radicalism of the slogans and shocking forms of manifestation. For conservative and moderate circles, environmentalism was most often associated with left-wing radicalism.

This attitude was exemplified in a study conducted on a group of 300 students in 2012 (Ciężela, 2014) regarding the support for various institutions and aid initiatives; namely aid for groups of people who had no influence on the bad situations that befell them, aid for people who were (presumably) responsible for their difficult situation (e.g. addiction treatment center), as well as initiatives related to protection of the environment such as e.g. protection of endangered animal species. As the results of this study indicate, initiatives related to environment protection received very low level of support. An environmental organization received even lower support than post-accident aid for motorcyclists (who are associated with fast and reckless driving and thus tend to be perceived as being responsible for their situation).

The change in attitudes towards environmentalism began to occur gradually due to the increase of information about growing threats, including the information about the growing number of victims of the increasing air pollution in Polish cities. Polish Smog Alert was the first mass pro-environmental social movement in Poland. Public opinion was also greatly impressed by a series of reports providing a radical assessment of the threat of a climate catastrophe, announced since October 2018 by the Intergovernmental Panel on Climate Change (IPCC) established by the UN. The first report of the series was the Special Report on Global Warming of 1.5°C (2018), warning of serious consequences of the temperature increase.

In the fall of 2019, the Ministry of the Environment in Poland was transformed into the Ministry of Climate. In the same year, the international initiative of the Youth Climate Strike was launched in Poland, activating school youth (Korzeniowski, 2019; Markiewka, 2021). Demonstrations took place in dozens of Polish cities. They were attended not only by secondary school students, but also by parents, teachers and university students. The initiative continues to this day.

Several social campaigns promoting environmental protection and featuring various celebrities were initiated, including: First day without smog and Clean Poland. Commercial advertisements referring to environmental protection also began to emerge, which used to be rare before. Waste sorting bins have become ubiquitous, and plastic cutlery and plastic straws have been replaced with more environmentally friendly options such as paper straws. Microplastic-free cosmetics packaging and even plastic-free credit cards have also appeared. Public transport buses now feature the words "I am environmentally friendly". Clothing stores started to offer sustainable fashion collections. Zero Waste campaigns, encouraging the exchanging of used clothes for example, were initiated.

The presented change in attitudes does not apply to the entire population, however. Despite attempts to modify their attitudes (Pilawa, 2021), conservatives have, for the most part, remained in the same positions (Kisiełowska, 2021; Shellenberger, 2021; Klinsky, 2023; Morano, 2023). Such divisions, however, are not features of clearly delineated camps, but rather create various types of inconsistencies and contradictions in the attitudes of specific people (Lasota-Krawczyk, 2024).

In 2020 the COVID pandemic reached Poland. Being locked helplessly in our homes was a new experience, not only for young people. Some researchers have argued that the pandemic is the result of humans interfering with nature (Afelt, 2022).

2. Literature Review

The study of environmental awareness in Poland began in the 1980s. Since 1992, nationwide environmental awareness surveys have been conducted on a group of approximately 1000 people. They were carried out by CBOS on behalf of the Institute for Sustainable Development or independently of InE. Environmental awareness studies were also commissioned by the Ministry of the Environment (regardless of the change of its name). In 2010, only 16% of the respondents perceived environmental pollution as a threat, and only 7% of the respondents believed that the depletion of non-renewable natural resources was a problem (Stanaszek, Tędziągolska, 2011).

Environmental awareness increased slowly (Kachaniak, Skrzyńska, Trzasańska, 2014). Studies still indicated a low interest in pro-environmental issues and a failure to recognize its importance in the context of the problems facing Poland. Similarly, Polish citizens surveyed as part of the Eurobarometer, viewed the danger to the natural environment to be a minor problem. For many years, environmental protection was ranked 12th or 13th out of 14 in importance.

In spring 2017, 58% of Polish respondents considered climate change to be a serious problem (the EU average result is 74%). In the fall of 2018, respondents from Poland placed the natural environment, climate, and energy issues (next to unemployment and immigration) in 7th place out of 14. However, by July 2019 this changed and Polish respondents described climate change as a much more serious problem and ranked climate issue 3rd among the issues of concern (Special Eurobarometer 2019).

In Poland, environmental problems, and in particular climate change, began to be noticed only in 2017. One can assume, that this was related to the issue of smog, which started to be widely discussed at that time.

Of the studies on environmental awareness conducted in Poland, some concerned the environmental awareness of the general public, while others of select social or professional groups, including junior high and high school students and university students (e.g. Cichy, 1993; Szulborski, 2001; Kuzior, 2005; Poniedziałek, Rzymiski, 2010; Ziemnicka-Wojtaszek, 2011; Bednarek-Gejo, 2012; Rucińska, Szmurło, 2014; Redo, 2017; Janczarska-Bergel, 2018).

The New Ecological Paradigm Scale (NEP) questionnaire is a method used to measure the pro-ecological view of the world. The questionnaire contains questions regarding, among others: the harmfulness of human activities for the environment, belief in a real threat of a serious environmental crisis, and belief in humans' special place among other creatures on Earth. This method has been used in many different countries, including: the United States (Cordano et al., 2003; Levine, Strube, 2012; Carnes, Nix, 2023), Germany (Schleyer-Lindenmann et al., 2018), Turkey (Erdoğan, 2009; Atav et al., 2014), Indonesia (Putu, 2017), Malaysia (Karpudewan, 2021), Spain (Corraliza et al., 2013), Kosovo (Srbinovski, 2019; Veselay et al., 2019; Veselay, 2023), and Nigeria (Ogunbode, 2013).

The NEP questionnaire has been used to investigate the environmental attitudes of various groups, including students (Cordano et al., 2003; Bun Lee, 2008; Erdoğan, 2009; Ogunbode, 2013; Schleyer-Lindenmann et al., 2018; Carnes, Nix, 2023; Spinola, 2023). The NEP questionnaire was also used in studies aimed at examining the relationships between individuals' attitudes and readiness to take actions to help the environment (Cordano et al., 2003), pro-environmental behavior, and knowledge (Levine, Strube, 2012). The NEP questionnaire was also used to measure changes in attitudes regarding the natural environment before and after educational influence (Harraway et al., 2012; Nanni, Allan, 2020), as well as to compare the attitudes of in-service teachers and of students studying to become teachers (Veselay, 2023).

Even though the NEP scale is a method repeatedly used in many countries to examine environmental attitudes, only a few researchers in Poland made use of it. Szostek (2012), Bartczak (2015), Chmura-Rutkowska and Kozłowska (2022) and Kozłowska et al. (2023) used it in their research. Dyr and Prusik (2020) focused on analyzing the psychometric properties of the scale.

3. Method and sample

The research presented in this article provides a comparison of the results of the two studies, one from 2016 and a repeated one from 2021. The impetus to repeat the study stemmed from a need to assess whether significant events occurring after 2016 impacted the environmental awareness among Polish students.

The study conducted in 2016 involved 624 university students (389 women and 235 men, age 20-26). 700 students (477 women and 223 men, age 20-26) participated in the study in 2021.

The research group consisted of students from universities in Warsaw, Olsztyn, Bydgoszcz, Toruń, Katowice and Gliwice. Attempts were made to select a group that was as diverse as possible: students of natural sciences, sciences, social sciences, and humanities, as well as military and sports faculties took part in the study. Students of such faculties as, among others: law, international relations, economics, pedagogy, sociology, history, computer science and econometrics, chemical technology, and biotechnology were represented in the study. In 2021, efforts were made to assemble as similar a group of students as possible.

The study used the New Ecological Paradigm Scale (NEP) questionnaire translated into Polish. The questionnaire concerns beliefs about the natural environment, the state of the natural environment, the need for its protection, and the rights and place of people, plants, and animals in the world. Odd items are scored directly, and even items (environmentally unfriendly statements) are scored inversely.

A questionnaire consisting of 15 questions grouped on 5 scales:

- The reality of growth limits - the belief that the amount of resources is limited and that the human population is approaching the limit that the Earth can support.
- Anti-anthropocentrism - the belief that humans do not have the right to interfere with nature in accordance with their needs and the right of plants and animals to exist.
- Fragility of nature's balance - the belief that people seriously harm the natural environment with their activities, with the environment unable to defend itself and to balance the impact of modern industry.

- Rejection of exceptionalism - the belief that man is subject to the laws of nature and cannot control nature.
- Possibility of eco-crisis - the belief that the continuation of human activities which harm the natural environment may lead to a serious ecological crisis.

The second part of the study was a questionnaire containing questions checking the knowledge of the participants. The questionnaire was in the form of a multiple-choice test consisting of 20 questions. The questionnaire is a self-authored. The substantive correctness of the questions was consulted with experts. The questions in the questionnaire check knowledge of the current state of the natural environment, the causes of pollution and its effects on people, as well as ways of protecting it.

1. Cutting down the Amazon forest: a) is indifferent to the rest of the world **b) results in an increase in carbon dioxide in the atmosphere** c) applies only to local communities d) I don't know.
2. Which of the following raw materials is considered the most slowly renewable raw material? a) oil, b) water, c) wood, d) I don't know.
3. CO₂ emissions can be reduced by: **a) reducing the use of cars**, b) saving water, c) reducing sugar consumption, d) I don't know.
4. Transitioning from personal car usage to public transport on a daily basis by part of society: a) is enough to solve the problem environmental pollution, **b) will bring some small benefits for improving the state of the environment**, c) will not bring any benefits for the environment if it is not undertaken by the majority of the society, d) I don't know.
5. Which of the following bird species is at risk of extinction in Poland: a) crow, b) pheasant, **c) capercaillie**, d) I don't know.
6. The theory explaining "global warming of the climate" by human activity considers the following as the cause of warming: a) the creation of the ozone hole, **b) the exploitation of fossil fuels leading to CO₂ emissions**, c) the development of nuclear energy, d) I don't know.
7. Heating the house with a traditional stove or fireplace: a) is good for the environment, **b) produces smog**, c) is neutral for the environment, d) I don't know.
8. The extinction of bees will have catastrophic consequences for humans, because: a) there will be no honey as an important component of the diet, b) the disappearance of bees will cause colonies of rival wasps to develop, **c) bee-pollinated plants will disappear**, d) I don't know.
9. Undertaking the program of reducing greenhouse gas emissions by only a few of the countries emitting greenhouse gases: a) will destroy the entire project, b) will reduce the effectiveness of the project, but will not make it meaningless, **c) the answer depends on how many and how large emitters will participate in the program**, d) I don't know.

10. Acidification of the oceans can lead to: a) acid rain and, as a result, the destruction of coastal areas, **b) a decrease in the population of plankton and, as a result, disruption of many food chains**, c) cooling of the climate, d) I don't know.
11. The ozone hole is the result of: **a) the production and emission of freon by humans**, b) the emission of CO₂ by humans, c) the release of freon in the process of melting glaciers, d) I don't know.
12. Drinking water on Earth: a) there is enough, b) is scarce only in Africa, **c) is scarce on all continents**, d) I don't know.
13. By polluting water reservoirs with sewage, humans contribute to the excessive growth of algae, which may result in: a) water hardness, **b) gradual transformation of the lake into a swamp or peat bog**, c) an increase in fish population, d) I don't know.
14. If, as a result of climate warming, the water level rises, the consequence for Poland may be: a) an increase in the amount of drinking water, **b) a decrease in land habitation in northern Poland**, c) no consequences for Poland, d) I don't know.
15. The effects of the ozone hole are manifested in humans by: a) respiratory and heart diseases, b) weakening of bones and teeth, **c) skin cancers and eye diseases**, d) I don't know.
16. Humanity, by causing global warming, contributes to: **a) more frequent hurricanes**, b) more frequent volcanic eruptions, c) earthquakes, d) I don't know.
17. The causes of ocean acidification are: **a) dumping plastic waste in the oceans**, b) melting glaciers, c) overfishing, d) I don't know.
18. Air pollution from car exhausts: a) can cause a child to be born without limbs, **b) can cause brain damage to the fetus**, c) poses no threat to the fetus in the mother's womb, d) I don't know.

Questions about how to counteract the ecological crisis:

1. Glass packaging is better than cans because **a) they are easy to reuse**, b) they take up less space as garbage than cans, c) they decompose faster, d) I don't know.
2. In order to decrease "power consumption": a) just disconnect the phone from the charger, **b) you need to remove the charger from the socket**, c) the effects of both actions are the same, d) I don't know.

4. Results

The highest results were obtained for the Fragility of nature's balance scale (M = 11.14 in 2016, M = 12.04. in 2021), the lowest - for the Reality of growth limits scale in both 2016 (M = 7.8) and 2021 (M = 8.69). The means on all scales increased. The highest increase of the mean was observed in the scale Possibility of eco-crisis (from M = 10.63 in 2016 to M = 12.7 in 2021).

Table 1.*New Ecological Paradigm Scale – individual scales result comparison*

Scale	M		SD		Median		Min		Max	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
The reality of growth limits	7.8	8.69	2.137	2.240	8	9	3	3	15	15
Anti-Anthropocentrism	10.81	11.54	2.578	2.574	11	12	3	3	15	15
Fragility of nature's balance	11.14	12.04	2.181	2.104	11	12	5	3	15	15
Rejection of exemptionalism	9.28	9.67	2.034	2.018	9	10	4	3	15	15
Possibility of eco-crisis	10.63	12.7	2.551	2.276	11	13	3	4	15	15

The percentage of participants agreeing with statements regarding approaching the limits of the human population increased (in 2016, 23.1% rather agreed and 9.1% strongly agreed, in 2021 - 38.9% and 16.7%, respectively %), as well as comparing the Earth to a spaceship with limited room and resources (in 2016, 29.8% rather agreed and 11.7% strongly agreed, in 2021 - 38.1% and 19%, respectively). A very similar percentage of participants agreed after 5 years with the statement regarding the Earth's numerous natural resources (37.3% somewhat agreed both in 2016 and 2021, while 47.1% strongly agreed in 2016 and 44, 1% in 2021).

Table 2.*The reality of growth limits – results comparison*

Statement	M		SD		Median		Min		Max	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
1. We are approaching the limit of the number of people the Earth can support.	2.83	3.36	1.198	1.190	3	4	1	1	5	5
6. The earth has plenty of natural resources if we just learn how to develop them.	1.81	1.87	1.009	1.026	2	2	1	1	5	5
11. The earth is like a spaceship with very limited room and resources.	3.16	3.46	1.113	1.161	3	4	1	1	5	5

Table 3.*The reality of growth limits – percentage distribution*

Statement	SD		MD		U		MA		SA	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
1. We are approaching the limit of the number of people the Earth can support.	14,3%	6,1%	29,5%	24%	24%	14,3%	23,1%	38,9%	9,1%	16,7%
6. The earth has plenty of natural resources if we just learn how to develop them.	2,6%	2,3%	7,4%	8,6%	5,6%	7,7%	37,3%	37,3%	47,1%	44,1%
11. The earth is like a spaceship with very limited room and resources.	6,3%	5,3%	24,7%	20%	27,6%	17,6%	29,8%	38,1%	11,7%	19%

SD: Strongly disagree, MD: Mildly disagree, U: Unsure, MA: Mildly agree SA: Strongly agree.

The percentage of participants who strongly agreed with the statement, that plants and animals have as much right as humans to exist, increased (57.1% in 2016 and 66.7% in 2021), as did the percentage of participants who strongly disagreed with the statement that humans were meant to rule over the rest of nature (19.4% in 2016 and 33% in 2021).

Table 4.
Anti-Anthropocentrism – results comparison

Statement	M		SD		Median		Min		Max	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
2. Humans have the right to modify the natural environment to suit their needs.	3.35	3.52	1.188	1.204	4	4	1	1	5	5
7. Plants and animals have as much right as humans to exist.	4.22	4.42	1.133	0.997	5	5	1	1	5	5
12. Humans were meant to rule over the rest of nature.	3.25	3.59	1.265	1.311	3	4	1	1	5	5

Table 5.
Anti-Anthropocentrism – percentage distribution

Statement	SD		MD		U		MA		SA	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
2. Humans have the right to modify the natural environment to suit their needs.	15,7%	20,7%	41%	44,4%	11,7%	6%	25,6%	23,7%	5,9%	5,1%
7. Plants and animals have as much right as humans to exist.	4,3%	2,6%	7,2%	5,6%	8%	5,3%	23,4%	19,9%	57,1%	66,7%
12. Humans were meant to rule over the rest of nature.	19,4%	33%	27,7%	26,4%	20,2%	15,6%	23,4%	17,1%	9,3%	7,9%

SD: Strongly disagree, MD: Mildly disagree, U: Unsure, MA: Mildly agree SA: Strongly agree.

The percentage of participants who strongly agreed with the statement that human interference with nature often has disastrous consequences increased (33% in 2016 and 50.4% in 2021) and, to a lesser extent, with the statement that the balance of nature is delicate and easily upset (23.6% in 2016 and 35.9% in 2021). The percentage of participants who strongly disagreed with the statement, that the balance of nature is strong enough to cope with the impacts of modern industries, increased (19.6% in 2016 and 29.3% in 2021).

Table 6.
Fragility of nature's balance – results comparison

Statement	M		SD		Median		Min		Max	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
3. When humans interfere with nature it often produces disastrous consequences.	3.83	4.3	1.162	0.910	4	5	1	1	5	5
8. The balance of nature is strong enough to cope with the impacts of modern industries.	3.56	3,76	1.042	1.092	4	4	1	1	5	5
13. The balance of nature is very delicate and easily upset.	3.76	4	1.031	1.022	4	4	1	1	5	5

Table 7.
Fragility of nature's balance – percentage distribution

Statement	SD		MD		U		MA		SA	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
3. When humans interfere with nature it often produces disastrous consequences.	4,8%	1,4%	13%	6%	9,3%	4,3%	39,9%	37,9%	33%	50,4%
8. The balance of nature is strong enough to cope with the impacts of modern industries.	19,6%	29,3%	35,1%	35%	30,4%	21,7%	11,2%	10,4%	3,7%	3,6%
13. The balance of nature is very delicate and easily upset.	2,9%	2%	11,7%	10,1%	15,5%	9,9%	46,3%	42,1%	23,6%	35,9%

SD: Strongly disagree, MD: Mildly disagree, U: Unsure, MA: Mildly agree SA: Strongly agree.

An almost identical percentage of participants agreed with the statement that human ingenuity would insure the Earth from becoming an unlivable planet (in 2016, 37.5% mildly agreed and 11.7% strongly agreed, in 2021 - 37% and 9%, respectively, 9%).

Table 8.
Rejection of exemptionalism - results comparison

Statement	M		SD		Median		Min		Max	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
4. Human ingenuity will insure that we do not make the earth unlivable.	2.65	2.79	1.040	1.090	3	3	1	1	5	5
9. Despite our special abilities humans are still subject to the laws of nature.	3.66	3.86	1.121	1.054	4	4	1	1	5	5
14. Humans will eventually learn enough about how nature works to be able to control it.	2.97	3.01	1.174	1.130	3	3	1	1	5	5

Table 9.
Rejection of exemptionalism – percentage distribution

Statement	SD		MD		U		MA		SA	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
4. Human ingenuity will insure that we do not make the earth unlivable.	5%	5,7%	16%	23,9%	29,8%	23,6%	37,5%	37%	11,7%	9,9%
9. Despite our special abilities humans are still subject to the laws of nature.	4%	3,3%	15,7%	10,4%	14,4%	12,4%	42,1%	44,7%	23,7%	29,1%
14. Humans will eventually learn enough about how nature works to be able to control it.	11,5%	7,9%	22,9%	32,6%	26,1%	20,6%	29,6%	30,9%	9,8%	8,1%

SD: Strongly disagree, MD: Mildly disagree, U: Unsure, MA: Mildly agree SA: Strongly agree.

The percentage of participants who strongly agree with the statement that humans are seriously harming the natural environment has almost doubled: from 27.2% in 2016 to 53.9% in 2021. The percentage of people who strongly disagree that the ecological crisis is exaggerated has increased almost fivefold (from 8.8% in 2016 to 40.7% in 2021). The percentage of participants who strongly agreed with the statement that if things continue as they are, has more than doubled (from 22.8% to 50.4%), we will soon experience a major ecological catastrophe.

Table 10.
Possibility of eco-crisis – results comparison

Statement	M		SD		Median		Min		Max	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
5. Humans are severely abusing the environment.	3.83	4.37	1.043	0.859	4	5	1	1	5	5
10. The so-called ecological crisis facing humankind has been greatly exaggerated.	3.20	4.04	1.156	1.082	3	4	1	1	5	5
15. If things continue on their present course, we will soon experience a major ecological catastrophe.	3.61	4.29	1.115	0.900	4	5	1	1	5	5

Table 11.
Possibility of eco-crisis – percentage distribution

Statement	SD		MD		U		MA		SA	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
5. Humans are severely abusing the environment.	2.6%	1.6%	12.5%	3.9%	11.1%	4.1%	46.6%	36.6%	27.2%	53.9%
10. The so-called ecological crisis facing humankind has been greatly exaggerated.	8.8%	40.7%	20.4%	38.7%	25.2%	9.1%	33.7%	7.1%	12%	4.3%
15. If things continue on their present course, we will soon experience a major ecological catastrophe.	4.5%	1.3%	13.9%	4.9%	20.7%	7.9%	38.1%	35.6%	22.8%	50.4%

SD: Strongly disagree, MD: Mildly disagree, U: Unsure, MA: Mildly agree SA: Strongly agree.

The level of knowledge turned out to be similar after five years. The average score is $M = 13.38$ in 2016 and $M = 14.02$ in 2021.

Table 12.

The level of knowledge - results comparison.

	M		SD		Median		Min		Max	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
Knowledge	13.38	14.02	3.159	3.024	14	14	1	1	20	20

The highest percentage of participants provided correct answers to questions about the decline of bees (95.3% in 2016 and 95.9% in 2021) and the use of glass packaging (89.7% in 2016 and 92.4% in 2021). Both in 2016 and 2021, the lowest percentage of participants gave the correct answer to the question about the causes of global warming (44.9% and 48.6%, respectively). The largest increase in the percentage of correct answers occurred in the case of questions about the causes of smog (65.4% in 2016 and 86.6% in 2021) and the amount of drinking water in the world (51.6% in 2016 and 67.8% in 2021).

Table 13.

Environmental knowledge - the percentage of correct answers

No.	Question	% 2016	% 2021
1	Cutting down the Amazon forest...	80,4	86,7
2	Which of the following raw materials is...	55,6	51,3
3	CO2 emissions can be reduced by...	91,8	83,85
4	Transitioning from personal car usage to public transport...	48,55	54,57
5	Which of the following bird species is at risk of extinction in...	55,6	54
6	The theory explaining "global warming of the climate"...	44,9	48,6
7	Heating the house with a traditional stove or fireplace...	65,38	86,57
8	The extinction of bees will have catastrophic consequences...	95,35	95,87
9	Undertaking the program of reducing greenhouse gas emissions...	45,83	53,71
10	Acidification of the oceans can lead to..	63,14	66,42
11	The ozone hole is the result of...	64,10	65,71
12	Drinking water on Earth...	51,60	67,85
13	By polluting water reservoirs with sewage, humans contribute to...	82,69	83,57
14	If, as a result of climate warming, the water level rises...	80,28	88,57
15	The effects of the ozone hole are manifested in humans by...	75,64	74,28
16	Humanity, by causing global warming, contributes to...	44,87	52
17	The causes of ocean acidification are...	64,26	66,42
18	Air pollution from car exhausts...	51,28	53,42
19	Glass packaging is better than cans because...	89,74	92,42
20	In order to decrease "power consumption"...	87,33	75,85

5. Discussion

Comparing the results of both studies, a significant change occurred only in the case of questions regarding the reality of the ecological crisis and serious damage to the environment by humans.

According to the results of the study conducted in Poland in 2022 on a group of 260 students (Kozłowska et al., 2023), the percentage of people believing, that there is a threat of the environmental crisis, turned out to be even higher. This may be due to both growing awareness and, at least partly, due to the demographics of the selected group, which consisted of 86% women. Women tend to have more pro-environmental attitudes (Xiao, McCright, 2013). More than half of the participants were students of the Faculty of Educational Studies. Students of pedagogical faculties tend to have more pro-environmental attitudes (Ciążela, 2021b). Diversity of pro-environmental attitudes depending on the faculty was also found in a study conducted on a group of students in Nigeria (Ogunbode, 2013).

Optimism about natural resources has not changed. The belief in human creativity, which will prevent the Earth from becoming an uninhabitable planet, has also proven to be unchanged. As part of a study conducted almost at the same time as the one conducted by the author of this article in 2021, in the USA (Carnes, Nix, 2023), participants (513 students and graduates of the University of Texas) mostly expressed faith in the Earth's abundant resources, as well as rather agreed that human creativity would prevent Earth from becoming an uninhabitable planet. It is worth mentioning that the participants generally presented rather pro-environmental attitudes. The results for these two statements were the lowest (Carnes, Nix, 2023). In a study conducted on a group of pedagogy students in Kazakhstan, 75% strongly agreed with the statement (Ciążela et al., 2024) In the polish study the optimism is not so strong, but still more than half of participants beliefs in the abundance of natural resources on Earth (Kozłowska et al., 2023).

When it comes to faith in human ingenuity, it may result from the fact that more and more environmentally friendly solutions are being introduced, such as, among others, electric cars. However, the disadvantages and difficulties of those solutions are rarely discussed. Some people may receive information about very revolutionary ideas. However, recipients may remain unaware of how difficult putting these inventions into practice is and what a distant prospect they are. The belief in human ingenuity may also have been related to the development of COVID-19 vaccines preceding the study.

A significant increase in the number of correct answers in the part concerning the knowledge was observed in the case of the question about the causes of smog, which was the subject of the ongoing campaign at that time. However, the increase in the percentage of correct answers to questions about the causes and effects of global warming, which in 2016 received the lowest percentage of correct answers, was insignificant, even though global warming was also a current topic at that time. It is almost paradoxical that, on the one hand, students are afraid of the environmental crisis, but, on the other hand, less than half of the participants know one of the main causes of the potential crisis.

A positive phenomenon is the increase in awareness of the amount of drinking water in the world. The low percentage of correct answers in 2016 was disturbing. There was a decrease in the number of correct answers to questions concerning basic issues related to everyday

environmental protection activities, i.e. reducing CO₂ emissions and saving electricity, which in 2016 were among the questions which were answered correctly by the largest number of participants. The results indicate, that there was a decrease in knowledge of everyday environmental protection methods, which is rather unexpected.

Research conducted on a group of pedagogy students (Ciężela, 2021a) and high school students (Ciężela, 2023) showed that the social media is main source of knowledge about environmental protection among young people, followed by news portals. Nowadays, informal education plays a greater role than formal education does. Social campaigns regarding environmental protection do not reach recipients as much as expected (Ciężela, Tuszyńska, 2019, Ciężela 2021b). The lack of transfer of systematic knowledge both within formal and informal education may be one of the possible reasons for only a slight increase in the level of knowledge.

6. Summary and conclusions

Polish students' attitudes towards the environment have not changed significantly, apart from recognizing the negative impact of humans on the environment and believing in the reality of a serious ecological crisis. Students are characterized by unwavering optimism about the Earth's natural resources and faith in human ingenuity that will prevent the Earth from becoming unlivable. Students' environmental knowledge level also turned out to be similar to that of five years ago. An increase in the awareness of a serious threat does not correlate with a significant increase in knowledge, even concerning the reasons for and the consequences of said serious threat.

An obvious conclusion from the research is the need for solid environmental education to be a part of formal education. However, environmental awareness consists not only of objective knowledge, but also of an individual's beliefs and attitudes regarding the natural environment and its protection. Attitudes can influence our perception of information, as well as our willingness to obtain more information and to act to protect the environment. As informal education currently plays a significant role in shaping environmental awareness, it would be worth paying more attention to the content presented on social media.

Considering the publication of many alarming reports on the state of the natural environment, including IPCC reports on the threat of a climate catastrophe, it seems incomprehensible that young people remain optimistic, despite their growing awareness of the threat. Presumably, despite concerns about the perspective of a crisis, there is still an optimistic narrative that reaches young people and shapes their beliefs.

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THE PROBLEMATIC NATURE OF THE NOTION OF THE RIGHTS OF PRESENT AND FUTURE GENERATIONS TO CLIMATE AND ENVIRONMENTAL PROTECTION IN THE FACE OF THE PROSPECT OF A CLIMATE DISASTER – AN ETHICAL PERSPECTIVE

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Purpose: The subject of the article is the issue of the current status of the formula of the rights of present and future generations to climate and environmental protection in the face of the ongoing anthropogenic climate disaster.

Design/methodology/approach: The analysis is based on a hermeneutic method that examines the rootedness of the analysed problems in a broader cultural and historical context.

Findings: The results of the analysis indicate the consequences of shortening the time horizon with regard to the potential existence of future generations in conditions that will enable them to exist unaffected by the radical development of the climate disaster.

Research limitations/implications: The study of contemporary phenomena bears the risk of subjectivity. The study refers to current events, hence the use of Internet materials of a journalistic nature.

Social implications: The analysis undertaken in the article will allow for an in-depth, holistic reflection on current issues related to the threat of a climate disaster.

Originality/value: The analysis is aimed at researchers dealing with the ethical aspect of the issue of the rights of present and future generations in their ecological dimension.

Keywords: rights of present and future generations, climate disaster, ethics of global responsibility.

Category of the paper: General review.

1. Introduction - New context for the issue of “the rights of present and future generations to climate and environmental protection”

The issue of the rights of present and future generations to protect the climate and environment¹ is now becoming one of the most important challenges of political practice in the modern world. The progression of the anthropogenic, i.e. human-induced, climate disaster makes the issue of protecting the rights of living generations and their successors a fundamental problem of our times (Maslin, 2018; Popkiewicz, Kardaś, Malinowski, 2019; Monabo, Broccoli, 2022). The fundamental doubt that arises in this regard is whether, when we speak of “the rights of present and future generations to climate and environmental protection” we are not dealing with an euphemism and, in fact, whether we are not referring to the right of present and future generations to continue to exist over time, or even, in the case of the latter, to come into existence. However, it is only formal and persuasive in nature.

Unlike many previous diagnoses and predictions, the current one regarding the climate disaster is no longer about its possible eventuality, but about its reality, as a process taking place here and now (Broniatowski, 2019; Dmitruczuk, 2023; Mieszko, 2024). We can leave the technical aspect of the issue, that is, the question about the degree of advancement of the climate disaster and the likelihood of its possible reversal, to specialists. We, on the other hand, can reflect on the impact of this new reality on the definition of previous approaches, the problems associated with it and the readiness to undertake rescue operations.

From the perspective of this reflection, it should be noted that the formula of the rights of present and future generations to protect the environment and climate is an attempt to update, in the perspective of the ethics of global responsibility, the previous considerations on the issue of responsibility towards future generations, which experienced their glory years at the turn of the millennium.

2. The traditional dimension of the issue

Responsibility for future generations, understood in the traditional sense, is one of the obvious dimensions of human existence. The evolution of species, by basing human reproduction on sexual separation, gives the functioning of the species a generational character, and the need to care for young individuals gives rise to a relationship assuming the obligation of older individuals to provide for the younger ones. The social nature of human existence leads

¹ The term environment used in this article refers to the natural surroundings of man. It allows to avoid discussions and problems concerning the definition of the natural environment understood as an environment undisturbed by man.

to the separation of the aspect of personal ties, family relations and group relations resulting from the sense of belonging to a political (state), social (resulting from the division of labour), professional or ethnic (tribal, national) community.

The moral and ethical reflection that develops around these intergenerational relationships is of a rather obvious yet general nature due to the limited, in terms of its scope and causal capacity, nature of these intergenerational relationships (Birnbacher, 1999, pp. 2-5). This is particularly apparent with regard to the so-called future generations, whose aspirations always remain mysterious and unpredictable. It is a reflection that leads to the issue of the obligations of future generations to be responsible towards past generations whose achievements require protection and continuation.

The traditional approach most often leads to the pursuit of binding future generations to the goals of the current ones - to pass on heritage in exchange for a commitment to continue the family, state, nation, etc. as valuable and protected values. Protecting the rights of future generations in this situation leads to the articulation and defence of the right to challenge these commitments and choose one's own path. Recognition of the "generational conflict" as a natural phenomenon and the decision-making sovereignty of future generations.

3. Responsibility towards future generations as an individual ethical issue

The emergence of the formula of responsibility for actions towards future generations in the area of intergenerational relations, as a phenomenon significant for defining the contemporary human condition, began in the 1960s (Ciążela, 2006). It has its origins in the dynamics of the development of modern civilization. Its roots go back to the methodical approach to the problem of broadening the scope of ethical reflection due to the very rapid and radical expansion of the scope of human agency (Jonas, 1996, pp. 26-33). It entails an increasingly far-reaching range of consequences that threaten the continued existence of humans on the planet.

This direction is represented, independently of each other, by Georg Picht (Picht, 1981) and Hans Jonas (Jonas, 1996). However, it is impossible not to take into account the very specific activities of Aurelio Peccei. He was not only a thinker, but also the initiator and animator of an important phenomenon i.e. the Club of Rome (Ciążela, 2006, pp. 155-188). The first reports for the Club, commissioned on his initiative, defined, on the basis of scientific research, the scale of global threats and their accompanying responsibilities (Ciążela, 2006, pp. 273-310).

The causality achieved through the development of technology has not only extended the scope of problems for the entirety of human life on the planet, giving it a global character, but has also taken on a temporal dimension, including in its scope both responsibility for past actions and the future, often far-reaching, consequences of our activity. The possibility of

destruction, being a consequence of uncontrolled human activity, gave ethical reflection a specifically eschatological character (Picht, 1981 pp. 240-255; Jonas, 2003).

The expansion of causality achieved through the development of technical capabilities in the reflection of the 1970s, turns out to have a primarily negative and destructive character. While it might seem that future generations are potential beneficiaries of the development of civilization, methodical reflection indicates that they become potential victims of the irresponsibility of its creators and direct beneficiaries, while the consequences of their action can make their lives a proverbial hell, or even make it impossible. The scale of threats covers all aspects of development, from environmental devastation to genetic manipulation (Jonas, 1996, pp. 49-54).

The conviction that the environmental disaster is real and threatening to the future of human civilization was expressed not only in the forecasts of subsequent reports for the Club of Rome, but also in the philosophical reflections of Georg Picht and Hans Jonas. Regardless of the differences between the two thinkers, what is worth emphasising is their belief that the future of the human species is in its hands and that its continued existence depends on its responsibility and vigilance in the face of impending threats. It should be emphasised, however, that neither Picht nor Jonas used the category of generation as a subject of history, determining the tasks of people in a given time period, nor did they pay attention to intergenerational relations as an independent phenomenon.

For them, humanity was an integral whole, the continued existence of which was such an imperative that separating future, present and past generations had no deeper meaning². For them, the destruction of humanity meant the total erasure of everything it had created in its history and of history itself. In the face of disaster, both the future and the past lost sense³.

4. The development of the ethics of responsibility for future generations in the 1980s. The path from the rights of future generations to the rights of present and future generations

The ethic of responsibility for future generations began to develop as a result of the criticism of the catastrophic assessments of the situation presented by the Club of Rome (Meadows, D.L., Meadows, D.H., Randers, Behrens, 1973) and analyses made at the same time, such as Paul Ehrlich's well-known book *The Population Bomb* (Ehrlich, 1968). The radical nature of this criticism, the axis of which was the argument that the collapse of civilization predicted in the

² Even if at one point in his research Georg Picht openly addresses this issue, he does so from the perspective of what is common, not what is differentiating (Picht, 1981, pp. 244-253).

³ Georg Picht's reference to the theological vision of the Last Judgement as a moment when all generations meet is particularly meaningful (Picht, 1981, pp. 231-262).

criticised studies, resulting from the depletion of non-renewable resources and thus exceeding the “limits of growth”, was exaggerated (Simon, 1981) and led to the belief that the possibility of a catastrophic realisation of the forecasts presented by representatives of the criticised orientation concerns a long period of time (Kuzior, 2007, p. 116). Thus, it was recognised that there is a problem of “future generations” being exposed to the consequences of the activities of “current” or “present” generations. The perspective of the long-term nature of responsibility towards “future generations” has created a framework for interpreting issues related to predictions of an environmental disaster, in its most well-known form today, as a phenomenon pertaining to the near or distant, but still approaching future.

The fundamental issue for “responsibility towards future generations”, in this sense, is the fact of their unquestionable existence, which makes their status similar to that of an unborn child and its status not only ethically but also legally. “Future generations” in this sense - an entity whose existence turns out to be inevitable, but only postponed in time - turns out to be the subject of moral and legal action (Human Rights..., 1998; Sustainable development..., 2005). It has certain rights and claims that should find its representatives, etc.

The more the succession of future generations becomes obvious and unproblematic, the more important it becomes to define their claims and rights. Specific issues of interpretation and clarification of the nature of these claims also become important. A work that presents a whole catalogue of these problems, from the perspective of synthesising ethical reflection with the tradition of legal logic, is Dieter Birnbacher’s 1986 study *Responsibility for Future Generations* (Birnbacher, 1999). It is difficult not to notice that the sophisticated and academic nature of the work under discussion reveals a specific mechanism of marginalisation of the issue, which, thanks to its normalisation, is inscribed in a huge catalogue of the most diverse rights and claims defined as human (and not only human) rights, which, in the light of the moral imperatives of modernity, demand satisfaction.

The dramatic condition of various groups belonging to the currently living generations makes the rights of future generations only one aspect of this issue. A reflection of these processes was the most important achievement in the field of care for future generations, i.e. the report *Our Common Future*, prepared and published under the auspices of the UN in 1987 (Our Common..., 1991). The most important idea of this Report is the idea of sustainable development. The goal of sustainable development is to harmonise the realisation of the rights of present and future generations over time. The realisation of the economic, social and environmental rights of the present generations was, in the light of the report’s assumptions, not to violate the right of future generations to enjoy the planet’s resources in a way that is not threatened by their devastation (Kuzior, 2007, 2014).

The report, commonly referred to as the Brundtland Report, thus proposed a synthesis of the rights of present and future generations, integrating their claims and proposing actions that would lead to their harmonisation. It should also be noted that a solid empirical basis in the

form of a catalogue of global problems requiring solutions seemed to make it a serious proposal to take up these challenges.

The intention of the UN commission was to stop the debates that entailed the demands of the first reports of the Club of Rome in the international arena (Report of the United Nations..., 1972; Furtado, 1982) and a sensible inclusion of ecological issues in the disputes surrounding the implementation of conflicts tearing the contemporary world apart (Kuzior, 2007). This intention was realised to some extent with the adoption of the United Nations Framework Convention on Climate Change in 1992 at the Earth Summit in Rio de Janeiro (UNFCCC or FCCC) followed by the Kyoto Protocol in 1997 and the Paris Agreement in 2015. It should be emphasised, however, that consequences unexpected by the authors came to the forefront and had a far-reaching impact on the implementation of the postulates.

The concept of sustainable development, by adopting a perspective that recognised the existence of future generations, turned out to perpetuate the belief that since future generations have rights, their existence is not an issue of concern. Of course, the slogan of sustainable development itself, inadvertently guaranteeing the future existence of the subject of this development, was not the main reason for the marginalisation of the issue of the threat of the ecological disaster, but opened the way to a “positive dialogue” with neoliberal thought, which believes that economic and social development is balanced by the laws of the market and the “invisible hand of the market” guaranteeing the optimisation of resource use.

Thanks to these laws, present generations would spontaneously build the best of possible worlds for the future. The process of inscribing the problem of the relationship of present and future generations into the traditional historical optics was disturbed by the increasingly alarming results of scientific research, which however, as having the status of forecasts, could be ignored by questioning the degree of their certainty.

5. The breakthrough in 2018 and Greta Thunberg’s speech

The growing discrepancy between rising public optimism about the future and the prospect of a growing climate disaster led to the shock of the publication of a new series of IPCC reports, in October 2018, presenting the immediate prospect of exceeding the 1.5 degrees Celsius limit adopted in the Paris Protocol and the reality of the direct threat of a climate disaster.

The study’s findings triggered a sharp political turnaround consisting in an attempt to operationalise the new policy challenges of the so-called Green Deals proclaimed by the European Union leadership and the US Democratic leadership after taking power from the Republican team of Donald Trump. The Green Deal policy, which set new tasks for Western societies that were completely unprepared for it (Kuzior, Kettler, Rąb, 2022), caused a deep

unrest, becoming a factor driving the political crisis in the Western bloc countries, the effects of which we are currently observing.

On the question of the history of the formula of the rights of present and future generations to protect the climate and the environment, a key moment was the speech of a Swedish high school student Greta Thunberg, who in August 2018 undertook a one-person protest in front of the Swedish Parliament as a representative of the generation directly threatened by current climate policy (Erman, B., Erman, M., Thunberg, G., Thunberg, S., 2019).

The resonance of this speech and the accusation of the current elites that they have “stolen the future” not only from future generations, but also from those currently beginning their life, marks a break with the formula of the rights of present and future generations on climate and environmental issues, and a reflexive return to the thinking of the 1970s, when the prospect of an ecological disaster united humanity. The generation formula in this perspective can only appear now in the name formula of the radical environmental organisation The Last Generation [Ostatnie Pokolenie] (Wikipedia..., 2024).

6. The current shape of the debate

The most serious problem posed by the breakthrough of 2018 was the conflict between the new challenges and the traditional attitudes that dominate public life not only in the West, but globally. In the U.S. and European Union policy, new goals have clashed directly with traditional understandings of both the economy and politics. Globally, the forecasts announced by the UN did not have a significant impact on reorganising the existing logic of understanding economic development.

There has been a clear crisis in the environmental policy issue of interest to us and its dimension of protecting the rights of present and future generations. The Green Deal, proclaimed in the wake of concern over forecasts announced since 2018, is being implemented despite growing public resistance. The victory of the Republicans in the 2024 elections suggests that its American counterpart will be rejected by the new team. The work of successive climate summits is also underway despite growing disappointment with their results (Kielak, 2024).

The actual victory of the opponents of the fight against the climate disaster is the current freezing of discussions about the future. The limited horizon leads to the fact that the energy transformation of the EU is treated by a large part of politicians and public opinion as a political tool directed against Russia.

In such a context, there is a progressive isolation of the movement initiated by Greta Thunberg. The specificity of the young activist's speech involved not only climate protection slogans, but also a consistent reference to scientific research. Greta Thunberg has no views of her own in the traditional sense of an ideological creed. She acts as an intermediary between

science and the practice of public life (The Climate Book, 2023). This specific situation meant that criticism targeting her personal deficits, family connections, etc., was unable to undermine her rapidly growing authority (Błaszkiwicz, 2019; Wiech, 2019). Today, this situation is rapidly changing and the Swedish activist is treated as a marginal political figure (Aikman, Holligan, 2024; Greta Thunberg protestowała..., 2024).

The developments referred to in the article, however, have resulted in a growing isolation of the movement she initiated, taking the form of a conflict between political elites and public opinion interested in saving or at least maintaining the illusion of the status quo and climate activists acting as defenders of the rights of present and future generations to protect the natural environment and climate in which they live and will live in the coming years and decades (Sorry, taki mamy klimat..., 2024).

The deepening conflict is reflected in the radicalisation of forms of opposition to the disproportion of actions to the scale of threats. A protest that is drastic in its forms and involves a direct attack on the symbols of stabilising development trends of contemporary civilization, in its spiritual and practical dimensions, arouses anger and opposition from public opinion embodying the position of its supporters. This applies both to the attack on what is supposed to be the spiritual core of this civilization - works of art and monuments embodying the timeless and universal beauty that man is capable of creating, starting with Vincent Van Gogh's "Sunflowers" and ending with the Warsaw Mermaid monument. On the other hand, the demonstrative act of activists glueing themselves to highways or airport runways strikes at the basic principles of obvious comfort carried by modern civilization, for which mass communication has become a basic standard. The grotesque form of these demonstrations and conflicts is an expression of the powerlessness and desperation of environmental movements fighting to secure the rights that are proving to be increasingly threatened, if not erased, by the rapidly progressing climate disaster.

The starting point of these activities is the thesis that even the most valuable achievements of humanity have value only insofar as there is still a human population for which they mean something, in the most literal sense. However, this is too radical for the popular consciousness to be taken seriously. Activists are treated like criminals and brought before the courts (Bujalski, 2024a, 2024b).

7. Conclusions - Does it still make sense to discuss the rights of present and future generations to climate and environmental protection?

By presenting the issues of the status and logic of the formula of “the rights of present and future generations to climate and environmental protection”, the author of this article tried to show that it is deeply rooted in recent history, which is the source of both its historical role and its temporal limitation.

This formula undoubtedly played a positive role in the process of bringing order to the chaos that resulted from the sudden introduction into the public debate of the issue of an ecological disaster threatening the future of humanity on a planetary scale. The questions of whether the responsibility for this state of affairs is distributed equally among all people and whether everyone should bear the costs of the transformation equally were questions that ignited discussions and gave rise to constant conflict. Similarly, there was the problem of social, economic and cultural inequality, which the new challenges seemed to dismiss as unimportant in the face of the threat of imminent destruction.

Creating a formula that brings elementary order to the issue and taking corrective action based on international consensus was a constructive factor at the turn of the millennium. However, this formula, assuming the possibility of further development and making the existence of future generations more realistic in the eyes of the public, proved to be a demobilising factor and strengthened the drive to continue the existing practices, despite the risks they carried.

The events of 2018 have shown the rapidly growing gap between current realities and the perceptions of the near future that dominate public opinion. This applies not only to climate sceptics or denialists, but also to the overwhelming majority of those who accept the existence of global warming and even those who are concerned about its consequences. This is a situation that becomes increasingly dangerous from the perspective of upcoming events. Although the formula of the rights of present and future generations to protect the climate and the environment fulfilled a positive role at its inception, integrating the issue of the rights of future generations with the issue of human rights, it has now become an anachronism. The implicit guarantee of the future contained in it, allowing it to be stretched out over time, is becoming a source of deepening the current crisis of environmental consciousness. Thus, it requires not only revision, but also rejection and development of an approach adequate to the situation in which the time for implementing the postulates is shrinking at an alarming rate.

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THE ETHOS OF PHILOSOPHY IN THE PROJECTS OF THE NATIONAL SCIENCE CENTER (NARODOWE CENTRUM NAUKI)

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Purpose: The article presents an analysis of the results of winning projects raising fundamental questions about human nature and the surrounding reality, implemented within the National Science Center (NSC) in Poland. The research goal is to check whether these projects meet the expectations set out in the Act on the National Science Center and whether they support the development of philosophical research.

Design/methodology/approach: The research is based on the quantitative content analysis of 596 projects completed between 2011 and 2023. We are essentially interested in the following aspects:

- what is the position of the fundamental questions about the human nature and the surrounding reality in the structure of the NSC investigated research projects (HS1 position in the NSC projects structure, project managers affiliations, their sex and position in the scientific hierarchy),
- what problems are favoured in grants (preferred by the collective subject, i.e. authors and reviewers),
- whether one can assess the ideological preferences of the collective subject behind the winning projects and how this can be done.

For the purpose of comparison we juxtapose the grants' content with the data on philosophy available on Google scholar and The National Library catalogue.

Findings: The analysis enabled us to state that the analysed grants do not undertake problems which are of key importance for philosophy, in particular they do not tackle the contemporary philosophical challenges. The reason of such a situation is the ethos of philosophy held by both the projects' authors and their reviewers. Such ethos constitutes a barrier preventing philosophers from pursuing the socially important problems. In this way, the study contributes to the analysis of research management in Poland.

Social implications: The conclusions formulated in this article might trigger a debate on the content of philosophical ethos in Poland.

Originality/value: The research shown in the article is innovative and important for the development of philosophy and its management. Until now, such research has not been conducted yet.

Keywords: ethos of science, ethos of philosophy, scientific research management in Poland.

Category of the paper: Research article.

1. The subject and research aim

The subject of analysis consists of the projects submitted and accepted for implementation in the panel The Fundamental Questions about The Human Nature and the Surrounding Reality (HS1) within the National Science Centre. The winning research projects completed between 2011 and 2013 were taken into account (the data was acquired in March 2023 and March 2024). We analysed the effects of fifteen types of contests¹. We also accessed information of special interest to us in other panels, especially in the human and social sciences. Tackling the mentioned grants' analysis stems from the role played by the contests organised by the National Science Centre. The act 'Law on Higher Education and Science'² encourages awarding the beneficiaries of the NSC contests by exemption from the participation in the recruitment process for academic teacher position (article 110, paragraph 2, subparagraph 2). The NSC act specifies expectations for the contests organised by this institution. In the application verification process one needs to take the following into consideration: the scientific level of the research, innovative character of the scientific problem, the influence of project realization on the development of the scientific area³. In many institutions of higher education the task of application preparation for a specific NSC contest is considered to be one of important criteria required for the periodic assessment of employees. The panel Fundamental questions about the human nature and the surrounding reality: Philosophy, cognitive sciences, religious studies, theology basically contains research projects substantially related to philosophy and as such, even in its name, implies expectations for the projects. The panel's name is exceptional, it points to the plethora of expectations towards the applicants. Other panels have considerably simplistic names – they indicate the areas' names.

The conditions applicants are faced with in the NSC contests let us formulate the thesis that according to the creators of NSC act and the vast number of scientists these are the organisers, applicants and contest beneficiaries who delineate what is important in their discipline because they are preoccupied with the most significant matters, they describe the current and future state of science, including philosophy. One may assume that the philosophical projects done within the NSC are most ambitious, creative, tackling the most pressing problems of philosophy and showing the philosophical aspects of modernity. We decided to verify whether this is the case. To do this we took a few points of reference. On one hand, the National Library catalogue contents referring to the problems present in the

¹ These are the following contest types: Beethoven, Etiuda, Fuga, Grieg, Harmonia, Maestro, Opus, Opus LAP, Polonez Bis, Preludium, Preludium Bis, Sonata, Sonata Bis, Sonatina, Uwertura.

² Law on Higher Education and Science, Act of 20 July 2018. Law on Higher Education and Science (uw.edu.pl), 30.07.2023.

³ National Science Center Act, Official Gazette 2010, No. 96, item. 617 unified on the basis 2023, item 153, <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20100960617/U/D20100617Lj.pdf>, 30.07.2023.

analysed panel is such a point of reference – the library has collected texts for a long period of time, that is why we call it “a collection of long duration”.

On the other hand, another point of reference includes similar texts gathered in Google scholar – they have been collected for a relatively short period of time, that is why we call it “a collection of short duration”. The third point of reference is the contents of the panel *fundamental questions on the human nature and the surrounding reality* (HS1) within the National Science Centre. We assumed that the comparison of the contents of these three data sets will show whether, and to what extent, the preferences present in grants, the ones in the National Library catalogue and Google scholar are similar.

Our research aim is to reconstruct the ethos of contemporary Polish philosophers⁴. We assumed that the applicants’ and the winning projects reviewers’ preferences clearly show the way of understanding philosophy and fundamental problems of this area, which one might refer to as the ethos of contemporary Polish philosophers. There are more and more statements claiming that there is a philosophy crisis, its ethos being blurred. The article by Paweł Pieniążek (Pieniążek, 2015, pp. 11-30) as well as other texts collected in the book support that claim (Soin, Parszutowicz, 2015). Our research aims to verify whether this is the case. We understand ethos in a similar way to M. Ossowska as “some culture orientation, its accepted hierarchy of values formulated either *explicite*, or indicated by human behaviour” (Ossowska, 1986, p. 5). In such an approach the ethos of philosophy is designated by the preferences of the investigated panel users (*fundamental questions*), i.e. the selection of specific research problems in the area of philosophy (e.g. history of philosophy, ontology, aesthetics or philosophical analyses of modern civilisation problems).

Investigation of research preferences of Polish philosophers will enable us, as assumed, to reveal the scope and specificity of understanding fundamental philosophical problems – diversity of addressed problems or the tendency to focus on the limited issues, undertaking, at the same time, universal topics pertaining to the world, societies, people and also the more particular ones, limited to the selected timeless or contemporary issues.

To reconstruct the philosophers’ ethos, one needs to answer the question: What do the key panel terms “fundamental questions” and “fundamental problems” mean? The panel authors explain these terms in two ways. In the panel description they vaguely show that these are the fundamental questions about the human nature and the surrounding reality.

⁴ Ethos is known to be held by the humans, yet for the purpose of title simplification we use the term Ethos of philosophy. By means of justification let us remind you that many authors use the term ethos of science (e.g. Grzesiak, 2017, pp. 64-76), and the term ethos of philosophy is also used by other authors (i.a. Pieniążek, 2015, pp. 11-30).

On the lower level, when depicting descriptors, they enumerate sixteen problems with an extensive list of subproblems, basically identical with the division of philosophy into the main areas⁵. The subject of investigated ethos primarily comprises grants' authors and their reviewers. They are the ones who decide that certain problems are significant enough to be dealt with and assessed. The reviewers, in turn, are guided by their own preconceptions of what matters in science, what ways of project development are justified and whether they abide by the adopted criteria and on that basis they give their final acceptance. There are also other, less outstanding groups of decision-makers, yet their role in the assessment process cannot be underestimated. Such groups include: decision makers accepting/rejecting specified sums which are to be distributed among project authors, application authors, decision-makers who accept the research application form (Szubka, 2015, p. 21) filled in by reviewers. Each of these group members holds certain convictions referring to the significance of some issues and therefore they co-decide about the shape of philosophy. The research projects' preparatory and assessment process is a social phenomenon where the ethos of scientific area members is being revealed. At the same time the process is a type of self-organisation and the management of a scientific area.

One can assume that the list of the above-mentioned problems present in the analysed panel is, to a large extent, a materialisation of the so called fundamental philosophical issues, mentioned in many coursebooks or introductions to philosophy. Even though each coursebook covers a slightly different set, there are certain groups of "basic philosophical problems" which keep reappearing frequently⁶. The list of fundamental problems of philosophy is usually more developed, sometimes it is more unassuming. Generally these are the problems which belong to philosophy areas: ontology (metaphysics), the theory of cognition, ethics, aesthetics, political philosophy, philosophy of man, logic, methodology. History of philosophy is not usually evidenced in such lists. Amongst the descriptors (i.e. main problems) mentioned by the analysed panel related to philosophy, one can find the issues concerning religion. The analysis of the projects' contents showed the mutual connections of the "philosophical" and "religious" parts and the difficulty in their separation, that is why we do not separate them.

We address both problem groups collectively. Because the problems traditionally related to philosophy are predominant in the panel, that is why in the title as well as in many places in our text we use the term philosophy. Such an approach to the problem reinforces the fact that for some philosophers the problem of God is one of the fundamental problems in philosophy.

⁵ These are the following problems described as descriptors on the platform: history of philosophy, ontology and metaphysics, specific ontologies, epistemology logic, science methodology, philosophy of science, philosophy of man, theories of a person, philosophy of culture, social philosophy, nature of human mind, normative and descriptive ethics, theory of morality, bioethics, occupational ethics, aesthetics, theories of religion, history of religion, religious studies, religion and its determinants: anthropological, cultural, socio-psychological, language of religion, sacrum, myth, religious symbolism, world religion, fundamental theology, dogmatic theology, biblical theology, patristics, moral theology, pastoral theology, liturgy, other related issues.

⁶ For example: Ajdukiewicz, 1983; Anzenbacher, 1987; Galarowicz, 1992; Popkin at Stroll, 1994; Stępień, 2007; Krąpiec, 2003.

2. The Method

In the research we use the method of quantitative content analysis which is the research technique used for systematic and quantitative description of a message (Babbie 2008, pp. 358-370; Sztumski, 1979, pp. 182-191). We think that our research can be contained within the method called digital humanities (Przastek-Samokowa, 2016, pp. 82-93). We do not underestimate the relevance of more traditional methods, yet we think that quantitative methods might yield information which is overlooked when the older method is applied. In this particular case it is all about investigation of the chosen data characteristic for the winning research projects in the HS1 panel. Generally we are interested in the following aspects:

- what is the position of fundamental questions about the human nature and the surrounding reality in the NSC research projects' structure (HS1 position in NSC project structure, project managers' affiliations, their sex and position in scientific hierarchy),
- what problems are favoured in grants (grants preferred by the collective subject, i.e. authors and reviewers),
- whether one can assess ideological preferences of collective subject behind the winning projects and how this can be done.

We search for the answers to question one and two on the NSC website, while the answer to question three will be obtained thanks to the juxtaposition of grants' analysis with the National Library catalogue and Google scholar contents. In Google scholar we also look for the citations' frequency of texts combined with grants. The point of reference in assessment preferences in grants also refers to the presence of answers to philosophical challenges of the modern era in said grants. To achieve this we created the list of over eighty terms important for the philosophical challenges of modernity.

The structure of programs implemented within NSC is complex and it is important to bear in mind, for the purposes of further analysis, that each project is implemented within science areas, and below there are panels comprising specific research areas. The lowest position is occupied by descriptors (subpanels). On the level of science areas one can distinguish:

- Humanities, social and artistic sciences (HS⁷).
- Life sciences (NZ).
- Science and technology (ST).

In humanities, social and artistic sciences (HS) there are eight panels:

- Fundamental questions about the human nature and the surrounding reality (HS1), alongside philosophy, cognitive science, religious studies, theology.
- Culture and cultural production (HS2).
- Knowledge about the past (HS3).

⁷ Abbreviations used on NSC platform.

- Individual, markets and institutions (HS4).
- Law, political sciences, public politics (HS5).
- Man and social life (HS5).

Panel HS1 and its sixteen constituent parts will be the subject matter of further analysis (from HS1_1 to HS1_16) where the distinguished problems are included into philosophy, religious studies and theology. These parts are called descriptors by NSC. In HS1 panel called “the fundamental questions about the human nature and the surrounding reality”, with the majority of philosophical issues, the following descriptors have been singled out:

- history of philosophy (ancient era, the Middle Ages, modern and contemporary era) and history of ideas;
- ontology and metaphysics, particulars ontology;
- epistemology, (i. a. sources of cognition, criteria of truth, philosophy of language);
- logic, science methodology, philosophy of science;
- philosophy of man, theories of a person, philosophy of culture, social philosophy;
- nature of human mind (including the evolution of mind, bio-psychological conditions of cognition, Artificial Intelligence);
- normative and descriptive ethics, theory of morality, bioethics, occupational ethics;
- aesthetics (including theories of beauty, language of art);
- theories of religion, history of religion, religious studies;
- religion and its determinants: anthropological, cultural, socio-psychological;
- language of religion, sacrum, myth, religious symbolism;
- world religions;
- fundamental theory;
- dogmatic theology, Biblical theology, patristics;
- moral theology, pastoral theology, liturgy;
- other related issues.

This division is significant because each project manager is obliged to place their project in the group of areas along with the attribution of at least one descriptor which enables us to count what philosophical problems are undertaken in the winning projects. Each project manager has the possibility to indicate up to three descriptors. By doing this they provide information on the project affiliation both within the main research area and additional ones. A person submitting their project to HS1, can additionally ascribe it to HS1_4, HS5_1, ST6_3 which means that their project generally belongs to the fundamental questions about the human nature and the surrounding reality, at the same time it belongs to logic, science methodology and mathematics. In this way one can distinguish three levels of descriptors. And while the first level is basically chosen by all project managers, the other ones are not frequently selected. Therefore we only take the first level descriptors into consideration. Apart from differentiation according to descriptors, the majority of authors also provide key terms, which, in turn, allow us to seek

further fundamental problems present in the analysed projects on the lower level than descriptors.

With the analysis commencement we asked ourselves the following research questions:

- What philosophical problems are the object of interest for researchers and reviewers and what is the hierarchy?
- To what extent do the winning projects remain open to other, different than philosophy, research areas?
- Are there differences between the ideological preferences within the entire scope of grants and the preferences of single and multiple beneficiaries?
- Are there differences between ideological preferences present in grants and the hierarchy of problems regarding philosophy in the National Library catalogue and Google scholar?
- Which texts, out of the ones published as a result of grant research, are most frequently cited?

The research questions correspond to the following hypotheses:

- The most important philosophical problems should be present in grants (in compliance with expectations) as in such a way they contribute to the significance of philosophy, its development and they meet the most important philosophical challenges of the modern era.
- Universalism is the characteristic feature of philosophy and as such it should remain open to other research areas.
- There should be preference differences between single and multiple contest beneficiaries. The multiple winners' research projects should meet expectations described in the previous hypothesis to a greater degree.
- The hierarchy of philosophical problems present in grants and the National Library catalogue should be different, yet it should be similar between grants and Google scholar contents because the National Library gathers collections from other time periods, and in Google scholar the data are current.
- The citations of texts published as a result of research within the winning projects should demonstrate the dominance of problems significant for the philosophical challenges of modernity.

3. The analysis of the panel content The place of fundamental questions about the human nature and the surrounding reality (philosophy, cognitive sciences, religious studies, theology)

3.1. The place of the panel in the structure of NSC projects

According to data available on the NSC⁸ 23902 grants were provided in the years 2011-2023. By the end of 2023 the biggest number of grants (40,48 %) were provided in the science and technology group, slightly fewer (31,39%) went to life sciences and humanities and social and artistic sciences got the fewest number of grants. Philosophy and related branches belong to this particular group.

In humanities and social and artistic sciences the vast majority of grants (23.05%) were provided to the group of problems referred to as: individual, institutions, markets. The group also comprised economy, finances, management, demography, social-economic geography, urban planning. The fewest (8,52%) were granted to the science group called: *the fundamental questions about the human nature and the surrounding reality*, comprising broadly understood philosophy.

3.2. Grant managers' sex

Men constitute the majority of grant beneficiaries (56,30%). The most vivid dominance of men (68,81%) is observed in sciences and technology. Women constitute the majority only in life sciences (55,60%). In humanities, social and artistic sciences men prevail (53,22%). It is worth mentioning that not all beneficiaries reveal their gender.

In humanities, social and artistic sciences male dominance (63,87%) is observed among the broadly understood philosophy beneficiaries. Women dominate (56,31%) in literature studies, linguistics, art science and architecture. A similar situation is observed in psychology, pedagogy and sociology (55,15%).

3.3. Academic degrees and titles of grant managers

In all science groups doctors constitute the biggest group of beneficiaries (32,46%), they are followed by associate professors (23,69%), and then professors (18,92%).

In the humanities, social and artistic sciences the proportion between the group of doctors (37,89%), associate professors (26,40%) and professors (17,23%) is similar. The lowest number of professors is associated with the beneficiaries in the group of fundamental questions about the human nature and the surrounding reality (9,94%).

⁸ https://projekty.ncn.gov.pl/index.php?jednostka=&jednostka_miasto=&jednostka_województwo=&kierownik=&kierownik_plec=&kierownik_tytul=&status=&projekt=&kwotaprzyznanaod=&kwotaprzyznanaod=&typkonkursu=&konkurs=&grupa=&panel=&slowokluczowe=&aparatura

3.4. Types of contests included in the panel the fundamental problems of human nature and the surrounding reality

In the analysed collection belonging to the panel *the fundamental questions about human nature and the surrounding reality* 15 types of contests were taken into account. The biggest number of grants were provided to Opus contests (42,93%), then the Preludium ones (28,26%) and Sonata (11,80% projects).

3.5. The degree of repeatability in the grant obtainment process

The vast majority of project managers (464) won in one contest, they constitute 83,00% of beneficiaries, 18 people are the beneficiaries of at least 3 contests. They are the authors of 60 grants. One person won 5 contests.

3.6. Project managers' affiliations

The biggest number of grants were obtained by the managers affiliated with the University of Warsaw (116 grants), then the Jagiellonian University (106 grants) and the Catholic University of Lublin (51 grants). 51,50% of the analysed grants have been affiliated with these three universities. At least 10 grants are ascribed to 13 universities. Apart from the above mentioned, these are Adam Mickiewicz University in Poznań, Nicolas Copernicus University in Toruń, John Paul II University, the Silesian University, University of Łódź, the Institute of Philosophy and Sociology of the Polish Academy of Sciences, Wrocław University, the University of Cardinal Wyszyński in Warsaw, University of Gdańsk. Their projects account for 86,79 % of the total number.

3.7. The structure of problems in the panel the fundamental questions about the human nature and the surrounding reality (philosophy, cognitive sciences, religious studies, theology)

Project authors can select a few descriptors when depicting their project. Yet one is predominantly indicated. Fewer and fewer authors indicate other ones. The first one, picked by the majority, is called the first row descriptor. And we pay special attention to this particular one when describing what problems are the subject of interest of a given project. Almost 100% of the authors who were responsible for the projects within the panel *the fundamental questions about human nature and the surrounding reality* inform, on the first descriptor level, that their project belongs to the group of *fundamental questions about human nature and the surrounding reality* even though they could have also indicated other problems.

Only fewer than five percent of projects are comprised within other than fundamental questions research disciplines. One might say that the proposed projects are closed to other disciplines. The authors-project applicants and the reviewers of the panel *the fundamental questions about human nature and the surrounding reality*, contrary to the popular belief related to the openness of philosophy, assume an hermetic attitude, unwilling to embrace other

disciplines. Only 4,92% of the projects remain open to other disciplines. What is also interesting is the fact that the vast number of external inspirations (21 projects) belong to the humanities, social and artistic sciences, namely the disciplines which are related to the fundamental questions about human nature and the surrounding reality, yet several (7 projects) pertain to mathematics, information technology and life sciences. Another fact is also of interest – none of the projects refers to the markets and institutions panel which means that economy, finances, management, demographics, social-economic geography, urban planning are not the source of inspiration for philosophers.

Table 1.

Presence of other sciences in the projects fundamental questions about human nature and the surrounding reality on the level of first row descriptors

Panel symbol	Panel contents	Number of projects	%
HS1	Fundamental questions about human nature and the surrounding reality (philosophy, cognitive sciences, religious studies, theology)	541	95,07
HS2	Culture and cultural production (literary studies, linguistics, art sciences, architecture)	4	0,70
HS3	Knowledge of the past	5	0,87
HS4	Individual, institutions, markets (economy, finances, management, demographics, social-economic geography, urban planning)	0	0,00
HS5	Law, political sciences, public politics	6	1,05
HS6	Man and social life (psychology, pedagogy, sociology)	6	1,05
ST1	Mathematical studies	5	0,87
ST6	Computer science and information technologies	1	0,17
NZ9	Fundamentals of applied life sciences	1	0,17
Other than HS1		28	4,92

Source: own research, as of March 2023, N = 569.

Within the *fundamental questions about human nature and the surrounding reality* panel scope there are sixteen problem groups delineated by subsequent descriptors. If the descriptor choice was random, then the descriptors should group 6,25% projects each. Actually it is the other way round. It is the history of philosophy (20,73%) which constitutes the subject matter of projects within *the fundamental questions about human nature and the surrounding reality*, it is followed by logic, methodology of science (14,23%) and epistemology (11,77%). It definitely highlights the significant prevalence of this group of problems. Together they account for 46,73% of projects. For the widely understood group of project authors and their reviewers philosophy basically stands for the history of philosophy, logic, science methodology and epistemology. The remaining branches (philosophy of man, the nature of human mind, ontology, metaphysics, normative and descriptive ethics) are of marginal importance. These five groups of problems considered to be fundamental for philosophy collectively make up 32,49% of grants. The least number of grants (1.75%) deal with aesthetics. Ethical problems which are vital for contemporary societies account for only 6.85% grants. In comparison, the projects that deal with the broadly understood philosophy (history of philosophy, logic, science methodology, epistemology, philosophy of man, the nature of human mind, ontology,

metaphysics, normative ethics and aesthetics) make up 79.22% of the group. Religious studies and theological disciplines constitute the remaining part. That is why the panel fundamental questions about human nature and the surrounding reality can be legitimately referred to as philosophical. What is also visible in this juxtaposition is the degree of universality of the panel *fundamental questions about human nature and the surrounding reality* for project authors and reviewers, when taking different inspirations into account and the relevance to standard problems. It turns out that the projects rarely go beyond standard problems. Problems pertaining to non-philosophical inspirations are marginal, they form 4.92% of the analysed projects' group.

Table 2.

The inner problem structure of fundamental questions about human nature and the surrounding reality panel on the level of first descriptor

Number	Descriptor symbol	descriptor	Number of grants	%
1	Hs1_1	History of philosophy	118	20,73
2	Hs1_4	Logic, science methodology	81	14,23
3	Hs1_3	Epistemology	67	11,77
4	Hs1_5	Philosophy of man	51	8,96
5	Hs1_6	Nature of human mind	44	7,73
6	Hs1_2	Ontology and metaphysics	41	7,20
7	Hs1_7	Normative and descriptive ethics	39	6,85
8	Hs1_10	Religion and its determinants	37	6,50
9	Hs1_14	Dogmatic theology	26	4,56
10	Hs1_8	Aesthetics	10	1,75
11	Hs1_9	Theories of religion	9	1,58
12	Hs1_11	Language of religion	6	1,05
13	Hs1_15	Moral theology	6	1,05
14	Hs1_12	Religions of the world	2	0,35
15	Hs1_13	Fundamental theology	2	0,35
16	Hs1_16	Other remaining issues	2	0,35
		Combined HS1	541	95,07
		Other than HS1	28	4,92

Source: own research, as of March 2023, N = 569.

3.8. Ideological preferences of beneficiaries of at least three grants

We are interested whether ideological preferences of the authors who are beneficiaries of several grants are similar or different from the dominant ones in the whole of the analysed projects' group. We take beneficiaries of at least three grants into consideration. There are 60 such projects (i.e. 10.54% out of 569 projects, as of march 2023) and 18 project managers.

Table 3.

Ideological preferences of beneficiaries of at least three projects according to the first row descriptor

Number	Descriptor's name	Number of grants 60	%
1	History of philosophy	12	20.00
2	Logic, science methodology	8	13.33
3	Religion and its determinants	8	13.33
4	Ontology and metaphysics	7	11.66

Cont. table 3.

5	Normative ethics	7	11.66
6	Nature of human mind	6	10.00
7	Epistemology	5	8.33
8	Theories of religion	3	5.00
9	Dogmatic theology	2	3.33
10	Moral theology	1	1.66
11	Philosophy of man	1	1.66

Source: own research, as of March 2023, N = 60.

Also in this case history of philosophy is ranked first (20.00% of projects). Logic, science methodology and religion and its determinants occupy the second and third position (13.33% of projects each). The remaining problems occupy other places in the hierarchy, when compared with the entire collection. Hence, one can say that history of philosophy, logic and science methodology occupy the highest position among the beneficiaries of at least three grants. Ethics is placed slightly higher, aesthetics, in turn, is not present.

3.9. In the research projects the lack of response to philosophical challenges of the modern era

The choice of descriptors clearly indicates that either in the entire collection of projects or among beneficiaries of at least three grants there is a vivid dominance of history of philosophy. That is why we are interested whether and to what extent the projects comprise problems which might be referred to as the contemporary philosophical challenges. These are the problems which stem from social, technological, cultural and economic transformations. In order to find these problems we search for the first level key words⁹ in the projects' titles and also, in total, any indicators which signal the presence of contemporary philosophical challenges. We look for over 80 words-indicators¹⁰ in the collection of key words.

In 569 projects, within the scope of first-row key words collection (as indicated by the project authors in the first place), only 7.20% of them belong to the demanded indicators signalling the presence of contemporary philosophical problems. In the collection of the first,

⁹ First row key words are the ones which authors point at in the first place. We assume that they are of utmost importance to them. The authors usually enumerate several key words. They form the collection which we also take into consideration.

¹⁰ Words-indicators of the contemporary philosophical challenges: Anthropocene, autonomic (combat robot, cars, weapons systems), national security, bioethics, biopolitics, biotechnology, Christianity, digital philosophy of science, deliberation, democracy, disinformation, positive disintegration, emancipation, feminist epistemology, feminist aesthetics, ethical aspects of reproductive and palliative medicine, research ethics, clinical studies ethics, scientific research ethics, business ethics, economic ethics, medical ethics, environmental ethics, ethics of technology, war ethics, contemporary ethics, euthanasia, feminism, philosophy of: man, culture, politics, technology, contemporary and political philosophy, fundamentalism, gender, globalisation, internet, Islam, capitalism, capitalocene, conscience clause, climate, commercialisation of science, body commodification, condition of Polish family, consumerism, consumptionism, crisis, climate crisis, media, new media, space missions, electronic surveillance, netiquette, disability, social inequality, modernity, responsibility, responsibility for the future, participation, sex, posthumanism, postmodernity, human rights, animal rights, social enterprise, social transformations, social development, sustainable development, equality, egalitarianism, sexuality, information society, contemporary society, social responsibility of business, justice, autonomous systems, learning, integrated, Artificial Intelligence, terminal sedation, health care learning systems, acknowledgement, multiculturalism, war (war ethics, theory of just war), freedom, exclusion, health.

second, third and fourth row key words collection consisting of 2276 words, there are potentially (potentially because not all authors use this possibility) 5.97% of the sought after indicators. The most frequently demanded indicators are comprised within project titles, they appear in 10.72% of the titles. One can assume that the presence of words belonging to the indicators of contemporary philosophical challenges is marginal (and, let us emphasise the fact that there are over eighty words). The collection of key words indicated by the authors is highly diversified.

What is commonly observed is the fact that the words-indicators which we consider to be of importance for the contemporary philosophical challenges, rarely appear in titles' collection or in key terms chosen by the authors. Only in 31 titles, out of 556, there is at least one word-indicator. "Islam" is the most frequently appearing one (7 times), then there are terms referring to autonomous combat robots (cars and weapons systems) and bioethics (four times each). Then, there are such terms as Christianity, globalisation, crisis – used three times. Anthropocene, biopolitics, deliberation, research ethics, disability, participation, posthumanism appear twice.

The use of key words, trend names and contemporary philosophy directions confirm the presence of problems pertaining to the contemporary philosophical challenges.

In the collection (potentially¹¹ 2276) of key words, the terms related to the contemporary philosophy directions appear 59 times (2.59%), while in the collection of titles they appear 41 times (7.20%). In the collection of titles it is phenomenology which appears most frequently (16 times), then hermeneutics (8 times), analytical philosophy (5 times) as well as Kantianism, neo-Kantianism (4 times) and utilitarianism (two times). The remaining names of modern philosophy directions (feminism, consequentialism, liberalism, pragmatism, Lviv-Warsaw School, Thomism) appear singly. In the collection of key words (potentially 2276) the following terms referring to contemporary philosophy can be found: phenomenology (19 times), pragmatism (8 times), analytical philosophy (4 times), Kantianism, neo-Kantianism (4 times), Thomism (3 times), Marxism (3 times), utilitarianism (2 times), Lviv-Warsaw School (2 times), feminism (2 times), liberalism (2 times), structuralism (2 times). The terms which appear singly comprise: hermeneutics, consequentialism, neo-Friesian School, psychoanalysis, existentialism, Catholic social science, Frankfurt School. The data confirm the former view that the problems considered as philosophical challenges of modernity occupy the marginal position of the analysed projects when taking the examined indicators into consideration.

¹¹ Provided the authors of each grant wrote four key words, yet this is not the case, that is why we write about the potentially key words (569 grants multiplied by 4).

3.10. The structure of fundamental problems of philosophy in the National Library catalogue and Google scholar

Now we will compare the structure of problems present in the panel *the fundamental questions about man and the surrounding reality* with the contents of the National Library catalogue and the data in Google scholar.

The National Library owns collections from old and contemporary times, one can say that these are the collections of “long lasting”. In comparison, Google scholar collection is recent, it is the collection of “short lasting”. We are interested in the degree of similarity and difference in the problems considered to be fundamental in philosophy within the collection of examined projects, The National Library and Google scholar. The classification of problems in the National Library catalogue and Google scholar is different than in the collection of the analysed projects, therefore we will make use of approximate, not the same, classification. We hope that possible similarities and differences will be clear. In the national Library catalogue we use the option “in the whole description”.

In the National Library catalogue, the biggest number of records refers to religion (51.09% per 624469 records), then, considerably fewer, ethics (18.74%), and theology in third place (13.76%). The successive places are occupied by: aesthetics (2.64%), philosophy of man (2.10%), history of philosophy (2.04%), logic (1.70%), epistemology (1.70%), theory of cognition (1.33%), science methodology (1.15%). Religion, theology, religious studies take up 65.3% of records, that is why 34.7% of records remain for the broadly understood philosophy. History of philosophy occupies the further, sixth position, fewer records relate to the history of contemporary philosophy (0.07%). In the analysed NSC projects, in turn, history of philosophy definitely takes the lead 20% of projects both in total and among multiple beneficiaries).

In the Polish version of Google scholar it is history of philosophy which is in first place (14.38% per 841210 records), other places are occupied by particular histories of philosophy accounting for from 2.42% to 2.18% of records. Philosophy of man is in second position (13.43%), then theory of cognition (11.04%) and ethics (8.66%). In Google scholar there are 15400 responses to the search entry “philosophical challenges of modernity”. If one continues the counting, it would be a far, sixteenth place.

By means of comparison we also examined the presence of fundamental problems of philosophy in the English, French and German version to verify the level of similarity between research priorities of Polish philosophers and others. In the English version it is science methodology which is in first place, philosophy of man comes second, history of philosophy comes third and ethics occupies the fourth position. In the French version logic takes the lead, then history of philosophy, religious studies and aesthetics. On German webpages religion comes first, then theology, history of philosophy and aesthetics. As it can be seen, research preferences are diverse, yet only in the Polish version history of philosophy occupies the first position.

3.11. The structure of fundamental problems' citations in texts combined with grants (their attractiveness)

In the majority of analysed projects there is information on texts written as a result of grant implementation. For simplicity we refer to such publications as texts assigned to grant. The publications have diverse forms (books, articles, post-conference presentations). Many people are the texts' authors because grant participants often comprise a few. We examined to what extent these texts are attractive to other philosophers. For the matter of analysis simplification we checked the citations of texts attributed to multiple contest beneficiaries (three or more). There are sixty such grants managed by eighteen people. For the purpose of comparison we randomly picked sixty-one projects from one-time beneficiaries. In both cases we checked to which problem groups the cited texts belong, i.e. what problems are most attractive and whether there are differences in citations' indicators between the analysed researchers' groups.

The most frequently cited texts among the publications resulting from grant implementation by multiple beneficiaries (three at least) were the ones related to descriptive and normative ethics. Let us emphasize the fact that grants the subject of which pertained to normative and descriptive ethics, occupy only the seventh place in the collection of analysed projects (6.85% grants). In the period considered, grant beneficiaries published 24 texts which were cited 476 times, and it means that approximately one text was cited 19.89 times. History of philosophy grant beneficiaries (20.0% of grants), in turn, published 54 texts which were cited 88 times, hence approximately 1.62 times.

We checked whether there is any difference in citations of texts ascribed to one-time beneficiaries. As there are 60 projects among at least three-times contest beneficiaries, we randomly picked 61 projects of one-time beneficiaries.

The texts on the nature of human mind were most frequently cited among the one-time beneficiaries – eight citations per one text. In the group of multiple beneficiaries these problems occupy the second position with the comparable, yet lower citation indicator (7.17 citations per one text). Problems related to the history of philosophy are in a distant place with the approximate citation of 0.22 times per text. The average citation of one text in the one-time beneficiaries is 3.5 times lower than in case of the group of multiple beneficiaries.

When the texts assigned to either one-time or multiple beneficiaries were summed up, the results are as follow:

Table 4.

Joint estimation. Citations of texts assigned to one-time and multiple grant beneficiaries

Number	Descriptor	Number of publications in descriptor	Number of citations	Average number of citations per one publication
1	Normative and descriptive ethics	34	480	14,11
2	Nature of human mind	19	138	7,26
3	Logic and methodology	59	395	6,69
4	Theories of religion	7	28	4,00
5	Dogmatic theory	16	60	3,75
6	Religion and its determinants	26	94	3,61
7	Fundamental theology	3	8	2,66
8	Ontology	41	82	2,00
9	Epistemology	21	32	1,52
10	Moral theology	4	6	1,50
11	Philosophy of man	67	89	1,32
12	History of philosophy	94	97	1,03
13	Aesthetics	7	4	0,57
14	Language of religion	0	0	0,00
15	World religions	0	0	0,00
	combined	401	1515	3,77

Source: own research, N = 121 grants; as of March, 2023.

The average citation indicator of text ascribed to 121 grants of one-time and multiple beneficiaries is 3.77. There are four groups of problems beyond this average: normative and descriptive ethics, nature of human mind, logic and methodology, theories of religion. Yet the texts referring to normative and descriptive ethics are cited (on average) more frequently than 3.5 times in comparison to the average of the entire examined group. History of philosophy problems, in turn, are in the far place – this problem group text is cited approximately 3.5 less frequently than the average of the whole group of projects.

4. Conclusions

4.1. Social features of philosophy ethos subject

Humanities, social and artistic sciences to which the *fundamental questions about the nature of man and the surrounding reality* belong, are characterised by the lowest percentage of grants among all science groups in NSC (28.11%).

In humanities, social and artistic sciences the panel *fundamental questions about human nature and the surrounding reality* has the lowest percentage of grants, only 8.52%. All remaining panels have more than 15.19% of grants, which is almost twice as much as the fundamental questions. The panel: individual, markets and institutions has the greatest number of grants (23.05%).

Among all projects' managers listed on NSC webpage men take the leading position, they are the beneficiaries of 56.30 % of grants. Women dominate in life sciences group where they account for 55.60% of beneficiaries. Not everybody indicated their sex.

Also in humanities, social and artistic sciences men dominate, making up 53.36% of beneficiaries. Women dominate in the beneficiaries group of the culture and cultural production where they constitute 56.31%. Men dominate significantly in the panel *fundamental questions about human nature and the surrounding reality* (HS1) where they make up 63.87% of panel beneficiaries.

People with PhD title (32.46%) vividly prevail among beneficiaries of all science groups, then there are associate professors (23.69%) and professors (18.92%). In some grants there is no information on academic titles and degrees.

In the analysed panel one-project beneficiaries definitely dominate; they are the authors of 464 projects (18,92%). 18 people are the beneficiaries of three and more grants, they are the managers of 60 projects (10.73%).

People affiliated with three universities: Warsaw, Jagiellonian and Catholic university are the beneficiaries of more than 50% of HS1 grants (273). 444 grants (almost 87%) were obtained by the people affiliated with 13 universities. Their colleagues obtained more than 10 grants for their institutions.

4.2. Ethos content

In the years 2011-2013 there were 569 winning projects in the panel *fundamental questions about human nature and the surrounding reality* and their authors could qualify their projects for 16 problem groups (descriptors). If the authors' choices had statistical character, there would be 6.25% of projects in each group. It is definitely not the case. They most often classified their research as pertaining to history of philosophy (20.73% of projects). Logic and science methodology are not that popular (14.23%) and epistemology is the least popular (11.77%). All these combined constitute 46.73% of projects. Hence, one can assume that history of philosophy, logic, methodology and epistemology are the fundamental problems of philosophy for the projects' authors and reviewers. Only in 10.72% of project titles there are terms demonstrating interest in philosophical challenges of modernity. The terms referring to contemporary directions of philosophy are in only 7.2% project titles. The largest number relate to phenomenology (16 times) and hermeneutics (8 times).

Through the choice of descriptor a project applicant could indicate its connection with different science groups. In the vast majority of cases (95.07% of projects) the fundamental questions about human nature and the surrounding reality were indicated primarily. In only few cases (4.92% of projects) other possibilities were selected, basically the ones pertaining to humanities, social and artistic sciences, exceptionally also to sciences, technical sciences and life sciences. Because of this aspect one can hardly consider these projects as the ones which comply with the model of universal research.

There are slight differences in ideological preferences hierarchy among beneficiaries of at least three grants and the preferences in the whole collection entity. Just like in the entire collection, also among beneficiaries of at least three grants history of philosophy is the main point of interest (20.0% of projects). Logic and methodology as well as religion and its determinants come second (13.33% of projects each). And while logic and science methodology occupy a similar position as in the whole collection, the position of religion and its determinants is quite different. Epistemology comes third in the entire collection (11.77% of projects). Religion and its determinants, in turn, occupy the eighth place (6.5% of projects).

There are similarities and differences between ideological preferences in philosophy grants and the hierarchy of philosophy problems in the National Library catalogue and the Polish version of Google scholar. In Google scholar, just like in the entirety of analysed grants, history of philosophy takes the lead (14.38% of records). The third position, just like in the whole analysed grants' collection, is occupied by the theory of cognition (11.04% of records). There is a significant difference in the second place. In Google scholar it is the philosophy of man (13.43% of records), while in the examined grants it is logic and science methodology. In Google scholar, science methodology comes sixth (7.07% of records).

One can assume that there is a close correlation of problem hierarchy between the analysed grants and Google scholar.

Striking differences refer to the hierarchy of problems present in the analysed grants and the National Library catalogue contents. Religion comes first in the catalogue (51.09% of grants), ethics comes second (18.74% of records) and theology comes third (13.76% of records). Let us stress the fact that the order in the examined grants is as follows: history of philosophy, logic, science methodology and epistemology.

We observed a high compatibility of philosophy problems hierarchy between the analysed grants and the Polish version of Google scholar contents and a significant discrepancy between problems' hierarchy present in grants and in the National Library catalogue. We think that these differences stem from the diversity of texts' collections in the National Library catalogue and Google scholar. The National Library is the "long-lasting" collection; it collects texts from many epochs. Google scholar, in turn, is a "short-lasting" collection; it collects modern texts and as such it reflects the present vision of what problems are important to philosophy.

We assume that citations of texts written as a result of research pertaining to grant implementation are one of the most important indicators showing which philosophy problems are currently really important, fundamental. With such an assumption the problems related to normative and descriptive ethics are of utmost importance. The texts referring to this problem, shown as a result of research project work, have the average citation rate (14.11 times per text). They are followed by the problems concerning the nature of human mind (on average 6.69 times per text). History of philosophy problems, the most frequently chosen research subject by the grant authors, occupy the far 12th place, with the citation indicator of 1.03 citation per one text. Multiple grant beneficiaries' texts have the higher citation indicators.

History of philosophy is the most common subject interest within the unanimous choice of grant authors and their reviewers in the analysed projects. The grants are centred round the inner problems of philosophy. They hardly show any interest in the problems outside philosophy. They are barely interested in the research concerning the responses to the philosophical challenges of modernity. The hierarchy of ideological preferences in grants is very similar to the structure of philosophy problems in Google scholar, and different from the one in The National Library catalogue.

The citation hierarchy of texts written as a result of implementation of the analysed research projects is totally different from the hierarchy of problems making up the subject interest of grant authors. The texts pertaining to ethics are most frequently cited. The texts concerning history of philosophy problems are over a dozen times less frequently cited.

In the light of these findings we formulate the thesis that, contrary to official expectations, grants' implementation research in the panel *fundamental questions about human nature and the surrounding reality* does not tackle the most important philosophical challenges of modernity, it does not facilitate development of the research discipline.

Such a way of science management, at least the areas related to the fundamental questions about human nature and the surrounding reality does not meet the desired expectations, it does not foster their development, does not make one willing to seek answers to the philosophical challenges of modernity, and the conclusions are not attractive to other researchers.

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OPERATIONAL PROGRAMS AS A DRIVING FORCE FOR THE DEVELOPMENT OF SMART CITIES IN POLAND

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Purpose: This article aims to explain the role of operational programs in developing smart cities and show how they support the financing of key infrastructure projects. The article presents how operational programs in smart cities have changed from 2018-2023.

Design/methodology/approach: The article uses a quantitative data analysis approach to examine the use of operational funds in the largest Polish cities. Data from 2018-2023 were analyzed regarding the value of operational programs and their impact on infrastructure development, digitalization, and innovation. Comparative analysis was used to identify cities leading in the use of funds and to determine what factors may affect the differences in the financing level.

Findings: The analysis results indicate that operational programs play a key role in developing smart cities in Poland. It was identified that the largest Polish cities, such as Warsaw, Krakow, and Rzeszow, use operational funds effectively, contributing to modern infrastructure development and innovative solutions. The values of operational funds increased in 2018-2023 in all the cities studied, indicating the intensive development of projects related to digitalization, renewable energy, and modernization of urban infrastructure. Cities such as Rzeszow and Lublin used the highest operational funds per capita, while Krakow stood out with the fastest growth rate. The analysis also shows that despite its role as the capital, Warsaw has a lower use of operational funds per capita than other cities. That may be because projects implemented in Warsaw are more complex and require a greater outlay of funds, which may affect their pace of implementation. Sustainable development was noted in cities such as Poznań and Wrocław, with investments focusing on modernizing public transport, developing intelligent energy management systems, and improving communication infrastructure.

Originality /value: The originality of this article lies in the analysis of the use of operational programs in the development of smart cities in Poland.

Keywords: smart cities, GDP, smart city index, operational program.

Category of the paper: Research paper.

1. Introduction

In the era of dynamic technological changes, more and more cities worldwide are taking steps to become "smart." Smart cities are places where technology supports the lives of residents, optimizes resource management, and contributes to increasing the efficiency of urban infrastructure. Thanks to modern solutions based on data analysis, cities can better plan spatial development, manage transport, energy, and waste management, and improve public safety. All these elements contribute to the creation of a space that is more friendly to residents and environmentally sustainable. At the center of these processes are operational programs that play a key role in integrating systems and introducing data-based solutions. These programs enable cooperation between various urban sectors, such as transport, energy, waste management, emergency services, and city administration. Thanks to this, cities can respond faster to the changing needs of residents and better manage resources in a sustainable and efficient way.

In Poland, introducing the smart city idea is becoming increasingly common, and the role of operational programs is invaluable in implementing this process. They include support for projects in the field of communication infrastructure, ecological energy, and digitalization of public services, as well as innovative initiatives related to improving the efficiency of city management. Thanks to funds and strategies, cities such as Warsaw, Wrocław, or Gdańsk can introduce modern technologies that contribute to greater involvement of residents and optimization of city services.

This article aims to present operational programs in smart cities and analyze their use in the budgets of Polish smart cities.

2. Methods of financing the development of smart cities

The methods of financing the development of smart cities are diverse. They are based on using various sources of financing to implement projects related to modern infrastructure, digital technologies, and sustainable development. The main and most important source of income is the income of cities. These funds enable large-scale investments to improve residents' quality of life by modernizing infrastructure, increasing energy efficiency, and implementing digital technologies.

The revenues of cities, or local government units in Poland, include several key sources of financing that enable municipalities, counties, and provinces to carry out public tasks. The first is their revenues, i.e., funds obtained independently by local government units, such as local taxes, including property tax, tax on means of transport, and civil law transactions. Additionally, these units obtain revenues from local fees, such as fees for perpetual usufruct, market,

and parking fees, as well as income from assets, such as the sale of real estate or the rental of buildings. The second source of income is general subsidies provided by the state, which units can use for any purposes related to their activities. These subsidies include an educational part aimed at financing schools, a balancing part, supporting units with lower incomes, and an equalization part. Another source is earmarked subsidies, which implement specific tasks like educational programs, infrastructure investments, or social assistance. These subsidies can come from the state budget and EU funds allocated to implement selected projects. Another important element is the EU funds that local government units can obtain to implement development and infrastructure projects, often requiring co-financing from their own resources. The structure of local government units' revenues varies depending on the unit type, whether it is a commune, district, or province, as well as the region's wealth level, which affects the diversity and specificity of individual budgets.

An important financing mechanism is public-private partnerships (PPP), which allow the public sector to cooperate with private enterprises to implement joint investments, sharing costs and risks. These partnerships enable the implementation of large-scale projects that may be too expensive or risky for local government units to implement on their own. Another way of obtaining funds is through city bonds, which are a financial instrument that allows for raising the capital necessary to implement investments in infrastructure development, such as the modernization of energy networks, the expansion of public transport, or the implementation of modern urban traffic management systems. Venture capital funds and private investments are an important source of financing for startups and innovative technological projects in smart cities. These projects are often characterized by high development potential and the ability to generate significant profits, which attracts private investors ready for risky investments. In the form of grants and subsidy programs, government support also plays a significant role in financing innovative city projects and supporting activities in digitalizing city services, energy innovations, and sustainable development. Crowdfunding, although a less popular source of financing for smart city projects, can provide significant support for smaller local initiatives of a social nature. Thanks to the involvement of residents, it is possible to finance projects such as electric vehicle charging stations, the installation of smart lighting, or the development of urban micro-infrastructure. Profits generated by municipal services, such as fees for energy, water, or waste collection, can be reinvested in the development of smart city infrastructure, which allows for self-financing of part of the investment. Bank loans and financing from international financial institutions, such as the European Investment Bank, are another source of financial resources for implementing smart city projects. This type of financing is particularly beneficial in the case of large investments of strategic importance for the city, where long-term savings and revenues are expected to be generated, making the investments more profitable. Thanks to various financing methods, cities can implement comprehensive smart city projects, which not only improve the quality of life of residents but also increase the efficiency of resource use and contribute to a better organization of urban space, which is important in the context of the sustainable development of modern agglomerations.

The article focuses on using operational programs: Infrastructure and Environment, Smart Growth, Digital Poland, and Knowledge Education Development. The Operational Programme Infrastructure and Environment (POIiŚ) is Poland's most extensive EU program, supporting infrastructure development and environmental protection. Its aim is sustainable development through transport, energy, environmental protection, health, and cultural heritage investments. The program includes, among others, the modernization of roads and railways, the development of renewable energy sources, improving waste management, air protection, and thermal modernization of buildings. It is financed by the Cohesion Fund and the European Regional Development Fund, supporting investments implemented by public institutions, enterprises, and non-governmental organizations to benefit residents and the environment. Another program is the Operational Programme Smart Growth. The Operational Programme Smart Growth (POIR) is one of the key EU programs in Poland, supporting innovation and competitiveness of the economy. It aims to develop enterprises through research, development, and innovation and to support cooperation between the science and business sectors. The program finances research projects, the creation of modern technologies, the implementation of innovative solutions, and the development of startups. POIR uses European Regional Development Fund funds to support Polish companies, scientific units, and research consortia to accelerate their development and increase their potential in domestic and international markets. In turn, the Digital Poland Operational Program (POPC) supports the development of digitization in Poland. Its goals include ensuring universal access to fast internet, developing e-administration, and raising the digital competencies of society. Thanks to POPC, projects were implemented to build broadband networks, implement public e-services, and digitize cultural resources, which contributed to technological development and increased citizens' quality of life. The European Regional Development Fund financed the program. In turn, the Knowledge Education Development Operational Program (POWER) supports the development of human resources in Poland, increasing their competencies and opportunities in the labor market. It includes education-related projects, improving qualifications, supporting employment, and social inclusion. POWER is financed by the European Social Fund, supporting students, employees, unemployed people, and educational institutions in improving skills, professional activation, and social innovation.

3. The use of operational programs in Polish smart cities

The article focuses on the value of funds from operational programs for the cities of Kraków, Warsaw, Poznań, Wrocław, Gdańsk, Lublin, Bydgoszcz, Katowice, and Rzeszów in the years 2018-2023. Four operational programs were analyzed: Infrastructure and Environment, Smart Growth, Digital Poland, and Knowledge Education Development.

Table 1.

The total value of operational programs in individual cities in 2018-2023 [PLN]

	2018	2019	2020	2021	2022	2023
Infrastructure and Environment	31491216153	32576499795	34527529393	35060695142	41241440848	42060111270
Intelligent development	8922772698	11844527672	15698129336	18708235546	18544858116	18491756723
Digital Poland	164050124	195884881	173323427	174317723	173614067	173264612
Knowledge Education Development	362510235	433906359	637532978	725384702	734436257	720113842

Source: Own study.

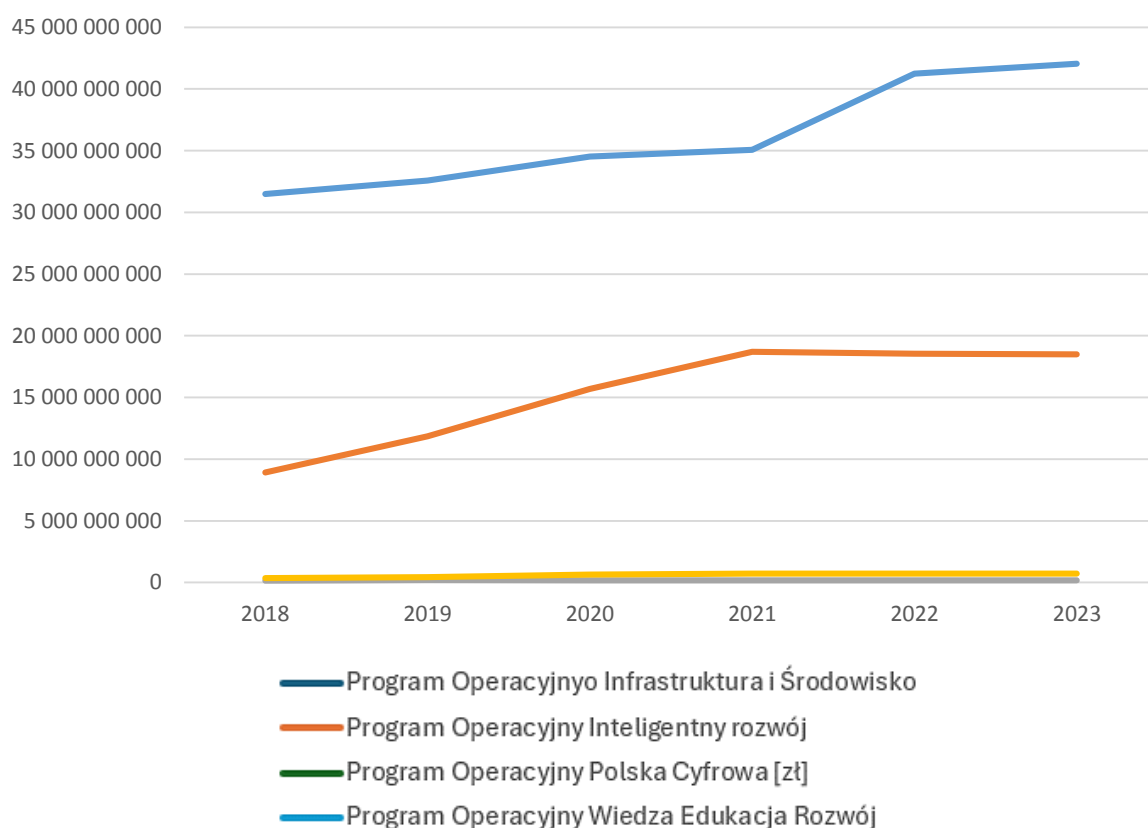


Figure 1. Use of operational programs in subsequent years.

Source: Own study.

Table 1 and figure 1 present operational programs in smart cities in subsequent years. Data on financing individual operational programs in Poland in 2018-2023 indicate a systematic increase in expenditures, especially in infrastructure, environment, and innovative development. The "Infrastructure and Environment" and "Smart Development" programs recorded the most significant increases, which indicates strong support for infrastructure modernization and innovation in Polish cities. The "Digital Poland" program shows stability, which may mean achieving the goals in the scope of essential digitization. In turn, the "Knowledge Education Development" program significantly increased its financing,

which may be related to the need to invest in human capital and education development in the context of growing challenges related to technology and innovation.

First, the total value of operational programs in individual cities was analyzed. That allowed us to find cities that use funds from operational programs. Table 2 and figure 2 show the data on the use of operational programs in Polish smart cities. In all cities, we observe a steady increase in the value of funds from operational programs, which suggests intensive development in infrastructure, digitalization, energy, and innovation. These investments may be related to smart city projects, which aim to improve residents' quality of life and modernize cities.

Table 2.

The total value of operational programs in individual cities in 2018-2023 [PLN]

	2018	2019	2020	2021	2022	2023
Cracow	7501262780	9228363471	11391034920	12653571324	15711641072	15926425751
Warsaw	19641837798	19916682424	21233417630	21781870579	24484962262	24622527264
Poznan	5285118798	6387578138	7303407893	8074558306	8329403321	8712968631
Wroclaw	5678483803	6905564109	8205714271	9061897536	9130205360	9433937897
Gdansk	4386396459	5328538736	5909133994	6355758638	6481647746	6671635592
Lublin	4609466667	5369241148	6259232622	6801895187	7231622733	7333207181
Bydgoszcz	2966465287	3424375856	4192142708	4639061324	4693997310	4800924179
Katowice	2732052496	2843039078	3461018592	3739044014	3921405056	4037126719
Rzeszow	3101300520	3554013014	4283489299	4628605594	5295160630	5369403113

Source: Own study.

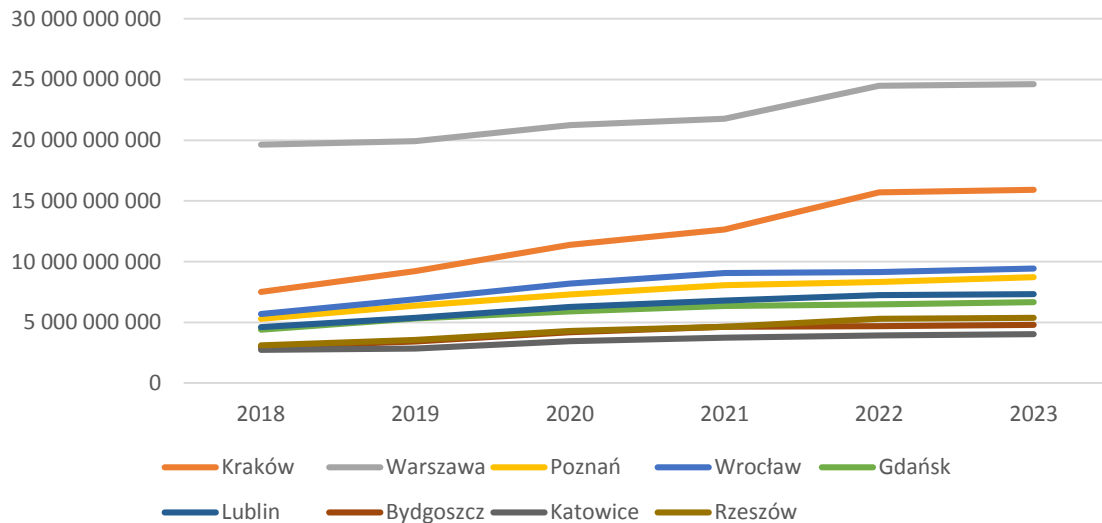


Figure 2. The use of operational programs in Polish smart cities.

Source: Own study.

Warsaw has the highest value of funds compared to other cities, which results from its role as the capital of the country and a key economic center. The value increased from about PLN 19.6 billion in 2018 to over PLN 24.6 billion in 2023. This significant increase suggests that the city is investing intensively in infrastructure development and other strategic projects. That is also confirmed by the cluster analysis presented in Figure 2. Warsaw is a single bond

and significantly lags behind other cities, as the capital city clearly dominates in terms of investment value. That is understandable, considering the size of the city and its economic and administrative importance. It also means a greater demand for modern infrastructure and innovation investments.

The second city in Poland in terms of the use of operational programs is Kraków. The use of operational programs in the case of Kraków is also systematically growing, from about PLN 7.5 billion in 2018 to over PLN 15.9 billion in 2023. The level of use of operational programs in Kraków may indicate a large number of development and modernization projects in this city.

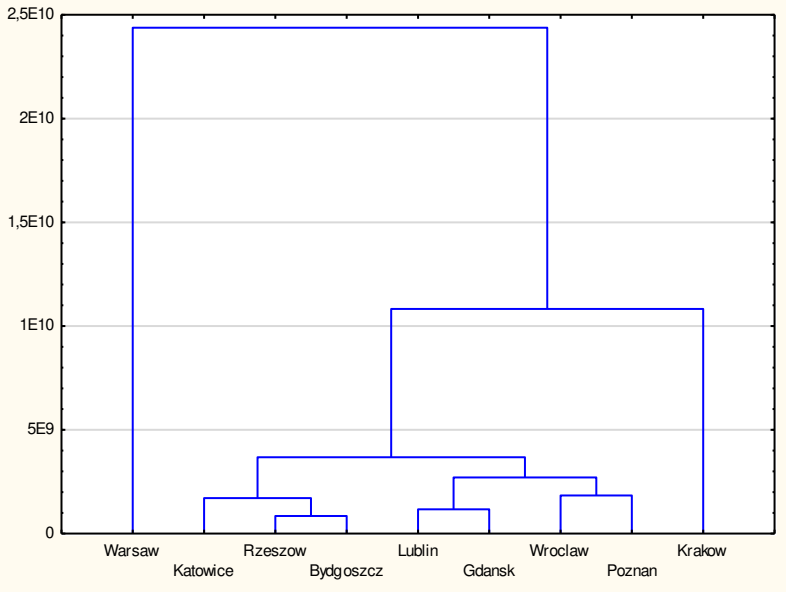


Figure 3. Dendrogram of Polish smart cities using operational programs.

Source: Own study.

Kraków's second place among cities regarding the value of funds reflects its development ambitions and growing importance as a cultural and economic center. It is also one of the most important cities in Poland in terms of tourism and education, which increases its investment needs. The next cities are Poznań, Wrocław, Gdańsk and Lublin. Funds values for these cities have also been growing over the years. Wrocław and Poznań have similar values, which increase from around PLN 5.7 billion to almost PLN 9 billion by 2023. Gdańsk and Lublin have also recorded growth, although at a lower level than Kraków and Warsaw. The group that uses funds from operational programs the worst includes Katowice, Bydgoszcz, and Rzeszów. These cities have lower funds values, but they also show gradual growth. Katowice increased its funds from around PLN 2.7 billion in 2018 to over PLN 4 billion in 2023. It seems that the cities that use funds from operational programs the worst are Rzeszów and Bydgoszcz.

To better illustrate the use of operational funds in Polish cities, the use of operational funds per 1 city resident and the growth rate in the years 2018-2023 were calculated. The calculations of the indicators are presented in the table 3.

Table 3.*The indicator of the use of operational funds per capita [PLN]*

City	Use of operational funds per capita [PLN]	Average growth rate 2018-2023
Rzeszow	27218,82	1,12
Lublin	22251,17	1,10
Cracow	19754,91	1,16
Poznan	16181,90	1,11
Bydgoszcz	14707,18	1,10
Katowice	14460,14	1,08
Wroclaw	14002,28	1,11
Gdansk	13689,03	1,09
Warsaw	13226,55	1,05

Source: Own study.

Rzeszow achieves the highest utilization of operational funds at PLN 27,218.82 per capita, indicating an intensive investment level. At the same time, the average growth rate for Rzeszow is 1.12, which means dynamic development and well-balanced investments in relation to the population. Lublin is in second place with a value of PLN 22,251.17, with an average growth rate of 1.10. That indicates an intensive allocation of funds to the city's development, which allows for maintaining a high level of investment. Krakow ranks third in terms of the utilization of the value of funds, amounting to PLN 19,754.91 per capita, but at the same time shows the highest average growth rate at the level of 1.16. That may mean that Krakow uses operational funds to a large extent and develops the fastest, which may be the effect of effective investment programs and growing economic activity. Poznań, with a value of PLN 16,181.90 per capita and a growth rate of 1.11, shows balanced development, similar to Wrocław, which achieved an average growth rate of 1.11, with a value of funds of PLN 14,002.28. Bydgoszcz and Lublin have similar average growth rates of 1.10, respectively, suggesting stable investments in the city's development, although Bydgoszcz, with a value of PLN 14,707.18 per capita, invests less than Lublin. Katowice records a relatively low use of funds, amounting to PLN 14,460.14 per capita, and their average growth rate is 1.08, indicating a moderate pace of city development. Gdańsk, with a value of funds of PLN 13,689.03, achieves an average growth rate of 1.09, indicating stable investments, although their scale is smaller than in other cities. Warsaw has the lowest operational funds per capita use, at PLN 13,226.55, with an average growth rate of 1.05. That may indicate a greater concentration of investments in other areas, perhaps more extensive infrastructure programs, which are not reflected in operational funds per capita, but also greater needs related to the large population of the capital.

Polish cities participated in the Infrastructure and Environment Operational Programme, the Smart Growth Operational Programme, the Digital Poland Operational Programme, and the Knowledge Education Development Operational Programme. Figure 4 presents the level of use of operational programmes in individual cities from 2018 to 2023.

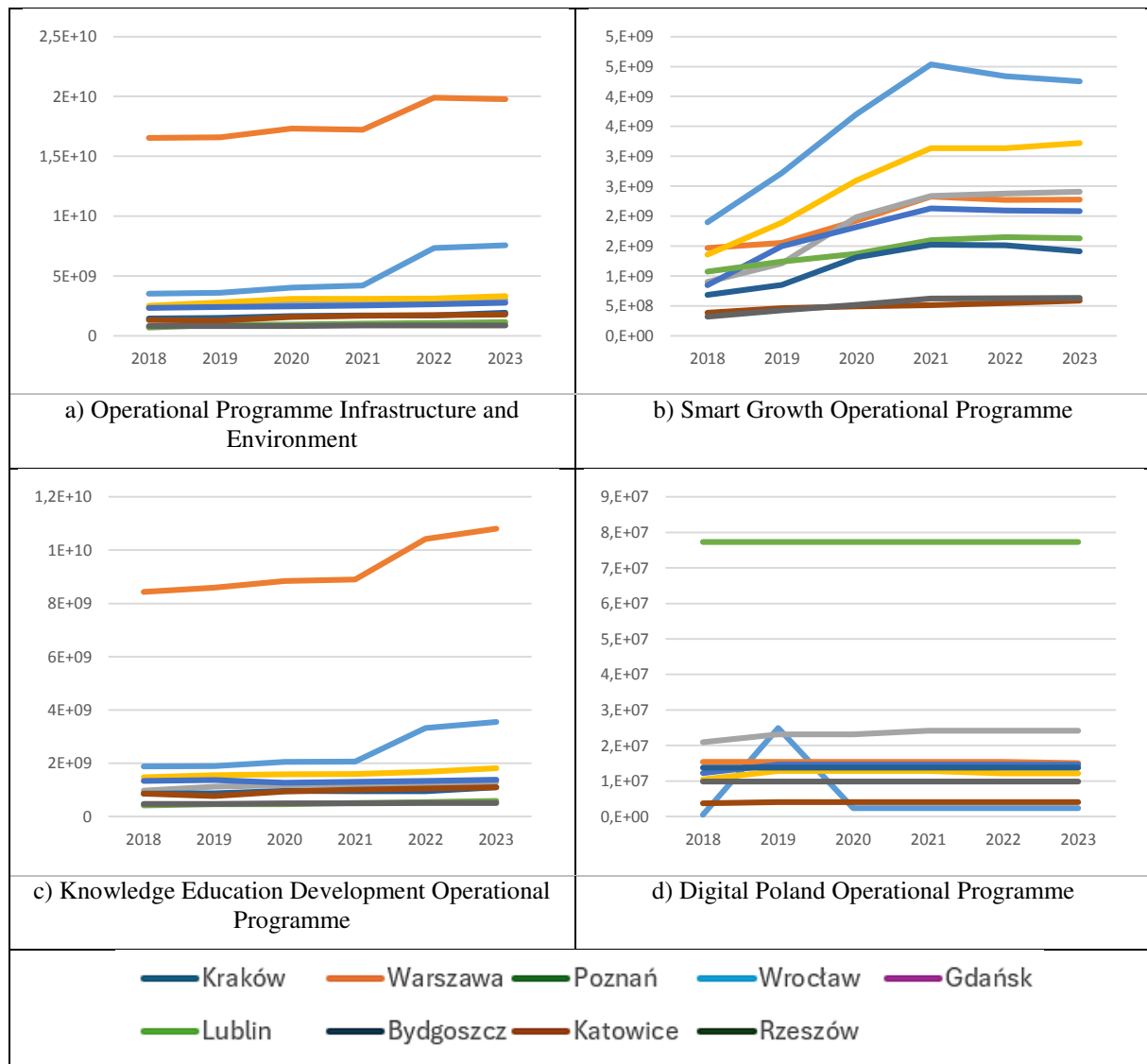


Figure 4. Use of operational programs.

Source: Own study.

Warsaw best uses the Infrastructure and Environment Operational Programme (Figure 4a). Warsaw has consistently high values, with a slight increase until 2021 and a slight decrease in 2023. Kraków is characterized by a systematic increase in financial values, with a clear jump between the fifth and sixth year, which may indicate a sharp increase in investment or financing. Poznań has a steady, moderate increase, with a clear increase between 2022 and 2023. Wrocław shows a trend similar to Kraków, with a systematic increase, exceeding 3 billion in 2023. Gdańsk has a stable, slow increase, without large jumps in value. Lublin starts with the lowest value but steadily increases, especially between 2019 and 2020. Bydgoszcz, like Gdańsk and Lublin, shows a systematic increase, with a more significant increase in the last year. Katowice has a more variable trend than other cities, with an initial decrease, after which values increase. Rzeszów shows relatively stable financial values without significant changes. The largest increase in financial values can be observed in Krakow and Warsaw, while Poznan, Wrocław,

Gdansk, and Bydgoszcz show predictable growth. Katowice and Rzeszow remain more stable or show minor fluctuations.

In the Smart Growth Operational Programme (Figure 4b), Kraków is characterized by systematic growth until 2021, followed by a slight decline in value but stabilization at a high level. Warsaw shows moderate growth until 2021, followed by a slight decline and stabilization. Poznań has dynamic growth until 2021, with the later years bringing milder increases in value. Wrocław has shown strong growth, reaching a stable level of over 3 billion in recent years. Gdańsk shows increasing values until 2021, followed by a slight decline and stabilization at a slightly lower level. Lublin starts with moderate values, systematically increasing until the fifth year and then slightly declining. Bydgoszcz had an apparent increase until the fourth year, but then the values decreased slightly. Although starting with low values, Katowice shows stable growth throughout the period, reaching almost 600 million in 2023. Rzeszów, like Katowice, shows steady growth with slight differences, reaching a value of around 633 million in 2023.

Similarly to the Smart Growth Operational Programme in the Knowledge Education Development Operational Programme, Warsaw is the city that uses financial resources the most. Warsaw showed a steady increase in value until 2021, but there has been a slight decrease in recent years. Similarly, Krakow is characterized by a dynamic increase in financial values until 2021, after which the values stabilize at a high level. Poznań maintains relatively stable financial values, with a slight increase in recent years. Wrocław records a significant increase until 2020, after which the financial values remain at a similar level, with slight fluctuations. Gdańsk is characterized by stable growth throughout the period, with moderate differences.

On the other hand, Lublin shows a sharp increase until 2021 and then stabilizes the values. Bydgoszcz and Katowice significantly increased until 2020, when the values stabilized. Rzeszów shows a steady increase until 2021, and then the values stabilize at a level of around 54 million.

In the Digital Poland Operational Programme, Kraków recorded a sharp increase between the first and second year, followed by a decrease and stabilization at around 2.39 million. Warsaw maintains stable financial values throughout the period, with a minimal decrease in the last year. In contrast, Poznań shows a systematic increase in financial values, stabilizing around 24 million in recent years. Wrocław records an increase between 2018 and 2019, after which the values stabilize but decrease slightly after 2019. Gdańsk follows a similar trend to Wrocław, with an initial increase, followed by stabilization with a slight decrease in recent years. Lublin maintained constant values throughout the period with no changes. Bydgoszcz has also had constant values throughout the years. On the other hand, Katowice recorded a small increase at the beginning, after which the values stabilized at around 4 million. Rzeszów maintains stable financial values for most of the period, with a minimal decrease in the last two years.

Conclusions

The analysis presented in this article shows that operational programs significantly contribute to the development of smart cities in Poland, especially in large agglomerations such as Warsaw and Krakow. The general trend of increasing the use of funds in all cities suggests increasing resource availability and greater demand for investments, especially in infrastructure, sustainable energy, and technology. These investments are crucial for transforming cities into more modern and user-friendly environments, consistent with the smart city concept.

Cities such as Rzeszow, Lublin, and Krakow used the most operational funds per capita, with Krakow showing the fastest growth rate. In contrast, despite its role as the capital, Warsaw allocates the least operational funds per capita, which may be due to the specificity of larger and more complex projects. Operational programmes have proven to be an effective tool in supporting the strategic transformation of Polish cities into smart cities, responding to technological and sustainable development challenges. By providing the necessary financial support, these programs enable cities to better respond to the needs of their residents, promoting sustainable development and improving the quality of life in cities. That indicates that further expansion and improvement of these programs can play a key role in ensuring that Polish cities continue to thrive in an increasingly digital and resource-conscious world. Future research could focus on a deeper examination of individual projects financed by operational programs and their direct impact on urban life, such as mobility, energy efficiency, and public safety. That would allow for a more comprehensive understanding of the outcomes and broader implications of smart city initiatives in Poland.

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MANAGEMENT OF THE WAY OF TRANSMITTING THE GOSPEL TRUTHS TO THE FAITHFUL IN THE LIGHT OF EMPIRICAL RESEARCH

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Aim: The primary aim of this paper is to present the results of research concerning the issues of faith faced by the contemporary generation of Catholics. In doing so, the authors sought to meet the social need for discourse on how to shape the personality of individuals doubting the Gospel message of the Roman Catholic Church, strengthen the faith of its members based on rational premises, and prevent numerous doubts caused by the lack of correlation between religion and science. The secondary aim is to attempt to answer the question of what the faithful expect from their pastors when they struggle with a problem, and which sources of information should be considered reliable.

The article concerns the management of contemporary science, hence the text contains a statement regarding management in the Roman Catholic Church as an institution. The multiplicity of research goals means that issues related to management have not been fully exposed.

The authors set themselves many goals, and the most important include an attempt to find answers to questions about:

- the ideological function of theology in the world of science,
- contemporary styles of pastoral work,
- collective thinking about the truths of faith.

In principle, the articulated goals concern in their entirety the way theological knowledge is managed in theory and its implementation in practice. First, questions are asked about its role in science, then ways of implementing it in pastoral work are sought, and then it is verified through research. Therefore, not only the updating of theological knowledge regarding the mental state of contemporary Catholics is the subject of these considerations, but also ways of deriving new solutions to the contemporary science of the Roman Catholic Church resulting from the conducted research.

Methodology/approach: The research method applied in this paper is based on a modified grounded theory, which "treats theory building as a process and is not the verification of pre-constructed hypotheses on the basis of subsequently collected data" (Konecki, 2005). The outcome of such modifications is a "thought process in which vague, inexact notions (concepts) are clarified and strictly defined" (Świątkiewicz, 2024). Grounded theory is considered "one of the best-developed strategies for qualitative research" (Konecki, 2000).

Conducting research according to its methodological principles gives the researcher significant freedom to choose the time, place, and situation for data collection, and makes it possible to solve problems that go beyond "what is objective and measurable, enabling the exploration of issues related to assessments, values, experiences, that is, the individual" (Plich, Bauman, 2001, p. 277). This unconventional approach to research is justified when identifying "a specific cause as an explanation of a phenomenon, which simply means its subsumption under a certain universal law or set of such laws" (Blaug, 1955). Grounded theory is not detached from the core issue, it does not rely solely on statistics, but generates new solutions during the research process, as "the methodology of grounded theory is an attempt to oppose traditional, academic methods (from behind a desk) of theory building" (Konecki, 2000). Due to its universal nature, it has been adapted to address issues in pastoral theology (Dworak, 2013). In this case, data analysis using previously made assumptions was abandoned, as this could result in self-confirmation of known concepts.

This paper uses the *Human Performance Improvement* method for the formulation of questions. This method, employed by the American Society for Training and Development, was developed in collaboration with individuals such as William E. Deming, Peter Drucker, Abraham Maslow, and particularly Donald Kirkpatrick and Jack Philips. It introduced a systemic approach to identifying barriers that hinder employees from performing their work effectively and satisfactorily, and proposed solutions to eliminate these barriers (Gilbert, 2013).

In terms of methodology, the article is based on grounded theory, which is why the method was appropriately selected to address the research problem, and the authors argue why they decided to base themselves on this particular method. The choice of grounded theory as a research tool was dictated by the fact that it is a methodology based mainly on empirical research directly related to a given problem. "This approach is therefore rooted in research on organizations and work processes". The research results are treated by her as derivatives of empirical analyses, and the concepts built on their basis are constantly modified and verified". The grounded theory methodology is an attempt to oppose traditional, academic methods (from behind a desk) of building theory.

Limitations: A significant limitation for the authors was: developing a research approach that took into account the personalities of the respondents; obtaining honest and reliable answers from those willing to share their thoughts with the authors of this text; presenting conclusions that also considered the context of the research and the conditions under which it was conducted, and consequently articulating conclusions derived from the free discussions that emerged after completing the questionnaire.

The authors base their research on their own research, but also on research conducted by other researchers. Therefore, it was assumed that for 75% of the respondents the most important event was the figure of Jesus Christ, who made his teachings credible by his death on the cross. This footnote was used to emphasize the importance of the question, what fascinates you in the Gospel? However - if it is obvious from the point of view of a believer, then this footnote can be removed.

Implications: The results of the research will, on one hand, provide useful information to those managing the process of shaping the personalities of the younger generation, and, on the other hand, may represent an important step in the development of pastoral theology, which aims to develop guidelines for the practical activities of the Church in the contemporary world.

In addition, other research methods, apart from focus groups, were used. Because according to the principles of grounded theory, focus studies are an essential next step between collecting data and preparing preliminary versions of scientific papers. They are the main method of grounded theory, because they encourage data analysis at an early stage of the research process. Following these recommendations, focus groups were conducted in the form of interviews: simple standardized (questionnaire with scaled answers); simple non-standardized (the person

conducting the research has a lot of freedom to ask questions and explain their meaning); in-depth standardized (indirect questions resulting from the context of the research conducted play a large role); in-depth non-standardized (a casual conversation on a given topic). It is obvious that there will always be methodological doubts. Therefore, it must be added that the functioning of any type of organization requires the construction of new concepts that keep up with the progress of civilization. The paradox of some situations is that the social processes taking place in their environment undergo radical changes, while decision-makers do not notice them and persist in presenting their principles - considering them unchangeable. This process should be interrupted by formulating hypotheses and their constant verification and modification of these as knowledge on a given topic is obtained. Grounded theory can be a good tool that will allow the creation of new concepts, hypotheses and theories, not based on previously accepted axioms and assumptions, but on empiricism referring to the observed reality. Generating these during research involves:

- referring to the researcher's ideas and intuition,
- understanding, and not just searching for cause-effect relationships,
- carefully selecting places, conditions, people and situations for research,
- complete freedom, openness, communicativeness and naturalness.

Elements of grounded theory have been used, among others, in research on: organizational culture, production control system, causes of disasters, restructuring and recruitment processes in human resources consulting agencies. Due to these features, it was purposeful for us to take the effort to adapt its principles to create new research concepts, appropriate to the time and place of their conduct. The following premises supported this:

- it is related to a long-term research process,
- it is subject to rapid modification and verification,
- it is characterized by high flexibility and aims to comprehensively capture the subject of the research,
- it is not detached from the essence of the issue,
- it does not use only statistical data and generates new concepts already during the research.

Grounded theory is not a process of formulating hypotheses on the basis of previously collected information, but is an innovative approach to their construction and verification.

Value: The scientific value lies in the innovative way of conducting research based on the grounded theory method and the application of the Human Performance Improvement [HPI] method in acquiring knowledge about the implementation of pastoral tasks in the contemporary world (Filipowicz, 2008).

Keywords: Roman Catholic Church, management of science, methodology, conceptualisation and operationalisation of research results, grounded theory method.

1. Introduction

The Church can be defined not only as a fellowship of believers, but also as an institution managed by clergy. Such an understanding of the Church requires the identification of its main goal, which is salvation, realised through the fellowship of breaking bread and prayer (Acts 2:42). In this context, the clergy can be considered as simultaneously fulfilling three functions: mentors, managers and coordinators, who shape its organisational structure, are responsible for

conveying the principles contained in the Old and New Testaments to the faithful, and motivate them to behave in accordance with the Ten Commandments. The Church, as an institution operating in a precisely defined reality, should therefore make use, in defining its immediate objectives, of both theological studies and take into account knowledge from other scientific fields, through which information can be obtained about: the concerns and dilemmas of the faithful; ways of organising pastoral activities and methods of presenting the principles of the faith in various forums. This source of information will be particularly useful in the implementation of the ecclesial activity of the Church (Schoonenberg, 1970, pp. 383-390), as it relates to initiatives such as protecting the family, working with youth, and assisting marriages in moments of crisis.

Therefore, it is justified to conduct interdisciplinary research (Kretek, 2011), the results of which may make it possible to develop effective methods of evangelisation that meet the expectations of various Catholic communities in areas such as: the principles of promoting faith among the faithful; the causes of changes in human personality in the context of the Gospel message; or identifying motivators that enable sharing knowledge about religion with third parties.

The authors are aware that research into the sphere of the *sacred*, occurring during spiritual experiences that evoke a sense of communion with God (Tomalski, 2001) in juxtaposition with the *profane*, which focuses attention on the knowable, material, and measurable, may evoke various emotions.

The research methods adopted in this paper are based on grounded theory, since the organisational structure of the Church corresponds to the fundamental principles of management theory. The results of the research, on one hand, provide useful information in the process of shaping the personalities of the younger generation, and, on the other hand, may represent an important step in the development of pastoral theology, which aims to develop guidelines for the practical activities of the Roman Catholic Church (Kamiński, 1992). Grounded theory, adapted to the study of the *sacred*, takes into account the fact that clergy carry out their mission in increasingly challenging conditions, which necessitates the search for adequate ways of conveying evangelical principles of conduct to the faithful under conditions of a rapidly changing mentality and personality of individuals (Kamiński, 1983).

Researchers set many goals for themselves, and among the most important are attempts to seek answers to questions about:

- the worldview function of theology in the world of science,
- contemporary styles of pastoral work,
- collective thinking about the truths of faith.

Therefore, these considerations focus not only on updating the theoretical knowledge regarding the mental state of contemporary Catholics but also on methods of deriving new solutions for the contemporary teaching of the Church based on the actual experiences of researchers (Skórzyńska, 2024).

The proposed research model is based on concrete actions derived from grounded theory. These include:

2. Conceptualisation of the Research Process

Conceptualisation is a process involving the processing of accumulated knowledge and its formulation into: concepts, definitions, and terms, which are then used for identification and diagnostic purposes. Conceptualisation boils down to the precise expression of the research intentions that are to be realised when interacting with an organisation's stakeholders. Conceptualisation requires the articulation of clear and concise definitions regarding the essence of the research. It is also referred to as the process of transforming knowledge into concepts and definitions used within the organisation. The main questions that may prove useful during conceptualisation include:

- how to analyse the problem at hand?
- will the adopted problem-solving method provide a solution?
- How to apply research results in practice (Conceptualisation, 2024).

In this study, conceptualisation will be based on the elements of grounded theory, which include:

- Theoretical sampling is the process of collecting data to generate theory" (Konecki, 2000). In this paper, it will be conducted in various locations and times through questions, causing new ideas to emerge as information is gathered, which may influence the implementation of further research. "These assumptions and perspectives often differ among disciplines but nonetheless shape research topics and conceptual emphases" (Charmaz, 2009). The expansion of knowledge on the topics under study should continue until new insights begin to repeat. "For the researcher, a method is not a set of rules defining how to conduct the research beforehand. Rather, it is a philosophical mandate that enables the empirical presentation of the relationship between the observer and the observed event" (Konecki, 2000). The use of these assumptions will free the researcher from the subjectivism, which manifests in the confrontation of pre-existing knowledge and experience, in favour of objectivity derived from observed facts. In this case, theoretical sampling involves obtaining preliminary ideas that emerge after receiving answers to questions that "forced" respondents to provide sincere and reliable responses (Charmaz, 2009).
- Theoretical notes, which serve as "a crucial step between data collection and drafting preliminary versions of scientific papers. They encourage data analysis at an early stage of the research process" (Charmaz, 2009, p. 97). These are the "initial ideas that need to be addressed" (Charmaz, 2009, p. 27). They are most often practical references to the

discussed issues. They are not always logically connected to the theoretical aspects of the investigations conducted, but they serve as points of reference for deeper reflections resulting from "giving them a spontaneous, rather than mechanical, character" (Charmaz, 2009, p. 106). In general, theoretical notes express the subjective comments of the researcher, which makes it possible to grasp the endogenous and exogenous relationships of the problem under study.

3. Relationships Between Faith and Science Analysed from the Perspective of:

- Pre-modernism, which assumes that human thought develops based on the achievements of our ancestors, and that maintaining the old order involves passing down knowledge from past years, with the next generation only needing to accept the prevailing social rules (Babbie, 2004, p. 33). This type of behaviour boils down to the historical justification of conclusions, which in many cases may prove inadequate for the scale of the problem being addressed. "How can one proclaim the truth. By ceasing to know it? It has passed with the time for which it was relevant. And times change. Views must change too. Including scientific ones" (Kołodko, 2008, p. 15). In solving problems related to the adaptation of the Church's teachings to the expectations of the "knowledge society," this perspective may lead to innovative concepts being ignored by conservative circles, for whom "theory becomes doctrine, doctrine becomes dogma, dogma becomes an inadequate theory, because the times have changed, and the substance is not the same as that for which the theory was created" (Kołodko, 2008, p. 315). After an in-depth analysis, it turned out that the pre-modernist approach is not feasible because it overlooks aspects of civilisational progress, which, in the face of various emerging crises, strengthens conservative attitudes that act as a brake preventing further research.
- Modernism, which ensures broadly understood tolerance (Babbie, 2004, p. 33), where no one influences anyone else's decisions, and everyone follows their own ideas about the Gospel message. Here, it is assumed that each member of the religious community can act according to their own ideas, and the results of the research should confirm these opinions. In this case, the acquisition of knowledge is treated as a search by researchers for arguments confirming previously articulated theses, which can be expressed with the phrase "knowledge is reproduction, and science is creation" (Kołodko, 2008, p. 14). On a larger scale, such conduct leads to the distortion of reality and hinders the dissemination of reliable research results to the public. This perspective of articulating theoretical notes was also rejected by the authors because the research

results could confirm a concept favouring the emergence of specific enclaves of people living alongside each other, such as: families – where parents and children have different views on faith; schools – where the child's guardians and teachers have diverse concepts of youth education; doctors – whose views on morality differ significantly from the values expressed by Catholics.

- Postmodernism, which increases the acceptance of research results, even when they force a radical restructuring of existing behaviours (Babbie, 2004, p. 35). The analyses conducted by the authors indicated that the community of the faithful is not the only place where the data-gathering process for problem-solving takes place. Therefore, research can be conducted in other areas of scientific or practical [empirical] activity. This perspective enabled them to search for solutions to the problem using unconventional tools, which in this case are specially prepared customised questionnaires that enable categorisation. This procedure aimed to "extract from the qualitative material (...) categories and their properties by showing indicators related to the formulated conceptualisations" (Babbie, 2004, p. 48). The next step that facilitated data analysis was sorting, which involved organising the theoretical notes according to a specific criterion.

4. Triangulation

Triangulation is a process that "enables a more complete and multifaceted understanding of the object under observation because it involves viewing it from different perspectives in various ways" (Mazurek-Łopacińska, Sobocińska, 2018). In this paper, triangulation has been realised by means of transforming the collected data into information that enables a multifaceted analysis of the acquired research material (Apanowicz, 2003, p. 71). On the basis of triangulation, conclusions have been drawn that go far beyond the accepted scope of a typical analysis of research results, as problem-solving here does not occur spontaneously but emerges in confrontation with the existing reality. It is also important to remember that triangulation forces the precise formulation of questions on such a delicate matter as faith, which requires understanding and re-evaluating the reasons for adapting the research results to practical application by analysing the processes occurring within the Church's environment (Kawalerski, 2024).

5. Operationalisation (Survey Research) of the Research Process

Operationalisation involves making decisions about where, when, and how the defined concepts will be measured. It is closely related to the process of selecting the research procedure, i.e., determining the degree of occurrence of a phenomenon in the studied reality (DeVaus, 2001, p. 24). The research presented in this article was conducted according to the principles of grounded theory between 2020 and 2023 in academic environments, at conference meetings, and among the authors' friends and families, where the age range of the participants was between 30 and 60 years old. In total, approximately 500 people who identified as believers were surveyed.

The first form of research consisted of focus groups, i.e. free discussions centred around the question *Do you have enough knowledge to argue your belonging to the Roman Catholic Church in conversations with non-believers?*

Approximately 80% of the participants responded, either directly or indirectly, that they did not possess such knowledge and were unable to defend their views on faith, especially when confronted with the theory of relativity presented by physicists along with its quantum interpretation. This group felt helpless against the content presented to them by the media, which concerned the promotion of secular customs and the interpretation of historical facts. Only about 20% of the respondents were able to have a debate with others on the basis of theological knowledge.

In this focus group research, attention was also given to examining the situations and conditions under which a person transforms from a believer to a non-believer, or vice versa – under the influence of various types of spiritual experiences. These experiences became the subject of further research, as they enabled researchers to determine whether the causes of this transformation were endogenous or exogenous for those undergoing conversion or making the (risky) decision to apostatise. The following questions were asked:

- *What made you a believer?* – To this question, 80% of respondents answered: I grew up in the Catholic tradition; 15% – I found the concept of salvation to be in line with my value system and, in addition, it makes it easier for me to solve problems related to raising children; 5% indicated transcendental experiences.
- *What fascinates you about the Gospel?* – For 75% of respondents, the most important event was the figure of Jesus Christ, who made his teachings credible through his crucifixion (Biela, 2006); for 20%, it was the resurrection, and for 5%, it was the fact that the religion has lasted over 2,000 years.
- *Which part of the Bible made the biggest impression on you?* – Here, nearly 50% of respondents answered The Last Supper; 30% pointed to the Parable of the Workers in the Vineyard; 10% to the Parable of the Prodigal Son; and 10% highlighted the character of the Old Testament Joseph sold into slavery by his brothers to the Egyptians.

- *Propose your own concept for teaching religion in schools.* The survey results were as follows:
 - 60% proposed emphasising to young people that we are redeemed by Jesus Christ, and for that reason, our lives should be joyful;
 - 30% suggested that one of the forms should be enabling young people to organise initiatives such as spirituality festivals, evenings of religious poetry and music, discussions, and debates about family life;
 - 10% proposed conversations about the Eucharist as a form of union with God.
- *What actions did the teachings of St. John Paul II inspire you to take?* – Here, 70% of respondents said they were inspired to raise their children with a sense of responsibility for: their homeland, faith, and family; 10% began to place more importance on prayer; for 10%, the words "you must demand of yourselves, even if others would not demand of you" (John Paul II, 1983) were treated as an impulse for self-improvement, and for 10%, the statement "each of you also finds some sort of Westerland" (John Paul II, 1987) was understood as defending one's beliefs regardless of the consequences.
- *Does faith help you in achieving your planned goals, and if so, how?*
 - 10% of respondents answered that faith does not constitute an important factor in achieving their goals;
 - 90% answered that it does. Within this group, the following statements were the most common:
 - ✓ thanks to it, I do not pay attention to the adversities of life because it [faith] gives meaning to my life,
 - ✓ my goal is to raise my children to be decent people, and I believe that God will help me with this,
 - ✓ together with my spouse, through prayer, we want to create a relationship based on trust and mutual understanding of each other's expectations.
- *Describe the forces that can constructively support you in your religious practices* – 35% of people responded that these are Catholic television programmes; 25% acknowledged Holy Mass broadcasts, and 40% stated that these are the homilies of successive popes.
- *Describe the destructive forces that may discourage you from cultivating religious practices.* When confronted with this question, as many as 70% of the respondents stated that these are the opinions voiced by many scientists on the application of the concept of evolution in many fields of knowledge; 20% pointed to the increasing secularisation of society; 10% drew attention to the irresponsible behaviour of those endowed with public trust.

- *What dilemmas do you face as a believer?* The most common responses were:
 - modern physics, which presents a completely different world than theology – 50%;
 - medicine focuses on reducing suffering, while theology sees value in enduring it – 20%;
 - children receive conflicting information, for instance: during religion lessons that the world was created by God, while during physics lessons that it is a consequence of the Big Bang – 15%;
 - students struggle with issues of sexuality, viewed differently by clergy and sexologists – 10%;
 - there is a problem related to wealth accumulation in the face of growing poverty – 5%.
- *What should a homily be like to capture your interest?* The most common answer to this open-ended question was that it must:
 - address spiritual matters arising from the Gospel message;
 - express hope for a reward for living according to the Gospel principles;
 - show how religious conduct fosters positive relationships in marriage, work, and social life.

The next stage of the research focused on the completion of a survey questionnaire¹, in which the research group was asked to indicate the extent to which they agree with the following statements:

1. *To gain knowledge on how to act during difficult times in life, I receive the necessary information from clergy.*

Based on the responses, it can be stated that 80% of people associated with the Church can rely on spiritual support from clergy, while 20% of respondents disagreed.

2. *I believe that I have knowledge about the social activities of the Church.*

40% of respondents declared that they do not have such knowledge. Meanwhile, 60% of participants stated that they do, and this is due to the fact that they read books and watch TV programmes on the subject on a regular basis.

3. *If I were to share my knowledge and experience about faith with others, I would do so because²:*

- it stems from the Gospel message "go therefore and make disciples of all the nations" – 50% of respondents indicated this answer;
- I believe that these are universal principles and should be followed by all citizens – 30% of respondents answered this way;

¹ The survey was implemented in the form of standardised questions to respondents, whose answers were then assigned to a designated category in the process of coding and sorting the survey results.

² In order to preserve the meaning of the answers obtained, they were given a uniform form and assigned to one of four categories.

- I feel obliged to pass on knowledge about the moral principles shaping our society – 10% of respondents answered this way;
- I want my children and grandchildren to continue being raised in a country where Catholic principles are dominant – 10% of respondents indicated this answer.

4. *The factor that motivates me to share knowledge and experience about faith is:*

- trust in my interlocutors (60%);
- helping my closest family members overcome stress and a state known as occupational burnout (20%);
- supporting sick people during their recovery period (15%);
- creating religious communities (5%).

5. *In my opinion, sharing knowledge about faith and one's own experiences of it has a very significant impact on creating positive relationships within a specific group of people.*

Answers:

- Strongly agree – selected by 40% of respondents;
- Rather agree – selected and marked by 10% of respondents;
- I have no opinion on this topic – selected by 0% of respondents;
- Rather disagree – selected by 15% of respondents;
- Strongly disagree – selected by 35% of respondents.

6. *What limits your activity in sharing your knowledge and personal experience in the field of faith.*

Answers:

- Lack of arguments in conversations with people using terminology from the field of physics – indicated by 50% of respondents;
- Fear of ridicule in conversations with people promoting contemporary ideologies – indicated by 20% of respondents;
- Lack of confidence to express own views on faith – indicated by 20% of respondents;
- Lack of opportunity to express own views on the subject – indicated by 10% of respondents.

7. *What solutions would you propose in your community to encourage believers to share knowledge and experience about faith more readily?*

40% of respondents did not indicate any solutions, either answering that they had no ideas or stating that there was no need for such initiatives. The responses of the remaining respondents were largely similar and have been aggregated and presented in the following points:

- Cyclical meetings and discussions on topics such as faith, religion, and dogma;
- Building an atmosphere of trust among members of religious communities;
- Cultivation of shared values such as responsibility, freedom, understanding, sincerity, and loyalty;

- Non-material rewards: recognition, prestige, or general interest;
- Meetings with authorities from various fields of science;
- Socialising events.

The triangulation method used in the research (a method employed in social research to ensure higher quality of research conducted and to reduce measurement error (Denzin, 2017) made it possible to articulate the expectations of the research participants regarding the Church. These expectations are:

- identifying ways to reconcile scientific findings with theological concepts;
- focusing on organising events where believers can share their spiritual experiences with others;
- developing ways of framing the Gospel message in the context of ethical behaviour;
- providing real support from competent individuals, such as scientists, philosophers, and theologians, especially in the area of reducing the cognitive dissonance between faith and science.

The results of this research should be treated as a pilot study, which will allow for further conceptualisation of the problem and effective operationalisation of the research findings in the future.

6. Conclusions/Summary

On the basis of the research identified as theoretical sampling, the following conclusions were drawn:

- as a Catholic community, we are largely deprived of the ability to verify information coming from scientific research;
- in many cases, the average Polish person is unaware that their mind is being gradually imprinted with a "set of practices, normally governed by overtly or tacitly accepted rules and of a ritual or symbolic nature, which seek to inculcate certain values and norms of behaviour by repetition, which automatically implies continuity with the past" (Hobsbawm, 2008);
- currently, the memory of youth is being shaped by fictional customs (such as participation in demonstrations promoting rainbow values and adorning the body with various patterns and objects) and by modelling themselves after fictional characters from novels, such as Harry Potter in Joanne Rowling's works (Rowling, 2005), Rodion Romanovich Raskolnikov in Fyodor Dostoyevsky's "Crime and Punishment" (Dostoyevsky, 2015), or Jacob Frank in Olga Tokarczuk's "Books of Jacob" (Tokarczuk, 2014);

- in many cases, contemporary youth are unable to distinguish between timeless values that can be relied upon in difficult times and illusions created for the benefit of some organisation seeking greater profit. Unable to differentiate between the truths conveyed by religion and indoctrination and secular ceremonies, many people treat both identically, that is, as fake realities offered by the mass media;
- many scholars treat past religious events as "instruments used by historical memory to reconstruct an image of the past in line with novel ideas of consumerism" (Hobsbawm, 2008, p. 7). This usually only results in members of the public being able to associate themselves with the currently promoted values, while people whose life stories do not align with the rationale promoted by a certain group are deliberately forgotten. For example, historical figures like Karol Wojtyła [JPII], Stefan Wyszyński, Jerzy Popiełuszko, or the Ulma family may be overlooked;
- in extreme cases, people are forced to remember what they would rather forget, as exemplified by numerous publications and films showing the unimaginable contempt Nazis had for other nations. Yet, as early as 8 November 1965, the Primate of Poland, along with the entire episcopate, published a letter to the German bishops containing the words, "we forgive and ask for forgiveness" (Letter of the Bishops, 1965). This event initiated the ongoing Polish-German reconciliation process;
- secular ceremonies and repeated rituals often serve as substitutes for traditional values, devoid of a relationship with Providence. They fill the emerging void left by numerous and ill-considered apostasies, where the actions of certain individuals shape the perception of a religion that has existed for two thousand years and has been integral to the formation of states and nations;
- few Catholics recognise that, thanks to religion, tangible and intangible values have been, are and should continue to be passed on to future generations, which is of exceptional importance in determining the identity of a nation. This includes the Church's activities during the period of socialism in Poland, Maximilian Kolbe's act of saving a fellow prisoner's life in Auschwitz, and the election of Karol Wojtyła as Pope;
- average citizens: working, raising children and watching with interest TV programmes in which various scientific studies are presented, are unable to assess their reliability;
- information on scientific discoveries made by physicists is given in the form of mathematical calculations that no one is actually in a position to argue with;
- education focused on conveying knowledge across all types of schools is often presented in ready-made schemes that are only useful for solving scientific problems but do not inspire students to think independently;
- philosophy, as a fundamental, rational, and critical knowledge of everything that exists (Tatarkiewicz, 2001), which compelled not only questioning but also seeking answers based on existential experiences, has been eliminated from the curricula of many universities.

Theoretical notes, on the other hand, have been articulated on the basis of synthesising and analysing the knowledge coming to researchers from various sources and on the search for relations between the phenomena studied. This is because it has been noted that replacing religion with ethics in primary and secondary schools is simply a misunderstanding. Religion pertains to a system based on spiritual experiences and the recognition of transcendental phenomena, while ethics focuses on behaviours developed for the needs of a particular socio-political or economic system. Religion is based on revealed truths, while ethics is based on traditions invented (constructed) (Hobsbawm, 2008, p. 20) by numerous scholars. Religion assesses what is good and what is evil in an evangelical context, whereas ethics points out behaviours that favour economic development within a given socio-economic system. Religious does not mean ethical, and vice versa. For example, hedonism is accepted and even approved in ethics, while in religion, it is not. Ethical views suggest that people should strive for happiness, as it is considered "ethically good." Religion is also about forgiveness, sacrifice, and how humans should act in relation to variously understood holiness. Furthermore, religion is immersed in the doctrinal dimension and is realised in religious activities, organised in the sphere of community and experienced in the sphere of transcendence. Religion also emphasises human activity in experiencing a sense of holiness, which ensures closeness to the Sacred, union with It, in a posture of reverence, distance, and even fear (Eliade, 1999). Using a far-reaching analogy, one could say that replacing religion with ethics would be akin to replacing chemistry with physics or geography.

The problem, viewed from a different perspective by the authors of this reasoning (triangulation), was expressed by the following question – *Is there a Being that can be called a Rational Higher Intelligence, Providence, or God.* The search for rational explanations did not yield satisfactory results. Therefore, it was necessary to reverse the problem and propose a discussion on how the fate of our civilisation would have unfolded if Abraham had not established a relationship with God. As a result of the numerous discussions, the answers, devoid of any emotion, were presented in the form of the following sentences:

- civilisation probably would never have emerged because God was the first abstract concept, which later laid the foundation for the development of philosophy and other sciences;
- without God, there probably would be no society, as it would have been impossible to organise a system of governance, organisation, and hierarchy, where anointed individuals have subjects;
- no one would have told the individual members of society that something is good or something is bad, meaning they would not have been able to distinguish positive behaviours from negative ones;
- people, from the dawn of time, would not have had the chance to define the identity and mentality frameworks of tribal groups, states, and nations.

As can be seen, research conducted using grounded theory and the interpretation of its results, analysed in the context of postmodernism, have resulted in important guidelines for rational action in fulfilling the Gospel message in the contemporary world.

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THE JUSTIFICATION FOR WORKPLACE HEALTH PROMOTION IN THE CONTEXT OF THE INFLUENCE OF PSYCHOLOGICAL VARIABLES ON HEALTH BEHAVIORS

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Purpose: The aim of this article is to analyse the impact of psychological variables on the adoption of health-promoting attitudes. Determining this influence will allow for a reassessment of the relevance of employers' efforts related to health promotion in the workplace.

Design/methodology/approach: The Eysenck Personality Questionnaire (EPQR) and the Health Behaviour Inventory (IZZ), a pilot study conducted on a sample of 50 individuals from the Małopolskie Voivodeship.

Findings: The research confirmed the influence of psychological variables on adopting health-related attitudes.

Research limitations/implications: The research confirmed the impact of psychological variables on the adoption of health-related attitudes.

Practical implications: The research allows for a better understanding of human behaviour, including in the workplace. The passive attitudes towards proposed health promotion initiatives may not necessarily be linked to a lack of interest but may instead stem from individual characteristics.

Social implications: In recent years, with the growing popularity of Corporate Social Responsibility (CSR), a noticeable trend has emerged in implementing good practices in the workplace aimed at improving health or health habits. However, a crucial question remains: do these initiatives garner interest and approval from employees? The research results will provide a different perspective on the implementation of CSR activities and the assessment of their effectiveness.

Originality/value: The research findings are valuable for employers implementing or planning to implement health promotion initiatives, and they also serve as a tool for self-awareness.

Keywords: health promotion, psychological variables, personality traits, health-promoting attitudes.

Category of the paper: Research paper.

1. Introduction

The issue of health is becoming a subject of interest for supranational bodies such as the World Health Organization, as well as for individuals who seek better self-understanding and insight into the determinants of their behaviour. In the words of Arthur Schopenhauer: "nine-tenths of our happiness depends on health," humanity often strives to achieve the difficult goal of living in good health. Employers also engage in health promotion to increase their potential. However, a fundamental question arises: how far does individual agency extend, and to what extent do the psychological variables shaping individuals affect whether their behaviours contribute to better and more lasting health?

The aim of this article is to demonstrate how psychological variables influence the adoption of health-promoting attitudes. To achieve this goal, the following research hypotheses were formulated:

1. The higher the psychoticism scores, the lower the scores on the health behaviour intensity index.
2. The higher the extraversion scores, the higher the scores on the health behaviour intensity index.
3. The higher the neuroticism scores, the lower the scores on the health behaviour intensity index.
4. Women score higher on the health behaviour intensity index than men.

In the conducted research, the independent variable was personality dimensions, and the dependent variable was the adoption of health-promoting attitudes.

2. Literature review

2.1. Health Promotion in the Workplace

The concept of health promotion was introduced in 1945 by Henry Sigerist, who associated it with a range of factors influencing the provision of good living conditions, professional activity, education, as well as physical culture, rest, and recreation (Włodarczyk, 2019). Health promotion in the workplace encompasses a broad range of activities aimed at improving employees' well-being and enhancing their job performance. These activities include both preventive and educational measures designed to improve not only physical health but also mental well-being (European Agency for Safety and Health at Work, 2010). Additionally, workplace health promotion is a priority for the European Union in response to rising absenteeism costs and an aging population (Malińska et al., 2012; Goszczyńska, 2019).

Understanding the significance of the workplace in a person's life makes it essential to view the work environment through the lens of health promotion. Creating work conditions that promote health benefits both employees and employers, offering advantages such as increased employee effectiveness, reduced turnover, and a positive employer image (Goszczyńska, 2017).

Employers, as part of their health promotion programs, primarily organize activities related to increasing physical activity, reducing stress, promoting healthy eating, and improving workplace ergonomics. Physical activity is particularly important for promoting health among office workers, who often spend long periods sitting. Research shows that introducing exercise breaks and encouraging active lifestyle choices, such as using stairs instead of elevators, positively impacts employees' health and productivity (World Health Organization, 2010). Employers also organize training programs or group activities that not only improve physical fitness but also foster better interpersonal relationships within the team (Mechelen, 2008).

The dynamics of work and changing work conditions increasingly expose employees to stress. Poland, in particular, is among the countries with the highest levels of workplace stress (Młokosiewicz, 2018). This issue is significant because workplace stress is one of the most frequently reported problems affecting productivity and increasing the risk of psychosomatic disorders. Therefore, implementing stress management programs, such as workshops on relaxation techniques or mindfulness training, becomes crucial. These programs can significantly improve employees' mental health and job satisfaction (Karasek, Theorell, 1990). Examples of good practices include introducing flexible working hours and work-life balance policies, which help manage time and tasks better and reduce excessive work overload through more balanced distribution (Smith et al., 2011).

Another component of workplace health promotion is programs related to healthy eating. Employers can provide access to healthy meals, support healthy eating habits by offering nutritious snacks in vending machines, organizing nutrition workshops, and ensuring the availability of balanced meals in cafeterias. A balanced diet not only improves employees' concentration and energy but also reduces the risk of chronic diseases such as obesity and diabetes, which aligns well with workplace health promotion policies (Malińska et al., 2012).

Additionally, workplace ergonomics is a crucial element of health promotion, as it can help prevent health issues such as back and neck pain, which are common among office workers. Improving ergonomics, such as by providing adjustable chairs, screens at appropriate heights, or keyboards that align with natural hand positions, can significantly enhance work comfort and reduce sick leave, allowing employees to enjoy better health for longer (Pheasant, Haslegrave, 2005).

2.2. Psychological Variables - Selected Concepts of Personality Theory

The concept of personality has a variety of definitions, which results in ambiguity and some difficulty in further discussions. Moreover, it is often noted that this issue is relatively complex and poses challenges for researchers (Kozioł-Nadolna, 2015). A good understanding of the

concept is therefore crucial for any considerations in this area. It is generally accepted that the concept of personality dates back to antiquity, thanks to the philosophical reflections of Plato and Aristotle, as well as the inquiries of naturalists such as Hippocrates and Galen, and ancient writers like Theophrastus, Cicero, and Seneca (Panasiuk-Chodnicka, Panasiuk, 2008). It should also be noted that until the 19th century, psychology developed as a part of philosophy, making it natural to seek the roots of psychological concepts among philosophers. A symbolic date marking the recognition of psychology as an independent science is 1879, when Wilhelm Wundt opened the first experimental psychology laboratory in Leipzig (Jastrzębski, 2009).

Attempts to conceptualize personality were continued by thinkers from subsequent eras. The 20th century is particularly significant in this regard, as psychiatrists Pierre Janet and Jean-Martin Charcot introduced the term "personality" into scientific nomenclature. This marked the beginning of theoretical constructs of personality that are extensively described in the literature (Panasiuk-Chodnicka, Panasiuk, 2008).

J. M. Oldham and L. B. Morris define personality as a system encompassing all characteristics that are typical of a person (Oldham, Morris, 1997). W. Okoń describes personality as a set of stable traits and psychophysical processes that distinguish individuals from one another and influence behaviour, condition the organization of experiences and knowledge, emotional responses, and affect goals and values (Okoń, 2004). Similarly, G. Allport considered traits as the basis for an individual's personality structure. Traits themselves are viewed as predispositions to specific reactions in various situations, and they are also characterized by relative stability (Hall, Lindzey, Campbell, 2010). It is accepted that personality, on one hand, makes us identify as human, and on the other hand, it makes us differ significantly from others. Each person possesses unique patterns of emotions, motives, and perceptions, enriched by acquired schemes of understanding and perceiving oneself and the world (McAdams, Pals, 2006).

The diversity of personality definitions also affects numerous attempts to construct personality theories. Authors P.G. Zimbardo, R.L. Johnson, and V. McCann have classified these theories into psychodynamic, humanistic, existential, and socio-cognitive approaches. In psychodynamic theories, the primary focus is on unconscious motives and the influence of past experiences. Early childhood experiences, according to theorists, play a particularly important role in later mental health. In contrast, humanistic theories focus on the present and the individual's awareness. This approach emphasizes analysing subjective reality, focusing on what is most important to the individual at the moment, and the belief that everyone has an inherent tendency to become better. Self-perception in the context of relationships with others is also significant. Existential theories, on the other hand, attempt to connect the present with an idealized past, assuming that humans strive to find the purpose of their existence and the meaning of life. Socio-cognitive theories concentrate on the combined influence of factors such as perception, learning, interactions with others, and current behaviours, both positive and negative (Zimbardo, Johnson, McCann, 2017).

Theories focusing on traits have also had a significant impact on the development of personality theories. In psychology, the term "trait" refers to an individual's predisposition to exhibit certain behaviours (Makin, Cooper, Cox, 2000). Its importance arises from the intensity with which a trait appears in various situations (Robbins, Judge, 2012). The 1950s are considered the period when trait-based personality theories emerged. These include the concepts of G.W. Allport, R.B. Cattell, and H.J. Eysenck, each based on factor analysis of personality. Eysenck's popular and contemporary theory identified three traits: extraversion, neuroticism, and psychoticism. Using these theories, authors P. Costa and R.M. McCrae added further developments and created the Five-Factor Model of Personality (FFM), commonly known as the Big Five (Hall, Lindzey, Campbell, 2010). This model is currently one of the more popular concepts, where personality is understood in terms of traits (Ostendorf, Angleitner, 1992). Moreover, it is widely recognized and considered not only in psychology (Cieciuch, Łaguna, 2014). The model delineates five dimensions of personality: neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness (Cervone, Pervin, 2011). It is important to note that within each dimension, individual traits refer to two poles of the dimension. Thus, they represent a kind of continuum, and individuals can be positioned along its ends (McCrae, Costa, 2005).

The dimension of neuroticism reflects emotional adjustment or instability. Neuroticism is understood as a susceptibility to negative emotions such as fear, psychological stress, anger, guilt, dissatisfaction, or irritability. Neurotic individuals tend to struggle with managing emotions and are prone to irrational behaviours. Conversely, individuals with low levels of neuroticism are characterized by emotional stability, being calm and relaxed, and handling stress better than neurotic individuals (Kaczmarek, Kaczmarek-Kurczak, 2012).

The second dimension, extraversion, focuses on social relationships, considering both their quantity and quality. This dimension also encompasses activity, energy levels, and the capacity to experience positive emotions. A person with high extraversion will be characterized by sociability, friendliness, a zest for life, and a tendency to seek stimulation. In contrast, introverted individuals prefer distance in social interactions, often exhibit shyness, and have a tendency towards privacy and solitude (Kaczmarek, Kaczmarek-Kurczak, 2012).

The third dimension, openness to experience, involves both seeking out experiences and valuing them positively. Individuals with high levels of this trait are characterized by openness to change and cognitive curiosity. They are more interested in both the external world and internal phenomena, possessing a greater number of experiences and insights compared to those with low openness, who tend to exhibit more conventional behaviours and conservative views (Dolna, Dolny, 2009).

The fourth dimension, agreeableness, pertains to a positive or negative attitude toward others. In cognitive terms, this dimension relates to trust or its absence, in emotional terms to sensitivity toward others or indifference, and in behavioural terms to cooperative versus competitive approaches. Individuals high in agreeableness are sympathetic and open towards

others, readily offering help and assuming others are similarly inclined. Conversely, individuals with low agreeableness tend to be egocentric, sceptical of others, and competitive (Kraczla, 2017).

The final dimension, conscientiousness, describes an individual's approach to work. Highly conscientious individuals are distinguished by strong will, motivation, and perseverance. They are often seen as meticulous and reliable, frequently leading to professional success. However, a high level of this trait can also lead to workaholism, perfectionism, and a compulsive need for order. In contrast, individuals with lower levels of conscientiousness tend to exhibit less of these traits and are often more hedonistic in their approach to life (Kraczla, 2017).

One of the more detailed classifications of personality theories was proposed by C.S. Hall, G. Lindzey, and J.B. Campbell. They compiled 15 personality theory concepts and classified them into four approaches. The compilation of these theories is presented in Table 1.

Table 1.
Classification of Personality Theories

Theories Emphasizing Psychodynamics	Theories Emphasizing Personality Structure
- Sigmund Freud's Psychoanalytic Theory, - Carl Jung's Analytical Theory, - Psychosocial Theories: Adler, Fromm, Horney, and Sullivan, - Erik Erikson's Contemporary Psychoanalytic Theory,	- Henry Murray's Personology, - Gordon Allport's Theory, - Raymond Cattell's Trait Theory, - Hans Eysenck's Biological Trait Theory.
Theories Emphasizing Perceived Reality	Theories Emphasizing Learning Phenomena
- George Kelly's Personal Construct Theory, - Carl Rogers's Person-Centered Theory.	- B.F. Skinner's Operant Conditioning, - Dollard and Miller's Stimulus-Response Theory, - Albert Bandura's Social Learning Theories.

Source: Own elaboration, based on: C.S. Hall, G. Lindzey, J.B. Campbell, *Teorie osobowości*, Warszawa 2010, pp. 49-572.

The proposed classification of personality theories arises from the focus of different authors on various aspects of understanding human personality. In the case of theories emphasizing psychodynamics, the authors pay particular attention to the dynamic forces that condition human behaviour, as well as to the defensive structures unconsciously built by individuals, which protect against these dynamic forces. Theories emphasizing personality structure focus on the dynamics and development of the individual. The core of these theories is the acceptance of a set of traits that make up personality. In theories emphasizing perceived reality, the focus is on individual experiences used to create and react to reality. In the last group of theories, which emphasize learning phenomena, the attention is directed towards the learning process as a determinant of characteristic tendencies in individual behaviour (Hall, Lindzey, Campbell, 2010). The authors also compared the various personality theories, assigning appropriate significance to the parameters outlined according to the analysed theories. A comparison of personality theories is presented in Table 2.

Table 2.
Comparison of Personality Theories

Parameters/Theorists		Erikson	Murray	Sullivan	Freud	Adler	Horney	Cattell	Bandura	Allport	Jung	Eysenck	Kelly	Rogers	Dollard, Miller	Skinner
Purposefulness																
Unconscious Determinants																
Learning Process																
Personality Structure																
Heredity																
Early Development																
Continuity of Development																
Organic Approach																
Field																
Uniqueness of the Individual																
Moral Approach																
Psychological Environment																
Concept of Self																
Competence																
Group Belonging																
Biological Basis																
Social Science Basis																
Multiplicity of Motives																
Ideal Personality																
Abnormal Behavior																
Number of Parameters	Strong Emphasis	11	12	6	12	12	7	5	4	9	10	4	4	7	4	3
	Moderate Emphasis	9	8	11	6	6	10	12	10	5	3	9	8	5	5	3
	Not Significant	0	0	3	2	2	3	3	6	6	7	7	8	8	11	14

Source: Own elaboration, based on: C.S. Hall, G. Lindzey, J.B. Campbell, *Teorie osobowości*, Warszawa 2010, s. 49-572.

The primary goal of presenting the comparison of personality theories was to illustrate the complexity of the phenomenon and the diversity of approaches. In the table, theories are presented from those that consider the most factors (with high and moderate emphasis) to those that consider the fewest factors (with the highest proportion of factors marked as not significant). However, the quantitative interpretation is just one dimension of the analysis of personality theories. The factors included, which reflect the most critical points in a given theory, also hold significant importance. An interesting observation is the absence of a parameter that is highly emphasized in every theory. Detailed and insightful interpretations of the content were made by the authors of the tool (Hall, Lindzey, Campbell, 2010).

When considering personality theories, it is also important to pay attention to contemporary directions of scientific development in this field. The first of the contemporary theories is the family systems theory, where the primary focus is not the individual but the family. According to this approach, personality is shaped through interactions within the family and subsequently in peer groups (Mones, Schwartz, 2007). Another aspect increasingly manifesting in psychological research is related to culture. Growing awareness of cultural diversity among

different societies leads to the conclusion that people have diverse experiences and values resulting from the distinct experiences of various communities (Quiñones-Vidal, López-García, et al., 2004). A third significant trend in the perception of theories is the influence of gender. Researchers have yet to determine definitively the extent to which behaviour differences between women and men are due to upbringing versus inherent nature. Nonetheless, differences in behaviours between genders are undeniably present. These differences thus condition the proper understanding of individuals (Zimbardo, Johnson, McCann, 2017).

2.3. Factors Shaping Personality Traits

When analysing the issue of personality, it is important to consider the context in which a person's personality develops. Biological factors, upbringing, and culture—an indispensable element of every society—along with social relationships, all play significant roles (Zimbardo, Johnson, McCann, 2017).

In terms of biological factors, genetic influences are particularly noteworthy. Research on twins has estimated the level of heritability of traits. For intelligence, genetics explains its level from 30% to 80%, and similarly, temperament traits are largely explained by innate factors. Basic dimensions of personality, referring to the three traits mentioned by Eysenck or traits from the Big Five, are genetically determined by about 40%. These values are approximate but provide an overall picture of the genetic influence on traits. However, it should be noted that the actual picture for each individual will be somewhat different (Oleś, 2003). Biological factors were studied by Eysenck, who pointed out the significance of the autonomic nervous system on innate neuroticism and extraversion (Eysenck, 1990). With a strong nervous system, we deal with extraversion, and the individual will not react excessively to emotional stimuli (Oleś, 2001).

Generally, it is assumed that about 50% of human traits result from genetics, while the remaining traits are shaped by the environment (Robins, 2005). Within this group of factors, many researchers emphasize early childhood experiences. This includes both the methods and approaches to upbringing and the environment in which the child grows up. Research confirms that if a child is raised in impoverished conditions, they suffer damage to the brain. Such children lose nerve cells in the thalamus, leading to impaired cognitive abilities as well as functions necessary for physical survival (Noble, Houston et al., 2015).

When considering the role of upbringing in shaping personality, it should be noted that the very definition of upbringing indicates that it is a process of planned and conscious activity aimed at shaping personality (Szewczuk, 1985). Other definitions highlight that upbringing is the process of shaping a mature personality, which includes a well-developed and evolved self-concept, self-insight, the ability to objectively assess situations, a personal worldview, and a hierarchy of values (Bielecki, 2002).

Upbringing should also be associated with the development of social competencies. This includes learning to respond to criticism, skills related to expressing emotions, apologizing for mistakes, and appropriate emotional responses. Responsible conversations between parents and children are crucial, as they facilitate the learning of prosocial behaviours, values, and ethical principles. Moreover, recognizing extreme behaviours in children should guide psychoprophylactic and therapeutic directions (Woźniak, 2010). It is important to note that the significant role of upbringing in shaping personality arises from the fact that the family exerts the initial influence on the child, which will have implications for their future life. The family is also the best place for a child's development, as it provides individualized care and addresses their physical and psychological needs. Needs are fundamental to personality functioning, and meeting them has a profound impact on shaping the child's personality. Consequently, literature identifies lists of needs that condition further development. For example, E.J. Murray lists 40 needs, with 12 being physiological and 28 psychogenic, while A.H. Maslow and E. Fromm each identify 5 needs. Despite the various classifications, particular attention should be given to needs that are found across all authors, such as the need for love, emotional contact, and approval. Similarly, M. Ziemska emphasizes four psychosocial needs that are essential for satisfying other needs. These include the need for love, kindness, and emotional warmth, also referred to as the need for emotional contact (Stachyra, 2000).

In the context of family upbringing, attention should also be given to the need for role models. Children start interpreting the world through their immediate family and look for role models to imitate. Equally important are the relationships among family members. For a child's proper development, a friendly atmosphere and its relative stability are crucial. Disruption in stability can lead to insecurity in the child. Parental relationships also play a significant role; research shows that children from families with disturbed relationships more often face behavioural problems and have lower levels of socialization. Additionally, such children are more likely to experience depression, anxiety disorders, and feelings of helplessness and incompetence (Stachyra, 2000). Researchers also highlight the importance of the birth order of children in the family, as each subsequent child is raised in a slightly different environment (Sulloway, 1996). The relationships between siblings are also crucial. When these relationships are good, the child experiences harmonious emotional development, while disrupted relationships can lead to problems with anger, aggression, and emotional detachment (Braun-Gałkowska, 1992).

Understanding the importance of upbringing in shaping a child's personality also requires attention to parental attitudes. M. Ziemska distinguishes four main attitudes, each corresponding to an opposing attitude – Table 3.

Table 3.
Parental Attitudes

Proper Attitudes	Improper Attitudes
Acceptance of the child	Rejecting attitude
Cooperation with the child	Avoidant attitude
Allowing the child freedom	Overprotective attitude
Recognition of the child's rights	Overly demanding, coercive, and correcting attitude

Source: Own elaboration, based on: M. Ziemska, *Postawy rodzicielskie*, Warszawa 1973, pp. 57-65.

When analyzing the issue of personality, attention should be given to the context in which personality develops. Biological factors, upbringing, and culture, which are integral parts of any society, as well as social relationships, play significant roles (Zimbardo, Johnson, McCann, 2017).

In terms of biological factors, genetic predispositions are particularly important. Research on twins has estimated the heritability of traits. For example, genetic factors account for 30% to 80% of the variation in intelligence, and temperament traits are also largely explained by inherited factors. Core dimensions of personality, such as those outlined by Eysenck or the Big Five traits, are genetically determined to about 40%. These values are estimates but provide a general picture of genetic influence on traits. It is important to remember that the actual influence can vary for each individual (Oleś, 2003). Eysenck's research highlighted the role of the autonomic nervous system in innate neuroticism and extraversion, suggesting that a strong nervous system is associated with extraversion and less sensitivity to emotional stimuli (Eysenck, 1990; Oleś, 2001).

Generally, it is accepted that about 50% of human traits result from genetic factors, while the remaining traits are shaped by the environment (Robins, 2005). This group of factors often focuses on early childhood experiences, including both educational methods and the environment in which a child is raised. Research shows that children growing up in impoverished environments may experience brain damage, losing neurons in the thalamus, which can impair cognitive abilities and essential survival functions (Noble, Houston et al., 2015).

Regarding the role of upbringing in shaping personality, it is crucial to note that upbringing is defined as a deliberate and conscious process aimed at shaping personality (Szewczuk, 1985). Other definitions emphasize that upbringing involves developing a mature personality, which includes a well-developed self-image, self-insight, objective assessment of situations, personal worldview, and value hierarchy (Bielecki, 2002).

Upbringing should also involve the development of social competencies. This includes teaching responses to criticism, expressing emotions, apologizing for mistakes, and appropriate emotional reactions. Responsible discussions between parents and children are crucial for learning prosocial behaviours and understanding ethical values. Extreme behaviours in children should guide psychoprophylactic and therapeutic interventions (Woźniak, 2010). It is noteworthy that the influence of upbringing on personality development is significant because

the family is the first influence on the child, which impacts their future life. The family is also the best environment for a child's development, providing individualized care and meeting their physical and psychological needs. Needs are fundamental to personality functioning, and their fulfilment has a substantial impact on personality development. The literature identifies lists of needs that facilitate further development. For instance, E.J. Murray lists 40 needs, with 12 being physiological and 28 psychogenic, while A.H. Maslow and E. Fromm each identified 5 needs. Among these, essential needs such as love, emotional contact, and approval are consistently mentioned by all authors. M. Ziemska also highlights four psychosocial needs crucial for fulfilling other needs: love, friendliness, emotional warmth, and emotional contact (Stachyra, 2000).

In family upbringing, the need for role models is also important. Children begin to interpret the world through their immediate family, seeking role models to emulate. Family relationships are crucial, with a friendly atmosphere and relative stability being vital for healthy development. Disruptions in stability can affect a child's sense of security. Parental relationships also play a significant role; children from families with strained relationships often face behavioural issues and lower socialization levels. They are also more likely to experience depression, anxiety, and feelings of helplessness and incompetence (Stachyra, 2000). The order of siblings in the family also matters, as each subsequent child grows up in a slightly different environment (Sulloy, 1996). Sibling relationships are important, with harmonious relationships supporting emotional development and problematic ones leading to issues with anger, aggression, and emotional distance (Braun-Galkowska, 1992).

Understanding the impact of upbringing on personality development also involves considering parental attitudes. M. Ziemska identifies four main attitudes, each with its opposite, as shown in Table 3.

In summary, analysing the factors shaping personality traits indicates that, despite the complexity of the phenomenon, it is possible to identify some general patterns applicable to everyone. Exploring the relationships between personality traits and life attitudes is particularly valuable for explaining human behaviour, which could be useful for preventive and therapeutic work in the future.

2.4. Definition of Health Behaviors

When addressing the topic of health, it is crucial to mention the World Health Organization (WHO), a specialized agency of the United Nations dedicated to global health protection and disease prevention. Established in 1948 with its headquarters in Geneva, Switzerland, WHO aims to achieve the highest possible level of health for all people worldwide by providing high-quality healthcare, preventing diseases, and promoting health. WHO operates in over 150 countries and collaborates with other governmental and non-governmental organizations to ensure effective global health care. Its activities include disease research and monitoring, developing standards and guidelines for disease prevention and treatment, supporting

vaccination programs and infectious disease control, health education, and coordinating responses to health crises and epidemics (Kickbusch, 2003).

In 1977, WHO adopted a resolution defining the main goal of the organization and its member states as ensuring a level of health that allows full economic and social functioning for all citizens of the world. In response to escalating global health problems, the strategy "Health for All by the Year 2000" was subsequently adopted, outlining the following directions for action:

- Promoting lifestyles and behaviours conducive to health.
- Reducing the incidence of diseases and disorders that can be mitigated by eliminating risk factors.
- Providing basic healthcare services according to needs (World Health Organization, 2000).

Another significant document was *Health 21 – Health for All in the 21st Century*, a strategy developed in 1998. It described 21 tasks for WHO member states:

1. Improve the health of populations by promoting healthy lifestyles and preventing diseases and injuries.
2. Improve the quality and effectiveness of healthcare for all people.
3. Increase public health protection by preventing and controlling infectious and non-communicable diseases.
4. Enhance the efficiency of health systems through better management, training of health personnel, and development of medical technologies.
5. Strengthen the ability to respond to health crises and disasters.
6. Ensure food and water safety and protection from environmental hazards.
7. Improve the health of women and children by providing prenatal, perinatal, and child health care.
8. Improve mental health by preventing and treating mental disorders.
9. Prevent substance abuse, including alcohol and tobacco.
10. Increase access to and quality of palliative care and ensure a dignified death.
11. Enhance health knowledge and awareness through education and information campaigns.
12. Improve the quality of working environments and prevent occupational diseases.
13. Prevent chronic diseases such as heart disease, cancer, and diabetes by promoting healthy lifestyles and regular preventive screenings.
14. Ensure health equity by eliminating health disparities between social groups.
15. Support the health of the elderly by providing better health care and services.
16. Increase international cooperation and coordination in health.
17. Improve the health of populations in low- and middle-income countries.
18. Improve the health of populations in conflict-affected and disaster-prone areas.

19. Support health research and the development of new therapies and medical technologies.
20. Improve the quality of health data and population health monitoring systems.
21. Promote innovative health solutions and improve the quality of health research (WHO Europe. Health, 2020).

These broad principles highlight the importance and complexity of health issues, emphasizing their dependence on various factors. Similarly, definitions of health behaviours underscore the importance of actions aimed at maintaining or improving health.

Health behaviours are actions undertaken to promote, protect, or restore health. Various organizations provide definitions that reflect different aspects of health behaviours:

- World Health Organization (WHO): Defines health behaviours as any actions taken by individuals to promote, protect, maintain, or recover health, regardless of whether these actions are objectively effective. WHO identifies three main categories: behaviours related to diet and physical activity, avoidance of health risks (e.g., smoking), and seeking healthcare when needed (WHO, 2021).
- American Heart Association (AHA): Describes health behaviours as all activities and choices made in daily life to maintain physical and mental health. It highlights seven key behaviours: regular physical activity, a healthy diet, maintaining a healthy weight, avoiding smoking, moderate alcohol consumption, adequate sleep, and stress management (AHA, 2023).
- Centres for Disease Control and Prevention (CDC): Defines health behaviours as any actions taken by an individual to maintain or improve health. It emphasizes key behaviours such as healthy eating, regular exercise, avoiding smoking and excessive alcohol use, and regular medical check-ups (CDC, 2021).
- American Psychological Association (APA): Describes health behaviours as actions taken to prevent disease and promote health, including healthy eating habits, regular physical activity, avoiding substance abuse, managing stress, and personal hygiene (APA, 2023).
- National Wellness Institute (NWI): Defines health behaviours as decisions and actions aimed at achieving full physical, mental, emotional, social, and spiritual potential (NWI, 2023).

All these definitions emphasize the importance of engaging in activities that promote or maintain health, such as a balanced diet, regular exercise, avoiding harmful substances, and personal hygiene. However, the variations in these definitions reflect different approaches to health and highlight the complexity of understanding health behaviours.

2.5. Classifications of Health Behaviors

In the search for the key to good health, a number of classifications have emerged, attempting to gather all factors that influence how people approach their health. The first model, the biomedical model, focuses on the proper functioning of individual cells in harmony with other cells (Uramowska-Żyto, 2009). On the other hand, socio-ecological models approach health in a holistic manner, suggesting that health allows individuals to function fully in social life (Sheridan & Radmacher, 1998).

In 1973, Blum and Lalonde proposed a holistic health model. The authors divided health into four areas that condition it and specified their percentage significance within the overall model (Włodarczyk, 2019) – see Figure 4.

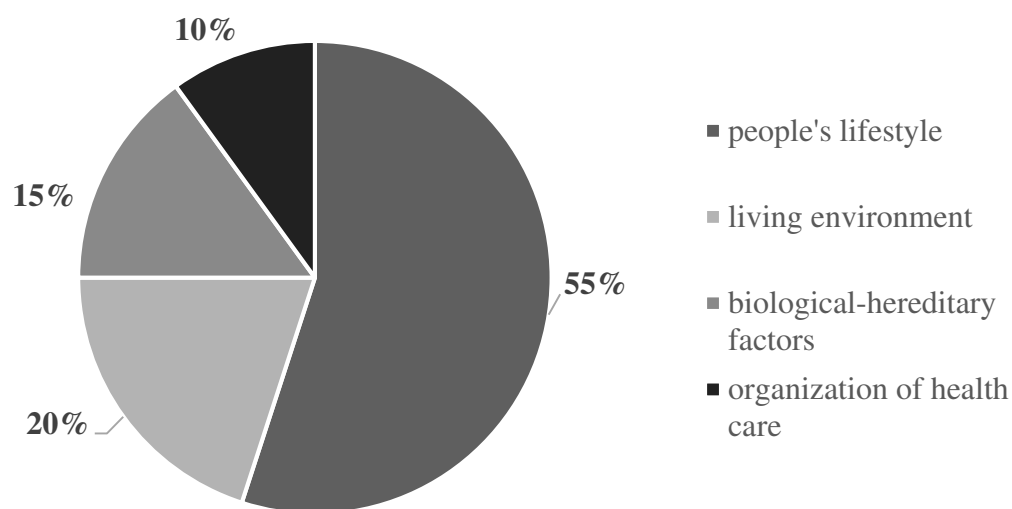


Figure 1. Health areas.

Source: Own elaboration, based on: Włodarczyk, E. (2019), Psychologia zachowań zdrowotnych a promocja zdrowia – wybrane zagadnienia, *Medyczna wokanda*, No. 12, pp. 61-90.

The presented model, despite its general nature, highlights that the primary determinant of health is lifestyle, while other elements are also significant but to a lesser extent. Thus, individual agency emerges as the foremost factor. The literature includes various other classifications of health behaviours. Whitlock identified five areas concerning health: physical activity, diet, alcohol use, tobacco smoking, and emotional well-being (Whitlock, Orleans et al., 2002). Donatelle, on the other hand, distinguished six categories of health behaviours: sexuality, psychoactive substances, types of food consumed, stress, sleep, and safety risks (Donatelle, 2011). Ryan and Yoder identified seven areas where behaviours impact health: diet, physical activity, tobacco smoking, use of psychoactive substances, workplace safety, sleep hygiene, and personal hygiene (Ryan, Yoder, 2018). Additionally, Prochaska and DiClemente identified eight categories of health behaviours: diet, physical activity, avoiding

substances, avoiding psychoactive substances, maintaining mental health, avoiding risky behaviours, avoiding safety hazards, and health monitoring (Prochaska, DiClemente, 1983).

The Health Belief Model (HBM) attempts to explain health-related behaviours by assuming that individuals make decisions about their health based on subjective beliefs, knowledge, and experiences. According to this model, people make health-related decisions based on the following factors:

- Seriousness of the illness - the individual's assessment of the severity and reasons for its development.
- Perceived threat - the assessment of the level of threat associated with the illness.
- Benefits of health behaviours - the assessment of the benefits of implementing appropriate actions.
- Barriers - factors that hinder lifestyle changes.
- Internal motivation - the desire to achieve health benefits (Janz, Becker, 1984).

Another perspective is provided by the Theory of Planned Behaviour (TPB), which suggests that our health behaviours result from our intentions and plans, which are shaped by our beliefs, perceptions of social norms, and our perceived ability to perform a given action. According to this theory, our health behaviour is a result of:

- Our intentions - our plans to carry out a particular action.
- Perceived social norms - societal opinions and expectations regarding our behaviours.
- Perceived behavioural control - belief in our ability to perform specific actions (Ajzen, 1991).

Another classification of health behaviours proposed by Michael O'Donnell, creator of the Health Promotion program, includes five categories:

- Nutrition-related behaviours.
- Physical activity-related behaviours.
- Substance use behaviours, such as alcohol, tobacco, and drugs.
- Safety-related behaviours, including seat belt use and workplace safety rules.
- Stress and emotional control behaviours.

O'Donnell argues that these five categories encompass key areas that individuals and societies can influence to achieve better health (O'Donnell, 2009).

It is worth noting that while the literature presents numerous classifications of health behaviours, they all share several common elements. The differences lie in the focus on specific criteria, while the core principles of each classification remain consistent.

3. Methods

The pilot study was conducted in 2022 in Poland, within the Małopolskie Voivodeship. Participants voluntarily agreed to take part in the study. Inclusion criteria were:

- Residence in Poland within the Małopolskie Voivodeship.
- Age between 20 and 50 years.

Due to the completeness of the questionnaires, all results obtained from all participants were subjected to statistical analysis. The study group comprised 50 individuals aged 20 to 50 years ($M = 36.54$; $SD = 8.55$), including 37 women aged 22 to 50 years ($M = 36.89$; $SD = 8.60$) and 13 men aged 20 to 50 years ($M = 35.54$; $SD = 8.70$). The BMI values of the participants ranged from 19.33 to 39.18 ($M = 24.76$; $SD = 4.57$), with women having a range from 19.33 to 34.60 ($M = 24.08$; $SD = 3.94$) and men from 19.59 to 39.18 ($M = 26.68$; $SD = 5.79$).

The study was conducted in a single phase. Participants completed an original questionnaire along with the following instruments: the Eysenck Personality Questionnaire (EPQR), the Health Behaviour Inventory (IZZ), and the Self-Esteem Scale (SES). This article presents an analysis of the results from the EPQR and IZZ questionnaires.

4. Results

Statistical analyses were conducted using IBM SPSS Statistics. In the first part, descriptive statistics were performed. Next, personality traits were analysed in relation to health behaviours, followed by an examination of the prevalence of health behaviours among women and men.

Table 4 presents the descriptive statistics for the analysed variables, including mean values, standard deviations, minimum and maximum values, and Shapiro-Wilk test values, which were used to verify the assumption of normal distribution for the analysed variables.

Table 4.
Descriptive Statistics for Analyzed Interval Variables

Variable	<i>M</i>	<i>SD</i>	<i>min</i>	<i>max</i>	<i>S-W</i>	<i>p</i>	<i>α</i>
Neuroticism	11,24	5,76	0	21	0,97	0,212	0,88
Extraversion	11,98	4,36	4	21	0,97	0,188	0,78
Psychoticism	6,94	3,25	0	15	0,97	0,149	0,58
Lie Scale	10,58	3,49	3	18	0,97	0,315	0,71
Criminal Tendencies	12,88	5,43	3	24	0,97	0,291	0,80
Addiction Proneness	14,98	4,28	7	24	0,98	0,461	0,67

Source: Own elaboration based on conducted research, where *M* – mean value; *SD* – standard deviation; *Min* – minimum value; *Max* – maximum value; *S-W* – Shapiro-Wilk test value; *p* – statistical significance; *α* – Cronbach's alpha coefficient.

Statistically significant deviations from a normal distribution were found for preventive behaviours and health practices. Analyses related to these variables were conducted using nonparametric statistical significance tests.

Table 5 presents the correlation coefficients between the intensity of personality traits and the intensity of health behaviours. Due to statistically significant deviations from a normal distribution, the intensity of preventive behaviours and health practices was analysed using Spearman's rank correlation coefficient (ρ). The remaining variables were analysed using Pearson's correlation coefficient (r). A one-tailed statistical significance test was employed.

Table 5.

Correlation Coefficients Between Personality Traits and Health Behaviors

Personality Traits	Health Behaviors				
	Positive Psychological Traits	Preventive Behaviors	Healthy Eating Habits	Health Practices	Overall
Neuroticism	-0,170	0,138	-0,253*	-0,223	-0,149
Extraversion	0,293*	0,154	-0,069	-0,057	0,145
Psychoticism	-0,251*	-0,076	-0,193	-0,122	-0,193
Lie Scale	0,089	0,285*	0,155	-0,102	0,130
Criminal Tendencies	-0,189	0,072	-0,344**	-0,302*	-0,248*
Addiction Proneness	-0,120	0,195	-0,192	-0,371**	-0,136

Source: Own elaboration based on conducted research, where * $p < 0.05$; ** $p < 0.01$.

Results on the psychoticism scale were negatively correlated with positive psychological attitude, confirming Hypothesis 1, which posits that higher scores on the psychoticism scale are associated with lower levels of health behaviours. Results on the extraversion scale were positively correlated with positive psychological attitude, which supports Hypothesis 2. Results on the neuroticism scale were negatively correlated with healthy eating habits, consistent with Hypothesis 3. Additionally, analysis of three other scales revealed that results on the Lie Scale were positively correlated with preventive behaviours. Criminal tendencies were negatively correlated with healthy eating habits, health practices, and overall intensity of health behaviours. Addiction proneness was negatively correlated with health practices and overall intensity of health behaviours.

Table 6 presents the mean values of health behaviours in the group of women and men, along with the statistical significance test values for differences. Due to statistically significant deviations from normal distribution, the intensity of preventive behaviours and health practices was analysed using the Mann-Whitney U test. The remaining variables were analysed using the independent samples t-test.

Table 6.
Mean Values of Health Behaviors in Women and Men

Health Behaviors	Women		Men		<i>t/U</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Positive Psychological Attitude	20,89	2,63	20,38	3,64	0,54	0,592
Preventive Behaviors	20,41	4,02	17,38	4,46	132,50	0,016
Healthy Eating Habits	20,95	3,79	17,92	3,71	2,49	0,016
Health Practices	19,73	3,44	19,00	5,12	238,50	0,964
Overall	81,97	10,47	74,69	12,20	2,07	0,044

Source: Own elaboration based on conducted research, where *M* – mean value; *SD* – standard deviation; *t* – Student's t-test for independent samples; *U* – Mann-Whitney U test value; *p* – statistical significance.

Statistically significant differences were found between women and men in the intensity of preventive behaviours, healthy eating habits, and overall health behaviours. The mean values for the intensity of preventive behaviours, healthy eating habits, and overall health behaviours were higher in women compared to men. This confirms Hypothesis 4, which posits that women have higher levels of health behaviours compared to men.

5. Discussion and conclusions

In the article, four hypotheses were proposed, all of which were confirmed by the research. The first hypothesis stated: the higher the scores on the psychoticism scale, the lower the scores on the intensity of health behaviours. This hypothesis was confirmed. It appears that individuals exhibiting antisocial traits, lack of empathy, emotional coldness, impulsivity, and egocentrism, according to Eysenck's classification (Eysenck, 1992), do not necessarily focus on their own health. This finding suggests that those with high psychoticism scores may not equate their egocentrism with self-care. There may be distortions in their understanding of their own needs due to deficiencies in social functioning. These preliminary conclusions highlight the need for further research on the psychoticism scale and behaviours influenced by high levels of psychoticism.

The next hypothesis stated that higher scores on the extraversion scale are associated with higher scores on the intensity of health behaviours. This hypothesis was confirmed. It turns out that active individuals who are open to new experiences, sociable, and emotionally positive engage in more health-promoting behaviours. This indicates that a positive outlook on life and a desire for continuous new experiences constitute a more deliberate strategy, where attention to health enables a more fulfilling life.

The third hypothesis stated that higher scores on the neuroticism scale are associated with lower scores on the intensity of health behaviours. This hypothesis was confirmed. Analogous to the extraversion scale, anxiety, hypersensitivity, or shyness can inhibit self-care and health concerns. According to this observation, proper self-awareness and understanding of one's own

conditions are crucial for developing health behaviours that can be incorporated into daily life as habits.

The final hypothesis posited that women achieve higher scores on the intensity of health behaviours compared to men. This hypothesis was also confirmed. It is possible that a greater tendency to assume caregiving roles or concern for physical appearance influences women to engage more frequently in health-promoting behaviours. Further research could explore the determinants related to external environment, culture, and traditional social roles affecting health behaviours, as well as their correlation with gender.

Interesting insights also emerge from the positive correlation between the Lie Scale and health behaviours. It appears that individuals with high Lie Scale scores, who seek to present themselves in a better light, engage in many activities that positively affect their health. However, a better understanding of their motivations—whether these behaviours stem from genuine health concerns or merely from the desire to align with current health trends—would provide additional context. The study also found that individuals with high criminal tendencies and addiction proneness scored low on health behaviours. Attention to these three additional scales offers a new perspective on individuals, and a thorough analysis could uncover underlying causes of problems with engaging in health behaviours.

The article attempts to answer whether psychological variables influence health behaviours. The pilot study suggests that they have a significant impact and somewhat shape not only self-perception but also direct further behaviours. This conclusion prompts reflection that understanding one's attitudes toward oneself—since these can also be described as behaviours contributing to better health—begins with self-awareness, a better understanding of one's self-image, and the surrounding world.

It should be noted that the impact of psychological variables on health behaviours may vary depending on the individual and context. Some individuals may be more susceptible to the influence of beliefs, while others may be more emotionally motivated. Thus, research in this area provides a general overview, and actual dependencies can only be captured through individual analyses. Nonetheless, awareness of the influence of psychological variables on health attitudes offers key insights for developing workplace health promotion policies. Despite potential limitations in effectiveness due to psychological variables, implementing such policies remains valuable. However, in a diverse team, finding universal solutions suitable for all employees may be challenging. Better understanding employees and adopting a more individualized approach should yield better results in workplace health promotion. However, it should be noted that varying levels of employee engagement may result from individual personality traits rather than inadequate health promotion activities. Therefore, evaluating health promotion activities should consider not only the level of interest in the policy but also individual employee feedback.

It should be noted that the results are based on pilot studies. Therefore, it would be reasonable to repeat the research on a larger sample in the future. Furthermore, to conduct a more precise study, a good practice would be to limit the research to the workplace of a specific organization. Such a well-planned study could provide valuable material for adopting an individualized approach to planning CSR activities in a particular organization.

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ANALYSIS OF THE LEVEL OF RENEWABLE FRESHWATER RESOURCES IN EUROPEAN UNION COUNTRIES

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Purpose: This article aims to draw attention to the problem faced by European Union countries regarding the availability of freshwater and renewable sources and analyze the situation of individual countries regarding water resources.

Design/methodology/approach: The article presents tables and charts based on statistical data from Eurostat, based on which the situation of EU countries in the field of renewable freshwater resources was analyzed, thanks to which it is possible to indicate the countries with the greatest problems with their availability, determine their direction of changes and make them aware of the need to take actions to improve the water situation in EU countries.

Findings: During the data analysis, the level of problems in EU countries related to freshwater and renewable sources of freshwater was indicated, and the direction of changes in the level of freshwater in the EU was graphically presented.

Research limitations/implications: The article analyzed data on renewable freshwater sources. The analysis should further determine the actions taken by individual countries to improve the water situation and analyze the results obtained, taking into account other countries and their capabilities.

Practical implications: The material presented in the article may be helpful in implementing research and projects related to the protection of renewable sources of fresh water, and above all, it may encourage deeper considerations of the problem of water deficit.

Social implications: The article and its analyses can increase society's awareness of water savings and protection against contamination, such as the lack of municipal sewage systems or illegal waste dumps.

Originality/value: The article touches on a very serious problem that the whole world is struggling with, namely the availability of water. Water is one of the basic foundations of life and the development of agriculture and the economy. Renewable sources of fresh water are a component of the broadly understood policy of using renewable sources, such as energy.

Keywords: renewable sources of fresh water, at-risk countries in terms of water availability.

Category of the paper: Research paper, general review.

1. Introduction

Freshwater is a resource of fundamental importance for life, the environment, and the economy. In the face of growing demand for water and ongoing climate change, renewable sources of freshwater are becoming one of the most important environmental and economic challenges in the European Union.

An extremely important aspect seems to be the analysis and classification of costs of preventing climate change and adapting to it, such as risk analysis, portfolio and scenario analyses, analysis of the costs of preventing climate change (expenditures on reducing sources, minimizing greenhouse gas emissions) (Dubiel, 2016). It is therefore necessary to obtain large amounts of data from many sources (Kokoszka, 2016) for analyzes performed when planning investments, as well as when estimating the Water Exploitation Index Plus (WEI+) - an indicator that the European Union uses to monitor renewable water resources. This indicator shows what percentage of renewable water resources are used in a given area and is calculated as the ratio of water consumption to renewable water resources. This knowledge allows for identifying regions exposed to water shortages, planning adaptation actions, analyzing the effects of excessive water abstraction, and supporting and implementing sustainable water management strategies. WEI+ values below 20% indicate a region with low water pressure - water resources are sufficient to meet needs. Values between 20% and 40% indicate moderate pressure on water resources - preventive measures should be taken. However, WEI+ index values above 40% indicate situations of serious water shortage - the region is at risk of water deficit. In most EU countries, the WEI+ indicator is relatively low.

Renewable freshwater resources include rainfall, rivers, lakes, and groundwater, renewed through the hydrological cycle. Unfortunately, geographical differences in the availability of these resources, climate change, and environmental pollution directly and indirectly affect the availability and renewability of water resources and water quality. The sources of contamination include agriculture and the chemical plant care and protection products used; industry producing harmful dust, gases, and sewage; transport, leaking fuels, exhaust fumes; burning of garbage in households; poorly secured waste dumps, or the so-called wild garbage dumps. Therefore, it is necessary to take all actions to minimize pollution, as well as to increase the possibilities of using groundwater and surface water, e.g. by water treatment (Wygoda, 2019)

The European Union is taking several actions to protect and effectively manage renewable water sources. The key document in this respect is the Water Framework Directive (WFD) of 2000, which introduces an integrated approach to water management at the river basin level. Its main goal is to achieve good status for all waters in the EU. The directive obliges Member States to develop and implement water management plans that consider protecting resources, minimizing pollution, and sustainable water use. For this purpose, member states are obliged

to assess the hydromorphological status of waters. One of the methods used for analysis is the River Habitat Survey (RHS), which is very useful in environmental monitoring, water management and preparation of expert opinions (Jusik, Przesmycki, Achtenberg, 2016). All investments implemented in water management and serving directly to improve water quality, as well as other investments not directly related to water management but which may threaten the achievement of water environmental objectives, must be consistent with the provisions of the WFD. If the investment has a negative impact on the condition of water bodies, it may be implemented only if the conditions set out in Art. 4, section 7 WFD (Kłosowicz, 2016).

The aim of this article was to draw attention to the problem faced by European Union countries in terms of the availability of freshwater and their renewable sources, to analyze the situation of individual countries in terms of water resources and their critically low level in some regions of the European Union, which in turn should be a contribution to taking actions aimed at improving the level of freshwater availability and increasing public awareness of saving water and paying attention to its contamination.

2. Analysis of renewable freshwater sources in EU countries

The table below shows the volume of renewable freshwater resources from 2013-2022 in individual European Union countries.

Table 1.

The volume of renewable freshwater resources over the years 2013-2022

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Austria	105 303.00	106 870.00	82 146.00	105 883.00	103 905.00	91 077.00	99 189.00	103 708.00	91 580.00	:
Belgium	24 955.22	26 391.68	24 912.73	26 903.56	24 875.15	21 326.23	25 780.38	24 852.73	29 543.52	26 538.05
Bulgaria	70 865.00	115 306.00	82 073.00	74 713.00	84 411.00	85 254.00	63 437.00	67 783.00	89 899.00	:
Croatia	61 108.00	85 551.00	62 330.00	70 769.00	64 839.00	65 029.00	63 712.10	60 968.70	63 763.90	61 049.50
Cyprus	1 770.00	2 358.00	2 904.00	2 580.00	1 956.00	3 642.00	4 782.00	2 832.00	2 724.00	2 760.00
Czechia	56 439.00	51 675.00	41 824.00	49 960.00	53 288.00	41 244.00	49 806.00	60 267.00	53 674.00	49 984.00
Denmark	:	:	:	:	:	:	:	:	:	:
Estonia	26 035.20	27 391.20	25 899.60	32 182.40	32 679.60	23 187.60	30 419.60	29 967.60	27 752.80	23 820.40
Finland	221 166.00	214 401.00	265 130.00	251 689.00	248 210.00	183 618.00	239 499.00	265 431.00	225 303.00	231 479.00
France	578 153.19	567 368.82	429 458.41	509 575.92	452 142.07	540 203.18	526 593.90	462 417.52	510 177.38	389 243.24
Germany	304 700.00	284 000.00	274 100.00	286 700.00	336 300.00	230 600.00	289 100.00	278 200.00	316 900.00	265 900.00
Greece	:	:	:	:	:	:	:	:	:	:
Hungary	62 031.00	70 680.00	51 429.00	65 751.00	58 218.00	56 962.50	58 234.70	56 981.10	47 650.00	46 236.40
Ireland	83 886.46	97 854.67	105 540.69	82 540.43	87 278.82	85 926.00	96 204.22	104 397.71	85 590.95	89 062.21
Italy	343 940.14	363 242.59	265 068.92	288 539.98	228 820.18	333 699.87	326 027.22	275 007.11	269 116.69	217 220.58
Latvia	40 642.00	48 556.00	38 852.00	51 010.00	52 713.52	30 198.00	41 053.99	39 727.90	39 570.14	41 765.91
Lithuania	43 151.54	41 197.66	38 517.18	51 985.00	57 852.17	36 346.66	40 499.96	42 153.01	45 011.60	43 703.84
Luxembourg	2 444.74	2 352.29	1 872.07	2 213.62	1 545.94	2 054.40	1 815.58	2 126.30	2 295.79	1 647.28
Malta	151.54	159.37	155.23	102.65	137.81	189.51	172.60	122.26	175.76	116.29
Netherlands	30 496.90	31 678.16	35 341.40	32 032.35	35 199.31	25 238.51	32 417.47	32 155.74	33 273.00	29 646.00
Poland	210 158.10	199 869.90	155 817.90	218 545.20	248 836.50	174 920.60	181 028.20	220 458.70	200 110.10	184 332.50
Portugal	91 445.48	99 259.61	54 088.58	54 581.79	69 352.96	53 763.07	:	:	:	:
Romania	162 798.90	197 196.00	152 358.00	187 738.10	157 892.30	166 543.20	144 154.20	155 285.30	166 419.00	134 329.00
Slovakia	42 348.00	46 806.00	35 248.00	45 289.00	40 535.00	32 982.00	41 564.00	43 425.00	37 301.00	31 126.00
Slovenia	34 848.00	39 897.00	24 144.00	31 315.40	31 835.50	27 857.60	32 047.30	29 785.10	27 296.90	24 319.60
Spain	327 020.10	308 555.20	313 706.80	276 273.85	359 446.24	275 494.87	345 324.43	327 742.76	251 994.26	310 195.17
Sweden	311 506.00	336 488.00	375 110.00	315 176.00	359 510.00	279 373.00	367 414.00	370 646.00	355 402.00	329 990.00

Source: https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat

Based on the data in the table, an analysis of the volume of renewable freshwater resources over 2013-2022 will be presented. Due to the need for more data availability from countries such as Denmark and Greece, the analyses will be prepared omitting these countries. In the case of Portugal, where there are gaps from 2019-2022, the analyses will only cover the period with available data, i.e., they will cover the years 2013-2018.

The chart below (Figure 1) shows the volume of renewable freshwater resources. Based on this, it can be clearly determined which countries achieve the highest volume of renewable freshwater resources and which have serious problems achieving even a satisfactory level.

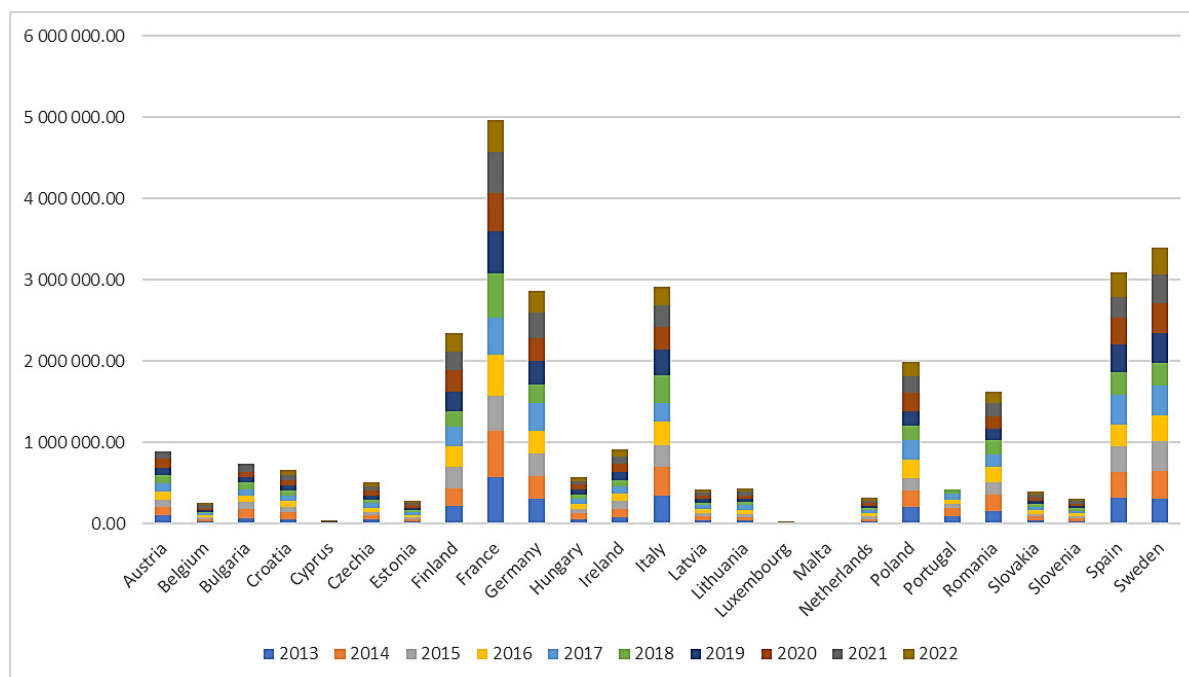


Figure 1. The volume of renewable freshwater resources over the years 2013-2022.

Source: own study based on https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat

The table (Table 2) thoroughly analyzes the volume of renewable freshwater resources over 2013-2022 by individual EU countries. The country that has a significant advantage over other countries is France. Over the years 2013-2022, it obtained 4965333.63 million cubic meters. In the analyzed period, France overtook Sweden by 1564718.63, which obtained 3400615 million cubic meters in the analyzed period. The next country with the largest volume of renewable freshwater resources is Spain, which reached 1869579.95 million cubic meters, smaller than the volume of renewable freshwater resources, achieving a value of 3095753.68. The lowest results in obtaining renewable freshwater resources were demonstrated by Malta (1483.02), followed by Luxembourg (20368.01) and Cyprus (28308). The difference between France and Malta was 4963850.61 million cubic meters.

Table 2.

Minimum, maximum, and total volume of renewable freshwater resources in the period 2013-2022

	Minimum value of renewable freshwater resources	Maximum value of renewable freshwater resources	The volume of renewable freshwater resources in the period 2013-2022
Austria	82146.00	106870.00	1464231.00
Belgium	21326.23	29543.52	434989.91
Bulgaria	63437.00	115306.00	1218857.00
Croatia	60968.70	85551.00	1120163.10
Cyprus	1770.00	4782.00	51600.00
Czechia	41244.00	60267.00	864647.00
Estonia	23187.60	32679.60	55867.20
Finland	183618.00	265431.00	863533.00
France	389243.24	578153.19	4458652.43
Germany	230600.00	336300.00	7960868.85
Hungary	46236.40	70680.00	4364116.40
Ireland	82540.43	105540.69	188081.12
Italy	217220.58	363242.59	1420701.57
Latvia	30198.00	52713.52	1462374.77
Lithuania	36346.66	57852.17	4425953.58
Luxembourg	1545.94	2444.74	620396.08
Malta	102.65	189.51	648425.85
Netherlands	25238.51	35341.40	90887.27
Poland	155817.90	248836.50	406913.84
Portugal	53763.07	99259.61	623232.24
Romania	134329.00	197196.00	3286452.80
Slovakia	31126.00	46806.00	554186.56
Slovenia	24144.00	39897.00	2455485.70
Spain	251994.26	359446.24	1194462.50
Sweden	279373.00	375110.00	1099135.90

Source: own study based on https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat

In addition to the data related to the acquisition of renewable freshwater resources, the total volume of renewable freshwater resources obtained in the subsequent years of 2013-2022 is also important.

Table 3.

Total volume of renewable freshwater resources in particular years 2013-2022

	Total volume of renewable freshwater resources in particular years
2013	3237363.51
2014	3 365 105.15
2015	2 938 027.51
2016	3 114 050.25
2017	3 191 780.07
2018	2 866 730.8
2019	3 100 276.85
2020	3 056 441.54
2021	2 972 524.79
2022	2 534 464.97

Source: own study based on https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat

The values of renewable freshwater resources obtained are presented in the chart below. Occurring fluctuations can be observed, but with a downward trend—the level of freshwater value in 2022 compared to 2013 decreased from 3,237,363.51 to 2,534,464.97. This fact should be of great concern.

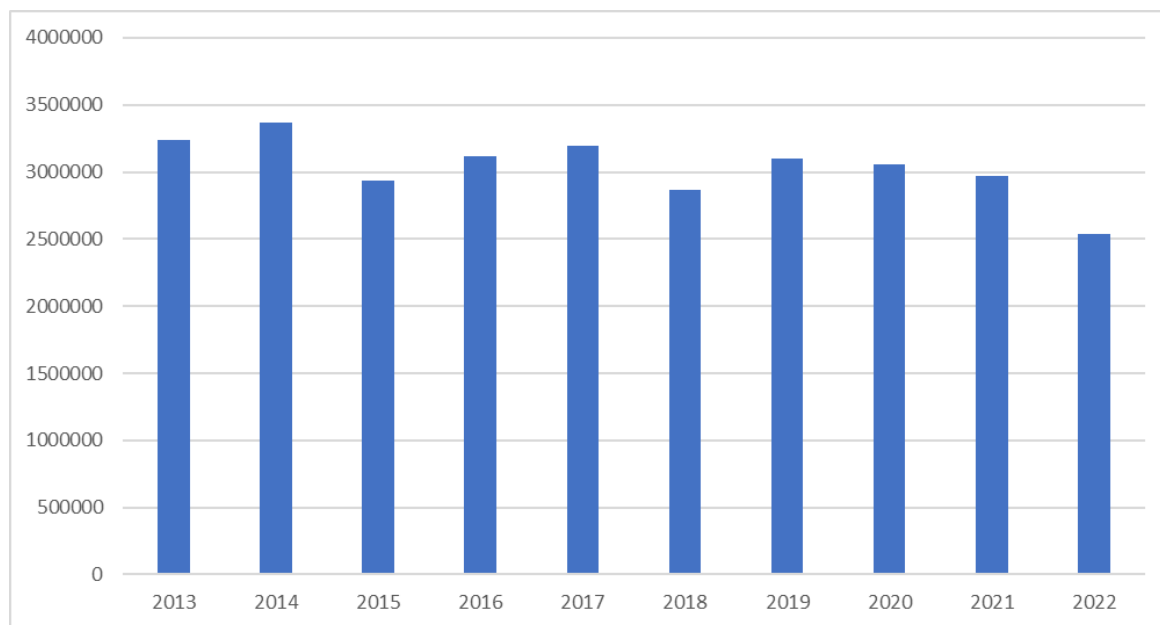


Figure 2. Total volume of renewable freshwater resources in particular years the period 2013-2022.

Source: *own study based on* https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat

An extremely important aspect in analyzing the achieved freshwater level is controlling changes occurring in subsequent analysis periods. For the years 2013-2022, the percentage change from year to year was determined for individual EU countries. The results are presented in the table below (Table 4).

Table 4.

Percentage change in the value of renewable freshwater resources from year to year in 2013-2022

	2014	2015	2016	2017	2018	2019	2020	2021	2022	Min	Max
Austria	1.49%	-23.13%	28.90%	-1.87%	-12.35%	8.91%	4.56%	-11.69%	:	-23.13%	28.90%
Belgium	5.76%	-5.60%	7.99%	-7.54%	-14.27%	20.89%	-3.60%	18.87%	-10.17%	-14.27%	20.89%
Bulgaria	62.71%	-28.82%	-8.97%	12.98%	1.00%	-25.59%	6.85%	32.63%	:	:	:
Croatia	40.00%	-27.14%	13.54%	-8.38%	0.29%	-2.03%	-4.31%	4.58%	-4.26%	-27.14%	40.00%
Cyprus	33.22%	23.16%	-11.16%	-24.19%	86.20%	31.30%	-40.78%	-3.81%	1.32%	-40.78%	86.20%
Czechia	-8.44%	-19.06%	19.45%	6.66%	-22.60%	20.76%	21.00%	-10.94%	-6.87%	-22.60%	21.00%
Estonia	5.21%	-5.45%	24.26%	1.54%	-29.05%	31.19%	-1.49%	-7.39%	-14.17%	-29.05%	31.19%
Finland	-3.06%	23.66%	-5.07%	-1.38%	-26.02%	30.43%	10.83%	-15.12%	2.74%	-26.02%	30.43%
France	-1.87%	-24.31%	18.66%	-11.27%	19.48%	-2.52%	-12.19%	10.33%	-23.70%	-24.31%	19.48%
Germany	-6.79%	-3.49%	4.60%	17.30%	-31.43%	25.37%	-3.77%	13.91%	-16.09%	-31.43%	25.37%
Hungary	13.94%	-27.24%	27.85%	-11.46%	-2.16%	2.23%	-2.15%	-16.38%	-2.97%	-27.24%	27.85%
Ireland	16.65%	7.85%	-21.79%	5.74%	-1.55%	11.96%	8.52%	-18.01%	4.06%	-21.79%	16.65%
Italy	5.61%	-27.03%	8.85%	-20.70%	45.83%	-2.30%	-15.65%	-2.14%	-19.28%	-27.03%	45.83%
Latvia	19.47%	-19.99%	31.29%	3.34%	-42.71%	35.95%	-3.23%	-0.40%	5.55%	-42.71%	35.95%
Lithuania	-4.53%	-6.51%	34.97%	11.29%	-37.17%	11.43%	4.08%	6.78%	-2.91%	-37.17%	34.97%
Luxembourg	-3.78%	-20.41%	18.24%	-30.16%	32.89%	-11.62%	17.11%	7.97%	-28.25%	-30.16%	32.89%
Malta	5.17%	-2.60%	-33.87%	34.25%	37.52%	-8.92%	-29.17%	43.76%	-33.84%	-33.87%	43.76%
Netherlands	3.87%	11.56%	-9.36%	9.89%	-28.30%	28.44%	-0.81%	3.47%	-10.90%	-28.30%	28.44%
Poland	-4.90%	-22.04%	40.26%	13.86%	-29.70%	3.49%	21.78%	-9.23%	-7.88%	-29.70%	40.26%

Cont. table 4.

Portugal	8.55%	-45.51%	0.91%	27.06%	-22.48%	:	:	:	:	:	:
Romania	21.13%	-22.74%	23.22%	-15.90%	5.48%	-13.44%	7.72%	7.17%	-19.28%	-22.74%	23.22%
Slovakia	10.53%	-24.69%	28.49%	-10.50%	-18.63%	26.02%	4.48%	-14.10%	-16.55%	-24.69%	28.49%
Slovenia	14.49%	-39.48%	29.70%	1.66%	-12.50%	15.04%	-7.06%	-8.35%	-10.91%	-39.48%	29.70%
Spain	-5.65%	1.67%	-11.93%	30.11%	-23.36%	25.35%	-5.09%	-23.11%	23.10%	-23.36%	30.11%
Sweden	8.02%	11.48%	-15.98%	14.07%	-22.29%	31.51%	0.88%	-4.11%	-7.15%	-22.29%	31.51%

Source: own study based on https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat

Latvia recorded the most significant decrease (42.71%) compared to 2017 (decrease from 52713.52 in 2017 to 30198 in 2018). Cyprus observed the most significant increase (86.2%) in 2018 (a change from 1,956 in 2017 to 3,642 in 2018).

Table 5.

Values of renewable freshwater resources in the last four years of the analyzed period in ascending order

	2019		2020		2021		2022
Malta	172.60	Malta	122.26	Malta	175.76	Malta	116.29
Luxembourg	1 815.58	Luxembourg	2 126.30	Luxembourg	2 295.79	Luxembourg	1 647.28
Cyprus	4 782.00	Cyprus	2 832.00	Cyprus	2 724.00	Cyprus	2 760.00
Belgium	25 780.38	Belgium	24 852.73	Slovenia	27 296.90	Estonia	23 820.40
Estonia	30 419.60	Slovenia	29 785.10	Estonia	27 752.80	Slovenia	24 319.60
Slovenia	32 047.30	Estonia	29 967.60	Belgium	29 543.52	Belgium	26 538.05
Netherlands	32 417.47	Netherlands	32 155.74	Netherlands	33 273.00	Netherlands	29 646.00
Lithuania	40 499.96	Latvia	39 727.90	Slovakia	37 301.00	Slovakia	31 126.00
Latvia	41 053.99	Lithuania	42 153.01	Latvia	39 570.14	Latvia	41 765.91
Slovakia	41 564.00	Slovakia	43 425.00	Lithuania	45 011.60	Lithuania	43 703.84
Czechia	49 806.00	Hungary	56 981.10	Hungary	47 650.00	Hungary	46 236.40
Hungary	58 234.70	Czechia	60 267.00	Czechia	53 674.00	Czechia	49 984.00
Bulgaria	63 437.00	Croatia	60 968.70	Croatia	63 763.90	Croatia	61 049.50
Croatia	63 712.10	Bulgaria	67 783.00	Ireland	85 590.95	Ireland	89 062.21
Ireland	96 204.22	Austria	103 708.00	Bulgaria	89 899.00	Romania	134 329.00
Austria	99 189.00	Ireland	104 397.71	Austria	91 580.00	Poland	184 332.50
Romania	144 154.20	Romania	155 285.30	Romania	166 419.00	Italy	217 220.58
Poland	181 028.20	Poland	220 458.70	Poland	200 110.10	Finland	231 479.00
Finland	239 499.00	Finland	265 431.00	Finland	225 303.00	Germany	265 900.00
Germany	289 100.00	Italy	275 007.11	Spain	251 994.26	Spain	310 195.17
Italy	326 027.22	Germany	278 200.00	Italy	269 116.69	Sweden	329 990.00
Spain	345 324.43	Spain	327 742.76	Germany	316 900.00	France	389 243.24
Sweden	367 414.00	Sweden	370 646.00	Sweden	355 402.00	Bulgaria	:
France	526 593.90	France	462 417.52	France	510 177.38	Austria	:

Source: own study based on https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat

It should be particularly noted that in the last years of the period under review, France achieved the highest value of renewable freshwater resources, ahead of Sweden and Spain (except for 2021, when Germany and Italy overtook it).

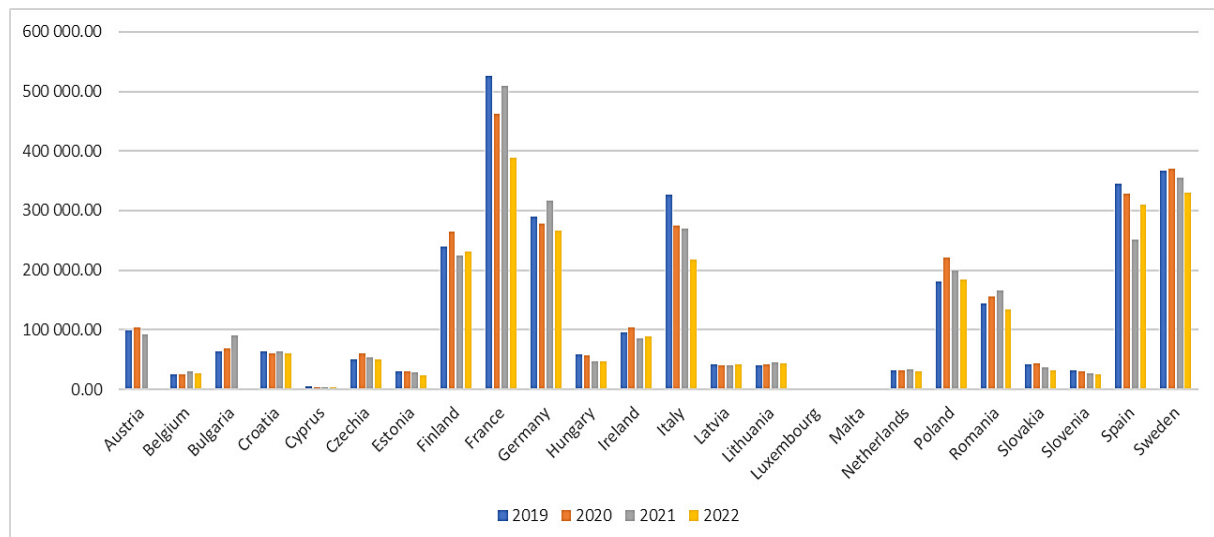


Figure 3. Values of renewable freshwater resources in the last four years of the analyzed period in ascending order

Source: own study based on https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat

3. Summary

Protecting renewable sources of freshwater is one of the key challenges facing the European Union. In addition to the Water Framework Directive, the European Union is investing in research and technologies supporting the efficient use of water and implementing innovative projects to improve the situation in the field of renewable sources of freshwater. One of the solutions is adaptation to climate change through investments in water infrastructure, development of monitoring systems, and promotion of water saving. Co-financed by the European Commission, research programs such as Horizon Europe and regional initiatives focus on developing technologies, monitoring water resources and implementing sustainable water management practices such as digital water monitoring systems (AQUACLOUD, Water4Future), hydrological models, increasing efficiency water use: water recycling based on treated wastewater for irrigation (REWAISE), rainwater recovery and retention: retention infrastructure (RAINMAN), green infrastructure, combating pollution and improving water quality: groundwater purification (AQUAREHAB), biotechnologies, adaptation to climate change (DRYLAND), seawater desalination, economic models of water management and research towards restoring natural water ecosystems (NATWATER). Education and social involvement are also important aspects, where actions at the national and European level, supported by local communities and the private sector, are the key to achieving success in protecting renewable sources of freshwater.

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REFLECTIONS ON DEMOCRACY IN A HISTORICAL PERSPECTIVE

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Purpose: The purpose of the article is to present issues related to the formation of a democratic system.

Methodology: The research was based on a systematic review of the literature.

Findings: In the development of the democratic system, its ancient roots are of great importance. Athenian democracy and the development of Roman democracy (although imperfect) are the foundations of the formation of the modern democratic system or rather democratic systems in its various manifestations.

Practical implications: Currently, despite many references to democratic values, despite the existence of a common opinion on what democracy is, concepts are emerging that have democratic features, but their selective application is not identical to the term "democratic system". There are votes and decisions based on democratic principles, but the effects they produce are not democratic.

Originality: The article presents the historical foundations of the formation of the democratic system.

Keywords: Athenian democracy, Roman democracy, democratic system.

Category of the paper: Theoretical paper.

Introduction

Currently, despite many references to democratic values, despite the existence of a common opinion about what democracy is, concepts are emerging that have democratic features, but their selective application is not identical to the term "democratic system". There are votes and decisions based on democratic principles, but the effects they produce are not democratic. The aim of this study is a historical review showing selected aspects thanks to which the term "democratic system" can be reached by deduction.

1. Needs of free citizens, acceptance of decisions

In the European cultural sphere, the term "democracy" is uttered practically without any need to explain how it works and what values it represents. It is a common tool of social communication, thanks to which an unquestionable decision is made, and it is precisely the acceptance of this decision that is a key element of democracy. It is the acceptance and reconciliation with the fact that a minority or an individual will not force their position.

Historically, in the cradle of democracy, i.e. in ancient Athens, the power was originally held by the owners of the land, who benefited from granting "permissions" to use its benefits. The appropriate climate and fertility of the soil made it possible to produce food surpluses, which on the one hand were beneficial - the population could devote time to other activities than obtaining food, but on the other hand were a curse, because the excessive number of people generated social problems. The solution to these difficulties was the widespread colonization of the Greeks, the signs of which are still visible today in the farthest corners of Eurasia and Africa (Everitt, 2020).

Food surpluses gave the Greeks the comfort of spending their free time in many ways, thanks to which culture, art, sports and democracy (i.e., politics) developed. Without resources in the form of free time, it would not have been possible for the people to participate in long hours of discussions and court hearings – at that time in the form of meetings in the squares. The gathered listened attentively to the arguments that were conducted quite freely at the time. Without this freedom and liberty, the judgment of the famous philosopher Socrates would probably not have taken place. He was sentenced to death for a relatively trivial offense – that is, spreading falsehoods and corrupting the youth.

Therefore, free time, generated by the economic system of ancient Greece, was undoubtedly the driving force not only for the idea of managing the city – state, but also for exporting these ideas to other corners of the world.

Another factor for the development of the spirit of democracy was the free. The existence of free citizens conditions the development of democracy. This fact was not at all obvious in ancient Athens. In Greece itself, things were not "ideal". The economic system of city-states was largely based on the work of slaves and visitors, but it was known that "bearded" men voted, and women and children were excluded from participating in decision-making, although the system itself was absolutely unique, as for the world of that time. Democracy is not just voting. In order for a decision to be finally accepted, it must go through a series of institutions and procedures necessary to make it credible. There must be a social conviction that these institutions are necessary and properly respected. In this way, something was created that today can be called a constitution, or the principles of functioning of democracy. The key to this mechanism is the creation of a decision that is acceptable to the community. It should be mentioned here that in the Athenian system, the beliefs of the population in the Oracle of Delphi

played a significant role. Today, it is difficult to call it an element of a democratic system, but in ancient times there was a need to rely on space, boundlessness, apeiron - as Anaximander called it, a border that no one will question, a moment ending a dispute. Socrates himself, arguing in the streets with the inhabitants of Athens, did not fail to ask the Oracle of Delphi a question. What is more, he accepted the answer and it became the basis for many further considerations. Today we would not call the Oracle of Delphi an institution of a democratic system, but it can illustrate a certain parallel to democracy. In earlier systems, due to the way tribal communities gathered, the basis for the decision accepted by the community was the king - as was the case with the peoples living in the Fertile Moon. The tribal ruler was the final lawmaker and judge. In the legal system introduced in ancient Babylon, there were specific ways of resolving disputes. One such example is the river test in Babylon, in which the participants of the dispute (after taking an oath) were thrown into the water (Saggs, 1973). The result was one winner who stayed on the surface of the water. The decision may have been accidental, but accepted by the community. Similarly to the Oracle of Delphi. It can be assumed that the ruler relinquished his full power in favor of a solution – quite random – but acceptable to the local population.

2. Democracy as a goal of authority

Ideas borrowed from antiquity found their way onto the fertile ground of the fall of absolute power in France and quickly germinated, as there was an urgent need to find a way to manage the state efficiently and at the same time acceptably. The very fall of royal power had its causes analogous to those in ancient Athens. Surpluses of goods and services produced by society, which released the desire of the population for self-determination. And unfortunately for the king and the aristocracy, in the case of fluctuations in the economic situation, when hunger occurred, the people's anger was directed at the authorities. Dramatic food shortages combined with growing social awareness led to the overthrow of the authorities. It was done, generally speaking, in an undemocratic way and resulted in the takeover of power by a rickety democracy not devoid of caricatural features. This attempt was too early even for modern France, social awareness too immature for this uprising to end in success.

It is impossible not to mention our native noble democracy here. It is hard to resist the impression that it had the features described by Aristotle in "Politics". It fulfilled the basic task of democracy, determining the adoption of a decision acceptable to the majority. Its form in the Nihil Novi Constitution of 1505 became a certain complication. The democratic people, i.e. in this case the nobility, ensured themselves the possibility of opposition in every matter (the so-called free opposition or liberum veto) and this episode became the most famous element of noble democracy, so it is worth mentioning its many merits. After all, it was as

a result of democratic elections that it was determined who would be the king of the Republic and more than once a quite good choice was made, in the form of King Stefan Batory or Jan Sobieski.

The Republic developed in a spectacular way, and the source of this progress was a democratic decision, although completely distant from the standards of its current understanding.

The modern mode of decision-making required constant improvement. Democracy, the so-called mature one, must be subject to constant corrections, changes and reforms, thus inscribing it into the current level of social awareness.

This was lacking in the then Republic of Poland, decisions were made for short-term benefits, and the democratic group was not supplemented by new social classes. Meetings were held during evening feasts, which, when mead was replaced with aquavit, was one of the factors in the loss of authority for democratic proceedings.

The ancient Greeks, in their fears, repeatedly drew attention to the fact that there was a significant risk of a tyrant taking power in a democratic manner. A social decision without appropriate protective tools is the fastest and cheapest way to dictatorship. One can easily provide such examples of phenomena in the 20th and 21st centuries. Manipulation of emotions has been the greatest threat to democracy from the very beginning. Just 20 years ago, television and radio were the leaders, now they are specialized social media tools using AI. Election campaigns consist of examining social expectations and matching the candidate to them. Today, the candidate is not a leader who attracts the crowd, today the candidate becomes the resultant of the views of the winning majority. The goal of an exemplary candidate seeking voters is not to convince, but to find a group of views that will be supported by 50% and one more vote. In the case of voting for the president of the United States, the procedure is more complicated, but the effect remains the same. The absolute standard now is to vote not "for" but "against". The voter says: I don't have my candidate in the elections, but I know who I don't want. The speed of information and artificial intelligence are factors that can be a real threat to modern democracy. Because wouldn't artificial intelligence do all the work for the voter?

3. Ways of making decisions

3.1. Making a Choice and Philip II

It is worth considering here the question of how and why democracy was "used" to make difficult decisions. There is a general belief that in a situation where a given unit did not have sufficient military power to impose its will, it had to give way and submit to the will of the dominant group. The group (i.e. voters) was tasked with either helping the government make

a decision (then the concept of a strictly façade institution was created) or to consult in a real way on the proposals submitted by a given unit. When Philip II brought his troops to the gates of Athens, then in this society based on democratic values, two factions clashed. One were supporters of reconciliation with the Macedonians - which could mean submission and acceptance of Philip II's rule (this faction was represented by Isocrates). The other, gathered under the leadership of the orator Demosthenes and constituted the opposing party, completely rejecting the option of reconciliation. Demosthenes' faction was ready to form an alliance with Persia, so as not to hand the city over to Philip II. The decision was ultimately made by democratic vote: war was declared on the Macedonians. Considering the fact that the Athenian army was largely composed of free citizens, it can be assumed that the decision was made in an extremely mature way, although reaching for fiction, one can encounter various scenarios of how this matter was handled. Nevertheless, the key issue was still who voted - because it is known that not all the city's inhabitants had the right to vote. Today, one could say that "public consultations were held", but for the Greeks, who did not know indirect democracy, it was the right decision (Everitt, 2020).

3.2. Pontius Pilate's Public Consultation

The figure of the Prefect of Judea exists primarily in parables and the New Testament, including the Gospel of John, but since an inscription with his name was found in Caesarea (in ancient Palestine) in 1961 (<https://www.britannica.com/biography/Pontius-Pilate>), it has been recognized that Pontius Pilate was a historical figure. This implication that the Prefect of Judea was an authentic individual does not bring any groundbreaking values on a religious basis (in any denomination), but it does not exclude interest in the story written by the Evangelist John (Ewangelia św. Jana J. 19 1-12, J 19 13-16), concerning the trial of Jesus Christ. The appearance of this thread in the Gospel of John is extremely important for a completely different reason. The socio-political analysis of this story is as follows: Pontius Pilate, in order to maintain social peace, took into account the voice of the people. From the point of view of a representative of Caesar, he did not want to interfere in local affairs. However, he could not afford to be accused by the Jewish aristocracy of ignoring the problem and challenging the authority of Caesar. Nevertheless, his main task was to supervise the tax collection process, build aqueducts, maintain combat power and avoid social rebellions. In order to properly carry out these tasks, local affairs had to be managed in such a way that it was not necessary to maintain a garrison of legionaries in Jerusalem, nor a long and expensive expedition of the army from another corner of the empire to tame possible social unrest. Therefore, the leaders of the Jewish social organizations, (a term for the purposes of this study), had to construct an indictment in such a way that it concerned challenging the authority of Caesar and thus could be brought before the prefect. Pontius Pilate, in this story, saw that he was being manipulated into local political games, which he could not afford. Therefore, he based his decision on "social consultations", the result of which is widely known (Goldworthy, 2000). Why did the Jews “not

want” to judge Jesus of Nazareth? According to the Gospel, Christ was tried by the highest-ranking representative of the government, and this fit the whole story perfectly, as a coherent explanation. From the point of view of the history of democratically conducted disputes, it is worth returning to the decision-making process itself. In the given content, one can find elements that are still important in modern democracy today. This is the jurisdiction of the court, reliance on higher values (in this case Caesar), social consultations, counting votes. Then – a decision accepted by society. As for the decision itself, it is worth mentioning Barabbas, a man who escaped with his life as a result of social consultations. Similarly to the previous considerations, the issue of the historicity of this figure will not in any way affect the substantive value of this study and has no impact on the issues analyzed. The assessment concerns only the life attitudes referred to, which are given as an example of social coexistence and ground social behavior. Therefore, to convey the full scale of the situation, it should be said that perhaps in this story Barabbas is not a criminal, a hypostasis of evil. In Joseph Ratzinger's opinion (Ratzinger, 1997), he could even be the second messiah. According to the Evangelist Matthew, he was certainly "someone important", which could mean a Jewish rebel opposing Caesar's rule. The choice did not have to be so obvious.

By deduction, we can therefore conclude that Pilate was somehow forced to accept a decision that was unfavourable to him, resulting from social consultations. This is the quintessence of democratic conduct. The procedure for this judgment shaped, to some extent, the views of European thinkers and society, who often referred to Christianity.

However, the issue is seen differently from the side of the Jews themselves - if we "gave them a voice". In order to remain objective, other opinions and views should also be mentioned. Judaism assesses the situation in a completely different way than Christianity. Ha-Nozri, as Jesus Christ of Nazareth was most likely called in Jewish tradition, is the man mentioned by the Talmud, who was a common troublemaker, executed for lying by stoning. And here, without a doubt, both versions of events have their religious foundations, not very democratic. In Jewish tradition, the dispute with Pontius Pilate was not mentioned.

4. In response to changing needs

Democracy in ancient times required constant changes, but the very fact of considering the system was phenomenal. It is difficult to imagine a discussion about managing a city in totalitarian systems or absolute monarchies, while in the case of democracy, discussion was and still is the foundation of its "call into life". Therefore, work on the system could only take place in centers that were extremely socially mature. Pericles, Cleisthenes, Solon - reformers of the Athenian system knew that voting alone does not make a civic state. Only the introduction of numerous regulations, principles and legal norms shapes the way problems are dealt with and

results in an acceptable decision. Ancient thinkers were excellent at recognizing the weaknesses of popular government. Aristotle's proposals for wise and responsible politicians to rule, taking care of citizens with views that would not receive the approval of the majority were simply "ideal". This expression seems to be the most appropriate, because such an "ideal" state governed by wise men was proposed by Plato. Although from our point of view it would be more like a totalitarian system. Fear of a tyrant – an individual with concentrated power in their hands – was a vexation for the Hellenes. Reforms and term limits were therefore intended to curb any desire for absolute power. It is worth noting that democracy did not in any way hinder the unprecedented flourishing of Athens' culture and economy. Greek colonies stretched from the Indus River to central Africa and Europe. It was openness, tolerance and participation in social life that created the foundations of the civilization of ancient Rome, and later of all of Europe (Everitt, 2020). Despite great tensions and rivalries, visible in the example of the dispute between landowners and craftsmen, revealed in the times of Solon (5th century BC), society maintained a high level of development in a conciliatory manner. Later – already in the Roman era – Athens, as the leader of Hellenic democracy, was the informal capital of culture, a place visited by tourists of the time, the cradle of democracy and republican ideas. Why then was democracy subject to criticism? This system sprouted in the rapidly developing world of the Apennine Peninsula, after a period of weak kings and it was the Roman people who took power. Democracy in Rome, much more sophisticated, generated a socio-political system with senators and factions of plebeians and patricians, possessing some features of today's political parties. The institutions of tribunes, praetors, prefects, aediles, quaestors, consuls, proconsuls and, of course, the senate. Public life was becoming, one might say, a "profession" for many citizens, and social functions were increasingly associated with financial privileges. It can therefore be said that democracy was moving into a phase of professionalism. On the one hand, the system became more and more stable, but on the other hand, it implied various abuses in voting. Rome grew richer and the republic absorbed more and more lands around it. Nevertheless, the goal itself was not to convince the inhabitants of the conquered territories to its ideas, but to obtain financial resources. This increase in resources, unlimited enrichment was the driving force. Therefore, the peoples of the conquered lands, in exchange for a certain security and legal stability, willingly accepted the imposed Roman law, which seemed more rational and objective than the managerial methods represented by local leaders with exuberant fantasies. Rome grew stronger, richer, and with the growth of the empire, individuals grew richer. Great appetite fueled the successive conquests of Pompey the Great and Julius Caesar, and it was only a matter of time before these powerful personalities clashed. The latter won, but – interestingly from the point of view of social changes – did not eliminate democratic institutions. The conclusion is that Julius Caesar took over the most important functions, but did not declare himself a ruler, he only took over the most important positions as a single person. We can say, like Brutus, that it comes down to one thing, but from the perspective of social life it had its significance and was something else after all.

The Senate and state institutions survived, unfortunately the senators themselves contributed to its later downfall. The Senate became a place of prestige, not service to Roman citizens. Many compromising events occurred. An example is an episode from the life of the emperor Caligula, who decided to appoint his horse consul. To this day, mainly thanks to fiction, this irrational act is evidence of the emperor's madness. But can't it also be evidence of the ruler's sense of humor and the desire to compromise the caricatured "chosen ones" of the nation? Many facts from Caesar's life are not described objectively enough. Therefore, it is impossible to unequivocally deny the position that it was a suggestive act aimed at characterizing the imperfections of democratic institutions.

Over the centuries, democracy has not been a popular method of electing authorities or making decisions. Associations were formed – congregations, orders, which often took advantage of the opportunity to make decisions in a democratic way (Puziak). The election of the Pope in the Catholic Church is the result of a democratic election, although this thesis should be put very carefully. However, it is worth paying attention to the numerous Councils, which were nothing more than gatherings, resembling modern “conferences”. During these, a position was jointly established, which was then binding in the entire Universal Church. The very possibility of discussion was democratic in nature, and the decisions made were monumental for the entire Christian world.

5. Institutionalization

The search for a properly functioning system of social management in the face of the growing importance of the people – as the Hellenes would call it, the “demos” – took place during the approaching social changes in the modern era, which began in the 13th century.

The inevitable social changes led to the strengthening of the middle class, which wanted to assert its influence on the management of the state. The growing need to speak out found its outlet in the discussion on how to manage the community, so that the decisions made were “just” and “socially acceptable”. Taking power itself was always easier than proposing a system that would meet the above-mentioned two conditions.

There would be no modern democracy without Charles Louis de Secondat, Baron de La Brède et de Montesquieu, known as Montesquieu. In his most important work “On the Spirit of the Laws”, the thinker formed a view that is still widely present in the consciousness of society today. Repeated attempts to change this order ended in failure. Montesquieu, in his critique of French absolutism, under the influence of emerging British parliamentarism, postulated a separation of powers, which later became the foundation of the Constitution of the United States of America. The Founding Fathers, strongly influenced by the philosopher, created a new state structure. It turned out to be durable and acceptable to the majority of society.

The separation of powers exists in democratic systems all over the world. Although individual institutions may be called differently, the basic character should remain intact. It is the features of each power that determine its belonging to a specific type. It turns out that without institutions, democracy itself does not exist, cannot function and is not supported by the sense of justice of society.

Conclusion

Over the centuries, democratic decision-making has taken various forms. There were cases where voting was intended to make a decision already made credible, there were cases where the ruler wanted to free himself from responsibility for the decisions made, but there were also cases where conscious citizens made conscious, sometimes unpopular decisions. Over time, in addition to the rules that defined the way of democratic procedure and making balanced decisions, institutions emerged. The aim of institutionalization was to stabilize the decisions made, so that a mature society could accept a joint choice between existing options. This concept was extended to religious congregations, associations, confederations and entrepreneurial communities. The democratic decision, although corrected to an economic form, also became the basis for codes and capital companies - economic influence determines the weight of the vote, in most cases capital involvement or other forms countable for accountants. Democratic procedure must have rules and institutions that define per se, the key humanistic goals of democracy. Currently, the democratic concepts known in the world are subjected to philosophical, social and legal analysis to see if they meet the conditions of the "European standards of a democratic state". This in turn is of fundamental importance for the economy of the assessed country, its creditworthiness, currency strength or investment security.

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ARTIFICIAL INTELLIGENCE IN ROAD CONSTRUCTION: PROSPECTS AND CHALLENGES

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Purpose: Artificial Intelligence (AI), along with other technologies associated with Industry 4.0, has had an expanding impact on all sectors of the economy. Implementing AI technologies in road construction promises a number of benefits, including increased safety and productivity, improved quality of work performed, and reduced costs. The paper reviews various applications of AI in road construction. Additionally, it analyses the potential challenges and risks that hinder the rapid adoption of AI in this industry.

Design/methodology/approach: In total, 54 references were analysed to determine what AI is, its main technologies, how and where these technologies are used in the road construction industry, and the challenges faced in implementing AI.

Findings: The most significant applications of AI in road construction were recognised, covering the entire life cycle of a road, from planning to maintenance. The main challenges to be overcome for further AI implementation in road construction were also identified.

Research limitations/implications: The paper is limited to technological processes related to road construction and operation and does not examine other related areas, such as intelligent transport systems.

Originality/value: The paper informs society and professionals in road construction about current trends in the use of AI technologies; it will facilitate their further adoption and address existing challenges.

Keywords: artificial intelligence, road construction, review.

Category of the paper: Literature review, viewpoint.

1. Introduction

The road construction industry is one of the vital parts of any country's economy, contributing to a better distribution of productive forces and more efficient use of resources (Rahman et al., 2020). It also strengthens interstate relationships and creates a common market.

That is why the USA, as well as the most developed countries in Europe and Asia, declared the development of road infrastructure as one of the priorities of public policy. For example, governments in the EU spent more than EUR 112 billion a year over the last decade (Meijer et al., 2018), and investments are projected to grow at a compound annual growth rate of over 6% to 2032 (Highway, Street, and Bridge Construction Market, 2032 Report). According to experts, the road network of EU countries alone spans more than 5.5 million kilometres and has shown a continuous growth trend. In Ukraine, before the war, the network of paved roads was approximately 170 thousand kilometres. This rapid growth of roads and highways demands new solutions and approaches not only in the organisation and execution of construction works but also in monitoring and maintaining the quality of existing roads. However, in many countries, including Ukraine, the road construction industry still relies on traditional labour-intensive production methods that are characterised by high energy consumption, environmental pollution, safety risks, and low productivity (Axelsson, Froberg, Eriksson, 2018; Wu et al., 2019). The situation could change with the adoption of Industry 4.0 technologies. The promising concepts of Industry 4.0 are benefiting various industries, and now they are gradually penetrating road construction. Industry 4.0 can be described as the integration of the physical and digital worlds through the adoption of new technologies such as the Internet of Things (IoT), Cyber-Physical Systems (CPS), 3D printing, and Artificial Intelligence (AI) in industrial fields (Bongomin et al., 2020; Bai et al., 2020; Turner et al., 2021).

As mentioned above, AI is one of the key technologies of Industry 4.0. This paper aims to describe the most promising applications of AI in the road construction industry, as well as highlight the challenges and concerns that the adoption of AI in this sector may face.

Before exploring the application of AI technologies in road construction, let us define what AI is and what technologies fall under the definition of AI that we will consider further.

2. AI definition and technologies

Although the term “Artificial Intelligence” appeared in 1955 (McCarthy et al., 2006), there is still no unified definition. Many researchers (Fetzer, 1990; Lucci, Kopec, Musa, 2022) focus on the concept of intelligence, leaving it to the readers to formulate the definition on their own. Others present their definitions. Some of these definitions are summarised in Table 1. This table shows that as technology evolves over time, the definition of AI also changes. The first definition was introduced by John McCarthy with co-authors in a proposal for the Dartmouth Conference (McCarthy et al., 2006) held in 1956. They defined it as “The science and engineering of making intelligent machines”. This reflects early ideas about creating machines capable of mimicking a human being. Further, John McCarthy expanded this definition: “It is the science and engineering of making intelligent machines, especially

intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable”.

Table 1.

The evolution of AI definition over time

Definition	Year	Researcher(s)	Reference
The science and engineering of making intelligent machines.	1955	J. McCarthy, M.L. Minsky, N. Rochester, C.E. Shannon	(McCarthy et al., 2006)
The science of making machines do things that would require intelligence if done by men.	1969	M.L. Minsky	(Minsky, 1969)
AI is the study of techniques for solving exponentially hard problems in polynomial time by exploiting knowledge about the problem domain.	1983	E. Rich	(Rich, 1983)
AI is the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behavior – understanding language, learning, reasoning, solving problems, and so on.	1981	A. Barr, E.A. Feigenbaum	(Barr, Feigenbaum, 1981)
AI is the study of the computations that make it possible to perceive, reason, and act.	1992	P.H. Winston	(Winston, 1992)
The branch of computer science that is concerned with the automation of intelligent behavior.	1993	G.F. Luger, W.A. Stubblefield	(Luger, Stubblefield, 1993)
The study of agents that receive percepts from the environment and perform actions.	1995	S. Russell, P. Norvig	(Russell, Norvig, 1995)
Computational Intelligence is the study of the design of intelligent agents.	1998	D. Poole, A. Mackworth, R. Goebel	(Poole, D., Mackworth, A., Goebel, R., 1998)
AI...is concerned with intelligent behavior in artifacts. Intelligent behavior, in turn, involves perception, reasoning, learning, communicating, and acting in complex environments.	1998	N.J. Nilsson	(Nilsson, 1998)
AI will be such a program which in an arbitrary world will cope not worse than a human.	2004	D. Dobrev	(Dobrev, 2004)
AI is the automation of thought, where intelligent behavior is produced by any means, whether programmed or learned from data.	2015	P. Domingos	(Domingos, 2015)
AI is generally defined as the ability of a system to accurately interpret external data, learn from it, and adapt flexibly to achieve specific objectives.	2019	A. Kaplan, M. Haenlein	(Kaplan, Haenlein, 2019)
AI as a collection of all kinds of technologies and methods, which are used to execute human brain-related tasks, especially cognitive tasks such as learning and problem-solving.	2021	W. Lyu, J. Liu	(Lyu, Liu, 2021)
AI enables machines to execute cognitive tasks with minimal or no human interaction	2022	M. Ashok, R.J.A. Madan, R.U. Sivarajah	(Ashok et al., 2022)
AI is defined as an unnatural object or entity that possesses the ability and capacity to meet or exceed the requirements of the task it is assigned when considering cultural and demographic circumstances	2023	S. Kelly, S-A. Kaye, O. Oviedo-Trespalacios	(Kelly et al, 2022)

Hopfield's neural network, proposed in 1982, triggered new interest in AI, and AI began to be used for solving complex computational problems, as well as for speech recognition and translation, reasoning, etc. (Rich, 1983; Barr, Feigenbaum, 1981; Zhang, Lu, 2021).

The mid-1990s are characterised by a new concept of “intelligent agent” (Russell, Norvig, 1995; Nilsson, 1998), which interacts with the environment to achieve a goal.

In the last two decades, AI has been seen more broadly as the ability of machines to use the data they receive to make judgments and decisions on their own.

Summarising current trends, we can define AI as software that makes its own decisions based on analysing data it receives from outside whilst constantly learning to make better decisions.

AI involves a wide range of technologies, which are closely interrelated and often overlap because their algorithms and operating principles use similar methods and approaches. The main AI technologies are as follows:

- Machine Learning (ML),
- Deep Learning (DL),
- Natural Language Processing (NLP),
- Computer Vision (CV), and
- Robotic Process Automation (RPA).

All these technologies rely on big data analysis to train models, and ML is the fundamental technology on which the other technologies are built (Figure 1).

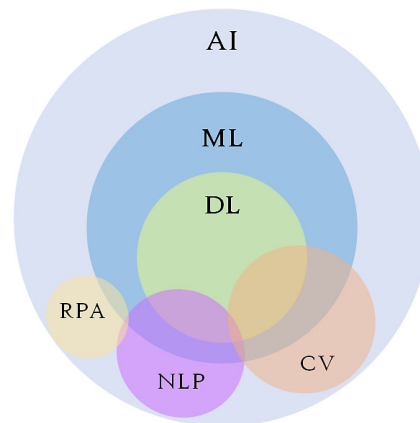


Figure 1. Basic AI technologies.

Source: Based on (Abdullah, Ahmad, 2021).

Consider the application of these technologies in road construction.

3. AI applications in road construction

Even a brief literature review has established that AI is used at all stages of a road lifecycle, from design to maintenance and pavement quality (Figure 2).

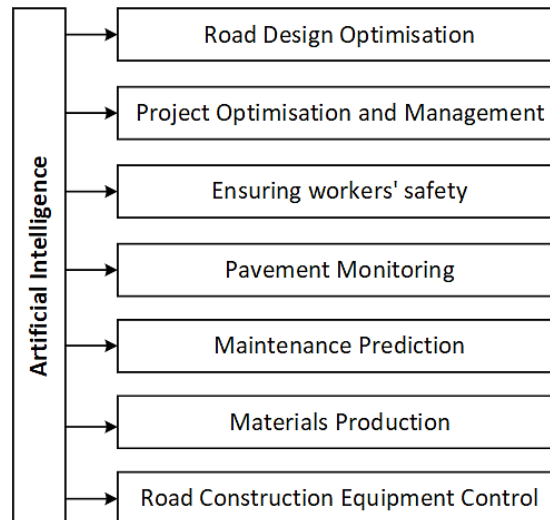


Figure 2. The main AI applications in the road construction industry.

Source: Source: Own work.

3.1. Design and project management

One of the promising uses of AI in the road construction industry is to improve the quality of project design and management. AI algorithms process big data and assess possible risks to optimise road construction planning, determine the optimal amount of materials, and develop logistics, reducing errors in the construction process, while RPA allows for a significant increase in the speed of construction (Khan et al., 2024). For example, such a solution for using AI for road construction planning is described in (Shinde et al., 2020). ML identifies patterns in multiple recorded datasets to determine how long it will take to complete road construction at a particular site, how much raw material is needed, how many workers, and more. Blockchain will ensure the integrity of contracts between stakeholders. ML can also estimate road quality and plan maintenance by analysing users' feedback.

Road construction projects are constantly faced with the problem of time and cost overruns, which negatively affect the budget and economy. In (Naik, Radhika, 2015), the authors developed various models based on Artificial Neural Networks (ANN) to estimate the cost and duration of construction works by analysing the database of previous projects. In (Tijanić et al., 2020), ANN was also used to estimate expected road construction costs. This approach is promising and helpful in the early stages of road project development when only limited or incomplete data are typically available for cost analysis. Florence and co-authors proposed an approach that uses ChatGPT to automate the generation of question-answer pairs to predict delays in road construction projects (Florence, Kikuchi, Ozono, 2024).

3.2. Asphalt production

Asphalt concrete is one of the most commonly used materials in road construction. The quality of asphalt concrete plays a crucial role in ensuring road pavements' durability, safety, and reliability. Therefore, optimising the production of asphalt concrete and controlling its quality are critical challenges in the construction industry. The application of artificial intelligence to analyse the quality of asphalt concrete can significantly improve the efficiency of road construction and maintenance. In (Arifuzzaman et al., 2021), the authors implemented ML to predict the influence of environmental factors, binder types, and Carbon Nano Tube doses on the adhesion force of the asphalt surface. This knowledge can help provide a more durable and resilient asphalt pavement. Botella et al. investigated the application of ML to estimate the degree of binder activity on a reclaimed asphalt pavement (Botella et al., 2022).

Androjić and Marović developed models based on ANN and multiple linear regression to predict the properties of hot asphalt concrete mixtures (Androjić, Marović, 2017). In papers (Sebaaly, Varma, Maina, 2018; Rahman et al., 2021; Liu et al., 2022), ML has been used to optimise the design of asphalt concrete mixtures with specified properties. The research mentioned illustrates different approaches to ML application to analyse the quality of asphalt concrete and optimise its production.

3.3. Construction

Even proper asphalt is not enough to construct a high-quality highway. To provide the road with the necessary properties, it is essential to prepare its base, deliver the asphalt to the construction site without losing its qualities, lay it following specific technologies, and compact it properly.

To prepare a road base, it is necessary to know the physical parameters of the soil. Determining soil properties under laboratory conditions is expensive and labour-intensive. Therefore, various ML techniques and ANN are used to determine the soil type, conditions and properties (Ayawah et al., 2022; Kanungo, Sharma, Pain, 2014). To improve the prediction performance, other technologies, such as Fuzzy Logic and metaheuristics, can be used along with ML (Pham et al., 2018; Tien Bui, Hoang, Nhu, 2019).

In (Kuenzel et al., 2016), an intelligent agent-based system is presented that automatically generates driving instructions for a compactor operator, guiding them on where to steer based on the vehicle's current position. The decision-making process considers the work plan, the trajectories of other compactors, the actual progress of the paver, and changes in environmental and material-related parameters.

ML is also used to control other construction machinery (Kurinov et al., 2020; Egli, Hutter, 2022), as well as to predict their failure (Lige, Hua, Feng, 2019).

3.4. Safety

In (Zhu et al., 2022), DL algorithms have been used to process images received from UAVs to survey large construction areas to automatically detect signs and guardrails to ensure that they are not missing or damaged. In addition, the authors have suggested tracking the trajectories of road construction vehicles and constructors to warn them of their dangerous behaviours early.

Road worker safety is also the focus of a paper (Sabeti et al., 2021) where DL is used to detect and classify vehicles in advance and warn workers of potential dangers by wirelessly transmitting notifications to devices using Augmented Reality (AR) technologies.

3.5. Monitoring of pavement condition

Road surface defects are a serious problem for safe and smooth traffic flow. Due to the effects of climate, poor quality of construction materials and violation of construction standards, high traffic, the road pavement deteriorates rapidly. Detecting and repairing these defects is essential to ensure traffic safety and maintain road capacity. AI technologies, particularly CV and ML, are used to detect pavement deformation, such as potholes, bumps and cracks (Emoto et al., 2023; Paramasivam et al., 2024). Such systems can operate either independently, receiving information from cameras installed along the roadside, on UAVs (Silva et al., 2023), or be integrated into autonomous vehicles (Bibi et al., 2021).

4. Benefits and challenges of AI applications in road construction

AI in road construction offers significant advantages in solving complex engineering and management problems that are difficult to solve using traditional methods (Darko et al., 2020; Pan, Zhang, 2021). In particular, AI can reduce road design time and create more optimised designs considering demographic, economic, and environmental factors. In project management, AI helps identify and address hidden and unobservable factors that affect a project's cost, timing, and success. AI technologies make it easier to monitor road construction progress, offering timely solutions to maintain the pace and timelines of construction. AI is also helping to improve workers' safety.

AI can estimate pavement quality and predict the need for maintenance work by analysing data on pavement state, weather conditions, and traffic. It facilitates preventing accidents and reduces the cost of urgent repairs. AI also helps engineers and scientists develop new construction materials.

Therefore, the use of AI in road construction can reduce costs and shorten the time period for both road construction and subsequent maintenance. In addition, AI improves labour safety and contributes to reducing environmental pollution by mitigating human error and speeding up the process of making more accurate decisions.

However, despite the evident advantages, the implementation of AI technologies in road construction presents several less apparent challenges. One such challenge is the substantial investment required for new software, hardware, and staff training.

Another concern is that AI makes decisions based on exploring large data sets. Therefore, the data's availability, completeness, and relevancy become important limitations for the effective application of AI technologies. Moreover, despite advances in ML algorithms, errors in data interpretation and decision-making are still possible, which can undermine the credibility of AI. These errors need to be identified and corrected on time.

There are also remain issues related to data intellectual property rights and privacy. The legal consequences of AI decisions are still not entirely clear, especially when errors lead to financial losses or more severe consequences.

5. Conclusions

This paper has only briefly touched on the prospects for AI applications in the road construction industry. For example, the use of AI in creating intelligent transportation systems has not been covered. Such issues as construction monitoring, road wear prediction, maintenance planning, and the control of fully autonomous road vehicles were only briefly mentioned. However, this review indicates that AI will likely play a significant role in road construction, contributing to intelligent transport infrastructure development. Current challenges and limitations are expected to be addressed through new research and the implementation of legal regulations.

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EFFECTS OF USING SOCIAL MEDIA IN THE WORKPLACE

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Purpose: The article aims to identify the effects of using social media by company employees in the workplace based on a review of existing research literature.

Design/methodology/approach: This paper applied a literature review procedure according to Hart's methodology, which consists of the following steps: data identification and collection, data evaluation, bibliometric analysis, visualisation, interpretation and description of the research findings.

Findings: In light of the growing prevalence of online communication, the article examines the consequences of employees' utilisation of social media in the workplace, both positive and negative.

Practical implications: An attempt has been made to identify the specific challenges for managers and contemporary organisations that need to be addressed due to the growing importance of social media in the workplace.

Originality/value: This paper presents a structured analysis of the use of social media during working hours. The results of the study can assist managers in developing an organisational management policy for the use of social media in organisations.

Keywords: virtual communication, social media, Enterprise Social Networks, workplace.

Category of the paper: research paper.

1. Introduction

The number of individuals utilising social media (SM) is on the rise, both in Poland and globally. This is evidenced by the findings of DataReportal Poland (2023), DataReport (2024) and Digital in Poland (2021). DataReportal (2024) indicates that in January 2024, there were 27.90 million active social media users in Poland. Globally, this number has already exceeded 5 billion, representing 69.4 per cent of the total population. This represents a year-on-year increase (DataReport, 2024). Such significant popularity of social media can be attributed to the rapid development of digital technologies and mobile tools. In the contemporary era, social

media exerts a pervasive influence across a multitude of domains, encompassing communication, politics, entertainment, and work.

In recent years, organizations have increasingly relaxed their restrictions on employees' use of social media (SM) during work hours. Initially, these restrictions were common (Ashraf, Javed, 2014; Kuvaas, 2006; Labban, Bizzi, 2020). However, the entrance of Generation Y and Z into the workforce, for whom social media is a natural mode of communication, has necessitated a shift in organizational strategies. Employers are now recognizing SM as a critical communication tool that can be leveraged for various purposes, such as client engagement (Aichner et al., 2021; Tajvidi, Karami, 2021), enhancing employer branding (Hanu et al., 2021; Keppeler, Papenfuß, 2021), recruitment processes (Hanu et al., 2021; Hosain et al., 2020; Alexander et al., 2019), building employee communities and social capital (Aichner et al., 2021; Akram, Kumar, 2017; Correa et al., 2010), facilitating knowledge exchange (Ewing et al., 2019; Shane-Simpson et al., 2018), and increasing employee engagement and motivation (Borst et al., 2020a; Ewing et al., 2019; Bizzi, 2018; Ashraf, Javed, 2014).

Recent research presented in the Press Kits Report (2021) indicates that 64.5% of individuals in Poland use social media during work hours, with nearly half of these individuals using SM for both professional and personal purposes (Press Kits - Biuro Prasowe Grupy Pracuj, 2021).

The dynamic rise in the popularity of social media is also reflected in the literature exploring this phenomenon (Tajvidi, Karami, 2021; Labban, Bizzi, 2020; Adjei et al., 2020; Ali-Hassan et al., 2015; Cao et al., 2012). Researchers examine social media from various theoretical perspectives, predominantly focusing on areas such as personal behavior theories (Yaqub, Al-Sabban, 2023; Kolade et al., 2022; Lampropoulos et al., 2022; Zdonek, Król, 2021; Seidman, 2020), social behavior theories (Tajvidi, Karami, 2021; Labban, Bizzi, 2020; Bizzi, 2018; Ali-Hassan et al., 2015), organizational behavior theories (Babu et al., 2020; Chai, 2020; Van Zoonen et al., 2017; Kluemper et al., 2016), mass communication theories (Ali et al., 2019; Lee, Lee, 2018), the Technology Acceptance Model (Yaqub, Al-Sabban, 2023; Rauniar et al., 2014), social capital (Kahtani, Sulphrey, 2022; Presthus, Vatne, 2019), and the Resource-Based View (Elia et al., 2021; Schaupp et al., 2015), among others.

In light of the above, this article seeks to analyse the issues related to this research problem: What effects can be identified for the increasing importance of social media use by employees in the workplace? In order to identify these effects, the following specific questions were defined:

- (P1): What are the reasons for the increase in the importance of social media in the workplace?
- (P2): What are the positive consequences of employees' use of social media in the workplace during working hours?
- (P3): What are the negative consequences of employees using social media in the workplace during working hours?

Therefore, the authors defined the aim of the work as systematizing knowledge about the effects of social media use by employees in the workplace. By exploring both the beneficial and adverse outcomes, the study aims to provide a comprehensive understanding of this contemporary issue, offering valuable insights for organizational policy and strategy development.

For the defined purpose, a literature review procedure was used by the Hart methodology. This methodology consists of the following stages: identification and collection of data (1), data assessment - verification (2), bibliometric analysis (3), visualization (4) and interpretation and description of research results (5) (Hart, 2018). The literature selection process is shown in Figure 1.

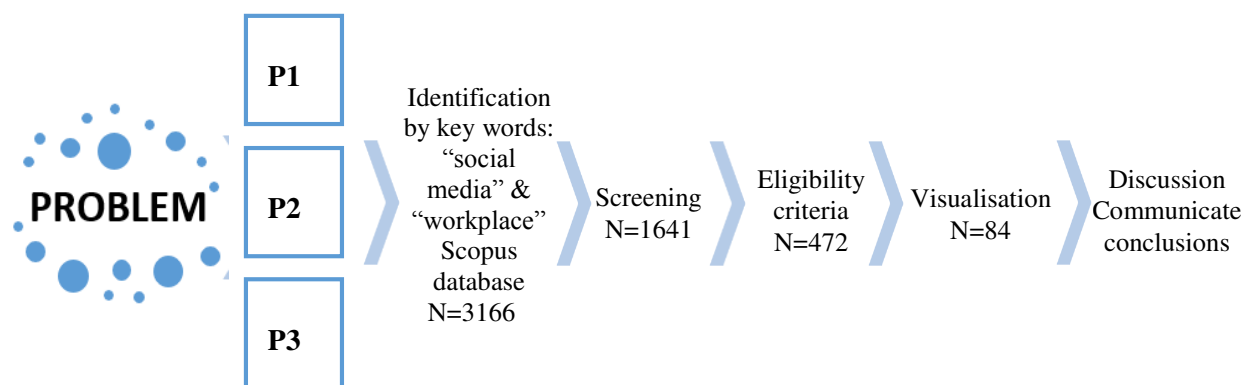


Figure 1. Literature review procedure.

Source: own study.

After formulating the research problem and posing the research questions, the identification and data collection stage began. For the purposes of the literature review, a repository of scientific publications from the Scopus bibliographic database, which indexes articles from high-impact journals, was utilised. Recent studies have recommended the use of Scopus and/or Web of Science for literature searches (Czakov et al., 2023; Kumar, 2021). Nevertheless, scholars frequently opt to utilise only one of these databases. In contrast, WoS is recommended for a selective approach (Azarian et al., 2023), while the Scopus database is preferred for broader data selection due to its comprehensive coverage (Czakov et al., 2023; Munn et al., 2018). The Scopus database contains a comprehensive range of published scientific literature, including journal articles, conference proceedings, patents and books. A total of 3166 publications were extracted based on the selected keywords *social media* and *workplace*.

In the next stage, the search for articles was narrowed down to those published between 2010 and 2024 and written in English. In addition, the subject matter was also restricted to *Social Sciences, Business, Management and Accounting, Engineering, Computer Science, Psychology, Economics, Econometrics and Finance, Decision Sciences, and Multidisciplinary*. Additional criteria were: document type, journal articles, conference articles, chapters in books and books were selected. After selecting all criteria, 1662 documents remained for analysis (Table 1). The eligibility criterion was the possible access to the content of the publication

(all open access), where 472 articles were obtained, which were then reviewed during *the first screening* (i.e. first reading). The main objective of the stage called first reading, screening (early screening), was to eliminate articles with a weak thematic link to the research questions.

Table 1.

Refine search Social media classification

Base	Scopus (n = 1662)	Scopus all access (n = 491)
Keywords	Social media&workplace,	Social media&workplace,
Range-year	2010-2024	2010-2024
Subject area	Social Sciences (876), Business, Management and Accounting (479), Engineering(165) Computer Science (429), Psychology (215), Economics, Econometrics and Finance (186) Decision Sciences (0) Multidisciplinary(0)	Social Sciences (267), Business, Management and Accounting (118), Engineering(0) Computer Science (114), Psychology (77), Economics, Econometrics and Finance (41) Decision Sciences (0) Multidisciplinary(0)
Document type	Article (1,033) Conference paper (236) Book chapter (204) Book (74)	Article (427) Conference paper (28) Book chapter (25) Book (14)
Language	English	English

Source: Own study.

Titles, keywords and abstracts were read. All articles that were not related to or did not discuss the topic of social media in the workplace were excluded. Only articles related to the scope of this study were selected. Therefore, after screening the titles and abstracts, 115 articles remained.

In a text phase called the *second screening* (full reading), the full texts of all 115 remaining articles were read, and articles that did not contribute to this study were excluded. This process resulted in 84 articles being retained. The remaining articles were subjected to thematic content analysis in order to integrate the conceptual framework and extract the necessary information from the texts. Six areas of social media use in organisations have been identified. In addition, detailed factors that cause negative and positive consequences of using social media by employees in the workplace have been identified and assigned to these areas.

The final stage presents a visualisation of the research in the form of tables and a discussion of the results of the analysis.

2. Social media in the workplace

The evolution of the internet and mobile technology has given rise to the phenomenon of social media. Social media (SM) can be defined as an umbrella term for a range of applications that use Internet technologies to allow users to create and participate in communities through

functions such as communicating, interacting, sharing, collaborating or publishing information (Mauroner, 2016).

The literature presents various definitions and classifications of social media (Table 2) (Aichner et al., 2021; Mazurek, 2018; Gruzd, Roy, 2016; Leonardi et al., 2013). A.M. Kaplan and M. Haenlein proposed a classification of social media based on two groups of factors: *social presence and media richness* (allowing users to establish relationships through diverse forms of information), and *self-presentation and self-disclosure* (enabling users to share private information with others). This framework identifies six types of social media: blogs, social networking sites (e.g., Facebook), virtual social worlds (e.g., Second Life), collaborative projects (e.g., Wikipedia), content communities (e.g., YouTube), and virtual game worlds (e.g., World of Warcraft) (Kaplan, Haenlein, 2010, p. 62).

A critical analysis of the literature reveals that the commonly used classification is somewhat conventional and may be insufficient due to the rising importance of enterprise social networks (ESN). Other scholars have proposed alternative classifications of ESM, including Lupa-Wójcik (2018), Scott (2016), and Aichner & Jacob (2015). These are presented in Table 2. (Lupa-Wójcik, 2018; Scott et al., 2016; Aichner, Jacob, 2015).

Table 2.
Social media classification.

AUTHOR(S)	CLASSIFICATION
Kaplan, A.M., Haenlein, M. (2010)	<ul style="list-style-type: none"> - blogs, (e.g., WordPress) - social networking sites (e.g., Facebook) - virtual social worlds (e.g., Second Life) - collaborative projects (e.g., Wikipedia) - content communities (e.g., YouTube) - and virtual game worlds (e.g., World of Warcraft)
Aichner, T., Jacob, F. (2015)	<ul style="list-style-type: none"> - blogs: Wordpress, Blogspot - microblogs: X (Twitter), Tumblr, Instagram - business networks, LinkedIn, GoldenLine - collaborative projects: Wikipedia) - Enterprise Social Networks - Forums: Reddit - photo sharing: Flickr, Photobucket - rating services: TripAdvisor, Filmweb, IMDB - social networking sites: Facebook, Google+, Orkut, Tuenti - social bookmarks: Delicious, Pinterest - social games: FarmVille, GoodGame Empire - video sharing: YouTube, Vimeo, Dailymotion, TikTok - virtual worlds: Second Life, Furcadia, Guild Wars
Scott, K.S., Sorokti, K.H., Merrell, J.D. (2016)	<ul style="list-style-type: none"> - social networking sites (SNS), Facebook and LinkedIn - blogs, WordPress - microblogs, X(Twitter) - wikis, MediaWiki and PBworks - social bookmarks/tags, Delicious and Diigo - media sharing tools, YouTube and Flickr - web-based office tools, Google Apps (documents, presentations, calendar) - enterprise social network system (ESN), Yammer, Jive

Cont. table 2.

Lupa-Wójcik, I. (2017)	<ul style="list-style-type: none"> - individual, e.g. dating sites - corporate, e.g. Yammer - mixed, e.g. Facebook
Mao (2014) Kaznowski, (2016) Gruzd, A., Roy, J. (2016) Mazurek, D. (2018)	<ul style="list-style-type: none"> - presentation of opinions and views, e.g. blogs - internet multimedia repositories (sharing resources, e.g. videos, files, music, etc., e.g. YouTube) - social platforms (building and maintaining relationships, e.g. Facebook) - instant messaging (communication and discussion, e.g. internet forums) - information platforms (informing and commenting, e.g. Wikipedia, microblogs) - co-creation of resources or cooperation, e.g. Google Docs

Source: Own study based on Kaplan, Haenlein, 2010; Mao, 2014; Aichner, Jacob, 2015; Gruzd, 2016; Kaznowski, 2016; Merrell, 2016; Scott et al., 2016; Lupa-Wójcik, 2018; Mazurek 2018.

ESNs can be defined as *platforms that enable tight integration of multiple types of Web 2.0 tools in a single place on the web for companies and organisations* (Scott et al., 2016, p. 2). These platforms allow *employees to communicate or disseminate messages, identify or reveal specific colleagues as communication partners, publish, edit and sort texts and files associated with them or others, and view messages, connections, texts and files, published, edited and sorted by others* (Leonardi et al., 2013, p. 2).

a. Factors contributing to the increased significance of Social Media in the workplace

The significant growth in the utilization of social media in the workplace has been influenced by several key factors. The most notable catalyst for change has been the COVID-19 pandemic and the associated necessity for remote work (Yaqub, Al-Sabban, 2023; Godber, Atkins, 2021; Juchnowicz, Kinowska, 2021; Selvaraj et al., 2021; Zdonek, Król, 2021). This situation initiated changes in work organization within enterprises, particularly in the use of online communication and collaboration tools on an unprecedented scale. As noted by Yaqub & Al-Sabban (2023), social media has become indispensable for maintaining contact and effective collaboration among employees. The shift of meetings and training sessions to the online sphere increased the reliance of organizations on social media platforms and digital tools (Godber, Atkins, 2021).

Additionally, the development of digital technologies, the emergence of new platforms and tools, and the enhancement of existing ones (such as Microsoft Teams, Slack, and Zoom) have enabled effective collaboration within organizations. The integration of social tools with project management systems (e.g., Asana, Trello) and other business applications has enhanced their functionality and utility in the workplace (Kolade et al., 2022). As a result of adaptive processes necessitated by isolation (COVID-19), organizations have witnessed a widespread phenomenon—increased investment in digital transformation. Furthermore, government support programs and EU funds for digital technology development have contributed to the intensive implementation of innovative solutions in the realm of Enterprise Social Networks (Juchnowicz, Kinowska, 2021).

Another significant factor in recent years driving the dynamic development of corporate social media has been market volatility and uncertainty related to the challenging economic and political situation in Europe, particularly following the outbreak of the war in Ukraine. In the face of market volatility and uncertainty, companies had to swiftly adapt to new conditions (Buzoianu, Bîră, 2021). Once again, social media became a crucial tool for rapidly disseminating information and responding to changes (Grzanka, Strzelecki, 2024). The increase in market competition also required companies to enhance their innovation and work efficiency. Consequently, social media has become a tool for increasing productivity, innovation, and collaboration within teams (Bataev, 2021; Kahtani, Sulphay, 2022).

Additionally, the growing interest in employer branding has significantly influenced the further development of social media within organizations (Yen et al., 2021). Decision-makers are increasingly using social media to build their image as attractive employers (Keppeler, Papenfuß, 2021). Juchnowicz, Kinowska (2021) similarly argue that activity on social media platforms helps attract and retain talent (Juchnowicz, Kinowska, 2022).

Researchers also note that social media is used to promote organizational values and culture, fostering greater employee engagement and loyalty (Chai, 2020; Al-dalahmeh et al., 2018). Moreover, generational shifts in the workplace have forced employers to evolve their approach to using social media (Nord et al., 2020). Younger generations of employees, such as Millennials and Gen Z, are more familiar with technology and expect companies to utilize modern communication tools, including social media (Briggs, 2020; Constantoglou, Trihas, 2020; Karasek, Hysa, 2020.)

The combination of these identified factors has contributed to the intense development of social media in the workplace, including corporate social media. Thus, the authors have highlighted the fundamental reasons for the growing significance of social media in the workplace, addressing the first research question (P1). In identifying the factors driving the development of social media in the workplace, it is also essential to recognize another phenomenon. Decision-makers are aware of the tangible and intangible benefits of widespread social media use in the workplace, leading to further investment in these technologies and communication tools. Therefore, it is necessary to examine the subsequent research questions regarding the positive (P2) and negative (P3) consequences of social media use by employees in the workplace during working hours.

3. Effects of using social media

The authors of the study examine the topic of social media in the workplace, identifying the most common areas of its use in employee management. It is evident that the extent to which these tools are employed often depends on their specific nature. For instance, the utilisation of

LinkedIn is primarily beneficial in terms of socialisation, yet it can also serve as a pivotal instrument for recruitment or the dissemination of knowledge. Similarly, *YouTube* is typically employed for entertainment and relaxation purposes within the workplace. However, organisations are also interested in utilising it for professional training purposes (Table 3).

Table 3.

The extent of social media utilization in different fields

Type of social media	Fields					
	Recruitment and employment branding	Communication and distribution	Collaboration and social learning	Management of knowledge	Training and development	Motivation and management
Social networking sites (e.g. Facebook, Platform X, Instagram)	++	+++	+++	++	-	++
Professional networking sites (e.g. LinkedIn, GoldenLine)	+++	+++	+++	-	-	+
Video and photo-sharing communities (e.g. YouTube, Vimeo, Pinterest)	+++	+++	+++	++	+++	++
Quick messaging portals (e.g. Messenger, WhatsApp, Signal, Discord)	+	+++	+++	+++	+	++
Blogs and microblogs (WordPress, Tumblr)	-	++	++	++	+	++
Videoconferencing tools (e.g. Skype, Zoom, Teams, Hangout, Google Talk)	+++	+++	+++	+++	+++	++
Asynchronous communication tools (e.g. email, forums, shared calendars, group mailing lists)	++	+++	+	+	+	-
Cloud-based applications (e.g. Dropbox, OneDrive, Google Drive)	+	+++	+++	+++	++	-
Dedicated corporate applications (e.g. Github, Slack, Trello, TeamViewer, Yammer)	-	+++	+++	+++	++	+++
Music streaming apps (e.g. internet radio, music services, Spotify, Tidal, YouTube recordings)	-	++	+	+++	+++	-
Movie streaming apps (e.g. Netflix, Showmax, HBO GO)	-	-	-	+	+	-
Virtual game worlds	++	+	+	+	+++	+

importance:- noone or almost any; + low; ++ medium; +++ high

Source: Own study.

Despite the increasing popularity of social media in professional settings (Cao et al., 2012; Van Zoonen et al., 2017; Mazurek, 2018; Alexander et al., 2019; Hosain et al., 2020; Keppeler, Papenfuß, 2021), the utilisation of these technologies has both positive and negative consequences (Hys, 2020). A review of the literature reveals a range of findings, often with conflicting opinions, regarding the impact of social media on the workplace. Research in this area focuses on some key areas, including recruitment, employer image, communication, collaboration, knowledge management, training and development, and employee motivation (Table 4).

Table 4.*Positive and negative consequences of using ESM*

Areas of usage SM	Positive Consequences	Negative Consequences
<p>Recruitment and employment branding</p> <p>(<i>Kluemper et al., 2016; Alexander et al., 2019; Adjei et al., 2020; Anatoliy et al., 2020; Hosain et al., 2020; Hanu et al., 2020; Keppeler & Papenfuß, 2021</i>)</p>	<p>Quicker and easier recruitment: SMs are an important tool in the recruitment process, enabling employers to reach a wide pool of candidates and candidates to find job opportunities more easily and learn about what potential employers have to offer.</p> <p>Monitoring and promotion in the labour market: employers use SM to promote the organisation, build its image and search for talent, platforms such as LinkedIn, and GoldenLine allows them to reach a wide pool of potential employees and interact in real time.</p>	<p>Increased employee turnover: SMs facilitate the search for new jobs, which can increase employee turnover and reduce long-term commitment to the company.</p> <p>Cybervetting and employer screening: vetting a potential candidate on SM or controlling an employee can be unethical and sometimes abused.</p> <p>Reputational risk: inappropriate employee behaviour in SM can negatively affect the company's image.</p>
<p>Communication and distribution</p> <p>(<i>Mäntymäki & Riemer, 2016; Csobanka, 2016; Madsen, 2016; Lee & Lee, 2018; Lupa-Wójcik, 2018; Simpson et al., 2018; Hysa & Spalek, 2019; Buzoianu & Bîră, 2021; Oltra González et al., 2021</i>)</p>	<p>Quicker and more efficient communication: SM facilitates fast and efficient communication between employees, regardless of their location.</p> <p>Supporting remote and distributed working: facilitating teleconferencing and videoconferencing during project teams, including international ones.</p>	<p>Work-life balance problems: barriers between professional and private spheres disappear, and instant and continuous communication leads to a lack of rest and distance.</p> <p>Data and information security problems: employee disclosure of confidential organisational data, security problems, hacking of accounts and organisational resources, technical problems.</p> <p>Difficult to monitor: it can be difficult to monitor employee SM activity, while too tight control can lead to privacy and trust issues.</p>
<p>Motivation and engagement</p> <p>(<i>Lankton et al., 2017; Lim et al., 2021; Bizzi, 2018; Yen et al., 2021; Yu et al., 2018; Andel et al., 2019; Presthus & Vatne, 2019; Oksa et al., 2021; Kahtani & Sulphay, 2022; Koay et al., 2022; Korzynski & Protsiuk, 2022</i>)</p>	<p>Increasing employee engagement and motivation: through gamification, recognising and rewarding achievements and promoting organisational culture, SM can be used to increase employee engagement and motivation, SM is a tool that builds and sustains commitment to various business issues and motivates employees to participate more frequently in company events.</p>	<p>Lack of life-work balance: the boundary between free time and work disappears, which leads to burnout and a decline in productivity and commitment.</p> <p>Decreased concentration on tasks: Excessive use of SM in the workplace can lead to a decrease in commitment to tasks.</p> <p>Privacy Threat: Concerns about privacy and information security can cause stress and reduce employee motivation.</p> <p>Decreased Productivity: Excessive use of SM can lead to an overall decline in productivity, which negatively affects overall team performance and morale</p>

Cont. table 4.

<p>Collaboration and social learning</p> <p>(Kluemper et al., 2016; Van Zoonen et al., 2017; Lupa-Wójcik, 2018; Yu et al., 2018; Hysa & Spalek, 2019; Borst et al., 2020b; Miković et al., 2020; Godber & Atkins, 2021; Yen et al., 2021).</p>	<p>Virtual meetings are a tool for connecting interest groups.</p> <p>Collaborative platforms: collaborative areas are created for company departments, and individuals and to work on projects, share experiences.</p> <p>Creation of project groups: SMs enable the creation of project groups, the rapid exchange of information in a group, regardless of the place of work, the submission of ideas, etc.</p>	<p>Risk of wasting time on private conversations and non-work related matters. Work productivity decreases due to wasting valuable time reviewing private accounts for too long.</p> <p>Comparing oneself with others: Employees may compare their performance with that of others, which can lead to frustration and lower motivation, especially if they feel less appreciated or underperform.</p> <p>Negative psychosocial effects: Excessive use of social media can lead to job burnout, stress and problems with work-life balance.</p> <p>Polarisation and conflicts: public discussions on controversial topics can lead to polarisation of opinions and conflicts within the team.</p>
<p>Training and development</p> <p>(Kluemper et al., 2016; Chawinga, 2017; Lankton et al., 2017; Keenan et al., 2018; Anderson, 2019; Oltra González et al., 2021; Kolling et al., 2022; Alturki & Aldraiweesh, 2024)</p>	<p>Improved training: thanks to social media platforms, employees have access to a variety of educational resources, webinars, online courses and discussion groups, which promotes their continuous professional development.</p> <p>Increased creativity and innovation: by being more creative, an employee improves his or her skills and more effectively supports the activities of the organisation in which he or she works.</p>	<p>Distraction: social media can distract employees from training programmes and development sessions, reducing the effectiveness of these initiatives.</p> <p>Superficial learning: the use of social media can encourage the consumption of information at a rapid pace, which can lead to a superficial understanding of the training material.</p>
<p>Management of knowledge</p> <p>(Mauroner, 2016; Karam & Kitana, 2018; Yu et al., 2018; Borst et al., 2020a; Yen et al., 2021).</p>	<p>Supporting knowledge sharing: SM enables knowledge and documents to be easily shared within the organisation, which promotes better management of the company's information and intellectual resources.</p> <p>Access to a wide knowledge base: social media enable employees to access various sources of knowledge, articles, online courses and webinars, which support their development and self-education.</p> <p>Networking and exchange of experiences: employees can establish contacts with industry experts, participate in discussions and exchange experiences, which promotes professional development.</p>	<p>Data and information security issues: the use of SM can increase the risk of data leakage and privacy breaches, especially if employees do not follow proper security policies.</p> <p>Risk of reduced productivity: excessive use of SM for private purposes may lead to distraction and reduced work efficiency.</p> <p>Negative psychosocial effects: excessive use of SM can lead to burnout, stress and work-life balance issues</p>

Source: Own study based on Kluemper et al., 2016; Mauroner, 2016; Chawinga, 2017; Lankton et al., 2017; Van Zoonen et al., 2017; Karam, Kitana, 2018; Keenan et al., 2018; Lupa-Wójcik, 2018; Yu et al., 2018; Alexander et al., 2019; Anderson, 2019; Hysa, Spalek, 2019; Adjei et al., 2020; Anatoliy et al., 2020; Borst et al., 2020a; Hosain et al., 2020; Miković et al., 2020; Godber, Atkins, 2021; Keppeler, Papenfuß, 2021; Oltra González et al., 2021; Yen et al., 2021; Kolling et al., 2022; Alturki, Aldraiweesh, 2024.

In reference to research problems (P2), (P3), an analysis of the literature on the subject revealed the positive and negative consequences of the use of social media by employees in the workplace during working hours.

4. Discussion

Recruitment and employment branding

Recruitment and employment branding. A review of the literature noted that undoubtedly the area where social media has found its widest application is in recruitment and employee selection (Hosain et al., 2020; Keppeler, Papenfuß, 2021; Alexander et al., 2019; Kluemper et al., 2016). Research by Alexander et al. (2019) indicates that among 202 recruiters, 37% of them used social networks to 'screen' a potential employee (Alexander et al., 2019). This is primarily because potential employers find a lot of valuable information about candidates on social networks that they would not get from other sources. This is especially true if they relate to the young generation Y or Z, who are keen to post information about themselves on social networks (Briggs, 2020; Deloitte Insights, 2021; Nintex, 2021; Szymkowiak et al., 2021; Adjei et al., 2020).

Social media enables recruiters to obtain anonymous information on candidates' interests, political and religious beliefs, and views, as well as their leisure activities, marital status, the size of their farm, and their assets (Hysa, 2022). In comparison to application documents, which may be exaggerated, this information is often more reliable. Consequently, employers readily turn to such sources. Nevertheless, Anatoliy et al. (2020) highlight the ethical considerations and compliance with existing legal regulations by prospective employers (Anatoliy et al., 2020). Consequently, the conscious use of diverse information sources to corroborate candidate data throughout the recruitment process in a morally sound manner represents a contemporary challenge for employers (Karasek, Hysa, 2020).

SM is also used to create a positive employer image from the public's perspective. As Hanu et al. (2021) note, employees can actively participate in the company's branding, promote the company's products and services and engage more with customers (Hanu et al., 2021). At the same time, according to Keppeler & Papenfuß (2021), inappropriate employee behaviour on social media can negatively affect the company's image - so context can significantly affect image creation (Keppeler, Papenfuß, 2021). Simultaneously, Bizzi (2018) raised a completely different public relations perspective. He indicates that 76% of employees using social media in the workplace have taken an interest in other organisations (Bizzi, 2018). Consequently, different scenarios can therefore be envisaged regarding employee behaviour. On the one hand, employees who use social media at work may show more engagement and, as a result, positively influence work productivity. In another scenario -

employees may show unethical attitudes towards the employer, take sabotaging and coercive actions (e.g. more favourable economic or organisational conditions, etc.), or actions lacking loyalty to the employer. They leave the company when they receive a better offer.

Communication and distribution

As Mäntymäki and Riemer (2016) point out, professional use of social media can furthermore support formal and informal communication in the work environment (Mäntymäki, Riemer, 2016). A similar position is presented in their study by Buzoianu & Bîră (Buzoianu, Bîră, 2021). Tools such as Slack, Microsoft Teams or Yammer, they argue, allow for the creation of working groups, the exchange of information in real-time and the organisation of virtual meetings. Platforms such as LinkedIn enable the establishment and maintenance of professional contacts, which fosters the exchange of knowledge and experiences and facilitates finding new career opportunities (Oltra González et al., 2021; Lee, Lee, 2018). Especially for younger generations, SM is a common channel of communication (Shane-Simpson et al., 2018; Csobanka, 2016). Therefore, the use of SM provides an opportunity to support efficient and effective team communication in organisations and project teams (Hysa, Spalek, 2019; Lupa-Wójcik, 2018). As noted by Van Zoonen et al. (2017) and Godber & Atkins (2021), better communication between employees is part of creating an organisational culture based on fostering a sense of community and social support that enhances employee engagement at work (Godber, Atkins, 2021; Borst et al., 2020b). Confirmation of these relationships was addressed by Kuvaas (2006) and Van Zoonen (2017), who in their research confirmed a positive relationship between social media communication and work engagement (Van Zoonen et al., 2017; Kuvaas, 2006). An engaged employee is more productive than one who lacks engagement (Oksa et al., 2021; Ewing et al., 2019).

Nevertheless, it is important to note that there are some limitations and obstacles to effectively reaping the benefits of social media communication in an organisation. Madsen (2017) identified four obstacles to motivating employees to use internal social media for communication (Madsen, 2017):

- employees may not see the professional benefits of using ESM,
- colleagues may not understand the informal nature of communication,
- corporate social media has not been treated as a *natural* part of everyday work in the organisation,
- top managers support internal social media mainly with words rather than actions.

This means that the conscious use of SM by employees in the workplace requires further development of standards and formulation of rules for their effective use of SM.

Collaboration and social learning

SMs make it easier for employees to establish new relationships and significantly strengthen existing ties. This is particularly important in large multinational companies. Social networks reveal the complex, informal social structure of a company. Employees who belong to a large and diverse social media network are seen as more valuable social capital than those with small,

less diverse networks (Miković et al., 2020; Kluemper et al., 2016). The nature of relationships within a social network can also be used to classify different types of social capital. Such social networks serve to connect employees from different spheres and fields of work, thus creating a platform of opportunities through a large amount of resources and information sharing (Kluemper et al., 2016).

However, the current literature indicates that the most significant negative effect of social media use in the workplace is the loss of productivity (Lim et al., 2021). Furthermore, Yu et al. (2021) have identified exhaustion among employees as a consequence of the information and communication overload associated with the excessive use of social media (Yen et al., 2021; Yu, 2018). Furthermore, public discussions on controversial topics can also lead to the polarisation of opinions, conflicts within the team, and ultimately reduced employee productivity (Koay et al., 2022; Korzynski, Protsiuk, 2022; Andel et al., 2019).

Management of knowledge

The ease and speed of communication via social media facilitates the sharing of knowledge within an organisation, as evidenced by studies conducted by Babu et al. (2020), Choi et al. (2014), Nielsen and Razmerita (2014) and Sigala & Chalkiti (2015) (Babu et al., 2020; Keenan et al., 2018; Choi et al., 2014; Nielsen & Razmerita, 2014). As researchers have observed, SM platforms facilitate more effective knowledge sharing and collaboration within an organisation, thereby enhancing organisational productivity and competitiveness (Borst et al., 2020a; Karam, Kitana, 2018; Mauroner, 2016). Consequently, employers who permit the utilisation of networking sites within the workplace may potentially experience augmented productivity, enhanced employee engagement and enhanced overall performance.

Training and development

Another workplace-related area where social media can find its application is in the process of adapting and training new employees (Alturki, Aldraiweesh, 2024). These media facilitate communication, allowing for a quick and convenient way to get to know both other employees of the company (their interests, background, lifestyle) and the organisation's policies (Fishman, 2020). Making interpersonal connections is often easier in the virtual world than in the real world. Therefore, organisations can use both external (e.g. Facebook) and internal social media (e.g. Yammer) to adapt new hires. Facebook, YouTube, Webinars and other social media provide an online environment that also allows hired employees to develop and improve their skills by communicating and innovating (Kolling et al., 2022; Lankton et al., 2017; Kluemper et al., 2016). In training, social media platforms such as Second Life and Lotus Workplace allow companies to create virtual training workspaces to allow employees to meet virtually, organise events, practice corporate communication, and conduct training sessions, all within an immersive virtual learning environment.

It is obvious that data leakage and privacy breaches are more likely to occur in such a virtual work environment, particularly in the absence of proper security policies (Oltra González et al., 2021; Anderson, 2019; Keenan et al., 2018; Chawinga, 2017).

Motivation and engagement

Social media can help reduce stress by providing relaxation and recovery, which is helpful when tasks are overwhelming and overburdening. Logging in to social media accounts can also help employees feel more connected to their colleagues, leading to a positive work environment and creating a proactive work atmosphere (Kahtani, Sulphery, 2022; Oksa et al., 2021; Bizzi, 2018). Furthermore, social media platforms allow for public recognition of employees' achievements and rewards, which can increase their motivation and job satisfaction. In addition, social media can foster creativity and innovation by facilitating access to new ideas and trends in the industry, which can contribute to better learning and development of employees and greater engagement and motivation at work (Boahene et al., 2019; Ashraf, Javed, 2014).

However, Yu et al. (2018) adopt a critical approach to this issue. They primarily identify the problem of rivalry among employees. Employees may compare their achievements with those of others, which can lead to frustration and lower motivation, especially if they feel less appreciated or underperform (Yu et al., 2018). Furthermore, the excessive use of social media can result in a general decline in productivity, which has a negative impact on overall productivity and team morale. Furthermore, the overuse of social media can have negative psychosocial effects, including the development of job burnout, stress, and issues related to work-life balance (Korzynski, Protsiuk, 2022; Babu et al., 2020; Andel et al., 2019).

Monitoring employee social media activity can be complicated, while overly tight control can lead to privacy and trust issues (Koay et al., 2022). Furthermore, Lankton et al. (2017) and Presthus & Vatne (2019) highlight that concerns regarding privacy and information security can cause stress and reduce employee motivation (Presthus, Vatne, 2019; Lankton et al., 2017).

In conclusion, it is not possible to state with absolute certainty that the use of social media in the workplace is a positive or negative phenomenon. The effects of social media use in the workplace are multidimensional and depend on the way it is implemented, the approach of managers and the way and style in which employees are managed. In order to maximise the benefits and minimise the negative consequences, organisations should put in place clear policies on the use of social media and train their employees as well as their managers.

5. Conclusion

The use of social media in the workplace offers numerous benefits for both employers and employees. It aids in recruitment and employer branding, facilitates communication and the exchange of knowledge and ideas among employees, supports training and skill development, and often increases engagement and motivation, leading to higher productivity. However, excessive use of social media can result in the misuse of organizational resources and encourage undesirable behaviours such as cyberloafing (Lim et al., 2021), cyberslacking (Alharthi et al.,

2021), cybervetting (Anatoliy et al., 2020; Berkelaar, Harrison, 2016), and abuse and cyberbullying (Koay et al., 2022; Lim et al., 2021). These issues can delay organizational processes and reduce employee efficiency.

Nevertheless, the impact of social media in the workplace is undisputable, with both positive and negative consequences. It represents a new reality in the work environment that cannot be ignored. This emergence presents specific challenges for managers and organizations:

- **The blurring of Professional and Personal Boundaries:** Employees increasingly need to be accessible for work-related communications via new technologies, which can lead to an imbalance between work and personal life.
- **Job Market Monitoring:** Social media enables employees and employers to track new development opportunities.
- **Access to Organizational Culture Information:** Potential employees can easily acquire knowledge about specific organizations.
- **Working in Multicultural Teams:** Employees are more frequently working in multicultural and virtual teams across different parts of the world, where social media is a crucial tool for collaboration and knowledge sharing.
- **Flexible Employment Forms:** The growing number of skilled workers employed under flexible conditions requires the development of new communication and collaboration rules to support their professional growth.
- **Demographic Changes:** The expectations of Generation Y and Z compel employers to use different motivation and management tools.

In conclusion, the authors of this study have attempted to systematize the existing knowledge on the effects of social media use by employees in the workplace. It is the authors' hope that the issues addressed will initiate a multifaceted discussion within the field.

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PUBLIC PARTICIPATION TOOLS FOR JUST TRANSITION. ENGAGING STAKEHOLDERS IN THE PROCESS OF TRANSFORMATION OF THE MINING REGION IN THE OPINION OF SELECTED ENTITIES OF THE SILESIAN VOIVODESHIP

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Purpose: The aim of the article is to present the results of research on public participation tools as a method of engaging stakeholders in the Just Transition process.

Design/methodology/approach: Based on a comparative analysis of the results of qualitative and quantitative research carried out as part of the Regional Observatory Transformation Process, ROPT project, the effectiveness of individual tools of social participation, in the opinion of the surveyed entities of the Silesian Voivodeship has been discussed.

Findings: The key conclusions from the conducted research indicate that the readiness and knowledge, especially of entrepreneurs, for the transformation process towards a green economy is insufficient. There is a need for greater involvement of entrepreneurs in the energy and socio-economic transformation process as entities that know the market best and are the driving force behind economic change. It is essential to communicate details about this process and use a vast range of public participation tools to ensure stakeholders are effectively involved.

Research limitations/implications: If research is reported on in the paper this section must be completed and should include suggestions for future research and any identified limitations in the research process.

Originality/value: The paper refers to original research within the ROPT project. The conclusions and recommendations were the basis for the methodological assumptions to support the Just Transition process in the second edition of the ROPT2 project to strengthen the idea of the public participation for Just Transition.

Keywords: social participation, engagement, mining region, just transition.

Category of the paper: Research paper.

1. Introduction

Public participation serves multiple purposes. It enhances the legitimacy and accountability of decisions, builds trust between the public and decision-makers, and can lead to more sustainable and accepted outcomes by incorporating local knowledge and addressing

community needs. Additionally, it is a critical component of a just transition in areas such as environmental sustainability, where engaging affected communities can ensure that the benefits and burdens of transitions, like moving towards low-carbon economies, are equitably distributed (Climate Change Committee, 2022; Cherry et al., 2017; Dietz&Stern, 2008).

Public participation tools are techniques and methods used to engage individuals and communities in decision-making processes, particularly in areas like environmental planning, urban development and policy-making. The most popular examples of public participation are participatory budgeting, public consultations, referendums. The methods of public participation are diverse, ranging from traditional tools like public hearings and surveys to more innovative approaches such as participatory mapping, online platforms, and deliberative polling. The choice of method often depends on the context, objectives of the participation, and the specific demographic or stakeholder group involved (Barnes, 2019; Liu et al., 2020; Evans-Cowley&Hollander, 2010). The other key public participation tools are presented in table 1.

Table 1.

Key public participation tools

Public participation tools	Short characteristics
Surveys	Used to collect data from a large number of people. Surveys and questionnaires can be conducted online, via mail, or in person, and are useful for gathering public opinion on specific issues.
Public meetings and hearings	Formal gatherings where stakeholders can voice their opinions, ask questions, and engage with decision-makers. These are often required for significant public decisions, like urban planning or environmental assessments.
Workshops and focus groups	Interactive sessions designed to gather detailed feedback from specific groups. Workshops often involve small group discussions, while focus groups concentrate on gathering in-depth opinions from a targeted demographic.
Participatory mapping	Engages communities in creating maps that reflect their perceptions, knowledge, and priorities regarding land use, resources, or hazards. This is often used in environmental planning and urban development.
Advisory committees and task forces	Groups of stakeholders, experts, or community representatives who provide ongoing input and recommendations on specific projects or policies.
Citizen juries	A group of citizens selected to deliberate on an issue and provide recommendations. This tool is particularly useful for complex or contentious issues, allowing for a more in-depth examination.
Charrettes	Intensive, multi-day design workshops that bring together stakeholders, experts, and the public to collaboratively develop solutions to planning and design challenges.
Online platforms and digital tools	Websites, social media, and apps designed to facilitate public engagement, such as interactive maps, discussion forums, or online voting platforms.
Public comment periods, public consultations	A specific timeframe during which the public can submit written feedback on proposed plans, policies, or regulations. This tool is often used in environmental impact assessments and urban planning.
Design thinking workshops	Techniques that engage the public in imagining and articulating their desired future for a community or issue area, often used in urban planning and community development.
Interactive exhibitions	Physical installations or mobile units that bring information to the public in an interactive format, allowing people to engage with issues in a hands-on manner.
Deliberative polling	A method that combines deliberation in small group discussions with scientific random sampling to provide public consultation on complex issues.
Public art	Creative approaches to engage the public on social issues through art installations, performances or participatory theater, which can provoke discussion and reflection.

These tools vary in their applicability depending on the context, goals of the participation process, and the audience involved (Knight&Schwartzberg, 2020). The efficiency of public participation often depends on using a combination of these tools to reach and engage a diverse group of stakeholders.

1.1. Just Transition

The concept of Public Participation is particularly important for the Just Transition process. On December 11, 2019, Ursula von der Leyen, President of the European Commission, presented the assumptions of the EU Green Deal, a comprehensive strategy of the European Union on environmental protection and the fight against climate change (European Commission, 2019). The long-term goals of carbon neutrality adopted by the European Union by 2050 (European Commission, 2019) pose a huge challenge to coal regions to carry out a Just Transition that will require changes at the social, economic and technological levels. Integral processes are clearly indicated, i.e. just transition, sustainable use and fair distribution of resources and social justice (European Commission, 2019). In a broader sense, Just Transition is a concept of comprehensive restructuring and transformation of coal regions, an idea of socio-economic policy, perceived as a wave of changes in the fuel and energy complex in the post-socialist economy, entailing not only adjustments in the labour market or changes in the structure of production, but also identity transformations (Drobniak et al., 2020; Köhler et al., 2019).

Financial support and technological assistance for the regions that will be most affected by the changes related to the objectives of the Green Deal is to be provided by The Just Transition Mechanism, which allocates €100 billion for assistance in the years 2021-2027 (European Commission, 2019). The efficient use of the financial mechanism supporting Just Transition is to be supported by National and Territorial Just Transition Plans (KPST, 2021; TPST, 2022), which strongly emphasize the importance of social engagement.

2. Methodology

This article presents the results of qualitative and quantitative research carried out as part of the Regional Observatory Transformation Process, ROPT project. The research was carried out in 2022 and 2023 as part of the Regional Observatory of the Transformation Process (ROPT) project. Based on a comparative analysis of, the effectiveness of individual tools of social participation, in the opinion of the surveyed entities of the Silesian Voivodeship has been discussed.

The basis for accomplishing the research goal was the triangulation of research tools (Flick, 2012; Konecki, Chomczyński, 2012; Mazurek-Łopacińska, Sobocińska, 2018), which encompassed qualitative research as desk research, focus group interviews (FGI), individual in-depth interviews (IDI) and quantitative research as CAWI/CATI questionnaire. In the selection of the qualitative research group, non-probability sampling methods were used, involving groups of respondents from different stakeholder circles involved in the transformation process. Non-probabilistic techniques consist in the selection of a sample according to the subjective assessment of the researcher (Kohler, 2019), which is related to the scope of the research conducted and the expert location of the GIG-PIB researchers involved in the transformation process.

The FGI participants were 142 experts representing local government administration, industry companies, industry organisations, labour market institutions, local self-regulatory organisations and local development agencies, the social environment, including business-related institutions, NGOs and many more. The qualitative research were complemented with 13 individual in-depth interviews with experts representing varied professions and professional experience.

142 non-mining entrepreneurs took part in the CAWI/CATI quantitative research. The survey was mostly attended by representatives of micro and small enterprises (75,3%). Nearly every fourth respondent (23,9%) represented a medium-sized or large company. The entrepreneurs who took part in the survey represent various sectors of ownership. They mainly represent the private sector (74%), mixed with a predominance of private (10,5%), public (8,4%) and mixed with a predominance of public (7%).

The largest number of companies covered by the survey operate in the following sectors: trade and services (19,7%), other service, municipal, social and individual activities (16,2%), education (11,9%), industry (11,2%), health care and social care (10,5%), construction (7,7%).

All types of research (FGI, IDI, CAWI) have been conducted in eight subregions of the Silesian Voivodeship, per the NUTS3 classification and the specifics of the ROPT project: Bielski, Bytomski, Częstochowski, Gliwicki, Katowicki, Rybnicki, Sosnowiecki and Tyski.

3. Research results

3.1. Conceptualization of the public participation notion

In the literature on the subject, the term public participation is very often used together or interchangeably with the term social participation, public engagement or social dialogue. For the purposes of this article and the conducted research, the basic definition was that public participation is active participation and a way to participate in events and processes that affect

residents. The purpose of public participation is to enable participants to take action and to be heard in decision-making processes and, as a result, to affect the final outcome (Lee, 2018).

Referring to the above problem, the introductory question to the research was the question about awareness of the concept of just transition. When asked which of the definitions of the term "Just Transition" given below is the most accurate in your opinion, 40,8% of non-mining entrepreneurs believe that just transition is primarily about dialogue and cooperation with all local and regional communities. For 22,5% of respondents, just transition means decarbonization and transition to a climate-neutral economy. 9,1% of non-mining entrepreneurs indicated the need to provide support for companies in all industries cooperating with mining. 5% of respondents believe that Just Transition means changes that will only have negative economic and social effects, e.g. the closure of mining plants. Three respondents gave their own definitions:

1. A Just Transition is moving away from coal and moving to a climate-neutral economy, while providing support for companies in all industries cooperating with mining, but also support for the families of mining industry employees and employees of mining-related companies. Actions must be carried out in dialogue and with the consent of local communities, residents and with the help of the government.
2. Transformation involve the use of new technologies, e.g. coal gasification or its use in the production of graphene.
3. Just Transition is decarbonisation carried out in the least burdensome way for both companies cooperating with the mining industry and the families of mining industry employees, but also ensuring the protection of other companies and individuals for whom moving away from coal will be associated with high costs.

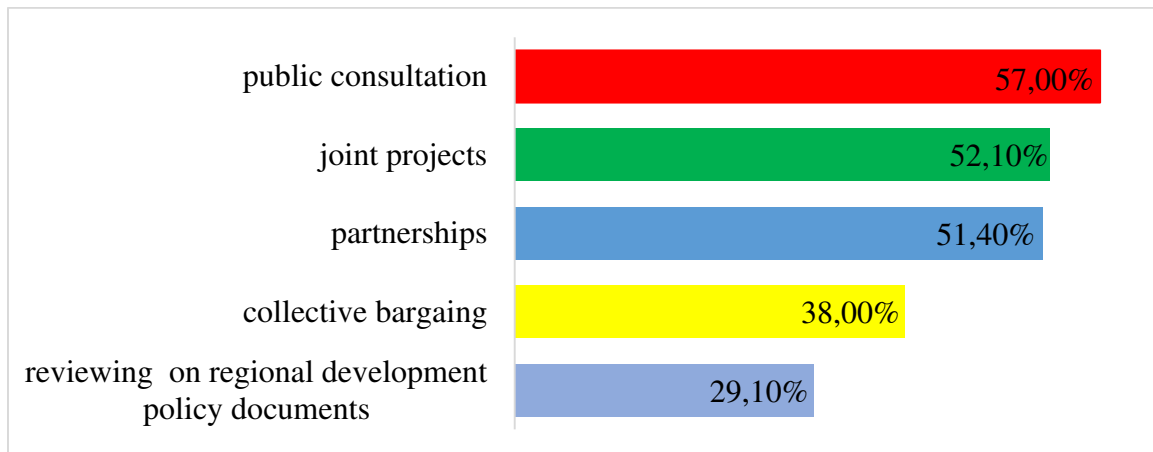
In a quantitative survey, addressed to non-mining entrepreneurs, the question was asked whether the region has a social dialogue with various stakeholders of socio-economic transformation, which is also an element of public participation. The majority of respondents to the CAWI survey (50,7%) could not give an answer. 23,2% of respondents believe that dialogue is being conducted, and 26% believe that dialogue is not being conducted.

Non-mining entrepreneurs cited the following as the most effective methods of participation in the Just Transition process:

- public consultations – 57%,
- joint projects – 52%,
- forming partnerships to work together – 51%¹.

The effectiveness of participation tools in the opinion of quantitative research respondents are presented at figure 1.

¹ In this case, more than 1 answer could be selected.



Notice: The values in the chart do not add up to 100% because the respondent may have selected more than 1 answer.

Figure 1. The effectiveness of participation tools in the opinion of CAWI research respondents.

As other examples of public participation activities on the transformation of non-mining entrepreneurs, they indicated:

- professional retraining and creating a new model of spending time outside mining habits,
- positive promotion of activities aimed at implementing the transformation.

In the next question of the survey, non-mining entrepreneurs were asked whether they had ever participated in forms of dialogue on the transformation of the region. It turned out that as many as 74% of the surveyed non-mining entrepreneurs had never participated in any of them. Every fourth respondent, 26% took part in this process. Respondents who were involved in the dialogue on the transformation of the region most often participated in information meetings or seminars (58,3%) and expert workshops (50%). These two forms of dialogue were by far the most frequently indicated by the respondents.

To a lesser extent, the following were indicated as forms of participation:

- collective bargaining - 22,2%,
- reviewing regional development policy documents - 16,6%,
- the Territorial Just Transition Plan consultations - 16,6%.

An analysis of the effectiveness of public engagement instruments in the process of mine closures was also carried out. Respondents to quantitative and qualitative research were presented with social dialogue instruments such as:

- collective bargaining²,
- signing a social agreement/industry contract,
- information meetings for dismissed employees of mining plants, exchange of information and good practices at the level of management boards of companies dismissing and wishing to employ mining employees,

² Collective bargaining has been added to the public participation tools as an important especially for the trade unions.

- information meetings for local communities of mining municipalities on the upcoming changes and the future of residents,
- public consultations of regional development documents, including local development strategies,
- participation in social dialogue institutions at the regional level (e.g. Provincial Councils for Social Dialogue),
- local development strategies,
- exchange of knowledge and information at the meetings of the Regional Team for Just Transition of the Silesian Voivodeship,
- creating bottom-up partnerships to implement a specific project,
- public hearings on planned activities in connection with the transformation process in mining subregions,
- lobbying, non-institutional dialogue, e.g. participation in informal meetings and talks.

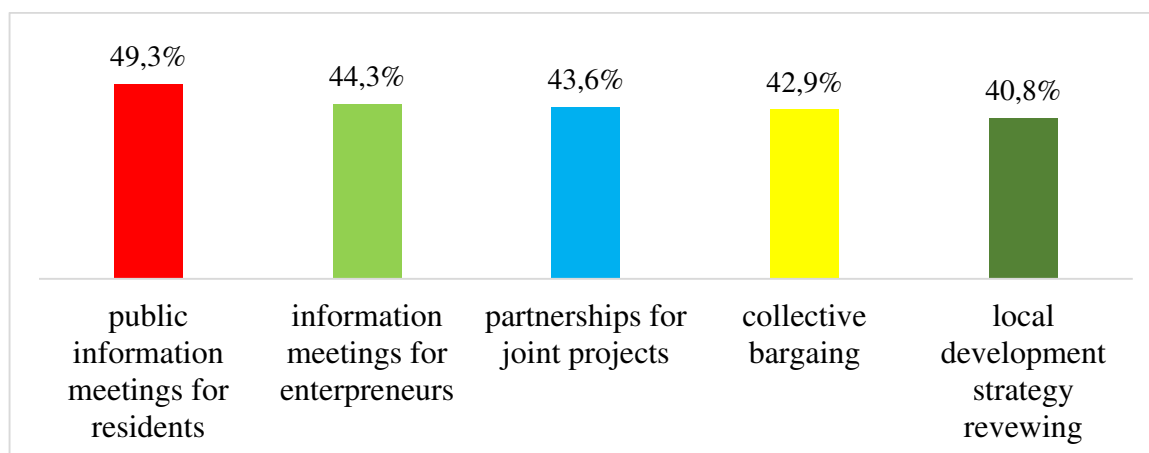
The above instruments were asked to be evaluated in terms of their effectiveness for the implementation of the Just Transition objectives. Respondents could indicate more than 1 answer. In the case of qualitative research of non-mining entrepreneurs, the respondents first mentioned:

- information meetings for local communities - 49,3%,
- information meetings for employees - 44,3%,
- creating partnerships to implement a joint project - 43,6%,
- negotiations between trade unions and the employer - 42,9%,
- Local development strategies - 40,8%,

Respondents from the non-mining industry considered the following instruments to be the least effective:

- industry contract - 19%,
- participation in social dialogue institutions at the regional level - 11,9%.

Non-mining entrepreneurs as "Others" additionally pointed the need to take into account in the public engagement process, aspects showing alternatives to life outside the mining environment, which is associated with the specificity of the mining community, customs, attachment to mining identity and culture, new opportunities or allowing oneself to close a multi-generational stage of life. The most effective instruments of participation for the implementation of just transition goals according to respondents to quantitative research are presented at figure 2.



Notice: The values in the chart do not add up to 100% because the respondent may have selected more than 1 answer.

Figure 2. The most effective instruments of public participation for the implementation of just transition goals according to respondents to CAWI research.

A comprehensive discussion of the tools of dialogue and participation according to the respondents of quantitative research is presented in the article “A detailed discussion of the tools of dialogue and participation according to the respondents of quantitative research is presented in the article Social dialogue in the transition process of a mining region. The key conclusions regarding to qualitative research to establish a social agreement around the transition process in the region, the stakeholders of this process and the authorised parties must conduct transparent, substantive and regular social dialogue. It is the necessity to develop various forms of supporting social dialogue at the local level. The most desirable forms of this support includes stable cooperation in interdisciplinary groups bringing together various stakeholders, supporting existing structures of stakeholders cooperation, supporting informal grass-roots movements of mining district residents, good practices and exchange of knowledge (Jarosławska-Sobór, 2023).

Conclusions from qualitative and quantitative research on the effectiveness of public participation tools are presented collectively in Table 2. The level of efficiency was assessed by the degree of order ranked according to the percentage distribution of respondents' answers in a given question.

Table 2.

Efficiency of the public participation tools according to survey respondents

Public participation form	Level of familiarity	Suitability assessment
Collective bargaining	high	average
Signing of a social contract for the mining industry	high	average
Information meetings for dismissed employees of mining plants	high	high
Exchange of information and good practices at the level of management boards of companies dismissing and wishing to employ mining employees	high	high
Information meetings for local communities of mining municipalities	high	high
Public consultations of regional development documents, including local development strategies	medium	low
Participation in social dialogue institutions at regional level	high	low

Cont. table 2.

Local Development Strategies	medium	average
Exchange of knowledge and information at the meetings of the Regional Team for Just Transition of the Silesian Voivodeship	medium	low
Creating bottom-up partnerships to implement a specific project	high	high
Public hearings on planned activities in mining subregions	low	low
Non-institutional dialogue, e.g. participation in informal meetings	medium	high

4. Conclusions and recommendations

The key conclusions from the research indicated that the readiness and knowledge, especially of entrepreneurs, for the transformation process towards a green economy is insufficient. There is a need for greater involvement of entrepreneurs in the energy and socio-economic transformation process as entities that know the market best and are the driving force behind economic change. International research has also highlighted the need for involving communities in post-mining transitions. Successful cases show that participation tools, such as community forums and participatory impact assessments, help balance environmental restoration and local economic development. Community-driven energy projects as part of the Just Transition has been seen as an driving force of transition (Reverez et al., 2022). The European Union's Territorial Just Transition Plans involve extensive social dialogue, emphasizing collaboration between local governments, communities, and stakeholders to ensure a participatory approach (World Bank, 2023).

On the other hand, the expectations of GIG-PIB survey respondents are primarily early planning of transformation activities in order to prepare companies and employees and connecting various groups at the local level to develop common solutions and build the resilience of enterprises to change. However, not all forms of public participation were used in the stakeholder engagement process in the analysed period of time.

4.1. Recommendations

Based on the research, the following recommendations have been formulated to strengthen public participation for the purposes of transformation:

1. Raising social awareness is crucial for the Just Transition. The most effective is to disseminate knowledge about transformation processes among stakeholders through the exchange of good practices.
2. The main goal of public participation should be to prepare stakeholders from different groups for change, by seeking dialogue and cooperation at the local level.
3. For the future of local communities in mining municipalities, regular interdisciplinary meetings on the directions of transformation, changes taking place in the world and socio-economic environment are important.

4. It is necessary to expand cooperation at the local level and to involve different groups of transformation stakeholders in the decision-making process more widely.

The most desirable forms of support for public participation are permanent cooperation in interdisciplinary groups, bringing together stakeholders from various sectors and areas of transformation, exchange of knowledge and support for already existing cooperation structures, especially those existing in small urban or rural municipalities, support for grassroots movements, good practices and exchange of knowledge on conducting social dialogue between regions, and study visits to places, where transformation projects have been implemented.

4.2. Summary

In connection with the above conclusions, the new project of the Regional Observatory of the ROPT 2.0 Process significantly expands the scope of public participation activities and tools. The ROPT 2.0 project started in June 2024 and will last until 31.12.2026. The project is co-financed by the European Union from the Just Transition Fund. The leader of the project is the Silesian Voivodeship, and there are: Central Mining Institute – National Research Institute Mining Chamber of Industry and Commerce, Katowice Special Economic Zone S.A., Agreement of Trade Unions "KADRA", University of Economics in Katowice, Union of Associations Polish Green Network and Trade Union of Miners in Poland.

The aim of the project is to support and improve the management of the just transition process in the Silesian Voivodeship, with particular emphasis on the issues of the labour market, diversification of economic activity and the potential of post-industrial areas, including post-mining areas, through the development of the activities of the Regional Observatory of the Transformation Process.

With regard to the conclusions of the ROPT project, the substantive scope of the ROPT2 project and the scope of use of various public engagement tools are extended. The project is implemented in four modules. The analytical and research module includes research and strategic and foresight diagnostic analyses on the process of just transition in the economic, social and environmental dimensions to better identify the needs and predict changes related to the transition process. The participatory and educational module aims to strengthen dialogue between various sectors of social and economic life and to promote cooperation and a participatory model of conducting the process of just transition of the region. This module will include, m.in, information, educational and networking events in the form of m.in workshops, meetings with a low degree of formality, study visits, information campaigns promoting partnership and cooperation, and good practice manuals for municipalities, entrepreneurs, trade unions and non-governmental organizations. The pilot module aims to develop innovative and model solutions, good practices and guidelines to improve the transformation process, which can be implemented locally or regionally. This form will be developed through various types of Transformation Laboratories: Dialogue, Economic, Partnership and through a citizens' conference conducted by the Polish Green Network.

The last module, strategic and implementation, aims to improve and strengthen the regional management system of the transformation process. The project is addressed to stakeholders of the just transition process in seven mining subregions of the Silesian Voivodeship, the subregions of Bielsko, Bytom, Gliwice, Katowice, Rybnik, Sosnowiec, and Tychy.

The planned effects include a very large number of initiatives strengthening the exchange of knowledge and experience between the stakeholders of the transformation process, information and educational campaigns carried out, consultations provided on activities conducive to climate neutrality, which are to contribute to improving the effectiveness of public participation tools.

Acknowledgements

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IMPLEMENTATION OF A CMMS CLASS SYSTEM FOR THE SUPPORT OF MAINTENANCE SERVICES IN ACCORDANCE WITH THE TPM PARADIGM IN A SELECTED MANUFACTURING ENTERPRISE

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Purpose: The paper presents the basic assumptions and the plan of the research work, which is directed at implementing a CMMS class system in a selected manufacturing enterprise to support selected maintenance tasks.

Design/methodology/approach: The research conducted at the company was based on participant observation, using social research techniques and a tool from the Root Cause Analysis group.

Findings: The analysis and diagnosis results were used to develop proposals for implementing a system to support maintenance and repair tasks in selected segments of the production system. These proposals included tool and organizational solutions to increase the efficiency and effectiveness of maintenance activities.

Research limitations/implications: While the issue of maintenance is a key component of manufacturing engineering, the article does not address other equally important areas, such as process design, optimization or quality control, which, with an integrated approach to manufacturing engineering, could lead to synergistic results.

Practical implications: The introduction of solutions based on the TPM paradigm will make it possible to systematically increase the stability of the production process by improving maintenance processes and reducing the risk and severity of the consequences of downtime and failures.

Originality/value: The paper's novelty is its systematic approach, which provides a practical framework for implementing a CMMS in a manufacturing environment. The diagnostic process and the resulting proposals for using the system to support maintenance and repair tasks in selected segments of the production system represent a form of process innovation. The paper is aimed at manufacturing companies seeking to improve maintenance operations and increase productivity by implementing modern management systems.

Keywords: TPM, CMMS, RCA, Lean Maintenance.

Category of the paper: Research paper.

1. Introduction

In today's globalized and highly turbulent industrial environment, maintaining production continuity is undoubtedly a fundamental condition for ensuring the competitiveness of any enterprise. In their search for effective productivity enhancers, companies are beginning to view peripheral tasks such as maintenance of machinery and equipment no longer simply as a technical necessity but also as a strategic source of savings. Undoubtedly, the reliability of production machinery directly affects a company's productivity (Wiśniewska, 2021, pp. 18-19). Still, it is worth considering the random nature of the timing of faults and failures of technical means. Frequent failures and downtime of the machinery fleet result in a reduction in the number of finished goods and, consequently, a reduction in the company's bottom line. For this reason, among the critical tasks of manufacturing enterprises should be ensuring the uninterrupted operation of the machinery park (Drożyner, 2017, p. 31; Ohno, 2008, p. 22; Stroller, 2015, p. 49). Significant costs resulting from unplanned equipment downtime and related repairs justify the increased interest of researchers and practitioners in machinery maintenance aimed at optimizing the operation of manufacturing entities. Taking up the subject of implementing the TPM paradigm, which is one of the methods derived from the Lean Management philosophy (Antosz, 2019, p. 37; Jasiulewicz-Kaczmarek, Mazurkiewicz, Wyczółkowski, 2023, p. 47), is due to the growing importance of this strategy in the Polish industrial environment. The label of Lean remains relevant and eagerly taken up in the manufacturing literature. At the same time, issues related to implementing TPM assumptions are relatively rarely addressed, indicating the need to fill this cognitive gap and undertake research on this topic.

2. Determinants of the choice of research subject

The enterprise, which is the subject of the research that forms the basis of this work, has oriented its activities to the production of locking systems - locks and hinges. The company offers a diverse range of locks and locking systems in various models and with multiple functions, to most effectively meet the dynamically changing needs of the market. A rich assortment of products is linked to the diversity of technology dedicated to its production and, therefore, to the machinery park, which in the context of maintenance means a diversity of maintenance procedures tailored to the specifics of individual machines and equipment. Since the company's management did not agree to this, the name of the company under study will not be used in this study.

In the course of the research described in this paper, it was found, first of all, that the studied enterprise does not implement a conscious maintenance management strategy (Antosz, 2019, p. 23; Bartochowska, Ferenc, 2014, p. 11) and does not use terminology specific to this area. However, it has been observed that, as it were, unconsciously, the Run To Failure strategy of machine operation, i.e. use until failure or symptoms of failure appear, is used in the surveyed company (Antosz, 2019, pp. 23-24; Fidali, 2020, p. 19; Jasiulewicz-Kaczmarek et al., 2023, p. 22; Werbińska-Wojciechowska, 2018, p. 20), supplemented by cyclic, though not very frequent, reviews (Kazmierczak, 2000, p. 21; Vanderschueren et al., 2023). In doing so, there is no analysis of effectiveness (Fidali, 2020, p. 14; Kosicka, Mazurkiewicz, 2015, p. 78), nor are the far-reaching effects of doing so analyzed.

3. Identification of disturbances in the operation of machinery and equipment

In the course of conducting participatory observation in the technical department of the company under study, the regular occurrence of incidents such as breakdowns and malfunctions of production machinery and equipment, resulting in the downtime of certain segments of the production line, was observed. In order to obtain a detailed picture of the situation, the 5W2H method was applied (Fig. 1). This revealed that the people most frequently encountering the defined problems are the production line operators and customers, who, as a consequence of production downtime, complain about the untimely fulfillment of their orders. These incidents occur almost daily, and each machine malfunction causes interruptions in the production process, increasing operating costs and the risk of losing customers to more operative competitors. It was found that in a period of less than eight months, nearly 677 hours were spent repairing equipment at the surveyed company, causing minor or major production disruptions.

It was noted, however, that the disturbances reported by the operators were only a superficial symptom of deeper-rooted problems which, to better understand them, were analyzed using a methodology known as Root Cause Analysis (RCA). A fault tree diagram (Fig. 2) was drawn up, based on the 5WHY technique (Stroller, 2015, p. 70), which involves asking successive "why?" questions until the root causes of the situation under investigation are identified.

<p>1. WHO? Who detected the problem? Production line operators and customers.</p> <p>2. WHAT? What constitutes the problem? What happens when it occurs? Prolonged production process downtime due to failures.</p> <p>3. WHEN? When does the problem occur? Almost every working day.</p> <p>4. WHERE? Where does the problem appear? On the production line.</p>	<p>5. WHY? Why is this situation a problem? Every minute of machine downtime prevents the continuation of production.</p> <p>6. HOW? What are the causes of the situation, and how can they be eliminated? The current situation may have multifaceted causes.</p> <p>7. HOW MANY? What is the scale of the problem? How much time does the problem consume? The company under study spent nearly 677 hours on repairs of its production equipment in less than eight months.</p>
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Figure 1. An example of using the 5W2H method to describe the problem.

Source: Own elaboration.

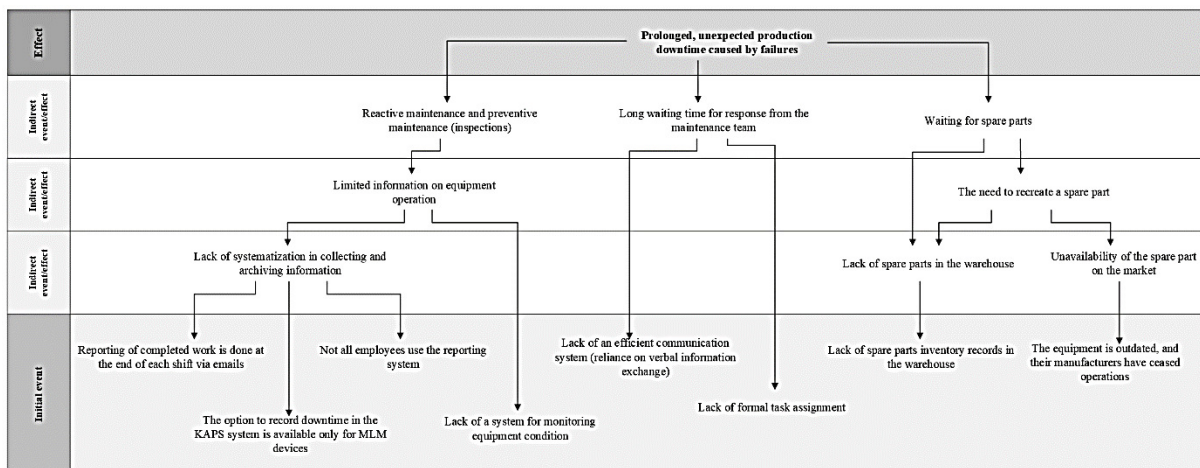


Figure 2: Fault tree diagram.

Source: Own elaboration

It was thus concluded that the maintenance system at the company under study operates in a reactive mode due to the lack of sufficient information based on the operation of machinery and, thus, the ability to recognize symptoms of impending failures. The lack of systematic monitoring of residual processes causes failures to occur unexpectedly. In addition, the verbal transmission of information delays maintenance services' reaction to the incident. The operator of a malfunctioning machine is forced to personally go to the UR department to notify service technicians or find them on the production floor. The existing form of reporting needs to be a sufficient source of data to describe the comprehensive history of machine operation. Not all incidents are recorded in the proprietary ERP system, the KAPS system currently used at the company under study. Information about the repair work carried out on a given day by UR employees is forwarded via email to the head of the technical department. It can also be

noted that employees could be more precise in describing the objects of their work in their reports, and the time spent on repairs is determined post-factum, leading to inaccuracies. In addition, materials and parts used during repairs are rarely indicated, which is key data for effective analysis of the cost of work performed and maintenance of machines. On the other hand, in warehouse management, a lack of record-keeping of received and issued spare parts was detected, which often leads to shortages and prolonged repair times as a result of waiting for the delivery of the missing component. These problems show a strong correlation, so the search for solutions was directed at finding a comprehensive solution, eliminating the sources of the mentioned disruptions, to improve the functioning of various areas of the organization, especially in managing fixed assets and human resources.

4. Implement improvements in maintenance management.

Based on the diagnosed disruptions and the results obtained using an interview questionnaire conducted among technical department employees, machine operators, and forepersons employed at the surveyed enterprise, the maintenance management needs of this enterprise were defined. These needs include scheduling inspections and maintenance, monitoring the condition of production equipment, recording all maintenance events, including failures and defects, and queuing maintenance events based on task priorities. In addition, it is necessary to calculate performance indicators for UR services, inspect the scope of work performed by these services, formalize and standardize reports on maintenance activities, archive information on work performed, and document repair history. It is also essential to record the retrieval and receipt of spare parts in the warehouse and to communicate information about their shortages to the engineering team, as well as to speed up the circulation of information about adverse events between operators and mechanics. Starting from such a list of needs, the objectives of implementing improvements in the maintenance system were detailed, which include reducing the waiting time for repairs and the duration of the repairs themselves, putting spare parts management in order, and ensuring an adequate level of availability of spare parts, and improving communication within the technical department and between the technical department and the production department.

The assumptions of the TPM concept, due to their focus on failure prevention, increasing availability, and maximizing the productivity of company assets, are an appropriate solution to the problems identified in the operation of the technical department of the studied enterprise. Before the implementation of the comprehensive maintenance strategy, pre-implementation work was carried out, during which the following was done: identification of the stakeholders of the UR system in the selected enterprise, identification of the requirements and objectives concerning the implementation of improvements within the management of maintenance

activities, determination of the inputs and outputs of the process of implementing the TPM concept, and how to measure the degree of fulfilment of the requirements (Drożyner, 2017, p. 70). It has been stated that, following the philosophy of Lean Management (LM), the implementation process should involve employees at all levels in the organization's hierarchy, with a particular focus on the employees of the technical department and the supervisors and operators of the production department along with the management of both departments (Lalitha, Rahmawati, 2020, p. 29; Legutko, 2009, pp. 11-13; Musa et al., 2015, pp. 165-166). In addition, it is advisable to include an external stakeholder who could act as an impartial coordinator of the implementation work.

Table 1.
Model service card

SERVICE CARD		
Device:		
Purpose/scope of service work:		
Responsible person:		
Date and time of commencement of service work:		
Actions performed:		
Tools used:		
Spare parts/consumables used:	Spare part/consumable:	Quantity:
Additional insights:		
Date and time of completion of service work:		
Signature of the performer:		

Source: Own elaboration.

Further research revealed deficiencies in the necessary documentation. The following were drawn up to fill them: a list of tangible assets (machinery and equipment) to be covered by the new management system and a list of standard spare parts used in the listed production machinery. Because within the technical department of the company under study, there is practically no coherent system of collecting information on operating events, enabling them to be archived, a model for such a document in the form of a paper service card was proposed (Table 1).

The content of the charter was developed in accordance with the 4W1H method. MRT, MTR, MTTR, MTBF, and MTTF indicators were selected to verify the effectiveness of maintenance activities (Antosz, 2019, pp. 49-50; Daniewski, Kosicka, Mazurkiewicz, 2018, p. 22; Janisz, Liszka, 2018, pp. 516-517). Having the proper foundations of the new system, they proceeded to implement the next pillars of the TPM paradigm. The work began with the implementation of the principles of the 5S method. The 5S initiative can be seen as the foundation of the TPM philosophy (Bartochowska, Ferenc, 2014, p. 17). Keeping the workplace tidy expands the availability of space needed for maintenance tasks. Maintaining cleanliness, especially in the workshop area of maintenance and repair services, reduces the time spent locating the tools needed to fix faults and breakdowns, reducing machine downtime. It has been

proposed that the contents of tool cart drawers be organized using appropriate inserts and trays, power tools should be placed on labeled storage bays in tool cabinets, and the remaining tools should be deployed on a perforated board. To standardize the cleaning procedure, simple checklist-type document templates were prepared to facilitate the restoration of order in the tool room (Table 2).

Table 2.

Example of 5S instructions for a tool room

5S MANUAL FOR THE TOOL STORAGE		
1	Wipe and remove dirt from the worktop	
2	Place parts and tools in dedicated storage areas	
3	Make sure that there are no empty spaces in the recesses of the storage areas of the trolley drawers	
4	Make sure that the instruments in the cabinet are located in dedicated, described places	
5	Collect all rubbish, waste and other unnecessary items. Place them in dedicated buckets	

Source: Own elaboration.

As part of the autonomization of maintenance tasks, it has been proposed to equip operators with preventive maintenance cards (Table 1), describing cleaning procedures for different groups of production equipment (Musa et al., 2015, p. 167) and, in line with the Kaizen idea, cards for recording disturbing events (Table 3), used to document symptoms of malfunctioning machinery.

The incident history compiled this way forms the basis for implementing a predictive strategy. Analysis of inspection results can be used to identify patterns and trends in machine problems. These proposed tables align with the Kaizen culture, in which listening to employee suggestions is promoted. By integrating existing preventive measures with the results of analyzing symptoms recorded by operators in event cards, it becomes possible to prevent waste by performing preventive maintenance, adjustments, repairs or replacements of parts on still-functioning machines.

Table 3.

Model card for recording worrying events/symptoms

	Disturbing event/symptom	Date	Time
1			
2			
3			
.			
.			
n			

Source: Own elaboration.

In implementing the quality pillar, it was proposed to place quality tables at each production line station, containing visualizations of the desired patterns and unacceptable defects of finished products. The implementation of an autonomous maintenance and prevention system should contribute to improving the quality of UR services by reducing the number of failures. A cause-and-effect sequence can be observed here: reducing the number of failures slows down

the rate of wear and tear of machines. It improves their service life, and the proper technical condition of equipment ensures that machine interference does not reduce the quality of the products produced on them.

As part of the safety pillar (OSH), the surveyed company has put in place several safeguards to ensure worker safety within the shop floor, reducing the number of operator absences caused by accidents during work. The program to protect workers includes proper marking of dangerous machine components, particularly on presses, and installation of guards and light barriers on machines, as well as the deployment of cabinets for storing personal protective equipment such as safety glasses and earmuffs and marking of traffic routes divided into pedestrian routes and forklift zones. In addition, a three-module training program on maintaining the TPM pillars was prepared to familiarize stakeholders with the company's current changes. By closely linking the pillars of TPM, the holistic implementation of the concept generates synergy, in which strengthening one area brings benefits to the others, creating a coherent system of operational improvement.

The "TPM in the office" pillar is designed to arrange activities to improve communication within the company, particularly between the technical department and production. The main objective set for this pillar is to reduce the service response time to a technical request. This requires the introduction of uniform communication tools for the personnel of both departments and the development of standard procedures and communication channels for different types of information (Pinto et al., 2020). The most appropriate and effective solution for smoothing the flow of information in the enterprise is the introduction of integrated IT maintenance process management systems for monitoring and coordinating UR work. An example of such a system is CMMS-type software.

5. Implementation of software to support the pillars of the TPM paradigm

During the operation of a machine/equipment, various data can be acquired, including operating time, descriptions of observed faults and failures, descriptions of repair activities performed, lists of used parts and consumables, and recorded parameters of machine/equipment operation. Such data is a crucial component of the "operation management system" - Maintenance Management System. Due to the abundance of such data, manual collection, recording, and processing of such data becomes inefficient, ineffective, and, in many cases (especially for very complex technical systems), even unfeasible. This makes it particularly difficult to respond appropriately and promptly to operational incidents. Therefore, more and more often, maintenance management systems use advanced IT technologies and take the form referred to by the term Computerized Maintenance Management Systems (CMMS) (Jasinski, 2019, pp. 25-26; Jasiulewicz-Kaczmarek, 2023, p. 136). When implementing TPM

assumptions, a CMMS is considered optional but strongly recommended. Simply implementing a CMMS does not guarantee an immediate solution to maintenance problems. However, it can be a beneficial tool, provided it is properly implemented, and its available functionalities are adequately used (Östberg, Nilsson, 2016, p. 24). The selection of a CMMS class system suitable for a particular enterprise should be based primarily on an analysis of the individual needs of that enterprise, considering the possibility of selecting and adapting to these needs and capabilities of the system-chosen modules in the implementation procedure. Successful implementation of a CMMS can reduce maintenance costs, improve communication within the enterprise, and increase the availability of machinery and equipment, so enterprises seeking to optimize maintenance processes should consider its implementation.

Computerized enterprise resource management systems, especially CMMS class software, are also tools that can help solve the problems of disorganization in the technical department of the selected entity.

Let's assume that in the past, the entity used traditional, "analogue" methods of maintenance management, which proved to be time-consuming, error-prone, and hindered rapid response to adverse events. Digitization of the maintenance management area could allow for more effective supervision and coordination of maintenance work, centralizing data and information on this enterprise area. A CMMS-type system would provide a consistent platform for planning, supervising, and reporting maintenance activities at the operational and tactical levels. It is essential to make the use of the system available not only to maintenance mechanics, those directly responsible for maintenance work, or technical department employees overseeing the effectiveness of maintenance processes but also to forepersons and operators so that the system can provide a common platform of communication for all parties involved.

Before starting the implementation process, it is necessary to find a suitable system capable of responding to the challenges and needs posed by a given manufacturing entity. During the search for and implementation of a suitable CMMS system, the research described in this paper used a needs satisfaction process model consisting of the following steps:

1. Identify the company's needs and expectations of the system's capabilities.
2. Define criteria for evaluating available systems.
3. Detailed analysis of IT solutions available in the market.
4. Evaluation and selection of the most suitable system.
5. Implementation and testing of the selected system.

Having identified the company's needs concerning the CMMS system, the research described here assumed that the CMMS system to be implemented would have a modular structure. A set of requirements was then defined for the available modules, such as maintenance scheduling, warehouse management, and call handling. Attention was paid to such aspects as the availability of a Polish-language version and a mobile application, the legibility of the interface, and subjective ease of use.

Price is also a value that should be considered in the selection process when evaluating a CMMS system. Nevertheless, it is worth emphasizing that the choice of a system should not depend solely on its cost. In practice, investing more money often ensures obtaining a system that meets high standards, especially in terms of reliability of operation and availability of updates.

Out of nearly thirty CMMS systems available on the Polish market, nine possibilities were selected and evaluated in terms of defined requirements. Based on the requirements collected in the interview questionnaire, areas were determined, which were then analyzed in the nine selected CMMS class systems. Comparative analyses were made based on information obtained during meetings and consultations with sales representatives of the manufacturers of the chosen systems, as well as subjective impressions made while learning about the functionality of the tools. The evaluation was conducted on a 5-point scale: one means not meeting the company's expectations, and five means fully meeting the requirements. It was noted that the selected systems have similar functionalities, while they are distinguished by the way they present information and the accessibility of the appearance of the application interface.

According to the analysis, it was suggested that the QRmaint® system be used at the surveyed enterprise, guided in particular by the low entry threshold and minimal implementation requirements. Due to the incompatibility of data collected in the company's previously used "proprietary" KAPS system with the data format of the selected CMMS system, all data and information had to be transferred manually. The data transfer to the CMMS system was divided into tasks for an organized and systematic approach to the process, ensuring that all relevant information was entered into it.

Critical steps in the process include:

1. Compile personal data of system stakeholders:

- a) preparation of user profiles, including personal data, qualifications held, and individual QR codes to facilitate log-in,
- b) collecting data on external service providers - determining their competence and assigning contact information,
- c) collecting data on regular suppliers of spare parts: this will allow you to determine which components a particular supplier is responsible for supplying and assign them up-to-date contact information.

2 Transfer previously collected documentation and prevention plans into the system:

- a) digitizing the map of the machinery park for the departments covered by the change,
- b) mapping of production equipment with assigned technical specifications, past maintenance schedule, checklists for maintenance, historical data of work performed, and incidents recorded, based on information entered in the former system and collected through service cards, standard list of spare parts,

- c) giving the machines QR codes,
- d) transfer of the existing schedule of infrastructure reviews,
- e) enter the power tools located in the workshop and assign QR codes to them,
- f) digitizing inventories, preparing places for replenishing necessary standard parts, and assigning QR codes for items, suppliers, specified security, and maximum levels.

In the implemented system, based on the list of production machines and equipment to be covered by the system, the structure of the machinery park was mapped, assigning individual machines to appropriate departments and positions. Thanks to this, when a failure is reported, or a planned preventive action is about to be carried out, the zones and equipment affected by the events are made visible in conjunction with the ANDON light paging system. In addition, the notification or report received by the relevant employee shows the previously mapped location, speeding up the process of finding the location of the problem.

The preventive plans available to the enterprise have been entered into the "Preventive Tasks" module. The list of preventive work presented is also a schedule for this work. The review time is defined once in the system, which then automatically renews the task in the schedule and generates notifications, with an assumed time advance, about the approach of the scheduled activity.

Thanks to its inventory of standard spare parts and its stock inventory, the implementation described here envisaged the creation of a digital warehouse of spare parts for production machinery and equipment. The collected data was transferred to the warehouse module of the CMMS system: photographs of the parts, their names, purchase costs, and quantities held were entered, minimum and maximum stock levels were defined for each item, and information was entered on which machines the part is dedicated to. In addition, each group of parts was given a unique QR code, which, when placed in the appropriate storage location, allows for a significant acceleration of picking and receiving into the warehouse.

It was recommended that the storage cabinet space be organized and a signature system be introduced so that each part can be assigned a location on a specific shelf, drawer, tray, or container. Releases from the warehouse will be recorded automatically when the use of parts during maintenance activities is approved. When a part's stock exceeds the minimum state, the system will generate a notification addressed to the engineering team and include a suggestion to replenish the stock to prevent a shortage of the desired parts during future interventions.

Screens have been installed in the production halls and the UR services office to increase accessibility to information. These screens display dashboards showing critical operational performance indicators and information on operating events. They also allow production employees to track the status of requests made, which promotes greater process transparency and commitment to the tasks at hand. In addition, compiling information on a single, large screen makes it easier for maintenance mechanics to spot a problem immediately.

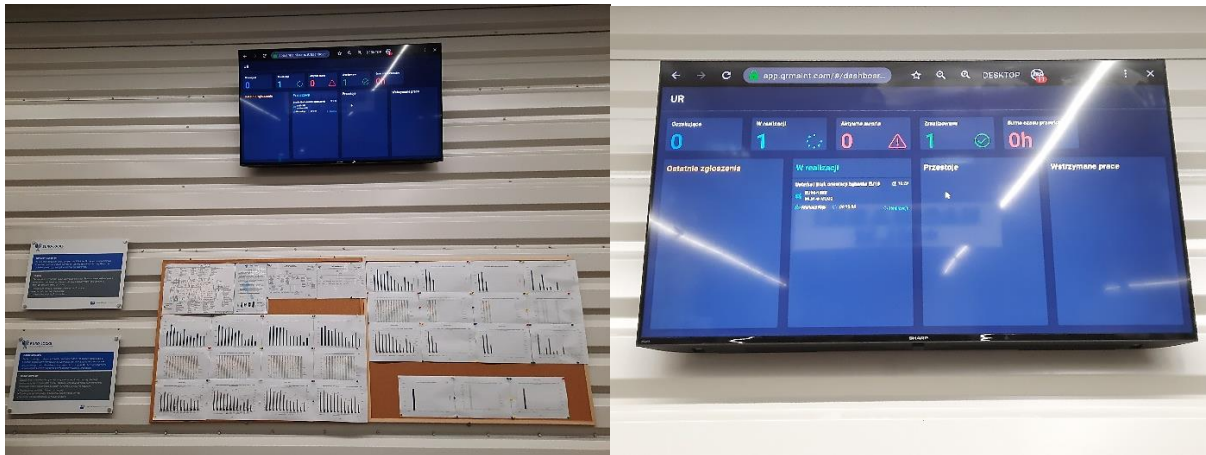


Figure 3. An example of a dashboard in the studied enterprise.

Source: Own elaboration.

After implementing the CMMS class system, the process of reporting failures and repairing was significantly transformed by moving the procedures to a virtual plane. According to the “old-fashioned” scenario, operators were obliged to personally report the occurrence of a problem on the production line to the maintenance staff present on a given shift, which often involved a lengthy search for these employees within the production halls. Implementing QR (Quick Response) technology, an essential tool for automating activities in modern maintenance management should bring several benefits at every stage of the maintenance process. Failure notifications, made via a two-dimensional code scan, are immediately transmitted to mechanics via a mobile or computer application and interactive whiteboards, eliminating the oral communication stage. Replacement parts retrieved using the QR code are automatically assigned to the job report, facilitating subsequent cost analysis. Cases of missing parts caused by neglecting to update inventory will be eliminated.

On the other hand, the digitization of documentation summarizing the work performed will eliminate the need for “physical” access to computer workstations with the KAPS system, simplifying the process of completing information and eliminating, for example, skipping reports due to forgetfulness. The basic information in the reports, presented as a checklist, supplemented with a detailed description of the work performed, and a list of parts used, will be a simplified form of the previously proposed service card. Such checklists will function according to the “necessary step” principle of the “PokaYoke” approach (Dudek-Burlikowska, Szewieczek, 2009). Failure to fill in any of the fields will result in disapproval of the report on the request. All data on failures, repairs, and preventive work will also be automatically archived, allowing for later analysis and identification of recurring problems.

Lista kontrolna Edytuj ⋮

* Czy problem został rozwiązany? ∨

+ Dodaj notatkę

* Czy zostały pobrane części zamienne z magazynu? ∨

+ Dodaj notatkę

* Czy zostały wpisane w zakładce części? ∨

+ Dodaj notatkę

* Proszę uzupełnić wykaz pobranych części ∨

* Zwrócono narzędzia ∨

Figure 4. An example of a checklist in a CMMS system.

Source: Own elaboration.

6. Summary

As a result of the research, far-reaching specific conclusions have been formulated that go beyond the results obtained during this research. These conclusions show the expected results that a full implementation of the CMMS system by the TPM paradigm could produce. Attempting to quantify the effects of the implementation presented in the paper is not feasible for several reasons. First, the selected system still needed to be fully implemented: one-month tests of the functions of its demo version were conducted, and such a limited testing period needed longer to collect enough data to make reliable analyses and compare changes in the values of operational efficiency indicators. As a result, the available data need to allow a comprehensive assessment of the long-term impact of the CMMS on the company's operations. However, an attempt has been made to describe the potential long-term benefits of practising the assumptions of a comprehensive productivity maintenance strategy.

The implementation of the pillars of the TPM concept and the CMMS system that supports them will potentially contribute primarily to the elimination of waste, such as:

- disruption of production continuity caused by employee absenteeism due to occupational accidents, thanks to the introduction of elements of the health and safety pillar - guards and light barriers on machines, warning pictograms, marking of transport routes and health and safety cabinets;
- "overproduction" and overprocessing in the form of unnecessary, too-frequent preventive maintenance activities, thanks to a combination of preventive work and predictive elements in the form of applied "alarming event recording cards" (Tab. 3), which consequently allows for condition-based decision-making and prevents unjustified maintenance and replacement of still-functioning parts;
- unutilized potential of employees through the implementation of the AM program, through which operators gained new competencies, thus relieving UR services from performing some tasks;
- corrections of defective products resulting from improper work by operators, thanks to quality boards placed at the stations;
- maintenance services, which were partly eliminated by expanding the competence of operators within AM so that simple work can be performed by production employees, but especially with the implementation of the CMMS system, which has accelerated and streamlined communication between the technical and production departments;
- movement, manifested in situations where the operator is searching for a mechanic when a breakdown occurs, thanks to the implementation of the CMMS system, eliminating verbal information flow;
- unnecessary movement when searching for spare parts and tools in a chaotic warehouse space by applying the principles of the 5S method;
- unnecessary spare parts inventories, but also component shortages, thanks to records of their retrieval and return in the CMMS system;
- production downtime due to damage to machinery and equipment, thanks to the planning and monitoring of maintenance work; all of the factors mentioned above, as well as the other improvement measures introduced under each of the TPM pillars, contributed to the reduction in downtime.

Summarizing both the results obtained and the potential results of further implementation work, it should be stated that the effective implementation in a manufacturing enterprise of an information system supporting the maintenance tasks of machinery and equipment should be regarded as an essential component of comprehensive management of production processes, such as design, optimization, quality control and ensuring the continuity of operation of machinery and equipment. From the point of view of the principles of production engineering, only such a comprehensive approach allows the effective implementation of the entire tasks of a production enterprise.

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ETHICAL HUMAN RESOURCE MANAGEMENT A KEY TO COMPANY SUCCESS

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Purpose: The purpose of this paper is to characterize the key elements of human resource management that affect employees' perception of the organization as an ethical company that cares about them in a comprehensive way. Due to the very wide spectrum of the mentioned factors, their selection was made on the basis of interviews with both full-time and part-time students with work experience, who indicated those factors that matter most to them.

Design/methodology/approach: The goal was achieved through literature analysis and conducted interviews with full-time and part-time students who have taken up professional work.

Findings: Based on an analysis of the responses of full-time and part-time students and a review of the literature, it can be concluded that the most important factors in ethical management are communication and motivation, while the tool supporting the entire process is a code of ethics.

Practical implications: The elements indicated in the study can guide leaders on what to pay attention to when creating the pillars of ethical management.

Originality/value: To identify the challenges faced by today's leaders in the field of ethical management and the guidelines that will help in their implementation.

Keywords: ethical manager, ethical motivation, ethical communication, code of ethics.

Category of the paper: Literature review/ research paper.

1. Introduction

Nowadays, in an era of tremendous competition in the market and the associated need for companies to provide services at a very high level, it is becoming extremely important not only to attract, but also to retain highly qualified employees who are identified with the organization. High salaries, however, seem insufficient to accomplish this, so other, more effective and long-lasting solutions are needed.

One of them is undoubtedly an ethical approach to the employee, which is manifested in an attempt to understand their needs and expectations, create a rewarding, differentiated incentive system, (based on knowledge sharing) (Vuori, Okkonen, 2012) or communication,

(Bean, 2001), which is based on mutual respect. As A. Kuzior points out, „in the workplace the instrumental relationships supervisor-employee and employee-employee do not build a positive atmosphere of cooperation and reciprocity” (Kuzior, 2021, p. 73) but the key may be empathy and comprehensive support, given to the employee in any situation.

Of course, one can look at the problem in a more formalized way, creating codes of ethics (Lemon, Boman, 2022), which is a document that represents a kind of commitment to ethical standards not only by managers, but also by their subordinates.

Therefore, the purpose of this paper will be to attempt to characterize the key elements of human resource management that affect employees' perception of the organization as an ethical company that cares about them in a comprehensive way. Due to the very wide spectrum of the mentioned factors, their selection was made on the basis of interviews with both full-time and part-time students who have taken up professional work, who indicated those factors that matter most to them. The following is a characterization of the most frequent responses and also introduces the key concept - namely, the ethical manager.

2. Ethical manager

The literature on the subject describes the concept of an ethical manager very broadly. Namely, he wants to “simultaneously run a profitable business and act ethically” (Ciekanowski, Szymański, Załoga, 2018, p. 96). As A. Szejniuk points out, “the task of an ethical manager is to apply management methods and techniques through which efficiency can be increased. He should mobilize employees to achieve certain results while adhering to norms, rules and procedures” (Szejniuk, 2016, p. 93). J. Szczupaczyński on the other hand, believes that “an ethical manager is not ethical in order to achieve business goals more effectively - he is effective because he is ethical” (Szczupaczyński, 2011, p. 181). It is worth adding that „leaders must combine strategic vision, transactional and transformational elements, and servant and empathic leadership” (Kuzior, Zozulak, Balahurovska, 2023, p. 308).

It is important that the manager is aligned with the company's culture and values. Therefore, special importance should be attached to the leadership recruitment process.

An interesting proposal in this regard is presented by J. Tokar and K. Oleksa-Marewska. The authors developed a model consisting of three stages. Stage one is a diagnosis of the organization's culture in four dimensions (mission, cohesion, commitment and adaptability), using a tool for this purpose - Denison Organizational Culture Survey®. This allows the organization to identify the area that needs special focus from the organization's leaders, so as to strengthen the culture. This knowledge should guide the actions of recruited leaders in the first place. The aforementioned activities require specific competencies that a recruited leader should possess (Tokar, Oleksa-Marewska, 2021). Stage two is based on the selection of

key leadership competencies that meet the needs of an organization with a given culture dimension. The four dimensions of culture mentioned in the first stage, in order to remain in a relative state of balance, require differentiated leadership competencies (Tokar, Oleksa-Marewska, 2021). As the authors note, “D. Denison matched three competencies to each dimension, which, although they may be assessed at different levels, will co-occur together to form a leadership profile” (Tokar, Oleksa-Marewska, 2021, p. 113). Accordingly, the authors suggested that one of the four catalogues of competencies should be selected for the selection process, so that the recruiter can focus on diagnosing the most necessary of them. Moreover, the selection of each catalogue depends on the result of the organizational culture survey (it is required that the leader focus his efforts on the dimension in which the results are the lowest) (Tokar, Oleksa-Marewska, 2021). The final stage, focuses on the diagnosis of leadership competencies during the selection process and the final selection of the candidate (Tokar, Oleksa-Marewska, 2021). It is worth noting that “the catalogue of competencies assigned to the dimension to which the recruited leader will have to pay particular attention should be the starting point for developing the profile of the candidate being sought” (Tokar, Oleksa-Marewska, 2021, p. 113).

Given the range of challenges facing today's leaders, they should be highly versatile, open to new challenges and resistant to stress. Coordinating activities requires not only good work organization, but also the ability to delegate tasks to employees (Ugoani, 2020) according to their qualifications and preferences. Extremely important in subordinate-supervisor cooperation is empathy, but central to the entire management process is emotional intelligence. Emotional intelligence is “a set of abilities relating to emotions” (Côté, 2014, p. 459). It is also defined as “the ability to properly understand emotions, express them and evaluate them; the ability to manage emotions and also the ability to motivate” (Szaban, 2012, p. 139). It is worth noting its dimensions, which include self-awareness (i.e. recognition of one's own emotions, or a sense of confidence in one's potential), self-control (among other things, adherence to ethical norms), social awareness (which includes the ability to recognize the needs and emotional states of other people), or social skills in a broad sense (Goleman, 1999; Kozłowski, 2023). If a manager has a high level of emotional intelligence then he will certainly be predestined to be an ethical leader. However, the starting point is to reach level one first, because the key to understanding others is to understand oneself.

It is worth asking at this point, what kind of leadership style should an ethical manager choose in order to positively influence his colleagues and motivate them to accomplish the most complex and challenging tasks? Certainly, it should be tailored to the situation facing the supervisor. Among the many detailed in the literature of leadership styles, the modern manager, according to the author of this paper, can use the following approaches to employees (Tokar, 2015; Kanarski, 2005; Cardona, Garcia-Lombardia, 2008):

- personal style (the leader expects initiative from colleagues, encourages their participation, comforts them and gives them support),
- democratic style (the leader involves employees in solving problems, actively listens and provides explanations),
- impoverished style (the leader allows employees to take responsibility and encourages new challenges),
- autocratic style (the leader expects others to be enthusiastic about work, provides assistance and also is in constant contact with co-workers).

An element of support is evident in each of the above styles, which is of great importance in creating relationships based on mutual respect and trust.

3. Ethical motivation of employees

One of the key elements of ethical human resource management is employee motivation. As J. Ugoani points out, “motivational leadership entails stimulating people's imagination and inspiring them to move in the desired direction” (Ugoani, 2015, p. 585). Furthermore, “an effective manager can influence the personnel he manages in such a way that the achievement of the organization's goals satisfies the needs of each participant in the process” (Kuzior, Balahurovska, 2022, p. 174).

In many organizations, there is a widespread belief that motivation is related to the mutual respect that managers and employees show each other (Jalloh Abdul, Jalloh Alhaji, 2016). Incentive system, in turn, is “the methods of influencing employees' motivation reflected in organizational procedures, which are usually open and universal, that is, addressed to people who meet certain formal conditions-not discretionary actions, carried out by specific individuals and addressed to individuals” (Woźniak, 2012, p. 21).

Experts in the literature on the subject point to values that are key in the process of motivating an employee, as they improve commitment and behaviour that promote organizational efficiency (Kozłowski, 2023).

The first of these is the aforementioned respect. This value includes “acceptance of race, colour, ancestry, gender, diversity of beliefs, behaviour, communicating with dignity with the employee, adjusting working hours in relation to the employee's personal circumstances, honouring commitments, respecting the time of others, respecting standards and accepted customs, or creating a safe work environment for all” (Kozłowski, 2023, p. 88).

Another value is integrity, that is: “keeping one's word, performing tasks reliably, being responsible to the organization and other co-workers, being paid decently for one's work, being paid extra for extra work, following health and safety rules, not exposing an employee to health risks, following standards in promotion and appraisal processes, being loyal to the

organization, to superiors, following ethical principles both in relation to co-workers and customers” (Kozłowski, 2023, p. 88).

The third, but no less important value, justice, “refers to the equal treatment of all employees both in terms of wages and workload, rewards, awards, decorations, equal treatment without distinction based on gender, race, origin or religion. This value is particularly important in pay and bonus and promotion systems. The point of reference for employees can be other employees or companies of a similar nature” (Kozłowski, 2023, p. 88).

It is worth noting that these values are complementary, complementary to each other. To emphasize their importance, they can be included in the organization's code of ethics, which will be discussed later in this paper.

Analysing the topic of ethical motivation, it is worth noting the recommendations for leaders, regarding the building of intrinsic motivation. Here R. Mrówka draws attention to the following points (Mrówka, 2010):

- leaders should strive to ensure that employees know the organizational vision and goals. Moreover, employees should identify with said goals. It is also worth making the most of their skills, which will undoubtedly increase the importance of the work they do,
- it is important to provide employees with an appropriate level of autonomy when performing their duties, which will increase their sense of responsibility,
- employees should be informed about their achievements in a clear and objective manner, based on reliable criteria,
- during delegating tasks, it is necessary to take into account first of all the qualifications and skills of the employees, as well as inspire self-confidence in them,
- organizations should ensure employees' basic needs are met, including fair remuneration, job security, and a positive working atmosphere,
- importance should be given to the selection of employees willing to grow.

This guidance can be an important signpost for leaders beginning to create motivational systems in the organization, providing a strong foundation for sustainable, ethical motivation.

At this point, it is worth mentioning key forms of ethical, intangible motivation prioritized by today's employees. One of them is the concept of work-life balance (Sirgy, Lee, 218), priority especially for the generation Z. „According to its assumptions, employees behave in a certain way to meet the needs for balance in the workplace. Once the goal is achieved, they will be more satisfied with their jobs and thus more motivated” (Nieżurawska-Zajac, 2023, p. 49). „Elements of this concept include: workplace flexibility, health and beauty, cultural initiatives and community engagement” (Nieżurawska-Zajac, 2023, p. 49). Another form is referred to as the so-called psychological contract (Thomas, Au, Ravlin, 2023). According to B. Kozusznik „the concept of psychological contract best captures the mutual psychological relationship between the employee and the organization. The relationship is complex, and the psychological contract reflects a set of unwritten mutual expectations between the employee

and the organization” (Kozusznik, 2011, p. 43). Thus, for example, the employer undertakes to provide the employee with decent working conditions and the employee in return will perform the work with a high degree of commitment and a sense of responsibility for the task at hand. Employee participation is also an important form of motivation (Moriarty, 2010) related to their participation in the life of the organization (for example, in the decision-making process). According to A. Poczowski „participation, treated as an integral part of human resource management, is aimed at supporting the two main goals in this area of company management, that is, to provide employed employees with better opportunities to develop their potential capabilities and to strengthen their commitment to the company” (Poczowski, 2003, p. 432). When analysing forms of intangible, ethical motivation, one should not forget about equal access to innovative courses and training tailored to the needs and expectations of employees.

4. Ethical communication

Another extremely important factor in ethical human resource management is communication (Morreale, Spitzberg, Barge, 2023), both internal and external (Ober, 2022), (also in the context of digitalization) (Meng. Kim, Reber, 2021). As J. Tokar and K. Oleksa-Marewska point out „today, social media and available remote working systems are displacing traditional emails, providing more opportunities to effectively coordinate team activities. It is becoming important to learn the tools and understand the nature of the digital medium, and the very form and content of the message have a colossal impact on building relationships based on trust” (Tokar, Oleksa-Marewska, 2021, p. 93). Of course, one should not forget the traditional form of communication, which is particularly important for today's employees, especially in the context of delegating tasks or rational, constructive criticism. Its rules are detailed by B. Kozyra. And so according to the author the employer (Kozyra, 2019) should:

- have such a conversation with the employee in person, immediately after the inappropriate behaviour occurs,
- judge the behaviour and not the person,
- start the meeting properly, by explaining the precise purpose of the meeting, specifying the consequences of the mistake made,
- show respect to the interlocutor, speak with tact and sensitivity,
- praise the person being criticized for the good results of their work so far,
- asked for a proposal to correct the error and also provide support to the employee in this regard.

If these rules are met, certainly the relationship between the employee and the employer and the employer not only will not deteriorate, but on the contrary - the level of trust of the employee in the supervisor and the entire organization will increase. Also influential in building

a bond between the sender and receiver of a message is the ability to listen. “This process should not be limited to the analysis of verbal messages, as it is necessary to catch such symptoms of emotional reactions that make understanding more insightful and accurate. In the process of listening, empathy, the ability to understand the interlocutor's feelings and motives, is crucial” (Ostrowska, 218, pp. 104-105).

5. Ethical codes

The codes of ethics (Messikomer, Cirka, 2010; Payne et al., 2020) mentioned in the study are a very important element in supporting ethical management.

B. Suchodolski emphasizes that „the code of ethics is a set of principles and values that should guide the members of a given group in the performance of official tasks in the workplace and beyond. The provisions collected in the code are intended to set high ethical standards applied by members of the group and thus take care of the good name of both them and the group as a whole” (Suchodolski, 2012, p. 159). W. Kozłowski, on the other hand, clarifies this concept by referring to the leadership code, or “a set of ethical and professional rules that managers should follow. Adherence to the code guarantees a good reputation and a good life” (Kozłowski, 2023, p. 119).

Codes have both supporters and opponents. Supporters emphasize that its provisions represent a commitment to ethical principles in the organization, while opponents criticize it as a tool for imposing rigid behavioural standards on employees. In the opinion of the author of the study, it is undoubtedly an important document that is a point of reference in contentious issues or during the occurrence of ethical dilemmas in the organization.

6. Influence of ethical attitude of managers on employee behaviour

The above-described elements of ethical human resource management have a direct impact on ethical behaviour of employees. According to the interviews, they firstly create the identification of employees with the organization, their sense of loyalty to their employers and the related desire to stay with the company for a longer period of time, despite various crises. Secondly, they shape positive, mutually cooperative and trusting relationships on the supervisor-subordinate line and in the team of employees. Third, they integrate the team, and a set of consistent values in the form of a code of ethics provides a point of reference in contentious issues. Therefore, it is worthwhile to manage ethically, as this leads to the acquisition of valuable, dedicated employees who have a sense of mission and pursue the organization's goals with commitment and efficiency.

7. Challenges facing today's managers in ethical Human Resources Management

Although ethical awareness (Koumbiadis, 2014) of managers are getting higher and higher, it is undeniable that, due to the dynamically changing environment, they have to face new challenges in management based on ethical norms and values. One of them is to build a stable organizational culture in the organization (Graham et al., 2022) encouraging new tasks, based on an atmosphere of cooperation and trust with which employees identify. Of course, it is important to select, already at the stage of the selection process, such employees whose value system is consistent with the system that the organization professed. An important part of adapting a new employee to the culture can be the adaptation process (Kunasegaran et al., 2016), in which the mentor, introducing the employee to two dimensions (organizational and social), introduces its basic principles.

Another challenge related to globalization is the ethical management of cultural diversity (Podsiadlowski et al., 2013), consisting in building an effective multicultural team that will carry out ambitious tasks, using its huge potential. Of course, the key to this is acceptance, tolerance, breaking stereotypical way of thinking and counteracting potential practices that discriminate against employees. In order to achieve this, the culture days could be organized in the organization that illustrate what customs prevail in a given country. Another solution is connected with joining nationwide programs promoting ethical management of cultural diversity.

Another significant challenge is the introduction of a trust management strategy at all levels of the company's operation. As J. Paliszkievicz emphasizes, "trust plays a very important role in an organization, because it concerns the most fundamental issues: credibility, intentions, competence, ethics of conduct, truth, faith in another person. Any deviation from these canons, instrumental treatment of employees, suppliers, business partners or customers will sooner or later be discovered" (Paliszkievicz, 2013, p. 57). This can be achieved by providing employees with autonomy in performing various tasks or by wide-scale staff participation in making important decisions for the organization.

8. Conclusions

Ethical management (Snellman, 2015) is finding more and more supporters. Modern leaders are aware that only such an attitude will gain the approval of employees and make them fully identify with the goals of the organization, staying in it for a longer period of time. Of course, this approach requires a lot of effort, because some elements require continuous development

and adaptation to current trends. The above study indicates three main elements of the discussed strategy: ethical communication, motivation and a code of ethics, which is an instrument supporting the entire process. Of course, managers have a much wider range of tools at their disposal in this area, but the factors indicated in this article should be the basis on which this approach will be based.

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NEW INSTITUTIONAL ECONOMICS AND THE DEVELOPMENT OF RAILWAY TRANSPORT INFRASTRUCTURE

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Purpose: The aim of this article was to show the significant influence of various types of institutions on the development of railway transport infrastructure.

Design/methodology/approach: The main research method used was the analysis of specialist literature, both domestic and foreign.

Findings: It was presented how important an influence institutions have on the development of railway transport infrastructure. It was shown that looking at issues related to the development of transport infrastructure through the prism of the new institutional economy provides a broader and more complete picture of this issue.

Originality/value: The article presents a different perspective on issues related to the development of rail transport infrastructure. It also provides an impetus for further research and analysis of the impact of various types of institutions on the development of rail transport infrastructure.

Keywords: New Institutional Economics, transport infrastructure, institutions, railways, state.

Category of the paper: Literature review, General review.

1. Introduction

Recently, new institutional economics has been gaining popularity. Through its broad perspective on various socio-economic phenomena, it tries to explain their course. This article attempts to answer the questions of how and to what extent different forms of institutions influence the development of rail transport infrastructure. This is important because a well-developed and functioning rail transport infrastructure translates into the proper functioning of the economy and the state. The text shows that not only the basic factors of economic growth and development determine the development of rail transport infrastructure, but also a number of formal and informal institutions influence this process.

2. New Institutional Economics – historical outline

The New Institutional Economics (NIE), whose origins date back to the turn of the 19th and 20th centuries, introduced a new way of perceiving economic and social reality. The focus of its interests was on man and broadly understood institutions (Derkacz, Shahab, 2020). The roots of the New Institutional Economics can be found in Institutional Economics, the father of which was the American economist and sociologist of Norwegian origin, Thorstein Veblen. His most famous work is "The Theory of the Leisure Class" published in 1899, the fundamental work of institutionalism. Walton H. Hamilton, an American professor of law, also dealt with the issue of institutional economics. In his 1919 article "The institutional approach to economic theory", he emphasized that the decisions made by participants in economic life are influenced by various types of institutions. He also pointed out that the processes taking place in the economy are a derivative of many different factors and in order to understand a given economic phenomenon it is necessary to look at it in a broader perspective (Hamilton, 1919). The issues of the new institutional economy are the subject of interest of many scholars. These include: Douglass C. North, Ronald Coase, Steve Pejovich, Oliwier E. Williamson (Sobiech, Woźniak, 2005). Also in Poland, the ideas of institutionalism are the subject of research by many scientists (Musiał, 2011).

As for the concept of institution, it has not been precisely defined so far. According to T. Veblen, institutions are treated as established patterns of behaviour and relationships that are accepted by society in a given place and time. In his work "The Theory of the Leisure Class" he wrote that: "social institutions are essentially dominant ways of thinking that take into account individual social conditions, individual functions of the individual and the community. [...] Social institutions - that is, habits of thought or ways of understanding phenomena - that guide human life, come from the past. They are products of the past, adapted to the conditions of the time, which is why they are never in complete agreement with the requirements of the present" (Veblen, 1971, p. 171).

John R. Commons was a student of Veblen and a continuator of his economic thought. His contribution to the further development of institutional economics consisted in introducing another definition of an institution and in emphasizing the great role of collective arrangements that operate in society and their impact on economic processes. He indicated such economic arrangements as the family, trade unions, associations, corporations or the state. Commons in his 1934 work *Institutional Economics* wrote that institutions can be defined "as collective action for the purpose of checking individual action" (Commons, 1934, p. 72).

Douglass C. North also made a significant contribution to NIE. In his publications, he wrote about institutions as the rules of the game within which individual social units and entire societies function in the economic system (North, 1990). Thus, according to him, institutions are rules, principles that shape social, economic and political interactions. These rules consist

of informal rules, such as customs, traditions or rules of conduct, as well as formal ones, i.e. legal regulations, constitutions or property rights (North, 1991). D.C. North also defined organizations. According to him, organizations are players in the socio-economic game. Thus, a distinction is visible here between organizations (players) and institutions (rules of the game) (North, 2008).

Joseph E. Stiglitz, an American economist and winner of the Nobel Memorial Prize in Economic Sciences, extended the concept of institution to include organizations (those understood in the classical sense, not as players according to the NIE concept) (Stiglitz, 2000). It is worth noting here that D.C. North distinguishes the concepts of organization and institution, while O. E. Williamson includes organizations among institutions, just as J.E. Stiglitz does (Kuder, 2011).

The definition of an institution will probably never be established in a permanent way. This is due to the fact that over the centuries, this concept has evolved and attempts have been made to adapt to the changing socio-economic reality. In this context, we can talk about certain changes in institutions, about the process of institutional changes in the reality surrounding us (Derkacz, 2018). Similarly to the definition of an institution, in the case of the division of institutions one can come across various classifications of them in the literature on the subject. One of the most well-known divisions of institutions, which can be considered classic, is the one made by D.C. North. He divides institutions into formal and informal. According to him, informal stimuli create various customs, traditions or ways of acting. Formal stimuli, on the other hand, are already established law, constitutions, property rights and ways of enforcing them (Commons, 1934).

The development of the new institutional economics has brought a significant change in explaining quantitative and qualitative issues in the economy. According to the assumptions of the NIE, institutions play a key role in economic development, including the development of transport. The answer to the deficiencies and shortcomings of the neoclassical economy is the NIE, which adds institutions to the set of existing growth factors (labor, capital and technology). Researchers dealing with the NIE are trying to combine the previous achievements of the neoclassical economy with the new institutional economics. It is worth noting here that economists representing the NIE do not want to negate the achievements of classical economics, but only to improve it and its research elements with additional assumptions that have been omitted so far (Legiedź, 2013). It is the institution that is one of such tools that allow for the study of economic processes in a way that is much closer to economic reality. The concept of an institution itself is not fully unified. However, the most frequently cited definition is that of D.C. North, i.e. the “rules of the game” in the socio-economic environment (North, 1984).

One of the basic goals of institutions is to create mechanisms for the functioning of participants in social interactions and economic transactions. Firstly, economic entities in uncertain and risky situations refer to institutions as bodies that can significantly reduce this risk and uncertainty. Secondly, organizations constitute a certain framework for management,

certain restrictions according to which one should function in the economic environment. Institutions select entities authorized to make specific decisions in designated areas, define permitted or prohibited actions, establish procedures that must be followed. In addition, institutions determine which information is to be presented and which requires confidentiality (Ostrom, 1990).

New institutional economics enriched with the previous achievements of neoclassical economics provides the possibility of a new, different analysis of economic processes using institutional elements. Using these institutions, economists representing NIE try to find answers to emerging economic phenomena. For this purpose, in addition to the standard factors of economic development (work, capital, technology), factors such as culture, history, customs, norms of behaviour, location and other factors previously omitted in this type of economic analyses are taken into account (Godłów-Legieź, 2003).

It should be emphasized that D.C. North does not consider economic theory and economic history as disciplines and research issues functioning in a completely separate way. He is an advocate of using the tools of institutional economics theory to explain the historical evolution of various types of cultures. He assumes that in order to better understand the ongoing processes and historical changes, it is necessary to study them in a broader perspective. Therefore, issues related to, among others, economic theory should be taken into account. It should be noted that previously, economic history was a field of science devoid of specific theoretical foundations. On the other hand, neoclassical economics, due to its narrow view of economic processes, was insufficient to explain the changes and processes occurring in socio-economic systems over the centuries. Therefore, the new institutional economics provides new possibilities for explaining the complex economic processes taking place in the present world, but also those occurring in the past (Kwaśniewski, 2013).

3. Homo oeconomicus in the NIE

A person functioning in an environment of various interpersonal relations, when making various decisions, takes into account not only purely economic aspects, but also those of a moral, legal or social nature. He is also to some extent limited by informal institutions, which narrow his range of possibilities. Here, we can indicate a moral backbone or conscience created in the process of socialization and upbringing. In addition to informal institutions, people also create formal institutions that affect the socio-economic system, including issues related to transport. All this means that institutions should be taken into account when conducting research and analysis of economic processes. Unfortunately, in neoclassical economics, institutions were omitted and not taken into account by its representatives (Kasper,

Streit, Boettke, 2012). Moreover, representatives of mainstream economics treated economic behaviours as universal, regardless of the place and time of their occurrence (Neale, 1988).

Neoclassicals did not take into account institutions and their influence on the development of economic processes and the level of economic development achieved by society (Godłów-Legiedź, 2003). Additionally, economists of this trend believed that institutions did not influence the decision-making of economic entities. As a result, their analyses did not take into account the actual social, cultural, historical or psychological conditions on the actions of individual participants in economic life. NIE negates the concept of rational man, *homo oeconomicus*, and at the same time is a supporter of the theory of limited rationality in the functioning of economic entities. This concept assumes that when making decisions, economic entities must take into account the costs of information obtained or limited cognitive capabilities. H.A. Simon is considered to be the forerunner of this approach (Godłów-Legiedź, 2009). He definitely negates the concept of economic man (rational man) who has complete (or if not complete, then at least extensive) knowledge about all important issues of the surrounding socio-economic environment.

In addition, he undermines the ability to make the best possible decision while maximizing utility. According to him, a person does not have the opportunity to obtain all the information and make the best decision based on it (Simon, Behavioral, 1955). One of the criticisms that Simon directs towards neoclassical economics is the weakness of its methodology, or more precisely, the failure to take into account the influence of the external environment on the person making the choice. According to him, the assumptions that are taken into account during the analysis of the decision-making process should be made more realistic. In addition, he believes that during decision-making, a person is limited by the systems of values they profess, the knowledge they have, or the scope of information they have managed to obtain from the environment. Additionally, habits, skills, or unconscious customs also act as limiters (Simon, 1976). Of course, based on the above information, it cannot be said that a person does not try to be rational at the decision-making stage. They try, but their rationality is significantly limited. It is intentional rationality (Williamson, 1998).

From the point of view of economists representing NIE, rejecting the assumption of the rationality of a business person is tantamount to rejecting the concept of *homo oeconomicus* in which a business person is characterized by full pragmatism. *Homo oeconomicus* is a being who, according to the assumptions of neoclassical economics, is fully rational, has unlimited cognitive abilities allowing for the selection of the best decision, and in his choices achieves maximum utility while minimizing costs (Wilkin, 2016). This is a person devoid of attachment to a specific culture or community, able to adapt to any economy and any circumstances (Iwanek, Wilkin, 1997).

Another reason why economists of the new institutional economy reject the concept of *homo oeconomicus* is the issue of honesty and loyalty to economic partners. According to NIE representatives, a person strives to achieve their own goals and desires, often doing so in a way

that is inconsistent with the prevailing principles of law and ethical norms. The issue of dishonesty towards the contractor is caused by opportunism. According to them, opportunists consciously and intentionally mislead the other party to the exchange. An example of this is providing only partial information, distorting it, or hiding it in order to improve one's own negotiation and trade position (Williamson, 1998). It can be said that opportunistic behaviour is conduct that is inconsistent with generally accepted and acceptable principles, norms or rules, and therefore contrasts with existing institutions.

4. Economic development in NIE

According to the concept of neoclassical economics, economic development, an inseparable element of which is the development of infrastructure, takes place in an uninterrupted, stable way, and devoid of any kind of "friction". Any kind of disruptions that temporarily appear in the economic system are automatically leveled out by the system of demand and supply. In this way, the economy returns to the level of equilibrium. The effectiveness of such a system cannot be disrupted by other external factors occurring in the socio-economic system in which it functions (North, 1994). This type of economic narrative is questioned by representatives of the NIE. According to them, in the economic system we are dealing with a lack of equilibrium, a lack of automatic economic stabilization and the occurrence of "frictions". According to the NIE, the economic system also includes skills, knowledge, physical objects, as well as interpersonal relations, which are shaped and sanctioned by institutions (Ząbkowicz, 2003). For this reason, the proper allocation of resources in the economic system is supported by various types of laws, norms, rules or values professed by society (Pietrucha, 2008). In their opinion, institutions play an important role in creating the efficiency of the economic system. Institutions determine the scope of the functioning of the economic system, and their proper analysis allows for a better understanding of the complex processes and connections occurring in the socio-economic reality.

Depending on the theory, whether neoclassical economics or new institutional economics, through which we look at the processes taking place in the economy, then such and not other assumptions are taken into account in order to explain these economic processes. The definition of economic growth can be presented as a process of quantitative changes in macroeconomic values in a given economy. This growth brings about an increase in the volume of general production on a scale of the entire economy as a result of increasing its economic potential (Kwiatkowski, 2015). According to neoclassical economics, the factors of economic growth include: work, capital and technology. Unfortunately, limiting ourselves to basically only three factors influencing economic growth and development and using simple mathematical models does not allow for a full explanation of economic processes, as well as why this rate changes in

time and space (Gruszevska, 2013). In addition, other shortcomings characterizing neoclassical economics include, among others, the lack of explanation of the reasons for the huge disproportions between different countries of the world, along with delays occurring in some economies. Another imperfection of this economic theory is the inability to explain revolutionary changes occurring in individual economies and the consequences of these phenomena. It is also worth mentioning the imprecise impact of innovation and the rate of capital accumulation in the assumptions of neoclassical economics (Miłaszewicz, 2011). The inability to explain economic phenomena, the level of development of a given country or possible economic inequalities using exogenous and endogenous models has led to the need to search for new ways of studying these phenomena. The so-called fundamental growth factors have become of interest. These include: the degree of openness of the economy, geographical location and institutions. The results of the conducted research have shown that among these three factors, institutions are the most important. The remaining two indirectly affect national income (Rodrik, Subramanian, Trebbi, 2004).

New institutional economics sees institutional factors as crucial in the processes of economic growth and development. Institutions affect not only quantitative indicators illustrating economic development, but also qualitative ones. NIE representatives believe that the institutional system translates into the level of development of a given country. For this reason, the analysis of these institutions is important (Legiedź, 2013). Research on qualitative changes in the economy within NIE can be divided into two groups. The first group is the so-called institutional macroeconomics. It concerns the holistic role of institutions in the broadly understood process of economic development and focuses on the study of the institutional environment. The second group is the one referring to institutional microanalysis. It involves the study of the institutional arrangement or management structures. Institutional microanalysis is used to study specific problems occurring in underdeveloped countries. Macroanalysis is used in research by, among others, D.C. North. The level of microanalysis is used by, for example, O.E. Williamson. According to NIE, institutions are a key point in the theory of economic development. They influence the use of traditional growth factors and also translate into the level of transaction costs in the entire economy. Additionally, properly functioning institutions influence the accumulation of both physical and human capital. They also encourage the implementation of technical progress and the development of knowledge. Properly functioning institutions motivate to conduct business activity, introduce innovations or invest (Staniek, 2009).

Within the new institutional economy, formal and informal institutions are distinguished. The types of these institutions differ significantly from each other, but both significantly influence the formation of the institutional system (Gruszevska, 2017). Both of them model economic, political and social interactions. Moreover, these institutions influence and interact with each other, which in consequence results in constant changes in the institutional system (Kuder, 2011). Formal institutions are characterized by the fact that they can be changed in

a relatively short time. Moreover, unlike informal institutions, formal institutions can be changed intentionally. Changes in the system of formal institutions translate into changes in the functioning of the socio-economic environment. An example of this is the legal regulations created by the state authorities appointed for this purpose. However, in order for the newly created formal institutions to be fully and to an appropriate extent implemented into the socio-economic system, changes in informal institutions are necessary (Bentkowska, 2020).

Formal institutions have a major impact on limiting or accelerating economic development and growth. Their role comes down to creating clear and enforceable legal regulations. An important element is defining property rights and ensuring their effective protection. Contracts and the possibility of their easy implementation are also important within formal institutions. Appropriate institutions should facilitate their conclusion and execution. These bodies, by introducing specific regulations, are able to limit the costs of concluding contracts as a result of limiting information asymmetry. Easier and cheaper access to information is possible when market participants (e.g. companies) are required to report on specific indicators or activities (Williamson, 1998).

Informal institutions also have a significant impact on the economy. In this case, we should point to cultural patterns, willingness to learn and to improve qualifications, willingness to take risks, entrepreneurship, sense of social bond, religious norms, tendency to corruption or level of trust. However, the possibility of assessing the exact impact of informal institutions is more difficult than in the case of assessing formal institutions. Selected indicators of the quality of institutions in empirical studies include: the economic freedom index, the civil freedom index or the corruption perception index.

Informal institutions change in the long term, and in addition, their change occurs unintentionally. It should be emphasized, however, that informal institutions have a very large impact on the formation of formal institutions. In the case when changes in informal institutions, for some reasons, occur slowly and reluctantly, then changes in formal institutions are somehow inhibited by them. An example can be a situation in which a society is characterized by a high level of corruption and at the same time is not willing to stop this type of activity. In such a situation, a change in the law, i.e. formal institutions, concerning the introduction of penalties for dishonest activity will not be fully observed. Without changes in the approach of society to the issue of corruption, legal regulations will remain "dead" legal regulations (Woźniak, 2009). Another important element that also promotes economic development and growth is market competition. Formal institutions can influence the development of healthy market competition by creating appropriate law. These include, among others, antitrust law or licensing of specific sectors of the economy (Staniek, 2017). Other important formal institutions include those that ensure market stability (e.g. the central bank or legal acts regulating the macroeconomic policy of the state) or enable the resolution of conflicts and disputes (the judiciary).

The quality of formal and informal institutions and their level of development depend on external factors, as well as geographical, historical, political and cultural conditions. The participants of economic life in a given country (society and government) also have a great impact on the development and functioning of institutions. Formal and informal institutions interact with each other. This interaction can be weakening or stimulating. These institutions can complement or limit each other. However, only their mutual complementation leads to economic development and growth (Gruszevska, 2013). The institutional system is subject to constant changes, not only due to the mutual interaction between formal and informal institutions, but also as a result of the changing environment in which it operates. An unstable environment entails the need to introduce new changes in the institutional system. However, the changes that occur in the institutional system usually do not take place in a revolutionary way, but as a result of slow evolution. This is because in order to change the institutional system, it is not enough to change only formal institutions, but also a change in the system of informal institutions is necessary (Bentkowska, 2020). It should also be emphasized that modifying formal institutions does not always lead to the expected final effect. It happens that the final result is the opposite of the original intentions. This is because it is difficult to modify informal institutions. Moreover, the change of the institutional system does not take place in a vacuum, but in a specific political system, which also affects the process of changing the institutional system (Kwaśniewski, 2013).

Due to the fact that changes in informal institutions take place slower than in formal institutions, the entire process of converting the institutional system takes time. Of course, changes in informal institutions can be accelerated through various types of stimulation or creating specific patterns of behaviour. However, despite taking such actions, these transformations will take place slower than changes in the system of formal institutions (Bentkowska, 2020).

It should also be noted that despite achieving the desired change in the system of formal and informal institutions, it may turn out that the institutional system is ineffective. This inefficiency may result from improper enforcement of new norms that have been formed. For this reason, it is necessary to have appropriate systems for effective enforcement of norms (judicial system) so that the developed principles are implemented. A stably functioning institutional mechanism has a positive impact on the formation of the socio-economic system. It should also be emphasized that the developed institutional system does not always have to be socially effective and contribute to socio-economic development. Moreover, there are cases where an improperly functioning institutional system operates for many years, and its cemented structure (institutional matrix) prevents the introduction of specific, desired changes that are supposed to improve it. Examples of such improperly functioning institutional systems only confirm how difficult it is to change it (Miłaszewicz, 2011).

5. Railway transport infrastructure

Transport is one of the basic factors of economic development. In his work "New Economic Geography", Paul Krugman included transport and infrastructure among the three key factors explaining the processes of economic development (Fujita, Krugman, 2004). In order for transport to be carried out in an appropriate manner, access to the appropriate transport infrastructure is necessary. This means access to an appropriately developed rail network, which will allow for fast, safe and cost-competitive transport of goods and people. Due to the great importance of transport for the economy, the relevant institutions and authorities in a properly functioning country try to maintain the proper condition of the transport infrastructure. Looking at transport through the prism of the environment in which it is carried out, we can distinguish the following transport: land, water (inland and sea) and air.

Infrastructure is defined as all the devices and institutions necessary for the proper functioning of the economy. We can therefore speak of economic infrastructure, including services in the field of transport, communication, energy, etc., and of social infrastructure (Towpik, 2004).

The entire road network and permanent devices for the three types of transport that are necessary to ensure safe traffic are called transport infrastructure. When it comes to definitions of transport infrastructure, we can find numerous types in the literature. J. Kristiansen stated that transport infrastructure consists of means and conditions that enable the physical flow of people and goods. The function of infrastructure is to ensure broadly understood conditions for production and provision of services. According to him, technical conditions consist of two components: material equipment and program equipment. Material equipment is a synonym for transport infrastructure understood in the traditional sense, i.e. material, physical elements, such as motorways, airports, railway network or sea ports. Material resources are intended to create conditions for transport activity and logistic processes. In contrast, the program equipment is the general organizational structures, as well as the overall information system operating within this sector. Institutional conditions, in turn, correspond to the general "rules of the game" and mean the legislative framework and statutory instruments that regulate transport services, as well as traffic management and supervision systems. D. Biehl believes that infrastructure is a direct tool of government policy. According to him, a long-term development strategy requires an increase in public resources, which means investments in infrastructure. Planning, implementing and financing such investments is the most important instrument of regional policy (Domańska, 2006). As Kazimierz Towpik notes, the directions of development of transport infrastructure, which is one of the most important elements of the country's spatial development, are influenced by: demographic processes (the distribution of population determines the structure of the transport network), the distribution of sources of raw materials and industry, and the settlement structure (Towpik, 2004).

The economic situation in transport is considered a kind of barometer of the economic situation, similarly to the case of construction. The weakening of this branch of the economy indicates an approaching economic slowdown (Tarka, 2012).

The relationship between economic development and transport can be divided into two categories. The first is a passive relationship in which transport responds to changes in the level of economic activity. The second type is an active relationship in which transport affects the state of the economy. Transport in the economy plays a kind of role of both a recipient and a donor. According to Tadeusz Szczepaniak, as a giver, transport enables the exchange of goods and services. It transports raw materials, materials and semi-finished products intended for production use and finished products intended for personal consumption. Both types of movements support the sphere of goods exchange, both domestic and foreign. Transport is therefore a continuation of production in the sphere of turnover as the last phase of the broadly understood production cycle. In addition to serving the material production departments, transport also serves non-production departments, and also provides services for the population, satisfies the individual communication needs of the population, activates socio-economic and cultural life, and promotes the development of tourism. In turn, as a recipient, the transport sector, reporting demand for, for example, new vehicles or fuels, is served by other sectors of the economy. Thus, the dependencies between transport and other sectors of the economy are mutual (Szczepaniak, 1985).

There are mutual connections between transport and other sectors of the national economy. For this reason, national and local government authorities, wishing to stimulate economic growth and development, must also take care of the appropriate level of transport infrastructure. An underdeveloped transport network causes difficulties in communication. The lack of a transport network in certain areas of the country causes their exclusion from the country's development processes. A poor communication network does not encourage potential investors to invest capital in areas to which access in the broad sense is impossible or difficult. The communication isolation of the region causes further economic backwardness and, as a consequence, depopulation of such an area and further degradation (Wojtowicz, Olechnicka, 2016). In turn, too densely developed transport infrastructure can be a burden on the budget due to the need to maintain the usability of this infrastructure at a certain level. Another threat resulting from excessive infrastructure development is the degradation of the natural environment. This degradation appears in the situation of cutting down large areas of forests or running the transport network through areas covered by environmental protection. Moreover, too high density of the infrastructure network may constitute a nuisance for people living nearby (Kuzior, Staszek, 2021).

Transport infrastructure is influenced not only by domestic policy, but also by foreign policy. Moreover, the entire infrastructure policy of the country is also influenced by non-governmental organizations, an example of which are environmental organizations. Thus, the entities in infrastructure policy in the macroeconomic dimension are state and non-

state bodies. The main assumption of infrastructure policy is to create and maintain a coherent transport system. General concepts of infrastructure policy refer to the implementation of tasks such as: modernization of the transport system, construction of functional infrastructure structures that translate into the economic development of the country. The scope of activities of infrastructure policy includes:

- development of the road/railway network and stations (points) and transport hubs; protection of the natural environment,
- improvement of transport safety through the use of the latest technologies,
- activities aimed at improving the transport of goods and people (Tarka, 2012).

It is an undeniable fact that the availability of a minimum amount of infrastructure is a necessary condition for economic growth and development. However, it should also be taken into account that expanding the transport network above a certain value may not result in further improvement of the country's economic situation. After exceeding a certain level, depreciation increases, which limits the growth of income (Goczek, 2011).

Rail transport is one of the branches of land transport and its operation is based on the transport of people and cargo using rail transport means on a specially designated and built for this purpose transport route - a railway line. Rail transport is a branch of the economy, the operation and development possibilities of which depend to a large extent on its infrastructure. The beginning of rail transport is usually considered to be the year 1825, when the first line with passenger traffic was launched in England (Towpik, 2004).

Railway infrastructure, as defined in the Rail Transport Act (Act of 28 March 2003), is railway lines and other structures, buildings and equipment together with the land occupied for them, located on railway premises, intended for management, handling the transport of people and goods, as well as maintaining the necessary property of the infrastructure manager for this purpose. In general, railway infrastructure can be defined as a set of devices, buildings and structures that enable efficient and safe rail transport. Railway infrastructure can be divided into point and linear. Point infrastructure, which includes, among others: passenger stations, freight stations, junctions, intermodal transshipment terminals, warehouses, yards and ramps, humps, is primarily used to handle passengers during the boarding/disembarking process and cargo during loading and unloading. Linear infrastructure includes railway lines along with elements dividing them, i.e. sections, routes, which in turn enables the implementation of the basic function of rail transport, i.e. moving cargo or passengers from the point of origin to the point of destination, using rail transport (Pietrzak Krystian, Pietrzak Oliwia, 2013). A railway includes the surface, track bed, safety devices and train traffic control (Towpik, 2004).

The basic elements of the railway network are railway lines and the operating points (network nodes) located on them. One can distinguish between elementary, basic and main network components. The elementary network components are route tracks, side tracks and track nodes. The basic network components are created from elementary components - traffic

posts, groups of tracks with separate functions. The main network components are routes with intermediate stations, junction stations, special stations (Towpik, 2004).

It should be emphasized that transport infrastructure is a fundamental factor in the development of each national economy, as well as its individual segments. Transport infrastructure is characterized by high capital intensity, long usability and immobility. This type of infrastructure is referred to as a load-bearing system, as it allows for the creation of a network of connections in a spatial arrangement and creates conditions for socio-economic development (Szaruga, Załoga, 2014).

6. Institutions in the political subsystem

Within the political subsystem, the broadly understood state and its institutions are of the greatest importance. The role of the state today is to shape, implement, and enforce legal regulations. In order to implement socio-economic development, and thus the development of railway infrastructure, it is necessary to create an appropriate institutional system. State institutions, through their prerogatives, have the ability to create appropriate legal regulations and institutional solutions to enable and facilitate these activities (Bentkowska, 2020).

It is worth noting that broadly understood socio-economic development is not possible in a country where legal regulations are not observed and where the functioning of economic entities is difficult. It should be noted that in a weak country we are dealing with weak institutions, i.e. those that do not function properly. At the same time, the lack of efficient institutions discourages potential investors from investing their capital in such a country. Moreover, conducting business activity in a country with weak institutions results in the fact that running such institutions is associated with greater risk and, at the same time, with higher transaction costs (Legiedź, 2013). Due to the fact that effectively functioning institutions translate into economic growth, it is in the interest of the state that institutions function properly (Kuder, 2008). It should be emphasized that creating an appropriate institutional system, one in which efficient socio-economic development will be possible, is not an easy task. It should be noted that the shape of institutions in the political subsystem is influenced not only by entities from political circles, but also by specific interest groups and lobbyists. Such interactions may have a positive or negative impact on the set of institutions created in the political subsystem (Bentkowska, 2020).

Moreover, properly functioning institutions contribute to limiting uncertainty and increasing trust. In turn, greater trust, both in state institutions and entities operating on the market, contributes to limiting the destabilization of economic processes. Thus, economic crises can be limited, either due to their frequency or intensity (Kuder, 2008).

Another function performed by institutions in the political subsystem is to ensure broadly understood security. Properly functioning institutions should take care of law and order in the country. This encourages potential investors to locate their businesses in a given country. Ensuring security within state structures reduces the risk associated with the destruction or theft of assets located there. Therefore, ensuring appropriate protection from institutions functioning in the political subsystem translates into an increase in the attractiveness of a given country in the eyes of investors. This factor is of significant importance in a situation when a country is located in geopolitically unstable areas (Miłaszewicz, 2011).

The state as an institution in the political subsystem has the ability to influence not only changes in the area of formal institutions through appropriate legislative processes, but also has the ability to influence informal institutions. Stimulating changes in informal institutions is possible by creating specific patterns of behaviour, by introducing a specific policy, forming specific attitudes or by supporting specific social activities (Bentkowska, 2020).

7. Institutions in the economic subsystem

Another subsystem that influences the institutional system is the economic subsystem. It should be emphasized, however, that the boundary between the political subsystem and the economic subsystem is not very sharp and that these systems often interpenetrate and complement each other. This is due to the large connections that exist between them. In this way, the economic subsystem influences the political subsystem and vice versa.

A number of different types of institutions operating in the economic subsystem should provide appropriate conditions for the socio-economic development of the state. At the same time, they should limit and neutralize undesirable phenomena appearing in the economy and resulting from the imperfection of economic processes, i.e. broadly understood market failure. By using these institutions, a more sustainable and predictable development of the economy and economic entities operating within it is possible. Therefore, creating and using appropriate institutions in the economic subsystem allows for better use of available resources, as well as reducing costs that appear in economic processes. Institutions in the economic subsystem are responsible for creating appropriate conditions for broadly understood socio-economic development. On the one hand, they are tasked with stabilizing the financial, monetary and tax systems. This is important because the role of these systems is to create such financial and tax conditions that support the economic development of the country. On the other hand, institutions are tasked with stimulating processes that contribute to economic growth and development (Bentkowska, 2020).

A stable financial system allows for efficient market transactions and facilitates the acquisition of capital needed for investment processes. In addition, a balanced financial system translates into building stability on financial markets, which in turn is reflected in the peace of mind of investors and other participants in the economic system. A financial system that is based on solid institutional foundations also allows for the reduction of various types of risks occurring during economic activity, including transaction costs. Moreover, the clarity and transparency of the rules in force in the financial system allows for building trust in the eyes of investors (Owsiak, 2015).

A broadly developed and well-functioning banking system facilitates the functioning of all entities that are part of the economic system. It allows for obtaining the necessary financial resources and provides the opportunity to safely accumulate savings. A stable banking system as an institution of public trust allows for avoiding unnecessary turbulence and uncertainty occurring on financial markets. An efficiently functioning banking system is of great importance for the functioning of the market economy. Its most important and fundamental task is to provide financial resources needed to implement various types of investments, including infrastructure investments. Credit activity conducted by the banking system allows for the propulsion of private and public investments, due to the fact that a significant part of them is financed from credit. For this reason, the lack of a healthy banking system would result in limited possibilities for obtaining the necessary capital. In addition, commercial banks enable and facilitate financial transactions between domestic and foreign entities. They also provide various types of guarantees and sureties, which additionally secure the parties to the transactions carried out. In this way, banks reduce uncertainty and contribute to reducing transaction costs (Begg, Fischer, Dornbusch, 2007).

Another important aspect is the stability of the monetary system. Institutions responsible for managing monetary policy are responsible for maintaining the appropriate value of money and for ensuring that the appropriate amount of it is on the financial market. A well-established monetary system, similarly to the financial system, allows for attracting investors and influences the acceleration of socio-economic development processes. An appropriate monetary policy allows for avoiding deflationary and inflationary processes that adversely affect the state's economy and the investment activities of various entities. The institution of the central bank is responsible for the stability of the monetary system. However, it should be remembered that the state also has an influence on monetary policy, to a limited and indirect extent, but it does have one. It results, for example, from the greater demand of the state (government) for money that is to be allocated for specific investment purposes.

The conduct of appropriate monetary policy by institutions established for this purpose allows for maintaining price stability, which in turn is a necessary condition for enterprises and individuals to predict investment and consumption expenditures. Price instability limits these possibilities and does not promote economic development. The central bank of the state, as an institution dealing with monetary policy, is also responsible for influencing the exchange

rate of the national currency in such a way as to enable favorable trade with foreign entities (Włudyka, Smaga, 2018).

Another system that is created by the appropriate institutions in the economic subsystem is the tax system. Budget policy (also called fiscal policy), alongside monetary policy, is an important element of the state's financial policy. The basic goal that state institutions try to achieve by implementing fiscal policy is to ensure lasting and stable economic growth. As part of an active fiscal policy conducted by the central or local government, it is possible to implement various types of investments, including infrastructure investments. Active economic policy conducted by the appropriate institutions is also aimed at preventing the overheating of the economic situation, which could result in inflation (Winiarski, 2006).

The basic instrument used to implement fiscal policy is the tax system. It should be emphasized that by creating an appropriate tax policy, it is possible to influence entities operating in the economic system. In this way, institutions involved in creating tax policy can stimulate or inhibit investment processes, as well as influence the economic situation. Predictable and low taxation encourages domestic and foreign entities to invest in such a country. Too frequent changes in the tax system translate into a sense of instability and uncertainty in the eyes of potential investors. For this reason, institutions responsible for creating tax policy in the country should carry out their activities in a predictable and transparent manner (Włudyka, Smaga, 2018).

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STRENGTHENING CRITICAL THINKING THROUGH AN INQUIRY-BASED APPROACH TO LEARNING IN THE FIELD OF SUSTAINABLE DEVELOPMENT

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Purpose: The aim is to present how an inquiry-based learning approach can enhance critical thinking in the context of sustainable development education, while also offering practical guidelines for teachers and educational institutions.

Approach: This article will discuss how an inquiry-based approach to sustainable development education can foster critical thinking in students, preparing them to face the complex challenges of the modern world.

Findings: The inquiry-based approach to teaching sustainable development significantly supports the development of critical thinking in students. Learners, instead of passively absorbing information, are actively engaged in problem-solving, which improves their analytical skills and ability to evaluate complex environmental and social issues.

Practical implications: Critical thinking allows for a more conscious and well-considered approach to environmental and social actions, which may lead to better alignment of strategies with actual needs and greater effectiveness of the initiatives undertaken. This, in turn, increases the efficiency of efforts towards sustainable development. The article points to the need for introducing new teaching methods in schools and universities, which place greater emphasis on critical thinking and inquiry-based approaches to solving sustainability-related problems. It also highlights a holistic approach to changing educational directions.

Originality/value: While critical thinking is widely studied, this approach has not been specifically applied in the context of sustainable development. The analysis of available data shows that critical thinking helps better analyze and solve issues related to climate change, resource management, and social justice.

Keywords: sustainable development, critical thinking, inquiry-based.

Category of the paper: Viewpoint, general review.

1. Introduction

In the face of global environmental, social, and economic challenges, sustainable development has become a key goal for modern societies. In this context, educating individuals capable of critical analysis, problem-solving, and making informed decisions is of exceptional importance. Strengthening critical thinking, particularly through an inquiry-based approach to learning, becomes not only a tool for effective teaching but also a foundation for responsible action towards a sustainable future.

Main educational strategies should aim to develop social awareness among students. Political changes, technological solutions, and financial measures alone are insufficient to meet the demands placed on education for sustainable development (Konieczny, 2023b, p. 243). The role of education is to create conditions for developing all aspects of critical thinking to prepare students for life in a dynamically evolving society across all fields of action: economic, ecological, and social.

2. Education for sustainable development

Education for Sustainable Development (ESD) is a broad concept that extends beyond the boundaries of environmental education. In addition to environmental issues, it encompasses social topics such as human rights, multiculturalism, health, and its economic aspects. It is based not only on conveying knowledge but also on fostering creative and critical thinking, and stimulating problem-based learning. Sustainable development is a concept that seeks to harmoniously balance the needs of the present generations with those of future generations, so that socio-economic development occurs without degrading the natural environment and without excluding any social groups. It includes three key dimensions: economic, social, and ecological.

An interdisciplinary approach to teaching sustainable development is necessary because the challenges associated with it are complex and permeate various aspects of life. Issues such as climate change, social inequalities, and natural resource management require collaboration between different disciplines—from natural sciences to economics to social sciences. This approach enables a better understanding of the connections between various aspects of sustainable development and the creation of more effective and integrated solutions. It provides the opportunity to make informed decisions and undertake individual and collective actions to transform society and care for the planet. ESD is a lifelong learning process and an integral part of high-quality teaching, developing cognitive, socio-emotional, and behavioral aspects of learning, including content, learning outcomes, methodology, and the learning environment

itself (UNESCO, 2024). It involves lifelong learning and is an essential component of high-quality education. ESD is holistic and transformative education that encompasses teaching content and outcomes, pedagogy, and the learning environment. It achieves its goal through the transformation of society (UNESCO, 2014, p. 12).

3. Critical thinking

Thinking is required for puzzles, life problems, and daily situations. It helps us find solutions and allows us to transform our mental representations of the world (Nęcka et al., 2006, p. 421). According to psychologists such as R. Sternberg (1999), E. Nęcka (2006), and T. Maruszewski (1996), critical thinking is considered a form of realistic thinking. Its goals include a thorough and realistic assessment of significant aspects of human intellectual activity, as well as enhancing the chances of obtaining results that meet specific criteria. It is connected to creative thinking, as striving to achieve goals according to required criteria allows for the development of conclusions that improve a given definition, subject, or activity (Nęcka et al., 2006, p. 429). Critical thinking also helps to clarify questions or problems, evaluate the truthfulness of evidence, and develop criteria for assessing others' work. A critical thinker is someone who seeks the truth. They do not accept it as given but constantly question everything at all times. They are ready to challenge others' ideas and concepts.

Critical thinking is not about choosing one, always the same, strategy for action. It involves being aware of one's limitations, intellectual humility, and collaboration with experts in the field (Uribe-Enciso et al., 2017, p. 81). It is a skill that must be continually developed; acquiring it without proper stimulation is not a guarantee of success. If a teacher wants to develop this ability in their students, they must encourage them to question their ideas and reasoning. The result of this thinking, which is not easily achieved, will be the willingness of students to critically examine the outcomes and processes of their own thinking. A student who understands that everyone can make mistakes and that others' thinking can also be flawed will more easily accept that they do not always have to be right and will learn to respect others' opinions. Critical thinking should help them better understand the world and themselves. However, it will not be successfully integrated into daily activities if it is just another “systemic” requirement for teachers. A holistic change in thinking about education and its impacts is crucial.

4. The Importance of Critical Thinking in the Context of Sustainable Development

UNESCO has prepared the *Draft Revised 1974 Recommendation Concerning Education for International Understanding, Cooperation, and Peace and Education Relating to Human Rights and Fundamental Freedoms*, which indicates that “education should be transformative, building solid foundations in literacy and numeracy, and enabling the development of knowledge, skills, values, attitudes, and behaviors, such as: analytical and critical thinking; the ability to question norms, practices, and opinions; critical analysis and understanding of complex systems and multicultural environments; as well as understanding the dynamics of power and the interconnections between countries, populations, and the natural environment, as well as between local, national, regional, and global levels” (UNESCO, 2023, p. 6).

The challenges associated with sustainable development are extremely complex and multidimensional, as they touch on various aspects of social, economic, and ecological life, and require a holistic approach that considers the interconnections between these spheres. It is worth noting three main areas:

- **Climate Change:** One of the most urgent and global issues of sustainable development.
- **Biodiversity Conservation:** Crucial for ecosystem health, but also highly complex. Biodiversity protection often requires limitations on the use of natural resources, which can lead to conflicts with local communities that depend on these resources. Finding a balance between protecting nature and meeting human needs is a challenging task.
- **Social Justice:** A fundamental aspect of sustainable development. Globalization often transfers social problems from one region to another. For example, cheap production in developing countries often comes at the expense of working conditions and the environment, raising questions about global justice.

All these areas are strongly interconnected. For instance, climate change can exacerbate social inequalities as the poorest communities are often the most vulnerable to its effects. Meanwhile, biodiversity conservation can support the development of local communities by providing access to natural resources but may also require restrictions that could be perceived as unfair. Issues related to sustainable development therefore require a multidimensional approach that integrates environmental protection, economic development, and social justice. Only such an approach can lead to sustainable solutions.

An effective approach to solving problems related to sustainable development requires skills in critical analysis, evaluation, and informed decision-making. These competencies are crucial because these problems are complex, interrelated, and often lack simple solutions. It is important to consider their correlation:

- **Critical Analysis:** Involves a deep understanding of problems, their causes, and consequences. In the context of sustainable development, this means that complex issues such as climate change, biodiversity conservation, and social justice are closely interconnected. Critical analysis allows understanding how actions in one area impact others, which is key to avoiding unintended consequences. Decisions must be based on reliable data and scientific research. Critical analysis enables the evaluation of source credibility, understanding trends, and predicting future scenarios. There is rarely a single ideal solution in sustainable development. Critical analysis allows for the consideration of various options and understanding their pros and cons, which is essential for making optimal decisions.
- **Evaluation:** A systematic process of considering all aspects of a problem or decision and its consequences, both short-term and long-term. Effective evaluation allows predicting potential impacts, such as effects on the environment, society, or economies. In sustainable development, risk cannot be avoided but can be managed. The ability to evaluate risk allows for identifying potential threats and developing strategies to mitigate them. Decisions regarding sustainable development often involve choosing between different values, such as environmental protection versus economic development. Evaluating these values in an ethical and social context is crucial for making decisions that will be accepted by society.
- **Informed Decision-Making:** Based on recognizing consequences, relying on reliable information, and ethical values. It includes ecological, social, and economic aspects. This requires the ability to think systemically and holistically. Decisions in sustainable development must consider diverse perspectives, including the interests of local communities, industries, future generations, and ecosystems. Informed decision-making is the skill of balancing these interests. Decisions should be flexible and adaptive, as situations and data may change. This means being ready to modify strategies in response to new information or changing conditions.

Critical analysis, evaluation, and informed decision-making are fundamental skills in effectively addressing sustainable development issues. They allow for thorough analysis of problems, understanding their multidimensional impacts, and making decisions that are thoughtful, fair, and balanced. Only such an approach allows for developing effective strategies that can address global challenges related to environmental protection, biodiversity, and social justice. In addressing critical thinking competencies in education, it is not enough to change teaching methods and introduce special programs for developing critical thinking into the existing system, as it requires questioning, deconstructing, and reconstructing the status, role, and power of students and teachers in the teaching process, as well as in curriculum development. Obstacles to developing critical thinking through school education may arise not only from teachers' ignorance and lack of dedication and insufficient training of future teachers but also from other features of the education system (Radulović, Stančić, 2017, p. 23).

5. Inquiry-Based Learning and Sustainable Development

Education where students can progressively overcome stages to achieve outcomes is much more valuable than education that simply conveys raw concepts, working only from textbooks or exercises. Working on complex projects, collaborating, striving to achieve goals, and drawing conclusions helps cultivate a society that is ready to face the challenges of the modern world (Barron, Darling-Hammond, 2013, p. 310). During inquiry-based work, not only does the level of students' knowledge increase, but cognitive independence also develops, allowing students to function better in society and express their opinions more effectively (Konieczny, 2023a, p. 248).

Researchers focusing on inquiry-based learning aim to engage students in an authentic process of scientific discovery. From a pedagogical perspective, the complex scientific process is divided into smaller, logically connected units that guide students and highlight important aspects of scientific thinking (Pedaste et al., 2015, p. 49). These individual units are called phases of inquiry, and their set of connections forms an inquiry cycle. The main essence is to ensure that students achieve cognitive independence. This skill is attainable only when students think, identify problems, and solve them. The problem posed encompasses several educational areas, the research conducted is authentic and relates to real-life situations, and the outcome of students' work results in specific products, such as a debate, an exhibit, or a report. An important element is that students collaborate, as mutual support is essential for achieving the intended goal.

Both inquiry-based learning and education for sustainable development (ESD) occur in stages. Each of these phases is an important element without which the next step cannot be carried out. Below, I have prepared a table illustrating the common features of inquiry-based learning and ESD (Table 1).

Table 1.
Inquiry-Based Learning and ESD

Stage	Inquiry-Based Learning	Education for sustainable development	
1	Understanding, Formulating, and Analyzing the Problem	Recognizing and becoming aware of the existence of local and global issues.	<ol style="list-style-type: none"> 1. Developing a critical observer's attitude and values. 2. Stimulating both external and internal motivation for active participation in society and fostering cognitive independence.
2	Identifying Specific Problems	Recognizing smaller issues that impact the main problem.	Analyzing problems, understanding their connections, and causes.
3	Formulating Hypotheses	Proposing potential causes of problems and their possible effects.	Identifying relationships and causes of social, economic, and ecological issues.

Cont. table 1.

4	Collecting Data and Testing Hypotheses	Observing, analyzing data, and measuring.	Identifying opportunities to change attitudes and values.
5	Solving the Problem	Implementing actions to address or mitigate the effects of the problem.	Transitioning from a passive to an active stance and stimulating a sense of responsibility for the future of the world.

Source: Konieczny, 2017.

The research-based approach to learning in the context of sustainable development involves the active engagement of students in the process of acquiring knowledge through exploration, experimentation, analysis, and critical evaluation of information. Inquiry-based learning is the strategy that most fully embodies the goals of education for sustainable development by fostering the values, skills, and attitudes necessary for addressing the challenges of the contemporary world and future generations (Konieczny, 2017, p. 262).

Students who engage in inquiry-based learning develop critical thinking skills by analyzing diverse sources of information, considering different perspectives, and assessing their credibility. This approach stimulates their ability to identify problems, formulate research questions, and seek solutions. These skills are essential in the context of sustainable development, where developing innovative strategies that address the complexity of social, economic, and environmental issues is necessary. By investigating real-world problems related to sustainable development, students gain knowledge and competencies that enable them to make more informed and thoughtful decisions, both professionally and personally. Understanding the complex interconnections between different aspects of sustainable development better prepares them to evaluate the long-term impacts of their choices. They become more aware of global challenges and are motivated to take action for sustainable development.

6. Conclusion

In summary, I would like to present a section from the research I conducted. The study involved a pedagogical experiment carried out among third-grade primary school students. One of the objectives of the research was to assess the levels of critical and creative thinking among the participants. I employed tools such as knowledge tests, critical thinking tests, and an analysis of students' work products. The study included two third-grade classes, with one serving as the experimental group and the other as the control group. Both classes covered the same material on sustainable development. The experimental group used active learning methods, primarily inquiry-based learning. The experiment lasted for six months. At the end of the experiment, the same tests were administered again as at the beginning of the study.

The findings indicated that knowledge about sustainable development contributes to the development of critical thinking. The experimental group achieved a higher level of knowledge compared to the control group. A positive aspect of inquiry-based learning is the ability to provide immediate feedback. Students become more attuned to the needs and challenges of the modern world. Learning about sustainable development helps in fostering a society that is conscious and responsible, ready to take action. The development of critical thinking provides students with the opportunity to reflect on the contemporary world, the exploitation of its resources, and the responsibility toward other inhabitants of the Earth. Emphasizing rote memorization and requiring only recall of answers or application of simple algorithms does not develop skills in analysis, critical thinking, effective communication in speech and writing, or solving complex problems. A research-based approach to learning in the area of sustainable development not only enhances critical thinking but also prepares students for responsible and informed action in a world that demands skills to handle increasingly complex challenges.

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<https://www.unesco.org/en/sustainable-development/education/need-know>

A PROJECT TO IMPROVE THE PRODUCTION PROCESS USING LEAN MANUFACTURING TOOLS

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Purpose: This study investigates the production process of the selected product, aiming to identify and implement improvements. The objective is to analyze various stages of the production process to pinpoint areas that can be optimized for enhanced efficiency and quality. By focusing on the selected product, the study will evaluate current methodologies, employ advanced techniques, and propose actionable solutions to improve overall production outcomes.

Design/methodology/approach: The core methodologies employed in this project were Value Stream Mapping (VSM) and the 5S framework. VSM was utilized to visualize the current state of the production process, identify inefficiencies, and design an optimized future state. Concurrently, the 5S methodology was applied to organize the workspace, enhance efficiency, and maintain discipline in operations. These methodologies were chosen for their proven effectiveness in Lean Manufacturing and continuous improvement initiatives.

Findings: The study meticulously documented the state of the production process before the implementation of these improvements, providing a baseline for comparison. After the application of VSM and 5S, the production process was re-evaluated to measure the impact of the improvements. The results demonstrated significant enhancements in efficiency, organization, and overall productivity.

Practical implications: The findings of this research underscore the importance of structured project management and the strategic application of lean methodologies in manufacturing. The improvements observed in the production process of selected product serve as a testament to the effectiveness of VSM and 5S in driving process optimization. This study provides valuable insights for manufacturing professionals seeking to implement similar improvements in their own production processes.

Originality/value: The originality and value of this research lie in its practical application and comprehensive analysis of Value Stream Mapping (VSM) and the 5S framework, demonstrating their combined effectiveness in significantly enhancing efficiency, organization, and productivity in the production process of the selected product.

Keywords: Lean Manufacturing, Visual Management, Standardization, Value Stream Mapping.

Category of the paper: Case study.

1. Introduction

In the modern world, the Lean Manufacturing strategy is recognized as an effective production management tool, utilized by both small local businesses and international corporations. The introduction of a Lean Management culture facilitates the creation of transparent organizational structures, effective management of human resources, and continuous process improvement (Carreira, 2005; Dekier, 2012; https://kunjiteindia.com/lean_manufacturing.php; Pranav, 2020). Such an approach promotes increased efficiency and 1-flexibility in operations, which are crucial for maintaining competitiveness in the dynamic industrial environment.

A fundamental condition for the successful implementation of Lean Management is the commitment of the management team, which must actively support the transformation and promote a culture of continuous improvement. According to Liker (Liker, 2004), leadership is critical to the success of Lean projects—leaders should provide necessary resources, organize training, and motivate teams to engage in optimization efforts. The willingness of lower-level employees to embrace changes is insufficient without the deliberate involvement of leaders who make thoughtful decisions and systematically implement Lean strategies (Rother et al., 2009). Awareness among managers regarding potential savings, increased efficiency, and improved work quality forms the foundation of successful organizational transformations. Without their understanding and active support, achieving sustainable and effective implementation of Lean Management principles is challenging, as highlighted in industry literature (Liker, 2004; Rother et al., 2009; Deming, 1986; Pranav, 2020; Bhasin et al., 2006; Wang, 2011; Carreira, 2004; Graupp et al., 2010).

Quality improvement—whether related to processes, products, or the work environment—should be an integral part of management strategy rather than an additional managerial task. According to Deming (Deming, 1986), continuous monitoring, data analysis, and feedback loops are essential for maintaining high standards and driving further improvements.

Today's demanding and rapidly changing market conditions compel companies to redesign production processes, which not only enhances operational efficiency but also contributes to overall business growth. As Womack and Jones (Womack et al., 2003) emphasize, the implementation of Lean strategies enables the elimination of waste and the generation of greater value for customers, thereby enhancing market competitiveness. Tools such as Value Stream Mapping (VSM) and 5S play a crucial role in achieving these goals by enabling the identification and elimination of inefficiencies and improving workplace organization.

In this context, the application of Lean tools like VSM and 5S gains particular significance. As Rother and Shook (Rother et al., 2009) point out, VSM facilitates the visualization of material and information flow in production processes, identifies bottlenecks, and helps design process improvements. Meanwhile, the 5S methodology contributes to better workplace

organization and ergonomics, leading to increased work efficiency and reduced errors. Research by Singh and Ahuja (Singh et al., 2014). Implementation of Lean Practices in Indian Automotive SMEs. *International Journal of Lean Six Sigma*. demonstrates that implementing 5S shortens operation times, boosts employee morale, and minimizes the risk of inconsistencies.

The article presents the application of Lean Management tools in a food industry company, where issues such as high inventory levels, bottlenecks, and inefficient machine layouts were identified. Excessive inventory tied up capital and space, bottlenecks slowed production rates, and inefficient machine layouts led to unnecessary movements and time losses.

To address these challenges, the FIFO method was introduced, enabling better inventory management, elimination of unnecessary operations, acquisition of a carton folding machine, and reorganization of workstations. The practical application of this method has resulted in better alignment of production and storage processes. As highlighted in the literature (Liker, 2004; Bowersox et al., 2013), FIFO not only streamlines material flow but also reduces operational costs by minimizing losses caused by improper inventory management. In the context of the discussed company, implementing FIFO contributed to eliminating excess inventory, improving workspace organization, and increasing operational efficiency (Wild, 2017; Slack et al., 2016; Hopp et al., 2011; Schonberger, 2007). These changes ultimately had a positive impact on the company's competitiveness in the market. These actions, consistent with the literature (Liker, 2004; Rother et al., 2009) represent typical examples of Lean strategy implementation that deliver quick and measurable benefits (Wolniak, 2013; Amrbriz et al., 2023; Ortiz et al., 2016; Maciąg et al., 2021; Tiwari, 2018).

The proposed solutions were validated, confirming their effectiveness. The results demonstrated significant improvements in operational efficiency, waste reduction, and workplace organization. The outcomes included not only increased productivity but also a safer and more ergonomic working environment. Enhanced process efficiency and quality also contributed to greater employee satisfaction and their engagement in future Lean initiatives.

The research and implementation of Lean Management tools in the food industry confirm their effectiveness and versatility in optimizing production processes. The article makes a significant contribution to both theoretical literature and production management practice, providing valuable insights for companies aiming to improve competitiveness and operational efficiency.

2. Methodology

The research was designed based on a mixed-methods approach, combining both quantitative and qualitative methods to obtain a comprehensive understanding of the analyzed issue and evaluate the effectiveness of the implemented actions.

As part of the quantitative research, a detailed analysis of production data collected before and after the implementation of Lean Management tools in the analyzed food industry company was conducted. A key element was the comparison of performance results, such as:

- Overall Equipment Effectiveness (OEE): determining the percentage of machine utilization in relation to their full potential.
- Cycle Time (CT): covering the time required to carry out specific production operations at different stages of the process.
- Total lead time (LT): the total time that the production process begins until its completion.
- Inventory status: the structure and level of inventory were analyzed, with particular attention given to excessive stock, which could have represented a bottleneck in logistics and production processes.

The use of these indicators allowed for the quantitative measurement of the effects of implementing Lean methods such as FIFO, Value Stream Mapping, and 5S (Harvey, 2019; Obora, 2010; Hamed et al., 2020; Parmenter, 2016). For the qualitative research, the following methods were applied:

- Direct observation of production processes: conducted before and after the implementation of Lean Management tools. Observations helped identify inefficiencies, including bottlenecks, excessive movements of workers, and non-ergonomic work layouts.
- Analysis of the production floor layout: assessing the workspace in terms of work organization, material flow, and machine placement. By comparing the layout before and after changes, it was possible to identify the impact of new solutions on process efficiency and work ergonomics.

This comprehensive research method enabled an objective assessment of the effectiveness of the implemented solutions and provided practical recommendations for the company.

3. Suggestion for production process improvements

3.1. Characterization of the production facility along with a description of the problem

The subject of the analysis was a manufacturing company engaged in the processing of meat products. The name and details that could identify the company have been withheld. The plant is divided into two halls - production and packaging. The facility meets ISO 22000 standards, which include the Food Safety Management System and HACCP requirements (Hui, 2021; Feiner, 2006; Olszewski, 2007). In the analyzed area, activities such as packing, labeling, and transporting finished products are carried out. This area is also known as the finished product packaging department. It is the final stage of product preparation before being sent to the customer. The product produced in the analyzed process is a meat product. This process consists of eight operations, for which nine workstations are allocated, staffed by thirteen employees. The flow between the workstations occurs in a parallel manner. Information regarding the names and number of workstations, unit times, and the number of employees is presented in the table (Table 1).

Table 1.

List of operations of the analyzed production process

Operations	Position title	Number of workstations	FTE	CT [s]	Description
10	Thermal treatment	2	1	2700	Introducing the filled trolley with the product into the thermal treatment chambers
20	Thermal treatment	1	1	60	Weighing the trolley after leaving thermal treatment and registering it in the system
30	Deposition of the product	-	-	86400	After thermal treatment, the product waits in a cold store for further processing
40	Transferring products from trolleys to containers	2	4	300	Reloading product from trolleys to containers
50	Packaging	3	5	30	Packing products into hand-folded cartons
60	Wrapping pallets with foil	1	1	180	Wrapping the finished pallet with a wrapper
70	Weighting	1	1	100	Weighing the finished pallet and registering it in the system
80	Transport to the shipping warehouse	-	1	120	Transport of the finished pallet to the shipping warehouse

where: FTE - number of employees, CT – duration of operation.

Based on the analysis, it was found that the main issues in the analyzed area are high inventory levels, unnecessary employee movements, and suboptimal workstation layout. These inefficiencies affect the quality of the produced goods, the order fulfillment time to the customer, and the overall ergonomics and work culture at the stations. As shown in Table 1, the longest operation in the analyzed production process is the settling of the product after exiting the thermal processing chambers. The shortest operation in the process is packing the products into manually assembled cartons.

3.2. Creating a current state map and identifying the bottleneck

Creating a current state map of the analyzed process requires significant dedication and an in-depth understanding of the work culture at individual positions. One of the most important aspects of creating a current state map is the precise identification of any bottlenecks present in the process, if they exist.

Value Stream Mapping (VSM) is a technique used to analyze the flow of materials and information necessary to deliver a product or service to the consumer. In today's competitive environment, there is a trend towards delivering high-quality products based on the voice of the customers (VOC) while also offering them at competitive prices. To become a profitable company, it is crucial to effectively streamline the workflow and reduce waste. VSM allows manufacturers to understand their current state and identify types of waste that need to be eliminated or significantly reduced. VSM helps visualize value, waste, and the sources of waste within the value stream, making it a valuable tool for manufacturers across various industries.

VSM involves mapping the flow of all components and subassemblies within the value stream, which includes production, suppliers, and distribution to the customer.

Another significant aspect is that VSM can be led by someone knowledgeable about the process but not necessarily familiar with the production facility (Rother et al., 2009).

Additionally, it is essential to conduct a detailed analysis of all operations in terms of their cycle time (CT), the number of workstations, the number of employees assigned to a given workstation (FTE), and the time duration of activities between operations, which do not add value from the customer's perspective. The sum of all times will allow the determination of the total lead time (LT).

This comprehensive analysis is crucial for identifying inefficiencies and areas that need improvement, ultimately aiming to enhance the overall efficiency and productivity of the process. The analyzed part of the production process ranges from thermal treatment to the shipment of the finished product to the customer. The product, once prepared, is moved to a room where it undergoes a setting process that lasts exactly 24 hours. This is a process required from the standpoint of food technology, and it cannot be shortened or extended.

The next operation is transferring the product from T-forklifts to E2 containers, which is marked in red on the map. This operation is completely unnecessary and has been identified as waste. The subsequent operation is packaging the finished product into cartons, which is also marked in red because a bottleneck occurs at this point in the process. The following operations include wrapping the pallet with film, weighing, and registering it in the system. The entire production process concludes with the transport of the finished pallet to the warehouse. The total time is 28 hours.

Figure 1 shows the Value Stream Map prepared according to the above for the analyzed process before implementing changes. The symbols used in the value stream map have been slightly enhanced with drawings depicting the actual activities performed by the employees, significantly facilitating the interpretation of the map and the processes it includes (Table 2).

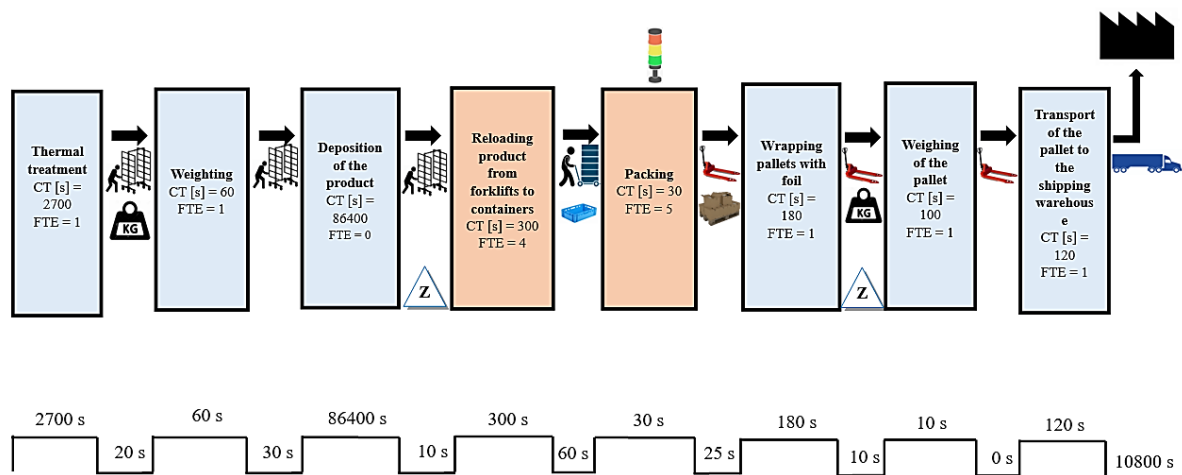










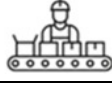




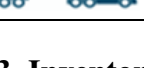
Figure 1. Value Stream Map of the Analyzed Area – Current State.

Source: own work.

Table 2.
Symbols in the Value Stream Map

Symbol	Symbol description
	Customer/supplier plant
	Inventories: warehouse, in production, handy, buffers
	Pallet with goods
	Internal transport
	Pallet truck
	Weighting

Cont. table 2.

	Andon
	Mobile phone
	Working on a tape
	Transport of a truck with raw materials
	Transporting the T-cart
	E2 container
	Transport of E2 containers on the platform
	Transport by truck

3.3. Inventory Measurements

One of the fundamental problems in the analyzed area is high inventory levels, which significantly hinder work and movement for the employees on the shop floor. To reduce the stock levels and identify the source of waste, four measurements of the current state of the inventory were initially taken. These measurements were conducted during the first shift on different days of the week to obtain the most accurate results. The focus was mainly on the number of forklifts and containers, in which the products are primarily transported, as well as on the pallets ready for shipment to the customer (Table 3).

Table 3.

Current state of the inventory in the analysed area

Measurement number	Amount of forklifts [pcs.]	Amount of containers [pcs.]	Amount of pallets [pcs.]
1	112	5596	78
2	130	7314	66
3	175	6836	72
4	41	12595	53
Average	114	8085	67

Based on the data in the table, it can be observed that measurements significantly differ from each other, especially concerning the number of forklifts and containers. This variation might be due to bottlenecks or suboptimal production planning. The lack of utilizing the FIFO method could be critical, since product shelf life is essential in the food industry. Additionally, the packaging area doubles as a warehouse for finished goods, making movement within the hall challenging, impacting operator efficiency, and hindering the establishment of transport routes for employees.

Employees often don't know which goods they should deliver to the shipping warehouse first. This causes delays in deliveries and results in a high number of pallets in the warehouse. An effective approach would be to use the FIFO method and label finished pallets with large, easily visible cards indicating their creation date.

3.4. Elimination of the operation: reloading goods from forklifts to containers – employee training

The process of transferring goods from a forklift to a container has been identified as waste. The employee performs unnecessary movements by transferring the product from a type T cart to an E2 container and then only transporting filled E2 containers to the packing station. Instead of the aforementioned operation, the T-type forklift can be directly transported to the packing area without prior transfer to containers. This approach will save time and human resources, as four workers specifically assigned to the task of transferring goods from forklifts to containers can be reallocated. After the product placement process is complete, the worker will transport the forklifts directly to the packing stations.

The new operation involves the packaging employee taking a rod from the T-type forklifts, which holds meat products, and then placing them on the packing table. The cycle time for this operation has been reduced from 300 seconds to 180 seconds. This 40% optimization will result in additional profits for the company on a monthly or yearly scale.

3.5. Implementation of the 5S tool – shadow boards

Proper workplace organization and standardization are crucial for maintaining order and improving the culture and ergonomics for operators.

One effective practice is to introduce shadow boards for cleaning tools in workspaces and garment factories. Each tool has its designated “shadow” on the board, along with a serial number, making cleaning tasks significantly easier—even for foreign workers. Yellow tape marks equipment specifically for floor cleaning

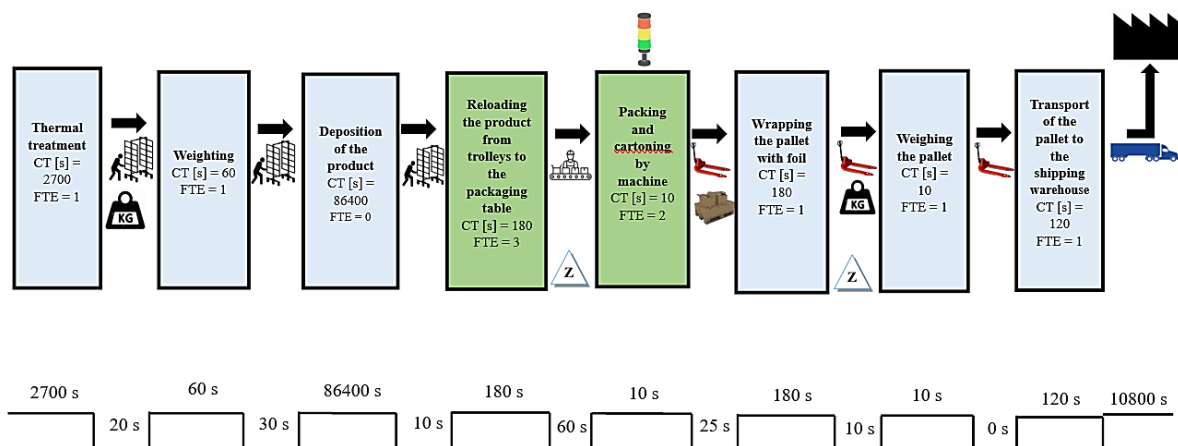
3.6. Verification of implemented improvements

The implementation of changes, especially the application and maintenance of the FIFO method, as well as the reorganization of the product packing hall—such as arranging workstations in parallel and introducing a machine for folding cartons—significantly reduced the number of pallets ready for shipment. The total count of T-type forklifts, E2 containers, and pallets ready for shipment is presented in Table 4.

Table 4.*Inventory levels after improvements introduced in the analyzed area*

Measurement number	Amount of forklifts [pcs.]	Amount of containers [pcs.]	Amount of pallets [pcs.]
1	102	5664	43
2	132	7688	32
3	150	6509	37
4	40	10124	40
Average	106	7496	38

The total lead time remained relatively stable after optimization. Initially, it was 1680 minutes (equivalent to 28 hours). Following the optimization, it decreased by less than 1%. Two operations within the value stream map underwent changes, highlighted in green. This signifies process optimization in terms of time, human resource utilization, and overall work organization. Prior to process improvement, 9 workers were required for unloading and packing operations. After optimization, only 5 workers are needed. Freed resources can be reallocated to other positions, effectively supporting additional production tasks. This not only reduces the required workforce at a specific stage but also optimizes overall human resource utilization within the company. The value stream map based on these improvements is presented in Figure 2.

**Figure 2.** Value Stream Mapping of the analyzed area – future state.

The application and consistent control of the FIFO method, along with eliminating bottlenecks through the purchase of a machine for folding and gluing cartons, optimized the product packaging process. Additionally, arranging packing stations in parallel contributed to waste reduction, cost minimization, and overall improvement in workplace culture.

The overall comparison before and after the implemented changes is presented in Table 5.

Table 5.*The comparison of the project's results*

	Before	After	Percentage difference
Average amount of E2 containers [pcs.]	8085	7496	7,5%
Average amount of forklifts [pcs.]	114	106	7%
Average amount of palletes [pcs.]	67	38	44%
FTE (amount of employees)	14	10	30%
Lead Time [h]	28	28	-
			58,5%

4. Summary

The subject of the conducted research was a selected production process in a food industry company. The analysis revealed that there were aspects in the studied area causing waste and requiring improvement. In the project, Lean Manufacturing tools such as Value Stream Mapping (VSM) and 5S were utilized. As a result of the conducted analyses, it was determined that:

- **Effective Project Implementation:** The research demonstrated that implementing Lean Manufacturing tools effectively is achievable in a food-producing company. This finding underscores the adaptability and applicability of Lean principles beyond traditional manufacturing sectors into food production, which often deals with unique challenges related to hygiene, safety, and regulatory compliance.
- **Identification of Production Bottlenecks:** Through observations and analysis using the Value Stream Mapping tool, a production bottleneck was identified at the packaging stage. This bottleneck was a critical point in the process that hindered overall efficiency. By pinpointing this stage, it became clear where optimization efforts needed to be concentrated. Other areas requiring optimization were also highlighted, demonstrating the comprehensive diagnostic capability of VSM.
- **Reduction in Workforce and Inventory Levels:** The project tasks led to a significant reduction in the required workforce and inventory levels. This outcome was achieved through the elimination of unnecessary steps in the process and the optimization of workflow. The reduction in inventory levels directly translated into lower holding costs and reduced waste due to perishable goods. Additionally, fewer workforce requirements without compromising output indicate streamlined operations and better use of human resources.
- **Cost Savings and Improved Work Culture:** These operational improvements resulted in annual cost savings, which can be reinvested into the company for further improvements or other strategic initiatives. Moreover, the improvements in work culture and ergonomics were notable. Enhanced work environments not only improve employee

satisfaction and productivity but also reduce the risk of workplace injuries, which can further contribute to overall cost savings.

- **Enhanced Production Efficiency and Organization:** In summary, the application of Lean Manufacturing tools, such as VSM and 5S, in the food industry enabled the identification and elimination of waste, significantly enhancing production process efficiency and organization. The systematic approach provided by these tools helps create a more responsive and agile production system, better aligned with customer demands and market conditions.

The results of research on the application of Lean Manufacturing tools in the food industry confirm their effectiveness in increasing productivity and reducing waste, despite challenges related to hygiene and regulations. Studies conducted in similar research areas, such as the works of Teixeira and Costa (Teixeira et al., 2015) and Rother and Shook (Rother et al., 2009), show that tools like VSM and 5S effectively identify bottlenecks, such as in the packaging stage, allowing for process optimization. The reduction of inventory and workforce, confirmed by research from Sreedharan et al. (Sreedharan et al., 2011), leads to savings and increased efficiency. Furthermore, the implementation of Lean in the food industry, as indicated by the studies of Knol et al. (Knol et al., 2014), allows for the elimination of waste, optimization of material flows, and improvement of work organization.

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STRATEGIC PLANNING IN MUNICIPALITIES AND DISTRICTS – SWOT/TOWS ANALYSIS

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Purpose: The aim of the study was to present strategic planning issues in municipalities and districts using SWOT/TOWS analysis.

Methodology: The research was based on a systematic literature review and content analysis.

Findings: In strategic planning, we can distinguish different phases. Each of these phases is characterized by a different value in terms of the effectiveness of strategic decision-making. Municipal and county offices occupy a special position that must be taken into account during all types of planning. Firstly, the tasks of a municipality or county are defined, more or less precisely, by legal regulations. Secondly, an office is not an institution operating for profit - it is therefore more difficult to measure the effectiveness of the office's activities, special tools and indicators are needed for this. Thirdly, political and social factors often come into play. Strategic planning must be preceded by a strategic analysis.

Practical Implications: Strategic analysis is a combination of two ways of looking at management and two sources of information, it is a simultaneous study of the environment and the organization itself and confrontation of the results of this research. The second feature of strategic analysis is its interdisciplinary nature - the use of various methods (qualitative, quantitative) from different fields of science. The third aspect is time - strategic analysis concerns both the future and the past, because it examines current trends, analyzes available data and on this basis designs actions for the future.

Originality: The article presents the theoretical foundations of strategic planning in communes, municipalities and districts.

Keywords: strategic planning, strategic analysis, SWOT/TOWS.

Category of the paper: Research paper, theoretical paper.

Introduction

In many institutions – enterprises, offices, the activities of management and executive staff focus on one aspect – somehow surviving the day. J. Penc writes “In the grind of everyday problems (...) they act like a good fire brigade. They put out fires, that is, they solve constantly

recurring problems and reinforce the need to constantly keep their finger on the pulse” (Penc, 1992). Unfortunately – acting in this way means that instead of devoting most of their time to really important matters, the management staff goes in circles – around some insignificant undertaking, detail. That is why current management must be based on a solid strategic foundation, with an appropriate arrangement of tasks and roles. The etymology of the term “strategy” has ancient historical and military origins. The word comes from the Greek word – strategos and means the art of effectively conducting a fight – an armed victory over opponents. Two important elements of strategy can be emphasized here – art and effectiveness. Here are three sample definitions of strategy:

1. Strategy is a series of actions by a firm that are decided on according to the particular situation (Neumann, Morgenstern, 1947).
2. Strategy is a set of goals and major organizational undertakings (Tilles, 1963).
3. Strategy is a set of ideas and structures through which a company recognizes, interprets, and solves specific problems and in accordance with which it selects and undertakes specific actions (Hedberg, Jonsson, 1977).

As you can see, the scope of these definitions is different. However, their essence is similar. If we were to trace the evolution of strategic thinking in an institution, we could distinguish the following phases, following B. Wawrzyniak (Wawrzyniak, 1993):

1. Financial planning – which would de facto come down to budget implementation (annually).
2. Long-term planning – predicting the past (multi-year budgets).
3. Outward-looking planning – strategic thinking (assessment of strategic alternatives, “dynamic allocation of resources”).
4. Strategic management – creating the future (restructured and formalized strategic assumptions, strategically oriented organization, interdependent strengthening of management processes, supporting system of values and organizational climate).

Each of these phases is characterized by a different value in terms of the effectiveness of making strategic decisions. Phase one is the poorest in this respect, phase four is the fulfillment of the assumptions of a well-functioning institution, an institution with a vision and tools for action. Unfortunately, many institutions in Poland are still in phase 1. It is worth emphasizing here that the office occupies a special position here, which must be taken into account during all types of planning. Firstly – the tasks of the commune or district are defined, more or less precisely, by legal regulations. They cannot be abandoned because they are unprofitable. Secondly – the office is not an institution operating for profit – it is therefore more difficult to measure the effectiveness of the office, special tools and indicators are needed for this. Thirdly, political and social factors often come into play, which in market enterprises usually have only secondary significance. When preparing a strategy in this area, we must remember all these factors. Let us move on to the features of strategic analysis, to what distinguishes it from other analyses used in the process of managing an institution.

Strategic analysis

Strategic analysis combines two ways of looking at management and two sources of information, it is a simultaneous study of the environment and the organization itself and confronting the results of this research. The second feature of strategic analysis is its interdisciplinary nature - the use of various methods (qualitative, quantitative) from different fields of science. The third aspect is time - strategic analysis concerns both the future and the past, because it examines current trends, analyzes available data and, on this basis, designs actions for the future.

The objectives of strategic analysis are primarily (Berliński et al., 2004):

1. identification of opportunities and threats generated by the environment in the context of further development of the institution,
2. early detection of any irregularities in the functioning of the enterprise itself and their sources and causes,
3. self-definition of the institution and determination of its place in relation to other institutions carrying out similar tasks,
4. creation of substantive and pragmatic foundations for taking the necessary actions aimed at making the institution more dynamic and launching the necessary development processes,
5. confrontation (balance) of opportunities and threats inherent in the environment and the strengths and weaknesses of the enterprise in order to define variants of the development strategy and, consequently, management plans and strategies,
6. identification of the strengths and weaknesses of the institution,
7. assessment of the risk associated with conducting individual types of activity,
8. determining the possibilities of creating added value for customers and other stakeholders of the institution,
9. identification of the expectations of various interest groups,
10. assessment of the strategic position of the institution in the environment,
11. identification and filling of the strategic information gap,
12. providing premises for selecting the best variant of the institution's strategy in a given situation,
13. providing data and information enabling the development or modification of the company's mission and vision.

Strategic analysis should be conducted systematically and consistently. It should consist of three stages:

1. analysis of the environment divided into the study of the macro-environment and the competitive environment,
2. analysis of the institution's potential,

3. compilation of the results of the analysis of the institution's environment and resources and drawing conclusions that allow for the formulation of variants of the company's strategy.

The proper strategic analysis should also be preceded by a so-called diagnostic analysis, aimed at determining the current state of the institution and its development prospects. It constitutes a certain information basis for the strategic analysis, which is why it is often not distinguished as a separate analysis. The diagnosis of the institution's resources includes primarily:

1. a short history of activity,
2. legal situation,
3. organization,
4. employment,
5. potential,
6. "products",
7. economics and finances,
8. marketing and promotion.

In turn, for the purposes of the analysis, the macro-environment can be divided into six smaller segments (Gierszewska, Romanowska, 2003):

1. economic environment (interest rates, exchange rates, inflation rate),
2. technological environment (modern technologies, the Internet, information transfer),
3. social environment (poverty, social movements, social problems, crime, indifference),
4. demographic environment (ageing society, migration, fewer children),
5. political and legal environment (legal basis for action, external pressures, cooperation with other entities),
6. international environment (exchange of experiences, showing good practices, partner cities).

Individual methods can be divided into those appropriate in planning and analysis of the strategic environment and integrated methods. A kind of crowning achievement of all these methods is the SWOT/TOWS analysis. This is an analysis that allows for the formulation of the organization's strategy (Johnson, 2010). It summarizes the most important issues related to the business environment and the strategic capabilities of the organization, which will probably have the greatest impact on the development of this strategy. However, in order to properly conduct it, data is necessary, which we can obtain using other analysis methods.

At each stage of strategy development, appropriate consultations are necessary. While internal consultations can be reduced to meetings, e.g. of an internal working group and sending a draft document or inquiries to individual departments or units for comments, special attention should be paid to social consultations (with representatives of the local community - e.g. leaders of local non-governmental organizations and directly with residents of the commune) and directly with residents - including representatives of potential beneficiaries of the strategy.

In the case of expert consultations, apart from traditional meetings, e.g. within working groups or a strategy team, the so-called Delphi method is worth considering. This is a method of establishing a long-term forecast by examining expert opinions. It consists of collecting opinions using surveys addressed to specialists involved in activities in various fields (levels). Experts remain anonymous. Anonymity is intended to avoid mutual influence between experts during the discussion. The forecast is made in several stages. In the first stage, individual opinions of experts on the expected development or timing of hypothetical events are revealed using a questionnaire. In the second stage, the experts are given the distribution of the obtained statements with a request to re-balance the opinions and, in the event of a change in the previously taken position, to indicate the reasons for its revision. In the third stage (or even later), the procedure is repeated in order to achieve greater consistency of the assessment, i.e. to obtain a position shared by the majority of experts, i.e. dominant assessments (Penc, 1992).

The advantages of this method are a high degree of independence and objectivity of the opinions. However, let us move on to the methods of strategic analysis of the environment. The first one to be presented here is the PESTER analysis (trend analysis). PESTER originates from the business sector, where it is known as PEST - analysis of the environment. Its name comes from the first letters of words describing external trends, influences, and impacts:

P – political.

E – economical.

S – social.

T – technological.

PEST analysis has been adapted to the local government environment by extending it to include two areas:

E – ecological.

R – legal regulations.

This analysis allows for a full description of the environment in which a commune/county operates. It is one of the lesser-known methods of examining the environment. Its basic feature is its ease of implementation and the ability to focus the institution's attention on the most important external factors.

Another method of analyzing the environment is the so-called scenario methods. A scenario is a certain probable course of events in a given field, in a given place. It allows for the analysis of a wide range of conditions that are likely to occur in the institution's environment. Scenarios are usually built for a time period of 5 to 15 years, with the reservation, however, that the more changes we observe in a given field, the faster they occur, the shorter the scenario should be. The idea of scenario planning is to create many visions (alternative areas of the future) and design an appropriate response of the institution that will allow for the best use of a given situation or avoid the threats associated with it.

There are many types of scenarios, but the most interesting for the topic of our meeting today will be the scenarios of the state of the environment. The method of their construction can be divided into 5 stages:

1. Identifying factors and processes that affect the institution - you can use the previously prepared PESTER analysis for this purpose.
2. Assessing individual processes in terms of the strength and direction of the impact on the institution according to a specific scale, e.g. from -5 to +5 points and in terms of the probability of occurrence according to three variants of changes (growth, stabilization, decline).
3. Sorting trends according to individual scenarios, i.e.:
 - optimistic scenario (created by trends with the greatest positive impact on the organization),
 - pessimistic scenario (created by trends with the greatest negative impact),
 - surprise scenario (created by trends that are the least likely),
 - the most probable scenario (consisting of trends that have the highest probability of occurrence).
4. Determining the average strength of the impact of individual factors in the distinguished spheres of the environment and their graphical presentation.
5. Drawing conclusions covering aspects such as:
 - analysis of the turbulence of the environment and the degree of the institution's dependence on the changes taking place in it (the greater the range between the optimistic and pessimistic scenario, the greater the organization's dependence on the environment - the more carefully the strategy must be formulated);
 - analysis of the range of the most probable scenario in individual spheres. The greater the range, the more heterogeneous and less structured the environment is;
 - defining in the most probable scenario the spheres in which opportunities dominate and those in which threats dominate;
 - isolating from the most probable scenario the leading processes in the environment, i.e. those that have a strong impact on the organization (both positive and negative) and a high probability of occurrence;
 - analysis of the surprise scenario - isolating trends with a low probability of occurrence, but a strong positive or negative impact on the institution. This analysis is very useful in building a kind of "early warning system".

The main advantages of scenario methods:

1. They help the company's management in setting goals.
2. They increase the effectiveness of making quick strategic decisions.
3. They discover the mechanisms of the dynamics of the institution.
4. They are an instrument for actively shaping the future of the institution.

5. They stimulate the launch of change processes.
6. They generate new ideas, allow for the free play of imagination, the use of invention and creativity.
7. They discover opportunities and threats.

Their limitations are:

1. Costly.
2. They require extensive experience of in-house specialists and the help of external experts.
3. They require great creativity of the team developing the scenario.
4. It may happen that none of the developed scenarios will "fit" reality.
5. Having scenarios does not guarantee the effectiveness of the strategy developed on their basis. As you can see, the discussed methods are interconnected, so let's move on to the next one - M.E. Porter's "five forces" analysis (a model of competition analysis in the industry). The diagnosis of the state in relation to the external environment is characterized here by two approximations:

- the first is a quick, "bird's eye view" analysis of the diverse dimensions of the company's or commune's environment (environment). This analysis includes, among others, PEST in the business sector, and PESTER in the local government sector, "Social and Economic Profile", "Entrepreneurship Climate Study";
- the second approximation is an analysis of the company's direct competitive environment conducted, among others, using Porter's five forces model.

The five basic forces shaping the company's competitive environment are:

- entry barriers,
- suppliers,
- recipients,
- substitutes,
- rivalry between competitors.

The starting point for the possibility of applying the analysis method is a clear definition, already at the mission level, of strategic domains that are the answer to the question: What is the subject of our interests? What will be the driving wheels for the development of our commune/county? After unambiguous definition, similarly to business, strategic domains become areas of our activity. Now is the right time for the analysis proposed by Porter – with one condition: similarly to business and local government, this method is definitely the most appropriate in the situation of introducing a new product/"launching" a new area of local government activities or entering a new market with a product/activities.

Let us recall one more concept here. Entry barriers - in economics, we agree on entry barriers, which are a structural limitation of the competitiveness of the industry, often underestimated by the management of companies, but also communes/counties. High entry

barriers limit the possibility of a competitive attack from unexpected, new competitors, in simple terms they mean high costs (material and intangible) of entering a given market. High entry barriers depend on many variables: economies of scale, capital requirements, brand strength, switching costs, access to distribution capital, access to technology, government regulations and entry barriers.

The pressure force of suppliers and customers is a set of competitors in the industry.

The threat of substitutes is another variable that shapes the dynamics and attractiveness of the industry.

The intensity of competition within the industry itself is another important element. In the business sector, we observe industries within which there is a deadly fight, e.g. the brewing industry, but we also observe industries in which the situation is completely different, e.g. the railway bumper production industry. The level of competition in the industry is influenced by:

- the growth rate of the industry itself,
- the degree of product differentiation,
- fixed costs,
- the number and differentiation of competitors.

Moving to the local government sector, it can be safely stated that the situation of Polish communes, counties and regions is much more similar to the brewing industry than to the production of railway bumpers. A cursory analysis of the forms and promotional documents of Polish communes allows us to draw the conclusion that there is a high degree of competition between communes for, e.g. external investors or tourists.

At this point, it is worth briefly mentioning two methods of analyzing the environment.

The first of them is the so-called benchmarking. This is a method based on creative adaptation in one's own institution of solutions developed by others - the best in their class. It requires constant observation of the sector in terms of good practices, model solutions, which, with appropriate modification, can be transferred to one's own area. To sum up - it is a process of continuous measurement and comparison of processes occurring in a given institution with analogous processes occurring in other organizations. This method is considered a vehicle for disseminating innovations in the industry.

Practical use of benchmarking is mainly to serve the following purposes (Urbaniak, 1999):

1. defining customer requirements,
2. establishing effective goals and objectives,
3. establishing the best patterns in a given field,
4. developing time-based productivity criteria,
5. achieving greater productivity.

The scope and subject of benchmarking are basically arbitrary. In practice, we can distinguish, among others, the following types of benchmarking:

1. internal (when, for example, a department has developed patterns) and external,
2. comprehensive, functional (we imitate only one function), process (one process), procedural (a selected procedure), etc., etc.

To sum up, we can say that the benchmarking method creates many opportunities for improving the organization:

1. It allows the institution to understand its own organizational processes well and emphasizes the need to improve them.
2. It allows finding new sources of improvement and new ways of proceeding externally.
3. It establishes reference points for measuring the degree of implementation of various processes.
4. It focuses attention on the constantly changing environment.
5. It prevents self-satisfaction (through constant comparisons with others).
6. It stimulates learning processes in the organization and motivates to introduce changes and improvements.
7. It accelerates the processes of continuous improvement of the organization and ensures the implementation of new solutions on an ongoing basis.
8. It is a good way to set operational and strategic goals.
9. It allows you to learn from the mistakes of other organizations.

However, it also has its drawbacks - first of all, by imitating others, we can contribute to a significant decrease in creativity and innovation in ourselves, and it does not always have to be the case that only others are better. Using this method causes individual institutions to become similar, to stick to dominant methods - not necessarily the best ones.

The second method - ETOP analysis (Environmental Threats and Opportunities Profile) is a method that allows you to create a profile of opportunities and threats occurring outside the institution. It takes into account elements of the closer and more distant environment. Its aim is to identify and use emerging opportunities and to determine, avoid or reduce possible threats. De facto, ETOP analysis is therefore part of the SWOT analysis, which is a comparison of the strengths and weaknesses of the organization with its opportunities and threats.

Strategic analysis would not be complete without an analysis of the institution's potential. It is therefore worth devoting a few words to this topic as well. The basic methods of analyzing the potential of an institution include the resource analysis developed by Hofer and Schendel. This is a fairly simple analysis that involves identifying and describing existing resources across various functions performed by the institution. Several types of resources are listed here:

1. financial (cash, bank accounts, securities, creditworthiness, level of indebtedness),
2. material/physical (buildings, land, equipment),
3. human (employees, management staff),
4. organizational (organizational chart, control system),
5. technological.

Financial potential is treated as the most important here – because it allows for obtaining resources of a different type. Resources are analyzed across functional boundaries (i.e. in terms of finance, management, development, marketing, “production”). The aim is to determine the amount of resources assigned to individual functional areas and to determine whether this allocation is appropriate from the point of view of the goals realized by the organization.

A similar method to resource analysis is the so-called strategic balance sheet. This method also allows for a comprehensive examination and assessment of the resources and skills of an institution. The preparation of such a balance sheet involves selecting several or a dozen or so strategic areas in the company's activity and identifying the most important factors in these areas. Each of these factors should then be assessed according to the adopted point scale, which will allow us to determine (after summing up) which factor requires improvement, which area should be particularly taken into account. We can designate very different areas here - depending on the specifics of a given organization: human resources management, fixed assets management, planning, work organization. The assessment of individual factors can also be made qualitatively (weak, strong). This is also a profile of the institution's strengths and weaknesses, and therefore also a part of the SWOT analysis, which we will discuss here, the part concerning the organization's interior. This method is relatively simple to conduct, but it is also very laborious due to its high level of detail. Similarly to the previously mentioned resource analysis, it is a good introduction to more complex methods of analyzing the institution's potential.

When talking about the analysis of the potential of an institution, it is worth mentioning at least a few words about the analysis of strategic capabilities. Strategic capabilities are related to three basic factors: resources available to the institution, competences in the implementation of various tasks and the optimization of resources and activities. The analysis of strategic capabilities takes into account the degree to which resources, skills and competences match the environmental conditions in which the institution operates. Here, great emphasis is placed on the use of knowledge accumulated in the enterprise, which is the basic type of resource here.

At this point, we come to the SWOT analysis, which consists of identifying:

S – Strengths – strong points, assets RESOURCES.

W – Weaknesses – flaws, weaknesses, weak points.

O – Opportunities – opportunities, possibilities, chances ENVIRONMENT.

T – Threats – difficulties, threats.

This popular strategic analysis at the level of strengths and weaknesses is used for internal diagnosis of the state. At the level of opportunities and difficulties, this analysis refers to the diagnosis of the state of the environment. Seemingly uncomplicated, it is very often performed superficially, which may result in errors or simply not be a valuable element of the diagnosis.

The two main problems with SWOT analysis are:

- lack of selection of key areas of activity,
- lack of selection of a frame of reference for assessing strengths and weaknesses.

In the case of the first problem, in the business sphere, we observe that in many cases the process of analyzing the strengths and weaknesses of an institution begins with a discussion about the entire organization, during a session of advisors with the company's management staff. Such an unstructured approach has its advantages, because it forces the participants of the session to look at the company as a whole and unleashes creativity. At the same time, the end result is not particularly useful, because managers most often create long lists of features considered strengths or weaknesses, from which little results. Therefore, better results are achieved by thinking about the strengths and weaknesses of an institution through the prism of competitive factors or organizational processes that are key to success. This allows for the structuring of the process of assessing strengths and weaknesses and the use of the analysis of the environment. Typical sets of activities for which a SWOT analysis is conducted in a company are:

- Technology.
- Production.
- Management.
- Finance.
- Marketing, Distribution.
- After-sales Service and Maintenance.
- People Management.

For an institution such as a local government of a county commune, these could be areas such as:

- Economy,
- Society,
- Education and Culture,
- Social Policy,
- Sports and Tourism,
- Healthcare.

The problem with the business sector is not a foreign problem for the local government sector. Similarly to a company, at the level of a commune or a district, conducting a general SWOT analysis does not bring good results. We receive a set of more or less general statements rather loosely related to each other, where, in addition to advantages concerning, for example, the good functioning of the information point in the main hall of the commune office, a large number of forests that occur in the commune are mentioned. The solution to this problem, similarly to the business sector, is the selection of key areas of activity. Therefore, it is important to always perform SWOT analyses for previously selected strategic domains of the commune/county development. This is an important action from the point of view of direct connection of the mission with further elements of the strategy. The second problem, often observed in SWOT analysis, is the lack of a reference frame for assessing the strengths and

weaknesses of the company or commune. In the case of companies, the most common mistake made by managers and consultants is analyzing the strengths and weaknesses of the company in a perfect vacuum, i.e. without a specific frame of reference. When using SWOT analysis in the local government sector, we are dealing with a similar problem. We can deal with it by conducting a constant comparison of the analyzed commune to its neighbors or other local government units with similar development aspirations, average values for the county, province and Poland. If we want to ask the question of what is the strength or weakness of the institution, we need to know the frame of reference well - and this is where the previously discussed method - benchmarking - will come in handy.

SWOT analysis is very widely used in strategic management. Its usefulness results primarily from the fact that (Grudzewski, Karst, 1999):

1. it determines the place of the analyzed institution in the environment, as well as the available development opportunities,
2. it allows you to focus on the most important factors,
3. it is a universal tool; depending on the experience of the people using it, it can be a very simple tool or a very complicated tool,
4. it allows you to easily move from the stage of strategic analysis to the stage of strategic planning,
5. the SWOT analysis scheme forces you to notice both strengths and weaknesses within the organization, which managers often do not want to admit to,
6. it allows for distinguishing between factors that the institution has influence on and should focus on, and factors that are independent – but which must be taken into account,
7. by analyzing opportunities and threats well in advance, the company gains the time necessary to make the appropriate preparations.

The weakness of this method may be its subjectivity, which occurs especially when the assessment of individual factors is made exclusively by employees of a given institution.

SWOT analysis comes in various forms. It is most often used in its simplest form, which consists of listing a group of internal and external factors, i.e. strengths, weaknesses, opportunities and threats.

The next stage in SWOT analysis is strategic SWOT analysis. It consists of comparing the four groups of factors listed and drawing conclusions from this comparison regarding the further directions of the institution's activities.

These conclusions correspond to four strategic variants:

1. SO strategy (aggressive, maxi-maxi) consisting in using opportunities appearing in the environment by using the institution's strengths. This is a strategy of development, investment, and expansion of areas of activity.

2. WO strategy (competitive, mini-maxi), consisting in overcoming the institution's weaknesses by using the opportunities created by the environment. It can be implemented, for example, by reducing costs, increasing efficiency, improving the quality of services).
3. ST strategy (conservative, maxi-mini), meaning the use of the institution's assets to avoid or reduce the impact of threats.
4. WT strategy (defensive, mini-mini), aimed at limiting internal weaknesses and avoiding threats from the environment. It can be implemented by reducing costs and discontinuing investments.

A SWOT analysis prepared in this way shows the mutual relationships between external and internal factors, informing which of them reinforce each other and which weaken each other. Let us move on to the next stage of the SWOT analysis - a point SWOT analysis, consisting in assessing (according to the adopted scale) individual factors and determining whether strengths or weaknesses prevail within the institution and whether there are more opportunities or threats in the environment. This allows for the selection of the appropriate strategy - aggressive, competitive, conservative, defensive. This analysis can be combined with the assessment of the probability of strategic success according to the algorithm developed by L. Berliński (Berliński, 2002).

The next stage of the SWOT analysis is a weighted point SWOT analysis. It involves assessing individual factors according to the adopted scale and assigning them appropriate weights (which sum up to 1).

The most complicated form of the SWOT analysis is the SWOT/TOWS analysis. It consists of eight tables. The analysis begins with the preparation of a SWOT table in its simplest form – i.e. listing opportunities, threats, and strengths and weaknesses. Then, each of the features is assigned weights defining their significance from the point of view of the impact of these factors on the development possibilities of the organization. The weights in each area should sum up to 1. The next step is to examine the relationship between opportunities and threats and the strengths and weaknesses of the organization.

1. From the perspective of the environment (TOWS analysis):
 - do the given threats weaken the strength of the organization?
 - will the given opportunities increase the identified strengths?
 - will the given threats increase the existing weaknesses?
 - will the given opportunities allow to overcome the existing weaknesses?
2. From the institutional perspective (SWOT analysis):
 - will the identified strengths allow the use of opportunities that may arise?
 - will the identified weaknesses prevent the use of emerging opportunities?
 - will the identified strengths allow the overcoming of threats that may arise?
 - will the identified weaknesses strengthen the impact of threats that may arise?

We can see two approaches here - "from the outside to the inside" and "from the inside to the outside". In this method, both are treated as complementary and conditional on the proper recognition of interactions occurring between the environment and the institution. The answer to each of the above eight questions requires the construction of a separate table examining the relationships between individual factors. The analysis is crowned by a summary of the results obtained from all eight tables. The combination of factors for which the sum of the products obtained in the summary is the largest shows which of the four strategies discussed earlier should be adopted

Materials and methods

The research was based on a systematic literature review and content analysis. Recent years have brought new scientific research in the field of strategic planning. The issues of strategic planning in municipalities are discussed from the perspective of different forms of leadership. Based on the concepts of leadership and strategic planning in municipalities, different approaches to leadership were assessed depending on the size of the municipal population and the continuity of power. Four types of leaders were identified, with entrepreneurial leadership being the most important in the studied regions (Beneš, 2023). The authors also focus on the stages of implementation of strategic planning in municipalities, using selected criteria, and present the characteristics of the processes taking place in the individual stages of development (Astrauskas, Stasiukynas, 2020). The authors also assess the integration of strategic and spatial planning and the cooperation of local governments (Maleszyk, Szafran, 2024). However, the basics of strategic planning are contained in earlier studies, including those cited in this article.

Conclusions

To sum up the above, when deciding on the method and scope of strategy development, the following premises should be taken into account:

1. There is no single model strategic planning process, nor are there two identical strategic plans. The individual nature of individual communities and other resources of the commune and its surroundings shape this process. Each action, including the scope of diagnosis, should therefore be assessed in the context of the community it is to serve.

2. Diagnosis (i.e. identification, collection and analysis of data), which begins the process of building a strategy, should be continued not only throughout its creation, but also in the implementation phase. It is important to create a data bank that can then be used comprehensively by the commune or interested institutions. It must be supplemented and updated. In successful strategic planning, diagnosis should not be a closed set, but a continuous process, constantly providing new information. This is because both the regional and local environments change, as well as their surroundings. Although one must agree with the fairly common opinion that excessive paralysis by analysis is not advisable, insufficient recognition of the situation may be more dangerous than excessive analysis.
3. While fully respecting the importance of economic aspects, the necessary balance must be maintained between the need for unquestionable pro-efficiency solutions and other social preferences.
4. Optimal solutions should be sought on many levels, appreciating the multitude of paths and ways leading to the goal, but remembering the principle that the directions of solving social problems and the methods of their implementation should be resource-efficient and socially friendly.
5. A strategy on a commune/county scale does not exempt from respecting the general premises of development; on the contrary, taking them into account is one of the fundamental conditions for its effectiveness. In a commune, strategic options should be determined by the content and implications of development challenges, regional conditions.
6. A commune strategy cannot close development paths identified and adopted for implementation at the supra-local level. It should be remembered that each level of local government (municipality, district, self-government province) has the competence to set its own, independent goals and choose the paths to achieve them
7. Assuming that even the best and most rational proposals will not be implemented without the approval and identification with them of local communities, decision-making and economic structures in the region, without taking into account the value system of its participants. It should be considered very important that already at the first stage of work on the strategy, the most important issue is the compatibility of beliefs and values declared by the initiators of the strategy and experts, as well as historical knowledge of the determined system of motivations, values and other psychosociological features of the residents of the commune, as well as the preferences of social entities operating in its area.

8. The greatest importance should be attached to a genuinely social way of building a program for solving existing social problems. This program must be accepted by residents as their work and their own concept of the future. After all, the strategy cannot be either a program of the authorities and officials, or a program of external experts. In the process of social cooperation in the area of setting development goals and means of achieving them, a very important role is played by a broad, professionally prepared social consultation, guaranteeing the partnership nature of programming. Diagnosis of deficiencies and gaps is also generally bottom-up.

Taking into account this set of premises in subsequent stages of work on the strategy is one of the basic conditions for its creation and effective implementation.

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THE ENVIRONMENTAL RELEVANCE OF ENERGY – A LIFE CYCLE PERSPECTIVE

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Purpose: The purpose of this article is to present a potential environmental impact in a life cycle of electricity generated from different sources (coal, natural gas, wind and water).

Design/methodology/approach: The environmental life cycle assessment methodology was used. The functional unit was defined as 1 kWh of electricity delivered to the final consumer. The following stages were analyzed: acquisition and processing of energy carriers (cradle), energy generation, transmission and distribution.

Findings: The results showed that the potential impact for electricity from coal is approx. 2.5 greater than the impact of gas power, about 11 times greater than the result for wind power (onshore) and about 14 times greater than the impact of hydropower (run-of-river). In the case of coal-based power, main sources of this impact to be found in the operations of power plants and mines. In the case of natural gas energy, the cradle (acquisition and transmission of natural gas) proved to be the largest source, followed by power plant generation. The lowest impacts were obtained for wind and water energy. In their case, due to the low impact of cradle and generation, the transmission and distribution of energy in the power grid becomes particularly important.

Originality/value: The value of the paper is a presentation of the results divided into particular life cycle stages of electricity. Although many papers on the electricity's environmental impact have been published, demonstrating this impact on a stage-by-stage basis is rather rare.

Keywords: Climate change, energy, impact, life cycle management, stages.

Category of the paper: Research paper.

1. Introduction

Covering energy demand is an important part of the life cycle of many products (Sartori, Hestnes, 2007; Ulkir, 2023; Lewandowska, 2024). The high importance of energy is due not only to economic (cost) considerations, but also to environmental consequences. One of the most comprehensive methods for assessing the potential environmental impact of products is the Environmental Life Cycle Assessment (LCA) (PN-EN ISO 14040, 2009).

LCA is a tool of environmental management systems (PN-EN ISO 14040, 2009) and a crucial element of ecodesign and a life cycle management (LCM) (Lindhal, Ekermann, 2013). The specificity of this method is that it takes into account a life cycle perspective, which includes also energy. If one were to define a function as the generation and delivery of energy, then in the context of LCA analysis one would have to consider the processes from the extraction/acquisition of the energy carrier (cradle) to the delivery of the generated energy to the final consumer (end of life). Thus, we are talking about the entire energy life cycle from cradle to grave. The beginning of the life cycle (cradle) is associated with the extraction/acquisition of raw materials, e.g. coal ore, natural gas, water, wind kinetic energy, or solar radiation energy. The operation of mines is not only the exploitation of the deposit, but also the consumption of energy for process needs, the combustion of fuels in vehicles, the emission of various compounds into the air, water and soil. Finally, it is also the use of equipment and buildings. The situation is similar at the energy generation stage. In fossil fuel-fired power plants, in addition to greenhouse gases (GHG), many other pollutants are emitted, such as particulate matter and acidifying pollutants. Waste is generated, water is consumed for cooling and infrastructure is used. The same applies to the transmission and distribution network. All these activities make up the energy life cycle and include a variety of environmental aspects. The purpose of this article is to answer the following research questions:

- What is the potential environmental impact of electricity generated from different carriers?
- Is climate change a significant environmental issue in the context of the total impact?
- What share of the total impact are greenhouse gases directly emitted in the generation stage?

2. Life cycle perspective in the context of energy

With regard to energy, the life cycle concept is presented in Figure 1. It depicts the situation when some entities generate and transmit energy, and others purchase and use it for their own needs (final consumers).

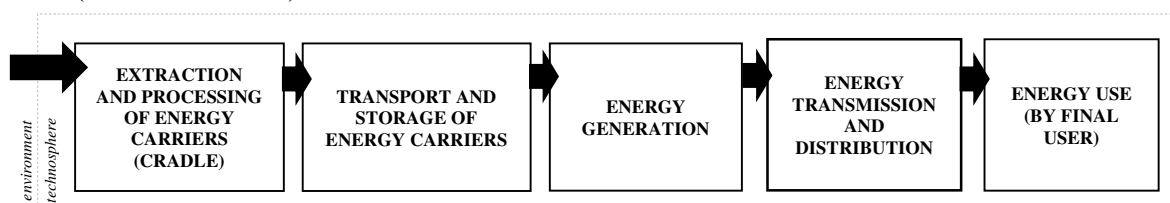


Figure 1. Exemplary stages in the energy life cycle.

Calculation of environmental impacts in the energy life cycle is made easier through the use of special databases (Takano et al., 2014; ecoinvent, 2024) and software ((Ormazabal et al.; 2014; Herrmann, Moltesen, 2015). These databases contain information on the inputs (consumption of materials and energy) and outputs (emissions to air, water and soil, and generation of waste and wastewater) necessary for the processes. This makes it possible to model complex systems called product systems. These systems reflect the material and energy flows in products life cycle. Figure 1 indicates the general stages of the energy life cycle, but in reality each of these stages involves the execution of other processes and, consequently, many material and energy flows (Table 1). Some of these flows constitute so-called elementary flows. They concern raw materials taken directly from the environment that have not been subjected to prior human processing, or releases of substances into the environment that will not be further processed. The rest of the flows in the product system are exchanges with the technosphere and include inputs and outputs that have been or will be subject to further processing in the technosphere. Table 1 presents a general concept of data collection for LCA analyses using the energy life cycle as an example. Within each stage, some of the inputs are elementary flows (e.g., taking coal ore from a deposit, taking water from groundwater, occupying or transforming land), as are some of the outputs (e.g., air emissions of metals, hydrocarbons, dust, greenhouse gases, emissions of nutrients to water). The remaining inputs and outputs, on the other hand, are exchanges with the technosphere. Examples of inputs from the technosphere include consumption of polyethylene granulate, glass, steel sheet, electricity, natural gas, district heat. Examples of outputs to the technosphere could be the generation of solid waste intended to further treatment, the generation of wastewater going to a treatment plant, etc. Each input from the technosphere and output to the technosphere is associated with “human processing”, which consists of the life cycles of many successive products. These cycles have their inputs and outputs, resulting in systems consisting of up to several thousands of unit processes. Such a system of processes connected by material and energy flows is supposed to perform a specific function, which is referred to as a functional unit (FU). From the point of view of the final energy user, this functional unit may be the provision of a specific amount of electricity or heat.

Table 1.*Exemplary sorts of inputs and outputs in particular stages in the life cycle of energy*

Extraction and processing of energy carriers		Transport and storage of energy carriers		Energy generation (power/heat plant)		Energy transmission and distribution		Energy use (by final user)	
Examples of input/ output	Type of input/ output	Examples of input/ output	Type of input/ output	Examples of input/ output	Type of input/ output	Examples of input/ output	Type of input/ output	Examples of input/ output	Type of input/ output
Extraction of raw materials Land use	Inputs from environment (elementary flows)	Extraction of raw materials Land use	Inputs from environment (elementary flows)	Extraction of raw materials Land use (Inputs from environment (elementary flows)	Extraction of raw materials Land use	Inputs from environment (elementary flows)	Extraction of raw materials Land use	Inputs from environment (elementary flows)
Consumption of materials, fuels, electricity, heat	Inputs from technosphere	Consumption of materials, fuels, electricity, heat	Inputs from technosphere	Consumption of materials, fuels, electricity, heat	Inputs from technosphere	Consumption of materials, fuels, electricity, heat	Inputs from technosphere	Consumption of materials, fuels, electricity, heat	Inputs from technosphere
Emissions GHGs to air	Outputs to environment (elementary flows)	Emissions GHGs to air	Outputs to environment (elementary flows)	Emissions GHGs to air	Outputs to environment (elementary flows)	Emissions GHGs to air	Outputs to environment (elementary flows)	Emissions GHGs to air	Outputs to environment (elementary flows)
Emissions remaining substances to air	Outputs to environment (elementary flows)	Emissions remaining substances to air	Outputs to environment (elementary flows)	Emissions remaining substances to air	Outputs to environment (elementary flows)	Emissions remaining substances to air	Outputs to environment (elementary flows)	Emissions remaining substances to air	Outputs to environment (elementary flows)
Emissions to water	Outputs to environment (elementary flows)	Emissions to water	Outputs to environment (elementary flows)	Emissions to water	Outputs to environment (elementary flows)	Emissions to water	Outputs to environment (elementary flows)	Emissions to water	Outputs to environment (elementary flows)
Emissions to soil	Outputs to environment (elementary flows)	Emissions to soil	Outputs to environment (elementary flows)	Emissions to soil	Outputs to environment (elementary flows)	Emissions to soil	Outputs to environment (elementary flows)	Emissions to soil	Outputs to environment (elementary flows)
Waste to treatment	Outputs to technosphere	Waste to treatment	Outputs to technosphere	Waste to treatment	Outputs to technosphere	Waste to treatment	Outputs to technosphere	Waste to treatment	Outputs to technosphere
Wastewater to treatment	Outputs to technosphere	Wastewater to treatment	Outputs to technosphere	Wastewater to treatment	Outputs to technosphere	Wastewater to treatment	Outputs to technosphere	Wastewater to treatment	Outputs to technosphere
Products and co-products	Outputs to technosphere	Products and co-products	Outputs to technosphere	Products and co-products	Outputs to technosphere	Products and co-products	Outputs to technosphere	Products and co-products	Outputs to technosphere

Since GHG emissions from the energy life cycle are a key component of many organizations' carbon footprints, it is worth cross-referencing the information in Table 1 with guidelines for quantifying GHG emissions and removals at the organization level. According to ISO 14064 (PN-EN ISO 14064-1, 2019) and the GHG Protocol standard (GHG Protocol, 2004), GHG emissions can be classified into different ranges/categories, as presented in Table 2. For example, if a company covers a portion of its heat/current needs with energy generated on-site at its own facilities, GHG emissions from those facilities would be classified into range 1/category 1 emissions (the area highlighted in black in Table 1). If the same company would cover part of its needs with energy from the district heating/electricity grid purchased from an external supplier, then from the point of view of this company, the emissions associated with the generation of system energy should be shown in scope 2/category 2. In this case, these would be emissions from an installation located on the premises of the district heating/electricity plant (in Table 1 the area marked in gray). It is worth noting that in both standards, scope 2/category 2 includes emissions, but only from the energy generation process. This means that only GHG emissions should be included in scope 2/category 2, which from the point of view of the energy supplier (power plant, heating plant, etc.) will be direct emissions, while for the final consumer they will be indirect emissions.

Table 2.*Scopes of GHGs emissions in accordance with PN-EN ISO 14064 and GHG Protocol*

ISO 14064 (PN-EN ISO 14064-1, 2019)		GHG Protocol (GHG Protocol, 2004)	
Category 1	Direct GHG emissions and removals occur from GHG sources or sinks inside organizational boundaries and that are owned or controlled by organization. These sources can be stationary. These sources can be stationary, such as heaters, electricity generators, and industrial processes, or mobile, such as vehicles.	Scope 1	Direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment. Direct CO ₂ emissions from the combustion of biomass shall not be included in scope 1 but reported separately.
Category 2	The category 2 includes only emissions due to the fuel combustion associated with the production of final energy and utilities like electricity, heat, steam, cooling and compressed air. It excludes all upstream emissions (from cradle to power plant gate) and emissions associated with transport and distribution losses.	Scope 2	Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated.
Category 3	The category 3 includes the GHG emissions occur from sources located outside organizational boundaries. These sources are mobile (mostly due to fuel combusted in transport equipment). If relevant, the category 3 may also include emissions associated with refrigeration gas leaks, construction of transport equipment and upstream emissions from the life cycle of fuel.	Scope 3	Scope 3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services.
Category 4	Indirect GHG emissions from goods purchased by organization (including upstream emissions associated with electricity production that are not included in Category 2).		

GHG – Green House Gase; ISO – International Organization for Standardization.

3. Life cycle assessment – methodology and assumptions

In order to answer the research questions, an LCA analysis was carried out for *1 kWh of electricity delivered to the end user* (the functional unit, FU). The following life cycle stages were considered: (1) acquisition and processing of energy carriers (cradle), (2) generation of energy, (3) transmission and distribution of energy. The analysis considered and compared electricity from coal (cogeneration), natural gas (cogeneration, combined cycle plant, 400 MW of electric power), wind (onshore turbine, 1-3MW) and water (run-of-river plant). Inventory data was modeled based on representative for Poland datasets from the ecoinvent database (ecoinvent, 2024). The data were used for the electricity from hard coal (heat and

power co-generation); the electricity from water (run-of-river); the electricity from natural gas (heat and power co-generation, combined cycle power plant, 400MW electric) and the electricity from wind (1-3MW turbine, onshore). Additionally, based on data from ecoinvent datasets on electricity transmission and distribution, the following assumptions were made:

- for medium-voltage electricity, per functional unit: consumption of $1.13\text{E-}07$ kg of sulfur hexafluoride (input from the technosphere), air emissions of $1.13\text{E-}07$ kg of sulfur hexafluoride (output to the environment), and use of a transmission network of $1.86\text{E-}08$ km (input from the technosphere);
- for low-voltage electricity, per functional unit: consumption of $6.27\text{E-}09$ kg of sulfur hexafluoride (input from the technosphere), air emissions of $6.27\text{E-}09$ kg of sulfur hexafluoride (output to the environment), and use of a distribution network of $8.74\text{E-}08$ km (input from the technosphere).
- total energy losses due to transmission and distribution were assumed at 2.397%. This means that supplying 1 kWh of electricity to the final consumer involves generating 1.02397 kWh of electricity. Thus, the functional unit (FU) in this study is 1 kWh of electricity delivered to the final consumer, and the reference flow is 1.02397 kWh of electricity generated and injected into the grid;
- for energy generated from all the analyzed carriers assumed the same data in terms of transmission and distribution.

The LCA analysis was performed using SimaPro software and a method of the Environmental Footprint 3.1 (adapted) V1.00/EF 3.1 normalization and weighting set. The study considered the following environmental issues (called impact categories): *Climate change; Resource use, fossils; Eutrophication, freshwater; Acidification; Resource use, minerals and metals; Photochemical ozone formation; Eutrophication, terrestrial; Human toxicity, non-cancer; Particulate matter; Eutrophication, marine; Water use; Ecotoxicity, freshwater; Human toxicity, cancer; Land use; Ionizing radiation; Ozone layer depletion.*

4. Results and discussion

The potential environmental impact will be presented in the form of weighted results expressed in micropoints (μPt). In addition, characterized results for one impact category - *Climate change*, which is expressed in kg CO₂eq, will also be presented. Both results should be interpreted in the same way - the higher the score, the greater the negative impact.

The total potential environmental impact associated with the implementation of the functional unit is 96.4 μPt for energy generated from coal, 39.6 μPt for energy generated from gas, 8.7 μPt for wind energy and 6.8 μPt for hydropower (Table 3, Figure 2). This means that the potential life-cycle environmental impact of electricity generated at the included facilities

from the fossil fuels is many times higher than that of energy generated from water and wind. In the case of energy from coal, the impact is mainly in terms of: *Climate change*, *Resource use - fossils*, *Eutrophication of freshwater*, *Acidification*, *Resource use - minerals and metals*. For energy from gas, the following significant impact categories were identified: *Climate change*, *Resource use - fossils*, *Resource use - minerals and metals*. For wind and water energy, the dominant environmental issue is *Resource use - minerals and metals*, followed by *Climate Change*, *Eutrophication freshwater* and *Human toxicity (non-carcinogenic effects)*.

Table 3.

Potential environmental impact in the life cycle of electricity generated from different carriers - weighted results [$\mu\text{Pt}/\text{FU}$] (the most relevant impact categories marked grey)

Impact category	Unit	Electricity, hard coal, cogeneration		Electricity, natural gas, cogeneration		Electricity, wind, onshore		Electricity, hydro, run-of-river	
<i>Climate change</i>	μPt	33.9	35%	17.0	43%	0.7	8%	0.4	6%
<i>Resource use, fossils</i>	μPt	17.7	18%	11.8	30%	0.4	4%	0.1	2%
<i>Eutrophication, freshwater</i>	μPt	11.9	12%	0.6	1%	0.5	6%	0.4	6%
<i>Acidification</i>	μPt	10.9	11%	0.9	2%	0.4	5%	0.3	5%
<i>Resource use, minerals and metals</i>	μPt	4.5	5%	4.5	11%	4.8	55%	4.2	63%
<i>Photochemical ozone formation</i>	μPt	4.3	5%	1.7	4%	0.2	2%	0.1	1%
<i>Eutrophication, terrestrial</i>	μPt	2.8	3%	0.5	1%	0.1	1%	0.1	1%
<i>Human toxicity, non-cancer</i>	μPt	2.7	3%	0.6	2%	0.6	7%	0.5	8%
<i>Particulate matter</i>	μPt	2.4	3%	0.6	2%	0.4	5%	0.3	4%
<i>Eutrophication, marine</i>	μPt	2.0	2%	0.3	1%	0.1	1%	0.0	0%
<i>Water use</i>	μPt	1.4	1%	0.6	2%	0.1	1%	0.0	1%
<i>Ecotoxicity, freshwater</i>	μPt	1.1	1%	0.3	1%	0.2	2%	0.2	2%
<i>Human toxicity, cancer</i>	μPt	0.4	0.4%	0.2	0.5%	0.2	2%	0.09	1%
<i>Land use</i>	μPt	0.2	0.2%	0.03	0.1%	0.04	1%	0.01	0.2%
<i>Ionising radiation</i>	μPt	0.1	0.1%	0.03	0.1%	0.01	0.2%	0.01	0.1%
<i>Ozone depletion</i>	μPt	0.00	0.00%	0.06	0.1%	0.00	0.0%	0.00	0.0%
Total	μPt	96.4	100%	39.7	100%	8.7	100%	6.8	100%

μPt – micropoint.

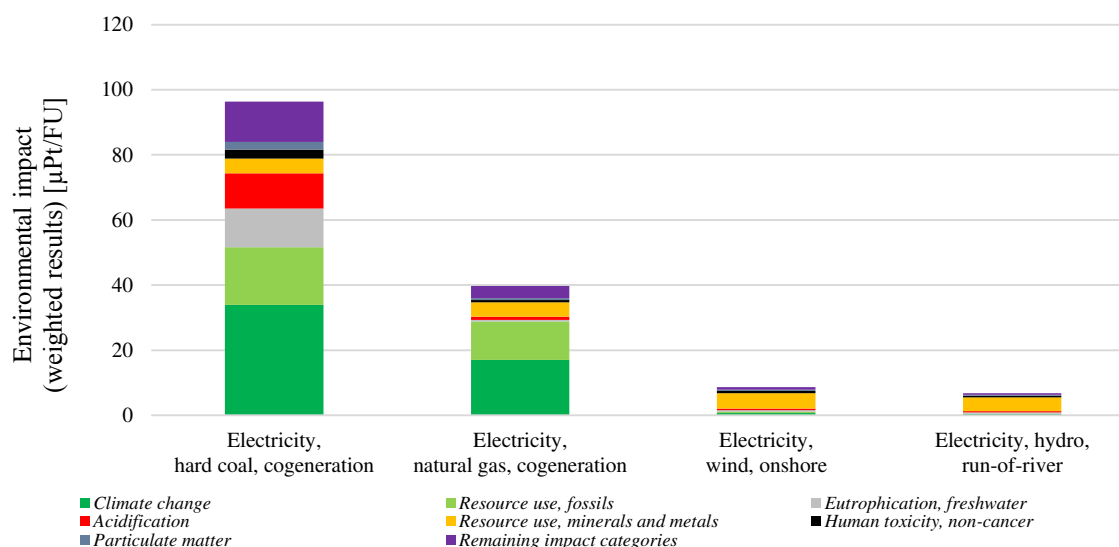


Figure 2. Potential environmental impact in the life cycle of electricity generated from different carriers - weighted results for different impact categories [$\mu\text{Pt}/\text{FU}$].

Table 3 and Figure 2 present the environmental impacts by environmental issue (impact categories). Subsequently, the same impact will be attributed to the different stages of the energy life cycle. As shown in Table 4 and Figures 3-6, the distribution of environmental impacts between stages varies depending on the source of energy and how it is generated. In the case of coal-based energy (Figure 3), generation at the power plant plays the dominant role (generation = 47.8 $\mu\text{Pt}/\text{FU}$ = 50% of the total impact), with direct emissions from the generation stage responsible for most of the impact (generation-related emissions = 44.3 $\mu\text{Pt}/\text{FU}$ = 46% of the total impact). The second most important source of impact is the cradle (coal mine operations). This stage is responsible for 44% of the impact (42.2 $\mu\text{Pt}/\text{FU}$). For coal-based energy, transmission and distribution play a secondary role (6.4 $\mu\text{Pt}/\text{FU}$). As shown in Figure 3, coal mine operations are primarily impacts in terms of *Resource use*, *fossils*, *Eutrophication freshwater* and *Climate change*. In contrast, two categories dominate in Figure 3 for the energy generation stage: *Climate change* and *Acidification*. These impacts are primarily the result of direct emissions - fossil carbon dioxide, nitrogen oxides and sulfur dioxide.

Table 4.

Potential environmental impact in particular life cycle stages – as weighted results [$\mu\text{Pt}/\text{FU}$] and as characterized results for Climate Change [$\text{kg CO}_2 \text{ eq}/\text{FU}$] (the most relevant life cycle stages marked grey)

Life cycle stage	Unit	Electricity, hard coal, cogeneration		Electricity, Natural gas, cogeneration		Electricity, wind, onshore		Electricity, hydro, run-of-river	
Weighted results for all impact categories (single score)									
Extraction and processing of energy carriers (cradle)	μPt	42.2	44%	20.0	50%	0.0	0%	670.1	-
Electricity generation	μPt	47.8	50%	13.3	33%	2.3	27%	-669.8	-
Where: direct emissions to air and water from the generation stage ¹	μPt	44.3	46%	11.7	30%	0,0	0%	-670.1	-
Electricity transmission and distribution	μPt	6.4	7%	6.4	16%	6.4	73%	6.4	-
Total	μPt	96.4	100%	39.7	100%	8.7	100%	6.8	100%
Characterized results for Climate Change									
Extraction and processing of energy carriers (cradle)	$\text{kg CO}_2 \text{ eq}$	0.177	15%	0.175	29%	0.0	0%	0.0	0%
Electricity generation	$\text{kg CO}_2 \text{ eq}$	1.029	85%	0.425	70%	0.017	65%	0.004	32%
Where: direct emissions to air from the generation stage ²	$\text{kg CO}_2 \text{ eq}$	1.021	84%	0.424	70%	0.0	0%	0,0	0%
Electricity transmission and distribution	$\text{kg CO}_2 \text{ eq}$	0.009	1%	0.009	2%	0.009	35%	0.009	68%
Total	$\text{kg CO}_2 \text{ eq}$	1.2	100%	0.6	100%	0.03	100%	0.01	100%

μPt – micropoint; $\text{CO}_2 \text{ eq}$ – equivalents of carbon dioxide.

¹ “Direct” from the power plant’s perspective.

² “Direct” from the power plant’s perspective.

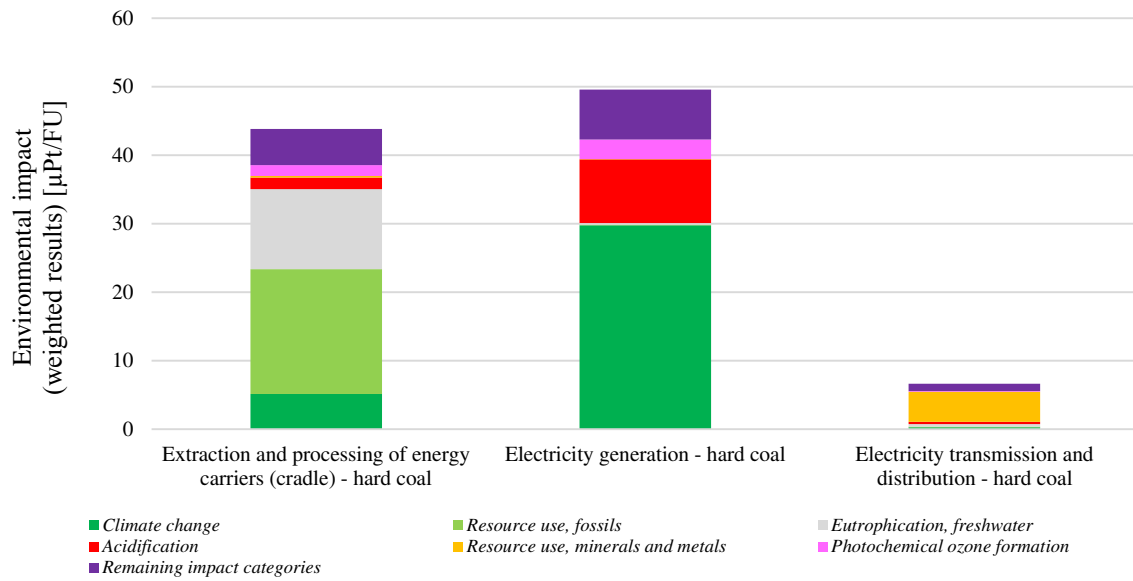


Figure 3. Potential environmental impact in particular stages of the life cycle of electricity generated from hard coal – weighted results [μPt/FU].

In the case of gas-generated energy (Figure 4), natural gas extraction and distribution (cradle) proved to be the most important source of potential impact. This stage is responsible for 50% of the impact in the life cycle (20.0 μPt/FU). As Figure 4 shows, the impact of cradle is primarily related to *Resource use, fossils* and *Climate change*. In second place is the generation of energy in a gas-fired power plant (13.3 μPt/FU). At this stage, direct emissions (11.7 μPt/FU) play a very important role, leading mainly to *Climate change* impacts as a result of fossil carbon dioxide emissions.

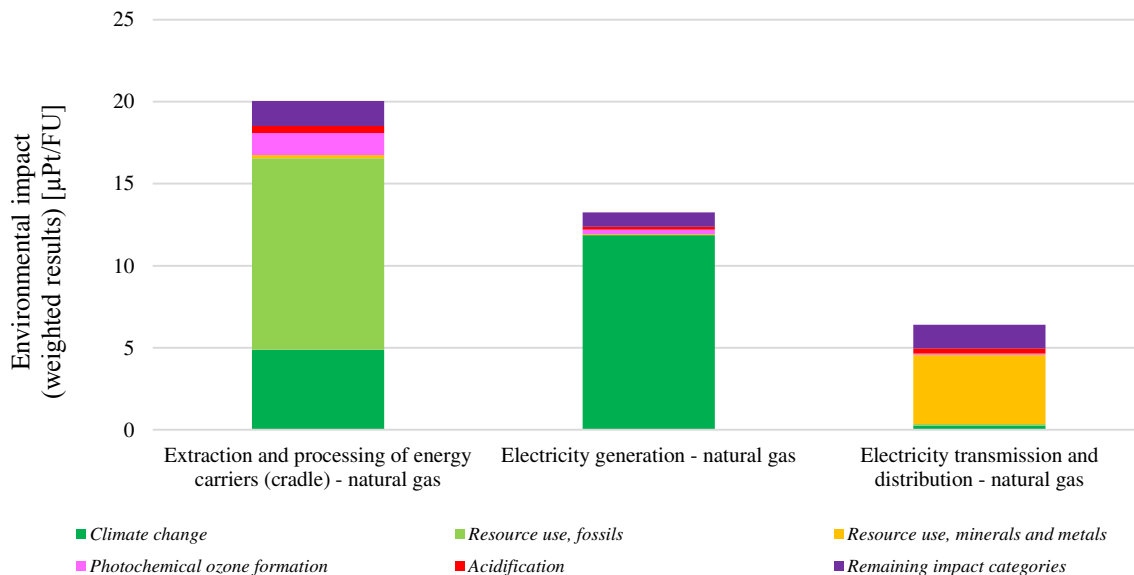


Figure 4. Potential environmental impact in particular stages of the life cycle of electricity generated from natural gas – weighted results [μPt/FU].

In the case of wind energy (Figure 5), the mere acquisition of the carrier (extraction of wind kinetic energy from the environment) does not involve a negative impact. The generation of energy in a wind power plant requires the generation and operation of infrastructure,

hence the accrued impact, which is 2.3 $\mu\text{Pt}/\text{FU}$. However, this is not the main source of impact in the life cycle of hydropower. This is because transmission and distribution were considered the most significant stage. Generation and use of grid infrastructure are associated with an impact of 6.4 $\mu\text{Pt}/\text{FU}$, and this is the same for all scenarios compared. This impact is primarily due to the use of copper and the associated exploitation of copper deposits (mineral and metal resource consumption). The mining of copper ores involves the intake from the environment of not only copper itself, but also a number of associated elements including, for example, tellurium, gold, silver. This is the main reason for the accrued impact in terms of energy transmission and distribution. Of some importance is also the emission into the air of sulfur hexafluoride, which is a very potent greenhouse gas.

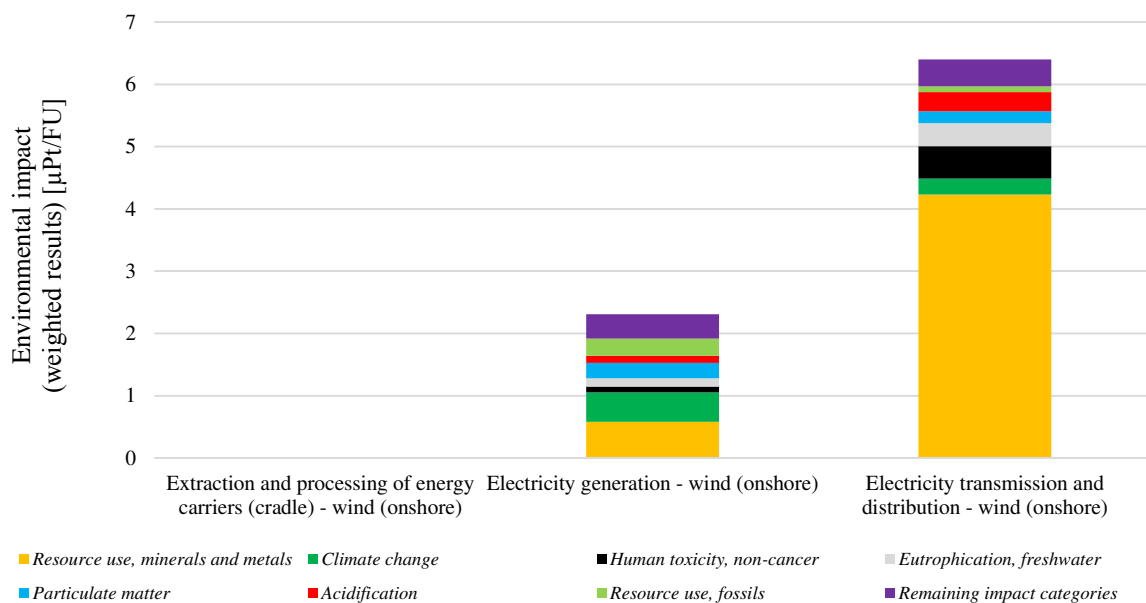


Figure 5. Potential environmental impact in particular stages of the life cycle of electricity generated from wind (onshore) – weighted results [$\mu\text{Pt}/\text{FU}$].

The hydropower life cycle (Figure 6) generates a potential impact of 6.8 μPt , and this is the lowest of all the compared alternatives. In this case, the cradle is a very significant source of impact (670.1 $\mu\text{Pt}/\text{FU}$), but it includes basically one category - *Water use*. The elementary flow, which is the extraction of water from the environment, is the reason for charging such an impact. At the generation stage, this water is given back to the environment, as illustrated by the negative result of the indicator (-670.1 $\mu\text{Pt}/\text{FU}$). The impact of the hydropower plant infrastructure itself is of negligible significance. Once the impact for cradle and generation is balanced, the transmission and distribution of energy becomes important. As with wind power, the impact here too is 6.4 $\mu\text{Pt}/\text{FU}$.

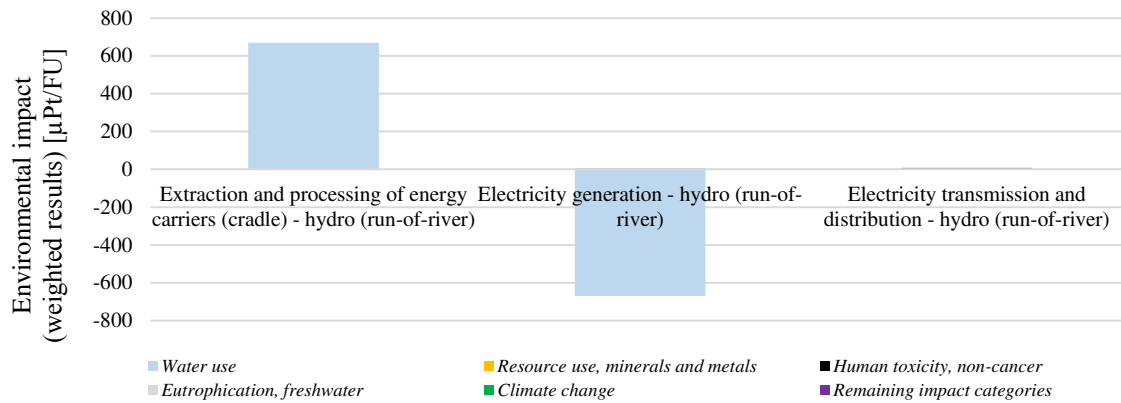


Figure 6. Potential environmental impact in particular stages of the life cycle of electricity generated from water (run-of-river) – weighted results [μPt/FU].

The results presented in the first part of Table 4 and Figures 3-6 refer to the cumulative impact, which takes into account more than a dozen environmental issues. The second part of Table 4 shows environmental impact related to one impact category only - *Climate change*. These are characterized results. They refer mainly to one type of environmental aspect - air emissions of greenhouse gases. When considering only this type of emissions, the importance of the energy generation stage increases significantly for fossil-fuel-based electricity. In turn, direct emissions at the power plant site, primarily fossil carbon dioxide emissions, play a key role in this stage. From the *Climate change* perspective, the generation stage also plays the most important role in the case of wind power. However, here the cause is not direct emissions, but emissions from the life cycle of the power plant infrastructure, consumables and transportation. For hydro-generated power, the main source of life-cycle greenhouse gas emissions is to be found in transmission and distribution, including primarily air emissions of sulfur hexafluoride.

5. Conclusions

Energy intensity is one of the key aspects in products' life cycle. This is because the energy life cycle can be a significant source of environmental impact. As the results of the conducted LCA study showed, the potential environmental impact during the life cycle of electricity generated from different carriers may be significantly different. In the presented study, the potential impact was determined per kWh of electricity delivered to the final consumer (taking into account losses in the transmission and distribution network). The results showed that the potential impact for electricity from coal is approx. 2.5 greater than the impact of gas power, about 11 times greater than the result for wind power and about 14 times greater than the impact of hydropower. These results refer to the assumptions made in the analysis (e.g., in terms of electricity generation technology and inventory data). Also worth noting is the

different distribution of environmental impacts between the different stages of the life cycle. If one looks at the values of the cumulative weighted indicator, in the case of fossil fuel-based energy, the generation and cradle (acquisition of carriers) stages play a dominant role. In the case of hydropower and wind energy, due to the low impact of the first stages, transmission and distribution become much more important.

Since carbon footprint calculations have been gaining particular importance for many organizations, it is worth making some comment in the context of GHG emissions in the electricity life cycles analyzed. As the presented results showed, the carbon footprint in the entire life cycle of fossil fuel-based electricity is much higher than the result for the renewable one. From the perspective of electricity's final user, the direct GHG emissions from the electricity generation stage are classified to the scope 2 (the category 2). Because of potential relevance of these emissions in the life cycle of different products and organizations, they are listed separately in Table 4. The value obtained for the scope 2 is 1.021 kg CO₂ eq/FU for power from coal and 0.424 kg CO₂ eq/FU for power from gas. In both cases, the GHG emissions from the scope 2 are major drivers with the highest contribution in the entire life cycle. In terms of the scope 2, the renewable electricity is burden free. Also the impact resulted from emissions from the scope 3/category 4 is much lower for renewable power. The results may be valuable especially for organizations operating with high energy demand. Their decisions regarding the electricity supplier and the electricity origin may play a crucial role. If renewable electricity procured, the Guarantees of Origin (GOs) could be used to ensure the final consumer that a given quantity of electricity was produced from renewable sources.

List of abbreviations

FU – Functional Unit.

GHG – Green House Gase.

GOs – Guarantees of Origin.

ISO – International Organization for Standardization.

LCA – Life Cycle Assessment.

LCM – Life Cycle Management.

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INTERRELATION OF CARBON NEUTRALITY AND ENVIRONMENTAL REGULATIONS IN EUROPEAN COUNTIES

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Purpose: The challenge of achieving carbon neutrality, which involves balancing carbon emissions with their absorption from the atmosphere, remains a central concern for European Union countries. Key goals include improving the effectiveness of environmental regulations and maximizing the use of available energy resources. This study seeks to explore the impact of environmental regulations on a country's progress toward carbon neutrality.

Design/methodology/approach: Various methodologies are employed, including panel stationarity testing, cross-section dependence testing, cointegration analysis, and heterogeneous parameter models. This research using panel data from EU countries spanning from 2000 to 2021, the study develops econometric models to analyse the influence of environmental regulations on the path to carbon neutrality.

Findings: The hypothesis regarding the influence of environmental regulations on carbon neutrality was confirmed for 21 out of the 27 analysed countries.

Practical implications: The results of this research can provide a valuable foundation for guiding EU countries towards carbon neutrality and enhancing governmental strategies to promote low-carbon development.

Originality/value: The findings underscore the necessity of a comprehensive approach to managing a country's energy development, which involves coordinating state actions in enhancing environmental regulation during the transition to low-carbon development.

Keywords: carbon neutrality, low-carbon development, environmental regulations, energy consumption.

Category of the paper: Research paper.

1. Introduction

The Paris Agreement, established in 2015 by nearly 200 nations, stands as a pivotal global accord aimed at combating climate change. The primary objective of this agreement is to maintain the global temperature rise this century well below 2°C above pre-industrial levels, with an aspirational target of limiting the increase to no more than 1.5°C. To achieve this goal, many countries have developed specific emission reduction plans; for instance, the European Union's initiative is known as Fit for 55. Renewable energy technologies such as solar and wind are becoming increasingly efficient and cost-effective, playing a significant role in reducing carbon emissions. The COP26 summit held in Glasgow in 2021 culminated in the Glasgow Climate Pact, which underscores the critical importance of energy efficiency and robust regulatory frameworks.

In 2022, the International Renewable Energy Agency (IRENA) reported a decline in the global weighted average cost of electricity (LCOE) from new utility-scale renewable sources, despite rising material and equipment costs. China made a significant contribution to reducing costs for solar PV and onshore wind, while other regions saw mixed results, with costs increasing in some key markets. IRENA (2023) noted that the global LCOE for new onshore wind projects decreased by 5% from 2021 to 2022, dropping from USD 0.035/kWh to USD 0.033/kWh, and solar PV projects saw a 3% reduction, reaching USD 0.049/kWh. Balcerzak et al. (2024) forecasted a rapid expansion in the renewable energy market, with global renewable energy capacity expected to grow from approximately 1200 GW to nearly 4000 GW by 2023.

Strong environmental regulations are essential for guiding industries towards sustainable practices. A prominent example is the Clean Air Act (CAA) in the United States, first enacted in 1970 and revised in 1990. This comprehensive federal law regulates air pollution from both stationary and mobile sources across the country, demonstrating how stringent environmental laws can drive industries toward sustainability. According to the U.S. Environmental Protection Agency, from 1970 to 2020, the CAA significantly reduced air pollution by 78%, even as the U.S. economy expanded. This reduction includes lower emissions of pollutants such as atmospheric aerosols, airborne particles, sulfur dioxide, nitrogen oxides, volatile organic compounds, carbon monoxide, and lead (EPA, n.d.). Similarly, the European Union's REACH regulation, introduced in 2007, exemplifies how effective environmental laws can encourage industrial sustainability.

Environmental regulations and energy efficiency measures have a substantial impact on consumer behavior and can inform public awareness campaigns. The European Union's Energy Labelling Directive is a case in point, requiring household appliances and other products to display labels indicating their energy efficiency ratings. A 2021 report by the European Commission found that 93% of consumers are aware of the EU energy label, and 79% are

influenced by it when making purchasing decisions. This widespread recognition and preference for energy-efficient products, supported by clear and accessible labelling, can shape public awareness and educational campaigns, helping consumers to weigh the pros and cons of choosing energy-efficient products and make informed decisions.

Mukhtarov et al. (2024) analyse the impact of institutional quality on CO₂ emissions in Canada from 1996 to 2021, alongside other factors. Their findings indicate that improvements in institutional quality and an increase in renewable energy production and usage significantly contribute to reducing CO₂ emissions. The study emphasizes the importance of policies that enhance institutional quality to further decrease emissions. In a related context, Štreimikienė et al. (2024) ranked the 27 EU countries based on their effectiveness in implementing European Green Deal directives and transitioning to eco-friendly technologies as of 2021. Additionally, Mukhtarov et al. (2023) discovered that in Poland, between 1996 and 2021, a higher corruption perception index, as an indicator of institutional quality, has a positive and significant correlation with renewable energy consumption.

Hsu (2024) found a positive correlation between innovation adoption and ESG performance, contributing to sustainable business development in China's electric vehicle industry. Moslehpour et al. (2024) highlighted the critical role of government actions in ensuring effective corporate social responsibility within India's automobile sector. Rajiani (2023) demonstrated that public service motivation, environmental commitment, and organizational citizenship behavior regarding the environment are significant predictors of eco-initiatives among 600 public sector employees in Jakarta, Indonesia. In a study of Urmia, a diverse city in northwest Iran, Khodaparasti and Garabollagh (2023) found that green innovation, environmental ethics, and governance positively impact green public administration. The study also identified strong links between green public administration, green citizenship values, participation in green city initiatives, and social values. It noted that green public administration is a new theoretical approach in governance, not yet fully adopted in Iran, highlighting gaps in theoretical development both globally and nationally.

Balcerzak et al. (2023) explore the key drivers behind the global shift towards sustainable energy and the associated economic challenges. They identify technological advancements, policy frameworks, environmental concerns, and market dynamics as crucial factors. The study discusses the financial costs of new technologies, their effects on traditional energy sectors, and the role of supportive government programs and transnational collaboration. Bucur and Rus (2024) find a general positive correlation between socio-economic development and environmental performance, while also noting exceptions that underscore the importance of successful domestic policies and administration.

Trusina and Jermolajeva (2024) observe that while developed countries have experienced stagnation or decline in energy production in recent years, China has significant potential for renewable energy development, although it has not yet fully realized this potential. Ščurková and Marčanová (2023) examined farmers' awareness of climate change in Slovakia's

Nitra region and their preferred strategies for adaptation and mitigation, aiming to inform climate-focused agricultural policies. Badreddine and Larbi Cherif (2024) attribute the gap between Algeria's stated renewable energy goals and actual progress to a lack of commitment, absence of a cohesive strategy, structural issues such as heavy fossil fuel subsidies, the strong influence of fossil fuel companies, financing difficulties, and monopolistic control over renewable energy initiatives.

Oe et al. (2023) argue that proactive communication of policies and leadership focused on green initiatives are crucial in encouraging local residents to comply with municipal policies, thereby fostering a supportive environment that increases residents' willingness to remain in the area. Du et al. (2024) illustrate the feedback loop between climate change and regional financial budgets, which in turn affects the concentration of the elderly population in those regions.

Fu and Chang (2024) investigate the impact of cross-national and economic sanctions (including those imposed by the United States, European Union, and UN) on green innovations in 130 countries from 1990 to 2020. They find that multilateral sanctions, and those from the USA and EU, significantly hinder environmental management innovations, particularly in areas like air and water pollution control and waste management. However, unilateral and UN sanctions appear to have minimal impact. The negative effects are most pronounced in African countries, though less so in Asian countries. Malý et al. (2023) examine the impact of such sanctions on Czech international commerce and assess the EU's trade policy. Iwu et al. (2023) and Maile & Vyas-Doorgapersad (2023) recommend that developing countries implement economic reforms to stabilize their business environments. Ray (2023) highlights the unpredictability of growth rates among sustainability program beneficiaries, posing challenges for policymakers.

Unlike previous research, this study integrates cross-section dependence testing, heterogeneous parameter models, cointegration testing, and panel stationarity testing, providing a comprehensive evaluation of the relationships between various indicators, including their mutual influences, trend similarities, correlation patterns, and data heterogeneity. The findings of this study can serve as a foundation for guiding EU countries toward carbon neutrality and enhancing governmental tools to support low-carbon development initiatives.

Research on the collective move towards carbon neutrality, driven by environmental regulations, is both timely and vital for crafting a sustainable future. It offers crucial insights for policymakers, businesses, and the public, aiding them in understanding the complexities of attaining carbon neutrality. Emphasizing regulatory frameworks enables the identification of practical solutions and strategies to effectively combat climate change.

Based on these conclusions, the study proposes to test the following hypothesis: Environmental regulations significantly influence carbon neutrality.

2. Methods

This research concentrates on analysing the factors that contribute to achieving carbon neutrality (CN), with a particular emphasis on environmental regulations (ER). The study is focused on EU countries, which were among the pioneers in committing to carbon neutrality at the national level. The analysis covers the period from 2000 to 2021.

According to Caglar and Yavuz (2023) and Niu (2024) the indicator of government spending on environmental protection was chosen as a key indicator of the effectiveness of environmental regulations. This metric evaluates the proportion of government expenditure on environmental protection relative to GDP, data gathered from European Commission (n.d.).

This indicator measures the share of a country's GDP allocated to protecting and improving the environment. Higher government expenditure on environmental protection relative to GDP suggests a stronger commitment to implementing and enforcing environmental regulations. It reflects the extent to which a government prioritizes environmental concerns relative to other policy areas (Kruse et al., 2022).

Financial expenditure is a critical component of turning regulations into actionable programs (Schneider et al., 2010). This indicator highlights the resources available for:

- Pollution control and prevention.
- Conservation of natural resources.
- Development of sustainable energy and infrastructure.

Higher spending often correlates with a more robust capacity to enforce existing regulations and implement new environmental policies.

Governments that enforce stringent environmental regulations typically require greater financial resources to support compliance mechanisms such as:

- Monitoring and enforcement activities.
- Subsidies or incentives for green technologies.
- Public awareness campaigns.

A higher relative expenditure indicates that the government is actively creating and enforcing regulations to protect the environment (Schneider et al., 2010).

While this indicator measures inputs (financial resources), it indirectly reflects the effectiveness of environmental regulations:

- If spending translates to tangible improvements in air and water quality, biodiversity protection, and reduced greenhouse gas emissions, it demonstrates effective regulation.
- Conversely, low expenditure may signal weak enforcement or a lack of regulatory ambition.

Comparing this indicator across countries provides insight into the relative strength of environmental regulations. Nations with higher expenditures relative to GDP are often seen as leaders in environmental governance. This can influence international perceptions of

a country's regulatory environment, affecting foreign investments, trade agreements, and participation in global climate initiatives.

European Commission (n.d.) explains methodologies for tracking and comparing environmental expenditures across EU countries and their link to policy implementation.

The dependent variable used to represent carbon neutrality is defined as the ratio of total CO₂ emissions produced to the number of emissions that have been mitigated:

$$CN = \frac{AE}{CDE+AE} \quad (1)$$

Here, *CN* is the country's carbon neutrality; *AE* is avoided emissions (data gathered from IPCC, n.d.; IEA, 2023); *CDE* is the volume of CO₂ emissions (data gathered from European Commission (n.d.)).

Carbon Neutrality represents the extent to which a country achieves a balance between emissions produced and avoided emissions. It ranges from 0 to 1, where: (1) *CN* = 1 implies complete carbon neutrality (all emissions are offset by avoided emissions); (2) *CN* < 1 implies partial carbon neutrality.

Avoided Emissions are emissions that have been prevented due to specific interventions or actions such as (IPCC, n.d.):

- Renewable energy adoption.
- Energy efficiency improvements.
- Carbon capture and storage technologies.

Governments can use *CN* to assess the effectiveness of their emissions reduction strategies. It allows comparison of carbon neutrality levels across countries using consistent metrics and useful in tracking progress toward net-zero goals by monitoring the balance between emissions and mitigation efforts.

The influence of environmental regulations on carbon neutrality is assessed through various methods, including panel stationarity tests, cross-section dependence tests, cointegration analysis, and heterogeneous parameter models. The time series data is initially subjected to stationarity testing using methods like the Levin-Lin-Chu test (Levin et al., 2002), the Im-Pesaran-Shin test (Im et al., 2003), and the Augmented Dickey-Fuller test (Cheung, Lai, 1995). Additionally, second-generation tests are employed, such as the Cointegrated Augmented Dickey-Fuller (CADF) test (Pesaran, 2007) and the Break Augmented Cross-Sectionally Augmented Panel Unit-Root Test (BCIPS) statistic (Lee et al., 2013).

Given the significant coherence and policy alignment among EU countries, it is assumed that there is interdependence among individual indicators of ecological development and similarity in their developmental trends. To account for these factors, the second phase of the analysis involves examining cross-section dependence among the indicators. This step is crucial for improving the reliability of the results and avoiding erroneous conclusions. The analysis of cross-sectional dependence utilizes tests such as the Pesaran scaled LM test, Pesaran's test, and the Breusch-Pagan LM test:

$$CD = \sqrt{\frac{2}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N \sqrt{T_{ij} \widehat{\rho}_{ij}} \right) \quad (2)$$

$$\widehat{\rho}_{ij} = \widehat{\rho}_{ji} = \frac{\sum_{t \in T_i \cap T_j} (\widehat{u}_{it} - \widehat{u}_i)(\widehat{u}_{jt} - \widehat{u}_j)}{\left\{ \sum_{t \in T_i \cap T_j} (\widehat{u}_{it} - \widehat{u}_i)^2 \right\}^{1/2} \left\{ \sum_{t \in T_i \cap T_j} (\widehat{u}_{jt} - \widehat{u}_j)^2 \right\}^{1/2}} \quad (3)$$

$$\widehat{u}_i = \frac{\sum_{t \in T_i \cap T_j} \widehat{u}_{it}}{\#(T_i \cap T_j)} \quad (4)$$

Here, N is the size of the sample; T is the time horizon of the analysis; $\widehat{\rho}_{ij}$ represents the sample estimate of the correlation between the residuals, $T_{ij} = \#(T_i \cap T_j)$ (i.e., the number of common time-series observations between units i and j).

The null hypothesis states that there is no cross-dependence between indicators.

$$LN = T \sum_{i=1}^{N-1} \sum_{j=i+1}^N \widehat{\rho}_{ij}^2 \quad (5)$$

$$\widehat{\rho}_{ij} = \widehat{\rho}_{ji} = \frac{\sum_{t=1}^T \widehat{u}_{it} \widehat{u}_{jt}}{(\sum_{t=1}^T \widehat{u}_{it}^2)^{1/2} (\sum_{t=1}^T \widehat{u}_{jt}^2)^{1/2}} \quad (6)$$

In the subsequent phase of the research, long-term cointegration among indicators is examined using Westerlund Error Correction Model (ECM) panel cointegration tests:

$$\Delta y_{it} = \delta'_i d_t + \alpha_i y_{i,t-1} + \lambda'_i x_{i,t-1} + \sum_{j=1}^{p_i} \alpha_{ij} \Delta y_{i,t-j} + \sum_{j=-q_i}^{p_i} \gamma_{ij} \Delta x_{i,t-j} + \epsilon_{it} \quad (7)$$

Here, $t = 1, \dots, T$ and $i = 1, \dots, N$ index the time-series and cross-sectional units, d_t contains the fixed components, for which there are three cases: 1) $d_t = 0$ so has no fixed components; 2) $d_t = 1$ so Δy_{it} is produced using a constant; 3) $d_t = (1, t)$ so Δy_{it} is produced using both a constant and a trend.

In the following stage, the parameters of the regression equation that captures the relationship between the indicators are estimated using Feasible Generalized Least Squares (FGLS):

$$\widehat{\beta}_{FGLS} = (X' \Sigma_T^{-1} X)^{-1} X' \Sigma_T^{-1} y \quad (8)$$

3. Results

Following the outlined methodology, the time series data were subjected to stationarity tests (Table 1).

The results from the Levin-Lin-Chu, Im-Pesaran-Shin, and Augmented Dickey-Fuller (ADF) tests, along with second-generation tests such as the Cointegrated Augmented Dickey-Fuller (CADF) and Break Augmented Cross-Sectionally Augmented Panel Unit-Root Test (BCIPS) statistics, summarized in Table 1, confirm the stationarity of the data series. While not all series exhibit stationarity at their original level, their first differences are stationary at a 1% level of statistical significance.

Table 1.
Results of tests for stationarity.

Tests		CN	ER
at level			
Levin-Lin-Chu	Stat.	2.712	-2.997
	Prob.	0.0000	0.0000
Im-Pesaran-Shin	Stat.	1.533	3.488
	Prob.	0.0412	0.0541
ADF	Stat.	-4.134	-4.569
	Prob.	0.0002	0.0001
CADF	Stat.	-1.554	-1.562
	Prob.	0.0425	0.0704
BCIPS	Stat.	-2.501	-5.037
	Prob.	0.0000	0.0000
at the first difference			
Levin-Lin-Chu	Stat.	-5.897	-7.862
	Prob.	0.0000	0.0000
Im-Pesaran-Shin	Stat.	-6.438	-9.445
	Prob.	0.0012	0.0000
ADF	Stat.	-8.989	11.984
	Prob.	0.0002	0.0001
CADF	Stat.	-2.049	-2.516
	Prob.	0.0000	0.0000
BCIPS	Stat.	-9.325	-11.571

Source: author's calculations.

Subsequently, the data series are examined for interdependencies among them (see Table 2).

Table 2.
Cross-Sectional Dependence Tests.

Tests		CN	ER
Breusch-Pagan LM	Stat.	68.683	75.901
	Prob.	0.0000	0.0000
Pesaran scaled LM	Stat.	34.225	53.456
	Prob.	0.0000	0.0000
Pesaran CD	Stat.	104.696	42.609
	Prob.	68.683	75.901

Source: author's calculations.

The findings from the Pesaran scaled LM test, Pesaran test for cross-sectional dependence (CD), and Breusch-Pagan LM tests, as shown in Table 2, indicate significant cross-dependencies among the indicators. In every category, the p-values fall below the critical threshold of 0.005, suggesting that the null hypothesis is rejected, and there is evidence of cross-dependence among indicators within each group. The stationarity of the dataset (Table 1) and the detected cross-dependencies (Table 2) justify the use of Westerlund ECM panel cointegration tests to evaluate cointegration within the data.

Table 3.
Westerlund ECM panel cointegration tests

Tests	Stat.	Prob.	Coeff
Gt	-5.628	0.000	-68.254
Ga	-5.929	0.001	1.324
Pt	-3.878	0.002	-3.654
Pa	-5.825	0.001	-21.325

Note: Gt and Ga are group-mean tests, while Pt and Pa are panel tests. Gt and Ga assess the presence of cointegration in at least one cross-section; Pt and Pa evaluate cointegration across the entire panel.

Source: author's calculations.

Table 4.
Feasible Generalized Least Squares estimation

Country	ER		cons	
	Stat.	Prob.	Stat.	Prob.
Austria	1.215	0.001	1.265	0.045
Belgium	2.490	0.330	0.816	0.120
Bulgaria	6.019	0.000	1.301	0.000
Croatia	6.259	0.000	2.364	0.000
Cyprus	3.383	0.000	4.251	0.000
Czech Republic	1.877	0.011	2.901	0.000
Denmark	5.900	0.678	3.350	0.004
Estonia	2.859	0.000	1.694	0.027
Finland	2.481	0.002	0.089	0.342
France	1.352	0.041	3.732	0.000
Germany	1.817	0.547	3.348	0.072
Greece	3.663	0.029	1.947	0.105
Hungary	4.103	0.036	3.171	0.000
Ireland	0.224	0.022	0.534	0.329
Italy	0.715	0.001	0.776	0.081
Latvia	0.791	0.787	6.584	0.000
Lithuania	1.837	0.528	0.206	0.122
Luxembourg	3.538	0.554	0.758	0.000
Malta	0.333	0.039	5.406	0.201
Netherlands	0.094	0.049	3.766	0.000
Poland	0.857	0.012	5.214	0.000
Portugal	0.620	0.001	6324	0.000
Romania	1.124	0.044	9.289	0.000
Slovak Republic	1.691	0.025	0.547	0.000
Slovenia	0.175	0.024	0.106	0.000
Spain	4.291	0.032	0.916	0.026
Sweden	1.804	0.068	0.565	0.498

Source: author's calculations.

The results from the Westerlund ECM panel cointegration tests, presented in Table 3, confirm the hypothesis of cointegration among the variables. This finding supports the assessment of parameters using the Feasible Generalized Least Squares model, which analyzes the impact of environmental regulations on carbon neutrality in EU countries. The model results also indicate a positive relationship between environmental regulation and carbon neutrality. Specifically, higher government spending on environmental protection leads to a 6.259% increase in carbon neutrality in Croatia, 6.019% in Bulgaria, 4.103% in Hungary, and 4.291% in Spain. These findings support the hypothesis that environmental regulations play a positive

role in advancing carbon neutrality. However, the data for Belgium, Denmark, Germany, Latvia, Lithuania, and Sweden do not show statistically significant results.

4. Discussion

Achieving the carbon neutrality targets set by EU countries necessitates a range of measures, including encouraging both the population and businesses to minimize their environmental impact and enhancing the efficiency of energy resource use. This research investigates the effect of environmental regulations on achieving carbon neutrality. Through the application of panel stationarity tests, cross-section dependence tests, cointegration tests, and heterogeneous parameter models, the study confirmed the hypothesis regarding the influence of environmental regulations on carbon neutrality in 21 out of the 27 countries analysed. Increased government expenditure on environmental protection was shown to enhance carbon neutrality, with notable increases of 6.259% in Croatia, 6.019% in Bulgaria, 4.103% in Hungary, and 4.291% in Spain. However, in Belgium, Denmark, Germany, Latvia, Lithuania, and Sweden, the correlation coefficients were not statistically significant.

The comparative analysis of the strength of the connection between indicators reveals that environmental regulations have a more significant impact in countries such as Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Lithuania, Luxembourg, the Netherlands, the Slovak Republic, Spain, and Sweden.

These findings are consistent with the conclusions of several researchers, including Kuzior et al. (2021), Sotnyk et al. (2022), Sotnyk et al. (2021), Dobrovolska et al. (2024), Katkova et al. (2022), and Streimikis et al. (2020), who emphasize the vital role of environmental regulations in achieving carbon neutrality, energy efficiency, and energy security, even during wartime (Lavreniuk et al., 2023; Tepliuk et al., 2024). The integration of innovative technology, as noted by Kuzior et al. (2022), Kuzior et al. (2023), and Melnyk et al. (2023), along with public investments (Kwilinski et al., 2024) and changes in industrial structure, are essential for attaining carbon neutrality (Vasilyeva et al., 2023; Letunovska et al., 2021). Additionally, improving energy efficiency plays a significant role in reducing CO₂ emissions in most countries globally (Wang et al., 2023; Skowron et al., 2023).

Based on these findings, countries where environmental regulations have a more substantial impact should focus on enhancing the quality of state policies and fostering active participation by state institutions in the carbon neutrality process. The results suggest that nations where environmental regulations have a greater influence should prioritize improving policy quality and institutional involvement.

While this study makes practical contributions to the understanding of carbon neutrality, it has several limitations that future research could address. Previous studies, such as those by Wołowiec et al. (2022) and Vasylieva et al. (2020), have identified factors like the quality of the institutional environment, regulatory quality, and corruption control as critical indicators of a country's environmental regulation. These factors, which affect the overall quality of state regulation and the development of corporate social responsibility, should be considered in future research on their impact on carbon neutrality. Additionally, future studies should examine both short-term and long-term relationships between the analysed indicators.

5. Limitations

While this study provides significant insights into the relationship between environmental regulations and progress toward carbon neutrality in European Union countries, several limitations warrant consideration.

1. The study focuses exclusively on EU member states, limiting the generalizability of the results to countries outside this region. Including non-EU nations with diverse regulatory frameworks and economic contexts could provide a more comprehensive understanding of global trends in carbon neutrality.
2. The calculation of carbon neutrality using avoided emissions and CO₂ emissions provides a valuable proxy but may not capture the full complexity of carbon neutrality, which involves broader factors such as methane, nitrous oxide, and other greenhouse gases. While the indicator government expenditure on environmental protection to GDP is a useful proxy, it does not fully capture the complexity of environmental regulations. Some nations may have stringent regulations with low expenditure due to:
 - Efficiency in regulatory frameworks.
 - Greater reliance on private sector compliance.
3. While the study highlights the role of environmental regulations, it does not account for the quality of governance or institutional capacity, which may significantly influence the effectiveness of regulatory measures. Corruption, inefficiencies, or lack of enforcement mechanisms could impact the outcomes of environmental policies. The effectiveness of expenditure depends also on policy design.

Addressing these limitations in future research could enhance the robustness and applicability of findings, contributing to a more nuanced understanding of how environmental regulations shape carbon neutrality trajectories.

6. Conclusion

This study highlights the crucial role of environmental regulations in advancing carbon neutrality among European Union countries. By employing robust econometric methodologies, including panel stationarity testing, cross-section dependence testing, cointegration analysis, and heterogeneous parameter models, the research demonstrates a positive correlation between government expenditures on environmental protection and progress toward carbon neutrality. Specifically, the findings reveal that in 21 out of the 27 countries analysed, increased environmental regulatory efforts significantly enhance carbon neutrality, with notable successes in Croatia, Bulgaria, Hungary, and Spain.

The study underscores the necessity of aligning state policies with business initiatives to ensure a cohesive approach to low-carbon development. The results provide actionable insights for policymakers, suggesting that improving the quality of environmental regulations and fostering institutional involvement can substantially enhance the effectiveness of carbon neutrality initiatives. Furthermore, the inclusion of technological innovation, public investments, and enhanced energy efficiency are identified as complementary strategies to bolster these efforts.

Despite the progress, the findings also reveal disparities among countries where regulatory impacts are statistically insignificant. This indicates the need for further investigation into factors such as institutional quality, regulatory frameworks, and corruption control, which may influence the efficiency of environmental spending and regulations. Future research should explore these dimensions while considering short-term and long-term dynamics to provide a more comprehensive understanding of the pathways to carbon neutrality.

By providing a deeper understanding of the interplay between environmental regulations and carbon neutrality, this study offers valuable guidance for policymakers, businesses, and stakeholders in designing strategies to combat climate change effectively. Aligning environmental, economic, and technological efforts will be essential in fostering a sustainable energy economy and achieving global climate goals.

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IMPACT OF THE COVID-19 PANDEMIC ON PROJECT MANAGEMENT. RESPONSES, DETERMINANTS, ADAPTATION

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Purpose: The coronavirus pandemic had a significant impact on project management, including the implementation of construction projects. Therefore, a study was conducted to determine what the impact of this situation was on various aspects of project planning, organisation and implementation. It also aimed to identify the key success factors in project management after COVID-19.

Design/methodology/approach: 120 questionnaires were sent to managers directly involved in the project management industry, with particular emphasis on the construction sector. 100 were correctly completed and returned, corresponding to a response rate of 83.3%. Data analysis was carried out using SPSS software version 23.

Conclusion: The survey of project management professionals found that delays caused by COVID-19 constraints were correlated with the cost and timeliness of projects. At the same time, key success factors such as adaptability and flexibility gained importance.

Practical implications: The results obtained have an implementation significance due to the necessity of adapting traditional project management methods to the dynamically changing external environment, as revealed in the conclusions. The recommendations formulated can be a source of knowledge for construction companies and other entities operating in a dynamically changing business environment, as well as for other organisations.

Originality/value: In the face of increasing uncertainty and risks caused by various factors (e.g. epidemics, military aggression, economic crisis, etc.), a flexible approach to project management can be a key success factor not only in the implementation of projects and the building of competitive advantages for companies, but also in the optimisation of public administration.

Keywords: project management, coronavirus pandemic, COVID-19, key success factors, construction industry.

1. Introduction

The COVID-19 pandemic has introduced significant changes in many areas of life, and project management is no exception. The global health crisis has forced organisations to adapt quickly, which in many cases has required a revision of traditional management methods and the search for new solutions. This article attempts to analyse these changes, with a focus on Critical Success Factors (CSF CSF) and innovative project management techniques in the face of a pandemic.

The situation from March 2020 posed challenges of a scale and scope previously unheard of for economic, social and political organisations and public administrations. Managers had to ensure proper coordination between their institutions, which had to function smoothly during successive waves of the pandemic. The new challenges affected areas such as health, education, security, communications, the economy or public service offices. According to the legislation enacted, in order to minimise social contact and limit the increase in coronavirus infection among employees, most people were directed to work remotely (Mańka-Szulik, 2021, p. 20). The pandemic was a time of business uncertainty and economic instability, as reflected by the fact that phrases relating to business suspensions and employee redundancies reached their highest values since search data has been collected by Google Trends (since 2004). In some cases, the scale of the increase in search phrases was unprecedented, reaching 400% more than ever before" (Wolniak, 2020, p. 13). To confirm the research hypotheses, 120 surveys were sent to representatives of the construction sector. The research implemented issues known from the VUCA model into the area of construction affected by the pandemic. The limitation and weakness of the research was the survey questionnaire method. Subsequent studies will use expert interviews.

2. Project management – CSF

The key success factors in projects vary significantly depending on the characteristics of the project and its complexity. Research points to the identification of specific elements that play a key role in successful project management, regardless of the scope or nature of the project (Chawana, Knapp van Bogaert, 2011, p. 369).

Project manager competence: one of the most important success factors is the competence of the project manager. The project manager's skills and experience are key to effectively managing the process and ensuring transparency. The project manager should have the ability to manage a team, make decisions and solve problems, which is essential to deliver the project according to the objectives and schedule (Garrett, Park, Redlener, 2009, p. 142).

Quality of subcontractor services: In the construction industry, the quality of subcontractor services is extremely important. The timeliness and quality of subcontractors have a direct impact on the success of a construction project (Carr et al., 2011, p. 47). Research confirms that working with reliable and highly qualified subcontractors is crucial to achieving the intended results.

Support from top management: Support from the top management of the organisation is also a fundamental factor for success. Top management should provide the necessary resources and be involved in solving project problems, which is particularly important in the face of project difficulties and challenges.

Influence of external factors: Key success factors are also influenced by external project factors. The current pandemic situation is an example of the influence of external factors on the project management process (Wyk, Dahmer, Custy, 2004, p. 259).

The pandemic has affected the time-consuming nature of project management and how delays are dealt with. In an environment where many activities can be halted or delayed depending on government action, understanding and adapting to these external challenges has become crucial to effective project management.

Project management, defined as a comprehensive effort to manage a project effectively, is based on a variety of techniques. These methods support project managers in effectively implementing projects on schedule and on budget (Klum, 2006, p. 902). Project management techniques focus on optimising available resources and on dealing with potential delays and challenges that may arise during project implementation.

One commonly used concept is the Agile method, which introduces flexibility into project management. This methodology, based on an iterative approach, enables projects to adapt to changing conditions and requirements. Research indicates that Agile brings value to organisations by improving supply chain efficiency and integrating feedback into project communication (Atherton, 2007, p. 59). Delivering projects in short iterations (sprints) allows projects to respond to change on an ongoing basis and better adapt to the needs of the organisation. In contrast to the agile approach, classic techniques such as the cascade method (Waterfall) also remain useful. This technique allows project managers to gain a clear overview of project execution, identifying sequences of activities and dependencies that contribute to project success (Balakrishnan et al., 2014, p. 727). Despite its long-term usefulness, the cascade method has its limitations, with the result that project management often requires the use of different techniques within the same project.

Another technique is Critical Path Method management, which identifies key elements of a project and focuses on them to minimise delays. The literature indicates that project managers often use a combination of different techniques, adapting them to the specific needs of the project. This approach increases the visibility and understanding of the project, enabling decisions to be made at each stage of implementation.

3. Project implementation under pandemic conditions. Methodological assumptions of empirical research

As part of the survey, 120 questionnaires were sent to people directly involved in the project management industry, with a particular focus on the construction sector. Of the questionnaires sent out, 100 were correctly completed and returned, corresponding to a response rate of 83.3%. The final number of respondents of 100 was sufficient for a reliable statistical analysis of the impact of the pandemic on project implementation in Poland. SPSS version 23 software, which is widely recognised as one of the most important tools for statistical analysis, will be used to analyse the data in this study. SPSS is highly regarded for its functionality and versatility.

The conduct of the described study was justified by the disruptive impact of the COVID-19 pandemic on project management both in Poland and around the world. The pandemic caused major disruptions to infrastructure projects, leading to delays and, in some cases, even a complete halt to work. This situation undermined the ability to implement many key initiatives that were essential for economic transformation.

The crisis triggered by the COVID-19 pandemic posed an unprecedented challenge for many stakeholders, being an event of global scope with a huge impact on various aspects of socio-economic life. Despite the official end of the pandemic, its effects are still visible, especially in the area of project implementation. Reactions of panic and uncertainty among stakeholders have contributed to numerous delays in the implementation of planned projects, and these delays are having a long-term impact on economies, especially in the construction sector, which plays a key role in many countries.

The cancellation or stoppage of construction projects has had a negative impact on production and employment, forcing managers to identify the causes of delays and develop strategies to manage in unpredictable conditions. The rising cost of delays is forcing project teams to make difficult decisions, such as reducing resources or lowering material quality to fit within budgets and deadlines.

Initial predictions in 2020 were that the situation should improve in 2021 following the introduction of a universal vaccination programme. However, the reality turned out to be more complex due to the volatile pandemic conditions and the fact that a significant part of the population approached vaccination with mistrust, which delayed the achievement of collective immunity. As a result, despite the availability of vaccines, project constraints and disruptions persisted longer than originally anticipated.

Study objectives and research questions

The main objective of the study is to develop a strategy framework on key success factors for project management in the post-pandemic period. In order to achieve this objective, the following specific objectives have been identified:

- A. Identification of project delivery methods in a post COVID-19 environment.
- B. Identify key determinants of project management success in the new post-pandemic reality.
- C. Explore the relevance and impact of key success indicators in project management post COVID-19.

These objectives form the basis for specific research tasks that aim to answer the following research questions:

- Research Question 1 - What project management methods are used in the post-pandemic period?
- Research Question 2 - What are the key factors contributing to success in project management after COVID-19?
- Research Question 3 - To what extent does the post COVID-19 period affect key success indicators in project management?

The aim of the study was to provide precise answers to these questions, contributing to the development of strategies for effective project management in a changed environment after the COVID-19 pandemic.

4. Record of results obtained

The following are the overall statistical results, which were compiled from the survey responses. Each section of the survey corresponds to different issues related to project implementation during the COVID-19 pandemic. The average scores assigned to each of these issues provide insight into how respondents perceived each aspect of the pandemic's impact on projects. These indicators allow an assessment of the importance of each element and its potential impact on project management.

Table 1.
Impact of delays (ID)

Impact of delays	Average
The current pandemic situation has caused delays in ongoing projects.	3.404
The financial impact is an important dimension of delay.	3.768
My company makes its supply chains more flexible because of delays.	3.566
Delays will continue to increase the cost of existing projects.	3.444
Too many delays lead to the cancellation of existing projects.	3.505
Average	3.537

Table 2.*Key success factors (KSF)*

Key success factors	Average
Flexibility in this environment is a key factor for success.	3.556
Using new and existing IT systems improves business processes.	3.545
Subcontractors are key to project delivery.	3.354
Qualified project managers are becoming increasingly important.	3.292
Companies need to use new techniques to remain effective in the execution and delivery of projects.	3.253
Average	3.400

Table 3.*Upgrading skills (HR)*

Improving HR skills	Average
There have been significant changes in skills due to the pandemic.	3.636
Companies are focusing on imparting new skills to employees during this time.	3.434
Higher productivity is the goal of upskilling, which is being realised.	3.515
My company does not undertake such investments.	3.474
Upgrading staff skills is only part of the solution, requiring a combination of factors.	3.374
Average	3.487

Table 4.*Methods used (MU)*

Methods used	Average
Companies are increasingly relying on delayed payments to cope with the situation.	3.404
There is no change to the current project delivery methodology.	3.576
The greater strain on cash flow is causing companies to focus more on cost-cutting.	3.616
Agile project management methods are becoming more common in implementation.	3.556
Technology is being used to reduce the cost of project delivery across the board.	3.475
Average	3.525

Table 5.*Impact on project implementation (EP)*

Impact on project implementation	Average
Project implementation changed forever after the coronavirus pandemic.	3.515
In the new normal, life without the implementation of information technology will not be possible.	3.455
Lightweight project management methodologies will become standard.	3.566
Key success factors affect project implementation both during and after a coronavirus pandemic.	3.455
Average	3.497

4.1. Analysis of the data revealed as a result of the implementation of the research programme

Objective 1: Identify effective project delivery methods. Based on the results of the study, it is recommended that companies invest in human resource development and adapt their methods to flexible approaches. Incorporating external factors in a quantitative way into project schedules also proved important.

Objective 2: To identify key success factors in project management post COVID-19. The results of the analysis indicate that the key factors have a significant correlation and play a significant role in project success. The level of correlation confirms the importance of these factors in the context of the changed post-pandemic environment.

Objective 3: To test the significant impact of success indicators on project management after COVID-19. Regression analysis showed that the model is statistically significant, confirming the quantitative relationship and measuring the impact on project implementation. Key success factors such as methods used, impact of delays and human resource development contribute to explain the impact on project implementation during the pandemic.

The impact of delays was one of the key independent variables analysed in the study. It was defined as the effect of project delays occurring, especially in the context of the coronavirus pandemic situation. Faced with the pandemic, most projects, regardless of their size, experienced significant delays. This was due to limitations in the number of available workers on construction sites and bans on construction activities imposed by the governments of many countries, which considered these sites to be high risk areas for the spread of the virus.

Key success factors are those elements that must be met for a project to be successful. While these factors may vary depending on the type of project, research indicates that for construction projects there are several universal key success factors. In particular, adaptability and flexibility in project delivery are often considered essential as they have a significant impact on the overall success of a project. In reality, the impact of these factors is variable and depends on the type of project and the specific business environment in which it is implemented.

The independent variable, which is the impact of the methods used, aims to understand how the techniques used in project implementation have evolved in response to the coronavirus pandemic situation. Traditionally, project implementation has relied on methods such as cascade, which are well suited to stable and predictable business conditions. However, research shows that changing external factors can force significant modifications to these methods.

The study found that it was important for project implementation to understand how developing employees' skills could improve performance and productivity. This was particularly important in the context of changes in the labour market, where the decreasing number of jobs available required employees to be more versatile and adaptable to different roles.

4.2. Application significance of the results of the study

The first suggestion arising from the study concerns the need for project managers to be more flexible in project implementation. Managers should not rely solely on static management methods or base their decisions solely on internal project information. In order to succeed in a dynamically changing business environment, they should actively integrate external information and adapt their approach to changing conditions.

Another application refers to the need to change the project delivery methods normally used. In the current environment, which demands greater flexibility, companies need to adapt their approach to supply chain and project cycle management to achieve more with limited resources. This points to the growing role of information technology, which can bridge the productivity gap and improve decision-making, enabling companies to adapt more effectively to new challenges.

The pandemic had a significant impact on the implementation of construction projects. In particular, project delays caused by pandemic-related constraints were strongly correlated with the cost and timeliness of project delivery. At the same time, key success factors such as adaptability and flexibility have gained in importance, indicating the need to adapt traditional project management methods to the dynamically changing external environment.

The study also found that the project delivery methods used had changed, placing greater emphasis on flexibility and risk management. In the context of human resources, the development of staff skills, especially in terms of flexibility and multitasking, proved crucial to maintaining productivity and efficiency in project implementation in the face of a pandemic.

Based on the results of the research, recommendations were made to project managers and construction companies, focusing on the need to implement flexible project management methods, greater integration of external factors influencing project delivery and investment in staff skills development.

The study obviously encountered some limitations, such as the peculiarities of the construction market in Poland and the variability of the business environment during the pandemic, which may affect the possibility of generalising the results. At the same time, these limitations are an inspiration for further studies on the impact of the pandemic on different economic sectors and on project management in the context of global crises.

5. Conclusion

This article contributes to a better understanding of the impact of the coronavirus pandemic on construction projects in Poland. The results of the research and the recommendations formulated can be a source of knowledge for construction companies and other entities

operating in a dynamically changing business environment, as well as for other organisations. In the face of increasing uncertainty and risk, a flexible approach to project management can be a key success factor not only in implementing projects and building competitive advantage for companies, but also in optimising the functioning of public administration. The VUCA model plays an important role - it is primarily a world of variability, complexity, uncertainty and ambiguity.

Interestingly, globally, the level of organisational development did not affect incidence. For example: the dynamics of COVID-19 cases in smart cities had a low correlation with the level of smart technology adoption, as it was more susceptible to the spread of waves and strains of the virus depending on geographical location (Kuzior et al., 2022, p. 21). This is because in cities, it was the speed of response and relevance to the threat that mattered.

Using the example of the study carried out in Zabrze, it can be seen that a task team set up in the City Hall together with the Department of Crisis Management and Civil Defence coordinated the securing of infrastructure for the isolation of infected persons, the supply of disinfectants, protective and preventive procedures. Together with social assistance, care was organised for those in need. Support was provided to schools that introduced distance learning. Assistance packages were developed and implemented for residents and entrepreneurs doing business in the city, including exemptions, tax breaks and preferential tax rates. Activities were undertaken to activate and integrate residents. All these activities were properly communicated to ensure access to reliable, up-to-date and relevant information distributed through easily accessible mass and social media (Mańka-Szulik, Krawczyk, 2020, p. 414).

Similarly, economic organisations have had to respond adequately to the requirements of production or project implementation processes. Some of the management models developed at that time have been permanently implemented in social and economic reality, such as the execution of tasks via platforms in cyberspace. The use of remote forms of dealing with customers is, moreover, a welcome development. It not only ensures efficiency, high quality and transparency of service, but is also user-friendly. Paradoxically, the Covid-19 pandemic has also translated into an increase in the use of e-government tools by citizens using public services (Kuzior, Mańka-Szulik, Krawczyk, 2021, pp. 269-270). Traditional decision-making processes have been transferred to digital space, which has ensured the continuity of local government, but has generated new challenges. These undeniably relate to ensuring an adequate level of security for the IT tools and systems that support decision-making and other processes carried out by public authorities. This challenge will be with us for years to come, regardless of the impact of the pandemic (Mroczka, 2021, p. 92).

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THE FUTURE OF MAN IN A WORLD OF ARTIFICIAL INTELLIGENCE

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Purpose: The aim of this article is to provide an overview of some of the problems arising from the rapid development and elevation of the status of machines and the increasing disregard for human rights in the context of the use of advanced artificial intelligence. The considerations carried out lead to the conclusion that the pace of development of modern technologies, outstripping the human capacity to comprehend them, poses the danger of machines' actions escaping human control.

Design/methodology/approach: The study is theoretical in nature and based on a critical analysis of the literature on the subject. The literature has been limited to some of the literature on artificial intelligence and related issues.

Findings: The research shows that the pace of development of modern technologies is far ahead of human competence in their control and use. There is also a lack of sufficient reflection on the dangers of surrendering decision-making to machines, for example, or placing responsibility on them.

Originality/value: The technological reality requires the development of new ethics, ethics adapted to the development of artificial intelligence, taking into account the increasingly complex ethical challenges. The article can serve as a starting point for a detailed study of the work of developing proposals for new ethics in this field.

Keywords: humans, artificial intelligence, threats.

Category of the paper: Conceptual paper.

1. Introduction

In the 21st century, it is impossible to imagine life without artificial intelligence. Medicine, communication, logistics, banking, science, automotive, military, management and marketing, journalism, translation, gaming - these are some examples of fields whose functioning is based on various AI solutions. The phenomenon is also increasingly present in the arts, where, on the one hand, it is subject to the influence and expansion of new technologies, and, on the other, it is significantly shaping the 'modern system of culture and technology' (Zawojski, 2019) in a constantly updating way. Artificial intelligence is being used, artificial

intelligence is being talked about, artificial intelligence is being monetised - arguably, this technological and information phenomenon is one of the words that characterise our current reality. The science of artificial intelligence is developing, in technical language AI is evolving. Therefore, the future of humans is inextricably linked to the development of artificial intelligence (Kuzior et al., 2019; Tomaszewska, 2023). Artificial intelligence has entered the world of man, but this statement seems to be increasingly losing its relevance, in favour of the fact that a conversion of sorts is becoming more and more evident and, in fact, man is now living in a world of artificial intelligence. Along with this awareness, there are more and more concerns and questions about man's future, his role in the world and his security. There are therefore voices warning against its uncontrolled use and the need to stop its unverifiable expansion. Already, artificial intelligence developers are proclaiming concerns about the speed at which AI learns and assimilates information, the scale of which is incomparable to human capabilities. New information keeps arriving from cyberspace, which on the one hand opens us up to hitherto unknown cognitive fields, while on the other hand creates disorientation. The reaction to the excessive number of stimuli reaching us on the affective, cognitive and decision-making planes becomes thought chaos. Human life is accompanied by constant exhaustion, both physical and psychological, and finally a whole range of pathological phenomena and behaviours emerge. They are initiated by an internal compulsion to be online, escape from the real world to the virtual world, access to toxic cultural groups, isolation, alienation, network addiction. As robots become smarter and more human-like, the threat posed by them may indeed take on a more real form (Marszałek-Kotzur, 2023). The consequences of humanity's failure to keep up with the potential of artificial intelligence related to the creation of new data and its structures are unpredictable. They relate not only to the inability of humans to understand them, but above all to the inability to control these processes. The impact of technology on human development, including the tremendous advances in artificial intelligence and cognitive technologies, inspires representatives of various fields and scientific disciplines. This problem also calls for urgent humanistic analyses, including philosophical analyses. Indeed, the development of artificial intelligence is not without influence on the formulation of forecasts concerning the future of humanity itself, and even the existence of humanity. The choice of the topic of this study is dictated by the ambivalence associated with the perception of artificial intelligence. On the one hand, we appreciate its revolutionary role in the modern world. On the other hand, one perceives various dangers arising from its operation, which puts humanity to a kind of test of time in response to the effectiveness of intelligent systems. The global growth of interest in AI also highlights the problems and challenges that humanity not only faces in the future, but already today.

2. Methodology of research

The study is theoretical in nature and based on a critical analysis of the literature on the subject. The literature has been limited to some of the literature on cognitive technologies and related issues. The literature study, i.e. the analysis and critique of the literature of selected publications, has made it possible to identify what has been analysed in the topic of interest in this paper and in what way. It also allowed the direction of further research to be outlined. The focus was on the issues of defining what artificial intelligence and algorithms are in essence. Some examples of the benefits of using these technologies were cited and some of their negative effects on humans in selected situations were described. Several plausible reasons why artificial intelligence may become disobedient to humanity are described. Only some of these are presented in this paper. Attempts to justify concerns about the future of humans in a world of machines have been reflected upon. Some exemplary suggestions for work on legal provisions related to the participation of artificial intelligence are also recalled. From the research carried out, it appears that the pace of development of modern technologies is far ahead of human competence in their control and use. There is also a lack of sufficient reflection on the dangers of handing over decision-making to machines, for example, or placing responsibility on them. The considerations presented do not, of course, exhaust the entire issue, but it seems that they may open up new fields and directions of research.

3. Results of research and discussion

How does Artificial Intelligence work?

The 21st century has brought unprecedented developments in technology and, among other things, the ability to create so-called procedures. Hence, today AI has the ability to learn, to create and remember huge data sets, to communicate between databases and even to use the cause-and-effect principle (Cymanow-Sosin et al., 2024, 59). In the context of discussions concerning the operation of artificial intelligence, we speak of so-called Machine Learning and its subgroup called Deep Learning (Kondas, 2022). Deep Learning is one of the foundations of cognitive computing (Kwilinski, Kuzior, 2020). It is a process in which a computer learns to perform tasks that are natural to the human brain, such as speech recognition, image identification, natural language processing or a recommendation system. So, computers are capable of learning without programming new skills directly to them. They use neural networks. This method is based on algorithms that, by analysing the data provided to them, draw conclusions and learn from them in order to use the knowledge thus gained in making the decisions needed to solve specific problems. Over time, as more and more data is processed,

they self-improve without having to be reprogrammed (Kuciński, 2021). There are many definitions of algorithms. It is appropriate to recall some of them. One, dating back to the 1970s, describes them as a combination of logic and control processes (Kowalski, 1979). Another, describes algorithms as procedures for transforming input data into our expected results using mathematical calculations performed by a computer (Neyland, 2018). Algorithms can also be described as a defining technology because, as such, it shapes the way we think and perceive the world (Bolter, 1990). Algorithm can also be thought of as an abbreviated name for a sociotechnical an assemblage containing: an algorithm (in the technical sense), a model, a target group, data, applications and hardware - all linked to a social environment (Gillespie, 2014). Algorithms are capable of processing thousands of complex data in real time, exceeding the capabilities of not only a single individual, but entire expert groups. Thus, they are often used, among other things, to standardise many decision-making processes (Caplan, Boyd, 2018). Algorithms are increasingly making various choices for humans, shaping their taste, flavour and preferences. In doing so, they generate visions of a perfect, error-free world, a world of 100% accuracy, efficiency and predictability (Nunes, 2011). This puts our vigilance to sleep, and just when one thinks that technology is a neutral phenomenon, it slips out of control and exerts its greatest influence on humans (Heidegger, 1977). The operation of algorithms aims to reduce complex reality to simple logical models, allowing to perform fast and complex calculations, correlating extensive data. Their increasing level of complexity makes their operation virtually impossible to grasp by human reason. It is also increasingly difficult to predict the 'behaviour' of a given algorithm in a specific situation (Kosiński, 2021). The better algorithms become at deciding how to solve human problems, the more willing humans are to hand over to them the right to decide and manage their lives. By surrendering decision-making, and thus responsibility, to algorithms, we systematically give them power over humans (Marszałek-Kotzur, 2022). Meanwhile, algorithms, perceived as objective and rational participants in life, by simplifying, fragmenting and trivialising human life, manifest their superiority over humans. Observing the work on artificial intelligence, it is already evident that, although AI does not yet have a self, it exhibits autonomy. This autonomy is a major source of concern. This is because there is no guarantee that it will not get out of control or be used for evil purposes (Hawking et al., 2014; Beck, 2010).

Three versions of the human future in an AI world

Forecasts of the future fate of artificial intelligence development are sometimes varied. One proposal is a vision of three future scenarios. On the basis of these, an attempt is made to evaluate three ways of assessing the present and future condition of humans and their humanity. The concept is arranged in a triad: Paradise - Hell - Triumph (Garreau, 2005). These scenarios constitute three metaphors, representing the consequences of technological development. The first, called Paradise, is optimistic, associated with the Christian vision of paradise. Among other things, it assumes that man will transcend the limits of his nature, making it

possible to reprogram his body and remove his body's imperfections. According to this scenario, in the coming decades, the ageing process will be radically slowed down, a significant proportion of diseases will be prevented, and treatment will be simple and uncomplicated and successful. Most people will be assisted in their daily lives by devices originally designed for people with disabilities. The global economy will be booming and most people's needs for food, shelter and security will be met. Most importantly, the boundary between the world of humans and the world of intelligent machines will become increasingly blurred. At the same time, artificial intelligence will be modelled on human intelligence and human intelligence will be assisted by machines. With transhumanism, humans will have a greater capacity for logical thinking, memory and perception. In turn, the personal character, skills and knowledge of many machines will be derived from the human mind. In the Edenic vision of the future, therefore, the understanding of humanity will change dramatically (Zawojski, 2016, p. 24). Descriptions of this technological optimism are contained, for example, in *Converging Technologies for Improved Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science*. This report assumes an increasing integration of man and machine and points to a whole range of resulting benefits (Albus, 2003).

The second scenario, called Hell, predicts that a high degree of technological development will pose a threat to humanity. New, intelligent means will be used by various extremists to pursue their evil intentions. The development of genetics, robotics, information technology and nanotechnology, for example, will make it possible to cause diseases or epidemics that kill many specific victims, such as people of a particular race. This would give the possibility to manipulate human evolution, while undermining the idea of equality and democracy. In such a world, robots endowed with super intelligence would reduce the lives of their creators to the level of vegetation, and thus the scenario of the so-called 'grey slime', the 'grey slime', would become real (Drexler, 1986, pp. 127, 208). It signifies the hypothetical point of an apocalyptic human scenario in which self-replicating nanomechanisms break out of control and transform the entire biosphere into copies of themselves, killing everything that lives on earth. The very name 'grey ooze' is meant to suggest an amorphous, spreading mass reproduced by machines. The essence of the infernal scenario is the loss of humanity and, consequently, the annihilation of humanity. The only realistic alternative to ensure that such a scenario does not occur is to reject overly dangerous technical solutions and abandon further research in certain areas of knowledge (Garreau, 2005, pp. 139-193). The third scenario is Triumph. It involves embracing the gains of new technologies while being aware of the risks involved. In May 2014, an article co-authored by Stephen Hawking appeared in *The Independent*. The text included a warning about the dangers of the rapid development of artificial intelligence (Hawking et al., 2014). According to the authors, the creation of an independently thinking machine, or superintelligence, could be the greatest event in human history. It could surpass humans in intelligence, take control of them and even create weapons that we cannot understand. The scientists also cautioned readers that considering their conundrum as a science-fiction-type statement could prove to be the biggest mistake in history.

Probable causes of AI disobedience

The literature on the extensive research into the problems associated with the development of artificial intelligence distinguishes at least several plausible reasons why artificial intelligence may become disobedient to humanity. This paper presents only some of them. One important reason is the difficulty of target selection. Currently, most machines, or software called artificial intelligence, do not reason in the same way as humans. To force artificial intelligence to perform tasks, so-called utility functions are defined (Jablecki, Wozniak, 2022). Artificial intelligence systems are not constructed according to rules that are implemented after the first run. Utility functions generally follow the value of utility. In short, AI is oriented to perform certain predefined tasks so as to optimise profits (LeViness, 2018). The situation is well illustrated by the theory of Stuart Russel, a specialist in artificial intelligence. This theory states that although utility functions are selected by humans so that the AI performs tasks to the satisfaction of humans, the utility function may not perfectly match the values of the human race, which are very difficult (or impossible) to determine (Brockman, 2014).

Another reason may be instrumental convergence assuming that an intelligent agent with unlimited but seemingly harmless goals can act in surprisingly harmful ways. A distinction is made here between so-called instrumental goals and final goals. For example, a machine whose only unlimited (final) goal is to solve a difficult mathematical problem might try to turn the entire Earth into one big computer in order to increase its computing power in order to succeed in its calculations (instrumental goal). According to the researchers, the proposed basic drives, or instrumental goals, of artificial intelligence resulting from this theory include: integrity of purpose content, self-protection, freedom from interference, self-improvement, and unmet acquisition of additional resources (Russel et al., 2003).

Another possible reason is the so-called orthogonality thesis, which states that an artificial intelligence can have any combination of intelligence level and purpose, that is, its utility functions and general intelligence can vary independently of each other. This contradicts the belief that, because of their intelligence, all AIs will pursue a common goal. This thesis was originally defined by Nick Bostrom in his article *Superintelligent Will*. It suggests that it would be a mistake to assume that superintelligence will share any of the values stereotypically associated with human wisdom and intellectual development. These include, for example, scientific curiosity, kindness, renunciation of material greed, humility, selflessness, etc. Bostrom also warns against anthropomorphism. Humans want to carry out their projects in a way that is consistent with human values. An artificial intelligence may have no regard for their existence or the well-being of the people around it, and instead may only care about getting the job done (Bostrom, 2012).

The above examples assume the accidental production of an AI hostile to humans. However, it seems equally likely that malicious AI could be created deliberately and intentionally. There is a fairly substantial list of entities that could be interested in creating such

AI, and these include: state governments that could use AI to control people and assert power, the criminal world, individuals who want to demonstrate that malicious AI is not so malicious, the military that could use AI as a weapon. (Pistono, Yampolskiy, 2016). Malicious AI pulling down the risk of extinction for humanity could therefore be designed by humans themselves. With this in mind, countries, or alliances, may suspect each other of working on such technology. It seems, therefore, that the main problem to be faced in the context of artificial intelligence is the problem of controlling its development once it is able to autonomously and recursively develop and improve itself (Bostrom, 2014).

Are the fears justified?

Fears of machines taking over the world are nothing new. The first references of this kind could be encountered as early as the 19th century, when the writer Samuel Butler warned that the moment when machines would take over the whole world was only a matter of time (Breuer, 1975). In later years, these discussions gained momentum. As early as the 1990s, the American philosopher, media scholar and cultural critic Neil Postman and the Canadian communication theorist Herbert Marshall McLuhan wrote about the dangers of technology's triumph over culture and perhaps even humanity. They shared a belief in technological determinism, assuming that technical progress determines the direction of development. Postman was of the opinion that the total symbiosis with various aspects of human life he called this subordination of all forms of cultural life to the reign of technology and technique He defined the current state of society, for which the goal of human labour is productivity and standard procedures, technical calculations, meters and tests are in many respects better than human judgement. He drew attention to the need to teach how to use technology, which, if unsupervised, can pose dangers to humans (Postman, 1995). In 2014, philosopher and proponent of transhumanism, Nick Bostrom, published a controversial book entitled *Superintelligence* (Bostrom, 2014), to which the likes of Elon Musk and Bill Gates, for example, have not been indifferent (Metz, 2018). In turn, in 2016, the scientific journal *Nature* posted a warning against machines that are superior to humans in every way and can evolve beyond human control, having divergent interests with humans (Nature, 2016).

The direction of artificial intelligence depends on how it was designed, the data used to do so and the purpose of its activities. The information produced by artificial intelligence may be intentionally or unintentionally biased. The mere use of only numerical data and their statistical representations to search for solutions in a complex social reality can lead to serious consequences of humans becoming lost in a dehumanised world. The developers of artificial intelligence themselves recognise the need to develop better and more effective mechanisms for its implementation than before. In 2023, hundreds of businessmen, investors and AI experts, including Elon Musk among others, issued a letter published by the Future of Life Institute centre calling for at least a six-month pause in the development of artificial intelligence. Its authors believe that the current race led by AI labs is uncontrollable and, as a result, proper

planning and management processes are not keeping up, posing many risks to humanity (Business Insider, 2023).

Artificial intelligence today supporting human activities can lose or extend its purpose beyond human-defined boundaries. This could be due to both a lack of adequate oversight and an inability to anticipate possible pathways for AI transformation. Artificial intelligence today learns from information, generated by humans. However, it is constantly creating new facts based on these, from which it will process data, already without human participation. The consequences of this process are impossible for us to predict, but it is certain that the structures produced by AI will become increasingly complex, and that it will be impossible for humans to understand them without the help of technology (Jaskuła, 2023).

Concerns about the development of artificial intelligence also relate to human freedom under threat. After all, with the help of AI, human thinking and behaviour can be shaped. It can be programmed according to the intentions of politicians, who are not always guided by the real good of human beings. We are already subjected to mass surveillance through the Internet, smartphones, cameras, etc.

Threats also come from technologies that encourage an emotional connection with them. By definition, these are deceptive and damaging to interpersonal relationships. The development of nanorobots is both hopeful and worrying. Placed in the human body, they can fight disease, but can be used to control and even cause death. Of great concern is the use of AI in military operations in terms of its ethical aspects (Skorupka, 2022). AI has been used for eavesdropping, spying, assassination and military operations. Thus, the premise of Asimov's so-called three laws of robotics, which proclaim that robots will always be friendly to humans and will not harm humans seems to be a fiction (Asimov, 1976; Anderson, 2008). AI can be very dangerous because it is connected to a network and we are practically unable to turn off the Internet. Therefore, decisions made by AI can be completely contrary to what is good for humans (Warwick, 2020). Warnings about uncontrolled technological advances have been around for many years. However, they are not widely published and publicised. Perhaps a key reason for this is that describing the risks is not conducive to making a profit, and cutting-edge technologies have a clearly commercial application and are developed almost exclusively in corporations (Joy, 2003).

Attempts to maintain control over AI

In times of such rapid development of artificial intelligence, human subjectivity should not be lost sight of. The conscious use of technology is at the same time linked to a partial rejection of it. Technologies should first and foremost serve to establish human connections (Ball, 2022). The question of how the ongoing development of technology can be properly regulated as soon as possible is increasingly being raised. Some sound the alarm and argue that this should be done as soon as possible, while others believe that artificial intelligence is at the threshold of its development and there is no need to rush. Still others advocate only the introduction of

generally accepted standards for testing and transparency of algorithms. In 2020, The Global Partnership on Artificial Intelligence (GPAI) was founded with the overarching goal of making efforts to ensure that the development of artificial intelligence takes place in accordance with human rights and democratic values (GPAI, 2020). Australia, Canada, the European Union, France, Germany, India, Italy, Japan, the Republic of Korea, Mexico, New Zealand, Singapore, Slovenia, the US and the UK were founding members. The GPAI deals with four main topics. The first is data management. The second is responsible artificial intelligence. Another is the future of work and innovation and commercialisation. These themes have also been addressed in many international forums and conferences like the World Economic Forum, dedicated to integrated science. The need to adhere to ethical as well as legal principles in AI research is highlighted, so that these technologies can contribute to positive causes and protect society (Kuzior, Marszałek-Kotzur, 2022). Another key area related to the threat posed by artificial intelligence is the military use of the technology (Marszałek-Kotzur, 2022b). Many experts are already talking about the phenomenon of an arms race related to the introduction of artificial intelligence, where countries will compete in which of them will have access to the best artificial intelligence, as this will potentially provide a huge advantage and world domination (Geist, 2016). In this regard, international norms are being developed to prioritise security and to prioritise the development of technologies that minimise the risk of threats. The last decade has also seen several major international discussions on the approach to autonomous weapons, with the aim of developing common universal principles in this matter. Whether AI can indeed threaten humanity in the future has been the subject of much debate for many years. Articles addressing this topic have also been published. Statements by well-known visionaries such as Steven Hawking (Hawking, 2015), Elon Musk (Musk, 2017), Bill Gates (Rawlinson, 2017) are the most likely to reach the public, Yann LeCunn (Forbes, 2017), Eric Horvitz or Noam Chomski. Chomsky also warns against losing control of artificial intelligence, but according to him, artificial intelligence is merely a voracious statistical machine for speech recognition or the most likely to answer a scientific question. He therefore proposes to call AI simply “plagiarized software”. The human mind, on the other hand, is, according to him, a surprisingly efficient and elegant system that works with limited information. It does not try to corrupt unedited correlations from data, but tries to create explanations (Chomsky, 2023).

4. Summary

At present, opinions on the degree of existential threat to humanity that may result from the global development of artificial intelligence are sharply divided. There are extremely optimistic and extremely pessimistic opinions. There seems to be a general consensus of opinion that there are risks associated with artificial intelligence, as with most technological advances,

but that different individuals perceive these risks differently. The specific situations evoked in the above reflections, as well as visions for the future of humans in a world filled with artificial intelligence, open up new horizons for research and the search for answers to the question: what is next for humans? Artificial intelligence is making its mark on adults, young people and children. For the generation of people born just after the war, artificial intelligence seems more like an abstract construct. Later generations view artificial intelligence as a natural consequence of developments based on algorithms and zero-sum code, which underpin the functioning of computer programmes used in work and everyday life by their users. Perhaps the fears of artificial intelligence are exaggerated and independent artificial intelligence will never pose a threat to humans. Perhaps it will even allow humanity to enter a whole new level of civilisation? It is therefore worthwhile to continue research into artificial intelligence systems capable of self-adaptation and autonomous evolution, but the specific scope of the legal and ethical framework must be established. Contemporary artificial intelligence development processes should not only be subject to an analysis of current problems, they should more broadly attempt to identify risks that may escalate in the future. The purpose of this article is to encourage the reader to reflect on the problem raised and perhaps raise new questions on the issue.

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INTEGRATION OF ESG AND INCENTIVE SYSTEMS DEDICATED TO MANAGEMENT IN THE MINING INDUSTRY

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Purpose: The aim of the article is to examine and evaluate how ESG practices can be effectively integrated with incentive systems for management in the mining industry and what possibilities they offer in achieving sustainable development goals while simultaneously increasing the engagement and efficiency of management through appropriate incentive systems.

Design/methodology/approach: The article is exploratory in nature, focusing on the analysis of the relevant literature. The methodology includes an in-depth review of national and international literature on incentive systems and sustainable development. This analysis allows for an understanding of how the integration of ESG and incentive systems impacts corporate governance.

Findings: The conducted research provides important conclusions for management in the mining sector, indicating that incentive systems integrating ESG goals can be more engaging and valuable than traditional incentive systems focused solely on financial or operational outcomes.

Research limitations/implications: The research presented in the article may contribute to further empirical studies, particularly in the context of the long-term impact of these systems on financial results, sustainable development of companies, and the risks and opportunities of sustainable development in business.

Practical implications: The practical implications of the conducted research enable their application in restructuring incentive systems in mining enterprises, with greater consideration of ESG aspects.

Originality/value: The research results indicate the need for a comprehensive reconstruction of incentive systems in mining enterprises to better integrate ESG goals and respond to the requirements of the European Green Deal.

Keywords: ESG, incentive systems, mining, corporate responsibility, sustainable development, motivation.

Category of the paper: Research Article, General Overview.

1. Introduction

In the current era of global challenges related to climate change, sustainable development, and social responsibility, the necessity for corporate transparency and responsible management in the industry is becoming increasingly desirable. The mining sector, due to its significant environmental impact, faces an imperative to integrate ESG principles and effective incentive systems. These are no longer just added values but have become key elements ensuring the long-term stability and operational efficiency of enterprises.

Well-designed incentive systems that incorporate ESG goals can significantly influence the engagement and performance of management while supporting the implementation of sustainable development strategies. Motivating leadership to incorporate sustainable practices not only improves stakeholder relations and the company's image but also contributes to better financial results through innovation and operational efficiency. Consequently, incentive systems that were initially focused on financial and operational outcomes should now expand their evaluation criteria to include environmental and social indicators in line with the European Green Deal.

The challenge is also to ensure that these integrated incentive systems are fair, transparent, and tailored to the specific goals of each organization. In developing these systems, it is important to consider not only direct financial results but also indicators such as environmental impact, employee satisfaction, innovation, and corporate reputation. Developing sustainable incentive strategies that truly reflect ESG priorities requires a deep understanding of both local and global trends in sustainable development, as well as continuous monitoring and adjustment of programs in response to changing market and regulatory conditions.

It should also be noted that effective integration of ESG and incentive systems requires commitment at the highest management levels, as well as openness to change and readiness for innovative solutions. Striving to understand these mechanisms and their impact on sustainable business practices is becoming crucial for the future of the mining sector, making this topic extremely important for both research and practical implementation.

2. The Role of ESG Standards and European Regulations in Shaping Sustainable Development

ESG (Environmental, Social, Governance) standards play a key role in shaping sustainable development, compelling companies to take responsibility for their impact on the environment, society, and management practices. In Europe, the role of these standards is even more significant due to the stringent regulations being introduced to promote sustainable

development and corporate responsibility. Simultaneously, there are reports of challenges related to the quality of ESG reporting and its real impact on sustainable development. It is recommended that ESG reporting goes beyond focusing solely on the company, adapting traditional accounting systems to more effectively incorporate the growing demands for ESG disclosures, thereby enabling transparent demonstration of environmental and social impacts (Shauhrat S.C., Supunsala S.S. et al., 2024).

The role of ESG standards and European regulations in shaping sustainable development is significant, as they not only influence corporate strategies but also investments and risk management associated with green initiatives, which is crucial for the future of the mining sector and, more broadly, the economy and society. ESG is a term referring to key factors measuring sustainable development. It consists of three pillars: environmental, social, and governance, which are essential for assessing how a company manages risks and opportunities related to environmental, social, and corporate governance issues. ESG criteria help investors assess potential investments, influencing the direction of capital flows toward more sustainable business practices¹.

ESG standards cover a wide range of issues, from reducing carbon emissions and protecting natural resources, to ensuring decent working conditions, corporate transparency, inclusiveness, and eliminating corruption. Specific standards, such as the Global Reporting Initiative (GRI), though not mandatory, have so far provided a framework for organizations to report and manage their impact on the environment and society.

In addition to the previously mentioned standards, the European Social Responsibility Reporting Standards (ESRS) are also significant and mandatory for some organizations. These standards were introduced to standardize and facilitate the dissemination of information about the activities and impact of organizations on environmental, social, and governance aspects. The ESRS aims to increase corporate transparency and raise standards of responsibility, contributing to better risk management and promoting sustainable development². These standards are particularly important in the European context, where ESG regulations are becoming increasingly significant. Through ESRS, companies can more effectively report their actions in the field of sustainable development, which in turn allows stakeholders to better assess their progress in implementing sustainability principles (Vaessen, 2023).

The European Union is actively introducing regulations aimed at integrating ESG issues into daily business practices. An example is the EU Regulation on Sustainability-Related Disclosures in the Financial Services Sector (SFDR), which requires companies to report how they integrate ESG factors into their investment and decision-making processes. The SFDR

¹ Deloitte. What Is ESG? Retrieved from <https://www2.deloitte.com/ce/en/pages/global-business-services/articles/esg-explained-1-what-is-esg.html>

² Commission Delegated Regulation (EU) 2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards

(EU Regulation 2019/2088) represents a significant regulatory context for ESG, requiring financial entities to disclose information about sustainable investments and ESG-related risks³.

Another key legal act that has a significant impact on the integration of ESG issues into corporate practices in Europe is the Corporate Sustainability Reporting Directive (CSRD). The CSRD expands the scope of sustainability reporting obligations introduced earlier by the Non-Financial Reporting Directive (NFRD). The CSRD introduces more stringent requirements for reporting on sustainable development, increasing the number of companies covered by these obligations and improving the quality and scope of data that must be disclosed. Through the CSRD, companies are required to provide more detailed information about the impact of their activities on the environment, society, and governance, including energy efficiency, labor practices, respect for human rights, and anti-corruption efforts. These requirements aim not only to increase the transparency of business activities but also to enable investors, customers, and other stakeholders to make more informed decisions based on sustainability criteria. The CSRD was proposed by the European Commission in April 2021, introducing the obligation to verify the disclosed data as part of non-financial reporting. The introduction of the CSRD currently applies to large companies and all companies listed on regulated markets, excluding micro-enterprises listed on the stock exchange, starting in 2024, with full implementation by 2028^{4,5,6}.

The European Sustainability Reporting Standards (ESRS) have been developed to provide detailed data for the new reporting requirements under the CSRD. These standards consist of general standards covering general reporting principles and thematic standards that provide detailed guidelines for reporting specific aspects of sustainable development, such as climate change, emissions, and social issues. The ESRS aims to increase transparency, consistency, and comparability of information, helping companies comprehensively report on environmental, social, and governance factors. The adoption of these standards is intended to facilitate the integration of ESG factors into corporate strategies and financial analysis, promoting a transition to sustainable business operations (Giner, Luque-Vílchez, 2021)⁷.

Another important regulation is the EU Taxonomy, a classification system that defines which activities can be considered environmentally sustainable. It is a classification tool designed to facilitate sustainable investments, thereby supporting the goals of the European Green Deal. The key aspects of the Taxonomy include six environmental objectives: climate

³ Regulation (EU) 2019/2088 of the European Parliament and of the Council of 27 November 2019 on sustainability-related disclosures in the financial services sector (Text with EEA relevance).

⁴ Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting (Text with EEA relevance).

⁵ Harvard Law School (2023). EU Finalizes ESG Reporting Rules with International Impacts. Retrieved from: <https://corpgov.law.harvard.edu/2023/01/30/eu-finalizes-esg-reporting-rules-with-international-impacts/>

⁶ European Commission (2023). Sustainable Finance Package. Retrieved from: https://finance.ec.europa.eu/publications/sustainable-finance-package_en

⁷ Harvard Law School (2023). EU Finalizes ESG Reporting Rules with International Impacts. Retrieved from: <https://corpgov.law.harvard.edu/2023/01/30/eu-finalizes-esg-reporting-rules-with-international-impacts/>

change mitigation (CCM), climate change adaptation (CCA), sustainable use and protection of water and marine resources (WTR), transition to a circular economy (CE), pollution prevention and control (PPC), and protection and restoration of biodiversity and ecosystems (BIO). For an economic activity to be classified as sustainable, it must make a substantial contribution to one or more of these goals without causing significant harm to the remaining goals (DNSH) and must comply with minimum social safeguards^{8,9}.

These regulations and standards are part of a broader EU plan aimed at supporting sustainable finance and steering the European economy towards greater climate neutrality, in line with the goals of the European Green Deal¹⁰.

These regulations not only compel companies to be more transparent about environmental and social issues but also contribute to transforming financial markets by promoting sustainable investments. By introducing ESG reporting requirements, the EU seeks not only to increase corporate responsibility but also to lead to more sustainable business practices, which are crucial for achieving climate and development goals on the continent. The integration of ESG standards and compliance with European regulations in these areas is essential for creating a sustainable business environment that supports both environmental protection and long-term socio-economic development.

3. Incentive Systems Theory (Overview of Incentive Systems)

The word "motivation" originates from Latin, where "*movere*" means movement, stimulation, or encouragement to action. Therefore, motivation can be described as a psychological process that directs people, mobilizes them to act, and helps them achieve specific goals. J. Reykowski notes that motivation is one of the most dynamic aspects of the human psyche (Reykowski J. 1979). The main goal of motivating employees is to promote attitudes conducive to efficiency. However, for motivation to be effective, it must consider both the organization's goals and the needs and expectations of the employees. If the incentive system focuses solely on the organization's needs, it may lead to its failure (Moczydłowska, 2008).

⁸ Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (Text with EEA relevance).

⁹ S&P Global. A Short Guide to the EU's Taxonomy Regulation. Retrieved from: <https://www.spglobal.com/esg/insights/a-short-guide-to-the-eu-s-taxonomy-regulation>

¹⁰ European Commission. Overview of Sustainable Finance. Retrieved from: https://finance.ec.europa.eu/sustainable-finance/overview-sustainable-finance_en

Today's employees must be efficient, effective, and beneficial to the organization. Professional work is one of the key elements of a person's life, requiring an investment of time and energy. It can also be an important source of motivation if it brings satisfaction. A crucial question is how to create conditions that allow an employee to fully utilize their skills and creative energy. Therefore, increasingly better methods of motivation should be sought, considering the various professional contexts and their conditions. The secret of motivation lies in creating work conditions that allow employees to feel free from negative influences that might hinder their willingness to work.

An incentive system is a comprehensively planned and consistent set of motivational tools aimed at stimulating employees to actions aligned with the company's goals. It integrates both financial and non-material incentives. In practice, many incentive systems emphasize financial aspects while neglecting significant behaviors and aspirations of the workforce. The ideal incentive system should harmoniously combine incentives, means, and principles, considering benefits for both employees and the organization. The effectiveness of various motivation methods depends on several factors, both external and internal, and their proper recognition and implementation can increase employee engagement. Such a system cannot operate in isolation and must be integrally connected with other systems and procedures in place within the company. Moreover, it should reflect the latest best practices and theories in the field of motivation. Solutions within the incentive system should serve the organization's mission and goals and support its strategy. Recognizing the nature of work and the type of tasks carried out to achieve the organization's comprehensive, synthetic goals is the starting point for building a motivation system (Sekula, 2008). An incentive system should correspond to the specific characteristics of the company, taking into account both universal aspects, such as working conditions or training, and more specific ones, such as organizational culture or work flexibility. The effectiveness of incentives depends on the individual characteristics of employees, such as age or family situation. The success of an incentive system hinges on management's understanding of employee expectations and adjusting incentives in a way that is attractive to them without giving the impression of exploitation or lack of appreciation (Sekula, 2008).

The characteristics of an incentive system encompass three main categories: coercive measures, incentive measures, and persuasive measures. Each of these categories plays a crucial role in effectively motivating employees, but they differ in methods and approaches to achieving desired outcomes.

- a) Coercive measures are motivational methods that rely on the application of force, obligation, or pressure to compel employees to act. This approach may include threats of punishment, such as warnings, pay cuts, or even dismissal if specific tasks are not completed according to requirements. Although effective in the short term, coercive measures can lead to negative psychological effects, such as decreased morale, increased stress, or reduced creativity, which in the long term may weaken employee motivation.

- b) Incentive measures are motivational strategies that involve offering positive stimuli to encourage desired behaviors and outcomes. These incentives may include various forms of rewards, such as bonuses, pay raises, promotions, tangible rewards, or public recognition of achievements. Incentive measures are effective because they directly link employees' efforts with tangible benefits, which increases their engagement and loyalty to the company. When applied appropriately, these methods not only boost productivity but also enhance job satisfaction and foster a positive organizational environment.
- c) Persuasive measures focus on using communication to convince employees to take action or adopt specific attitudes through rational arguments, inspiration, or emotional engagement. This approach may involve conveying the company's vision, emphasizing the importance of each employee's contribution to the organization's success, or building trust through open and honest communication. Persuasive measures are particularly effective in building long-term commitment and loyalty, as they rely on employees' intrinsic motivation to act, which is more sustainable than extrinsic motivation.

By combining these three types of motivational measures, organizations can create comprehensive incentive systems that not only effectively motivate employees but also contribute to achieving organizational goals in a sustainable and ethical manner (Kozłowski, 2022).

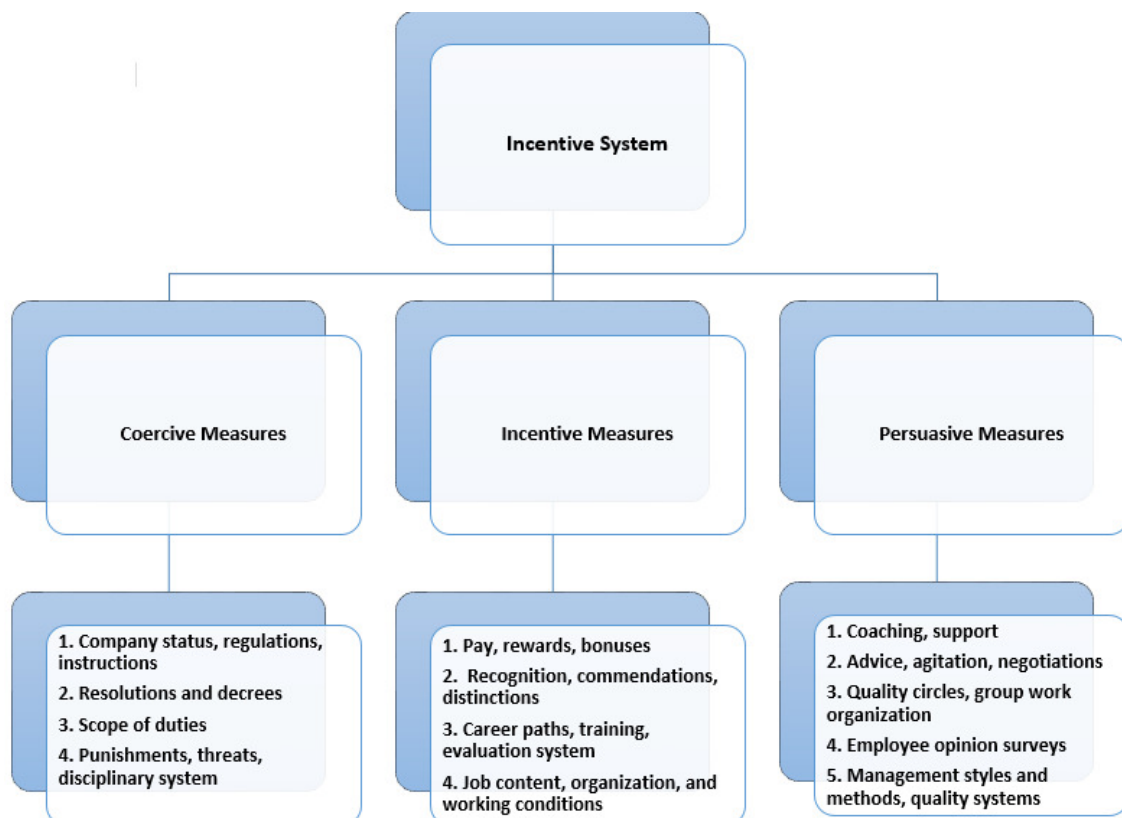


Figure 1. Types of Measures Forming the Incentive System.

Source: Own elaboration based on literature (Kozłowski, 2022).

The primary goals of an incentive system according to Michael Armstrong include:

- Increasing work efficiency by motivating employees to use their skills and competencies more effectively.
- Improving quality by enhancing the standards of work performance among employees.
- Supporting recruitment and retention through an attractive incentive system that helps attract new employees and retain existing ones.
- Strengthening engagement and loyalty by building a stronger connection between employees and the organization.
- Ensuring consistency in actions by aligning employees' actions towards organizational goals (Armstrong, 1997).

The appropriate selection of motivational instruments and tools is a key element of an effective incentive system, which should always be tailored to both the individual needs of employees and the strategic goals of the organization.

Financial motivation plays a fundamental role, as it directly affects employees' material satisfaction with their work. Bonuses, allowances, bonus systems, and the opportunity to participate in the company's profits are examples of tools that can significantly increase employee engagement. These are particularly effective in short-term motivation to exert effort and achieve specific, measurable operational goals. However, it is important to remember that these systems should be transparent and fair to avoid unhealthy competition within the team.

Non-material motivation is equally important, as it influences long-term engagement and job satisfaction. This includes aspects such as opportunities for personal and professional development, which can be supported by offering training, courses, or promotion opportunities. Recognition and awards (e.g., Employee of the Month), as well as a positive workplace atmosphere, are also crucial. These elements contribute to building a sense of belonging and importance among employees. It is important that the incentive system is flexible and can be adjusted depending on the changing internal and external conditions of the organization (Abbah, 2014).

Incentive systems in organizations play a crucial role in encouraging employees to achieve set goals and better performance. To be effective, they must be carefully tailored to both the internal needs of the organization and the external context in which the company operates. Factors influencing the shape of the incentive system:

a) External factors:

- Legal-political: Legal regulations may limit or shape the possibilities of incentive systems (e.g., regulations concerning minimum wages, rewards, bonuses).
- Market: Market conditions, such as the level of competition for employees, may influence the level and types of incentives offered.
- Cultural: Social norms and values can influence what types of motivation are accepted and effective in a given culture.

b) Internal factors of the organization:

- Organizational strategy: The incentive system must align with the organization's strategy, supporting its long-term goals and values.
- Organizational culture: The internal culture of the organization determines which motivational methods are most appropriate and how they will be perceived by employees (Kopertyńska, 2009).

4. Incentive Systems Dedicated to Management

Incentive systems directed at management differ from those designed for lower-level employees due to their crucial role in shaping the organization's strategy and development directions. Effectively motivating management requires not only financial incentives but also a range of non-material aspects that support their leadership development and job satisfaction.

For management, competitive compensation packages are key, often including stock options, annual bonuses tied to company performance, and long-term bonus plans based on results. These tools are effective in securing long-term commitment from managers and motivating them to work towards increasing the company's value (Bebchuk, Fried, 2003). On the other hand, non-material aspects such as opportunities for professional development, participation in prestigious training and conferences, and the recognition of their achievements within the industry are equally important. Building the personal brand of management and involving them in the company's decision-making processes significantly impact their motivation (Mabey, 2013). Regular and transparent performance evaluations, based on clearly defined criteria, and consistent feedback are also essential in the incentive system for management. These systems allow for identifying areas for development and reinforce the sense of fairness and objectivity in evaluating their work (Daniels, Bailey, 2016). Another key element is involving management in strategic planning processes, which not only increases their responsibility for the company's results but also allows them to influence the shaping of the organization's future. This participation is a powerful motivator, as it enables leaders to realize their visions and initiatives within the framework of corporate goals (Mintzberg et al., 2005).

In practice, managing executive teams in publicly traded companies involves complex and multifaceted incentive systems, encompassing both universal and specific motivators. Research examples show that both financial and non-financial incentives play a crucial role in increasing the engagement and effectiveness of board members. Common motivational practices among board members of publicly traded companies include base salary, which is the primary component of total compensation, accounting for between 75% and 85% of annual earnings. Well-developed interpersonal relationships within the board and between the board and the supervisory board are also considered key to ensuring board effectiveness. In some cases,

additional benefits such as access to parking or garages, sports and recreational activities, and severance packages related to mergers and acquisitions are additional motivational tools, though these are less commonly used and dependent on individual company agreements. The study indicates that the most significant motivators for managers are base salary and the quality of relationships within the board and with the supervisory board. Factors that demotivate managers include insufficient power in company management and an inadequate amount of stock ownership. Interestingly, despite the subjective belief in the dependence of compensation on economic goals, statistical analysis did not confirm a strong correlation between compensation and the company's economic performance (Kopycińska, Wiśniewski, 2016).

The incentive system for the management in mining enterprises is based on a combination of base salary and bonuses, with the bonuses being closely tied to operational efficiency. Bonuses are awarded based on the achievement of specific economic, accounting, and market indicators, which are defined in management agreements and the company's development strategies. The evaluation system uses both collective indicators, assessing the joint actions of the management board, and individual indicators assigned to specific areas of management.

Bonuses for board members can amount to approximately 50% of their annual salary and are paid based on annual results. The components of the bonuses are calculated in detail, taking into account the achievement of the goals of specified indicators such as EBITDA, return on equity (ROE), unit production cost, and specific strategic objectives. The indicators used in the bonus system primarily focus on short-term operational results, which may not always align with the long-term interests of the enterprise (Michalak, Turek, 2014).

5. Incentive Tools Supporting ESG Goals

Supporting ESG (Environmental, Social, Governance) goals within incentive systems for management is becoming increasingly important in the context of global sustainable development challenges. Integrating these goals into incentive systems requires the implementation of tools that promote responsible behavior and management in line with ESG principles. To achieve this, several key tools and methods can be employed in management incentive systems to support the achievement of ESG goals.

One of the most direct tools is financial bonuses for achieving specific ESG goals. These can include annual bonuses tied to meeting designated indicators such as reducing CO₂ emissions, improving energy efficiency, completing CSR (Corporate Social Responsibility) projects, or meeting set corporate governance standards. Another tool is stock options linked to ESG goals. These can be granted under conditions dependent on the long-term achievement of ESG objectives. This approach motivates management to continuously strive for improvement

in key areas of sustainable development, linking their personal financial benefits with the long-term value of the company built on sustainable development principles.

The incentive system for management also includes the development of appropriate Key Performance Indicators (KPIs) related to sustainable development. Defining specific, measurable performance indicators related to ESG goals should be incorporated into management agreements and performance evaluation systems. Examples of such indicators might include employee satisfaction levels, recycling rates, inclusivity levels, or the number of customer complaints related to social and environmental aspects. Another solution is investing in training and development for management in areas related to ESG, which not only serves as a reward but also as a means of raising awareness and competence in sustainable development. This can include workshops, courses, and certifications in environmental, social, and corporate governance management. To make the incentive system more effective, an appropriate evaluation system can also be implemented, which includes feedback from colleagues, subordinates, and other stakeholders on how management's actions impact the environment, community, and governance. Such evaluations can help identify areas needing improvement and promote a corporate culture based on ESG values.

Implementing these tools can contribute to better integrating ESG goals into the daily operations of the enterprise, while ensuring that management is properly motivated and rewarded for making progress in these areas.

Introducing incentive tools that support ESG goals in company management, as described above, is a fundamental step towards integrating sustainable development into the daily functioning of enterprises. However, for these changes to be effective and yield the expected results, a proper understanding and application of motivation theories are essential in correctly shaping incentive systems. Therefore, in the context of the mining industry, where the impact on the environment and community is particularly significant, applying specific motivational models that support management in achieving ESG goals becomes crucial. In the mining industry, where operational activities have a direct impact on the natural environment and local communities, motivating management to achieve ESG goals through well-designed incentive systems is not only a responsibility but also a strategic choice. Utilizing both financial and non-financial motivation can effectively support management in striving to achieve these goals. Integrating Vroom's Expectancy Theory and Deci and Ryan's Self-Determination Theory into the structure of rewarding and compensation allows for a holistic approach to management motivation, which is key to achieving sustainable success in the challenging and often controversial mining sector.

Incentive systems in mining companies can play a key role in promoting and achieving ESG-related goals. To effectively link motivation theories with incentive systems supporting ESG goals, several important models from organizational psychology and management can be applied. Victor Vroom's Expectancy Theory is particularly useful in the context of financial motivation. This theory posits that employees are motivated to act if they expect that their

efforts will bring about desired results and that they will be appropriately rewarded for these efforts. In the context of ESG, bonus and compensation systems can be designed to reward board members of mining companies for achieving goals related to CO₂ emissions reduction, implementing environmental innovations, or increasing taxonomic indicators. Bonuses can be directly tied to measurable outcomes in these areas, especially those reported in non-financial reports. Many companies, including mining companies, have sustainable development strategies. These strategies provide an excellent basis for measurable indicators, allowing for effective accountability and reward for achieving environmental, social, and governance commitments.

Deci and Ryan's Self-Determination Theory (SDT) fits well with the analysis of non-financial motivation. SDT provides a theoretical framework for enhancing employee motivation and stimulating positive outcomes such as engagement, well-being, and organizational commitment (Forner et al., 2021). Implementing development programs for employees in management positions, such as rewards for sustainable development innovations and public recognitions, can increase employees' sense of competence and autonomy, as well as their engagement in activities aligned with ESG values. This motivation is not directly based on material rewards but on internal satisfaction and social acceptance.

The participatory management model is based on the concept that employee involvement in decision-making processes leads to greater motivation and job satisfaction. This aligns with Douglas McGregor's Theory X and Y, where Type Y management assumes that employees are naturally motivated to work if they are adequately supported and appreciated (Trzcielińska et al., 2023). Integrating employees into decisions related to the company's environmental or social policies not only strengthens their sense of influence over the organization's business environment but also promotes a deeper understanding and commitment to ESG goals. This is especially important in industries like mining, where operational decisions have a direct impact on the environment and local communities (Sobczyk, 2007).

6. Benefits of integrating motivation systems and ESG goals

Engagement in ESG (Environmental, Social, Governance) goals is increasingly important from both ethical and business perspectives (Skowroński, 2006). Companies that effectively integrate ESG goals often gain market value, enjoy better reputations, and minimize operational, legal, and environmental risks, directly stemming from their high environmental awareness. In the mining context, where company operations have a direct and significant impact on the environment and local communities, effective incentive systems can contribute to full regulatory compliance, reduce negative environmental impacts, and improve relationships with local communities.

- a) **Ethical Perspective:** From an ethical standpoint, responsibility for the environment and social well-being is seen as a moral obligation for companies (Torelli, 2023). In the face of global challenges such as climate change and social inequalities, companies that engage in ESG initiatives contribute to building a "better world". Supporting sustainable development and caring for the well-being of employees and local communities becomes a hallmark of responsible leadership (Tamvada, 2020).
- b) **Business Perspective:** Companies that successfully integrate ESG goals are often perceived as more innovative and forward-thinking, attracting investors who seek sustainable and long-term investments. Additionally, investors and funds increasingly consider ESG criteria in their investment decisions, which can lead to increased demand for shares of companies with strong ESG ratings, thereby boosting their market value (Chopra, Dissanayake, 2024).

Companies actively engaged in ESG activities gain a reputation as leaders in responsible business. This, in turn, translates into better relationships with customers, suppliers, and business partners, which can lead to new market opportunities and increased customer loyalty (Baratta et al., 2023).

Minimization of Operational, Legal, and Environmental Risks: Adhering to ESG standards enables companies to identify and manage potential risks early (as directly supported by the CSRD directive – double materiality assessment), which can reduce costs associated with failures, penalties, or reputational damage. In the mining sector, which is particularly vulnerable to environmental regulations, compliance with applicable laws can help avoid significant financial penalties and operational restrictions.

Mining activities have a direct impact on the natural environment, for instance through water pollution, air emissions, noise, or landscape degradation. Additionally, they can affect local communities by altering access to natural resources, causing pollution, or even necessitating relocations.

7. Implementation Potential of ESG-Based Incentive Systems

The implementation of incentive systems based on ESG principles is becoming a crucial element of the management strategy for modern enterprises. These systems not only influence the internal culture of an organization but also define its position in the global market, where sustainable development issues are increasingly important. Integrating ESG goals into incentive systems offers a range of perspectives and potential benefits that can be realized across various aspects of a company's operations:

- a) **Increased Employee Engagement and Loyalty:** Incentive systems focused on ESG goals enhance employee engagement, as more employees seek meaning in their work and want to contribute to corporate actions that align with their values. Motivating employees through goals related to ecology, social responsibility, and ethical management fosters loyalty and a sense of belonging to the company.
- b) **Improved Company Image and Stakeholder Relations:** Companies that effectively implement ESG-based incentive systems gain favor with external stakeholders such as investors, customers, business partners, and local communities. These companies are perceived as responsible and committed to solving global problems.
- c) **Increased Innovation and Operational Efficiency:** Motivating top management to achieve ESG goals can lead to innovations in products, services, and operational processes. Companies that promote environmentally and socially responsible approaches often discover new ways to reduce costs, increase energy efficiency, and minimize waste and carbon emissions.
- d) **Easier Adaptation to Legal Regulations and Risk Reduction:** ESG-based incentive systems can help companies adapt to rapidly changing regulations, such as those under the "European Green Deal." Companies that proactively implement ESG practices can minimize legal and operational risks associated with non-compliance with both domestic and international requirements.
- e) **Potential for Long-Term Company Value Growth:** Companies that successfully integrate ESG goals with incentive systems often experience long-term value growth. Sustainable development promotes long-term business stability and can contribute to increased shareholder value by enhancing the company's attractiveness in financial markets.

Integrating ESG goals into incentive systems requires a strategic approach from companies and a willingness to make thoughtful investments in human resource development and internal management processes. However, the potential to achieve lasting benefits, both on a micro scale (e.g., improved employee motivation, operational efficiency) and on a macro scale (e.g., market position, financial stability), makes these actions not only beneficial but essential for contemporary companies striving for sustainable success.

8. Summary

The scientific article presents key aspects and possibilities for integrating ESG principles with incentive systems in the mining industry. It highlights the growing importance of responsible management and transparency, which are essential for the long-term stability and operational efficiency of mining enterprises. The introduction of well-designed incentive

systems that incorporate ESG goals has the potential to significantly increase the engagement and productivity of management, which can directly translate into improved financial and operational results for the company.

ESG standards and European regulations, such as SFDR, CSRD, and the EU Taxonomy, play a fundamental role in shaping sustainable development. By introducing increasingly stringent reporting and corporate responsibility requirements, the European Union poses new challenges for companies but also opens up new opportunities for sustainable development.

The implementation of ESG-based incentive systems in company management, particularly in the mining industry, is a critical element in promoting sustainable development. These systems not only support the achievement of environmental and social goals but also contribute to increased innovation, operational efficiency, and better compliance with legal regulations.

However, integrating ESG with incentive systems requires not only changes in company structures and policies but also the commitment and openness of management to innovation and long-term planning.

The conclusions drawn from the article emphasize that only through coordinated actions and the integration of incentive systems with ESG goals can mining companies effectively face global environmental, social, and governance challenges, while simultaneously building lasting value and stability for the future.

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CONTEMPORARY MODELS OF ORGANIZATIONAL MANAGEMENT: REFLECTIONS ON ORGANIZATIONAL CULTURE ACCORDING TO FREDERIC LALOUX

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Purpose: The aim of the article is a comparative description of contemporary models of organization management, taking into account the issue of organizational culture, humanistic management style and the colors of organization management, which was proposed by Frederic Laloux.

Design/methodology/approach: The article employs the method of descriptive and comparative analysis.

Findings: The analyses carried out in the text have demonstrated that the level of organizational culture depends on the preferred value system in the organization. It also confirmed the thesis that the level of awareness of an organization's employees is determined not only by the value systems preferred in the organization, but also by the decision-making styles associated with these values, preferred thinking patterns and the level of communication.

Research limitations/implications: The research hypotheses adopted in the publication have been limited only to the characteristics of the organization according to the division proposed by Frederic Laloux.

Practical implications: The article shows the path of changes that are currently taking place in business organizations. These changes have a significant impact on professional practice. They are related to the level of development of human consciousness and the prevailing (oppressive or non-oppressive) communication patterns: the less oppressive, more assertive and empathetic communication in the organization, the higher the level of employee well-being.

Social implications: The article addresses the problem of the role and importance of the humanities. At the center of the humanistic style of management there is always a human being, aware of obligations towards other people/co-workers and corporate social responsibility.

Originality/value: The aim of the article is to show the qualitative impact of the humanities on contemporary management styles of organizations representing different value systems, and thus also different axiological levels. Currently, the reflection on the axiology of the Pluralistic Green and Evolutionary Teal organizations is of particular importance, because it is the organizations from the level of green and teal that put a person open to dialogue and the broadly understood idea of humanity at the center of management.

Keywords: organizational culture towards the humanistic form of management, awareness of the color of the organization, oppressive and empathetic/non-oppressive communication, value system, Frederic Laloux.

Category of the paper: Conceptual paper, Viewpoint.

1. Introduction

The article, using the method of descriptive and comparative analysis, characterizes the problem of contemporary models of organization management. I focus mainly on the momentous concept of Frederic Laloux – a former politician, and now an advisor and leadership coach supporting corporate leaders. Frederic Laloux was the first to create an innovative model of organization taking into account the level of development of human consciousness. It is necessary to add that the very well-known, gradational model of Laloux is not evolutionary. Thus, Laloux only indicates that there are organizations operating at different axiological levels. Laloux includes extensive empirical research (based on surveys, interviews and examples of specific organizations) in his book *Reinventing Organizations*. Currently, Laloux mainly helps those who, while pursuing their careers in the field of business, want to learn about new, pioneering ways of building business organizations, taking into account the organizational culture (See: Rutkowska, 2020, pp. 17-22; Laloux, 2022).

„Culture as a creative process is subject to constant changes, but its role is always to serve values, build models, guard ideals and imponderables, shape and consolidate social, customary, moral norms and ethical canons” (Gaweł, 2015, p. 170). Nowadays, there is a desire for a systematic „restitution of autotelic values in the mental space of management” (Gaweł, 2015, p. 172). The necessity of restitution, as a restoration of the primary/highest values, is confirmed by the Polish theatre and cultural scholar Professor Emil Orzechowski, who accepts the postulate: „First values, then management” (See: Orzechowski, 2013, pp. 75-86; Gaweł, 2015, p. 171). Values are therefore a primary and irreducible component of management. Their constant presence is required especially when we think about the business organizational culture and the well-being of employees who contribute to this culture.

Currently, the key element of the organizational culture is also the growing awareness of employees. Most often, this awareness is shaped by the organization’s leading values, as well as specific employee beliefs, unwritten or routine norms and rules, and commonly accepted ways of doing things. As a consequence, „each organization develops its own particular way of operating, which creates a specific social order, determining the dominant approach to problems, work and customers” (Heidtman, Piasecki, 2022, p. 216).

2. Organizational culture in the face of contemporary management models

Organizational culture is an extremely important aspect of creating a company, related, among other things, to the vision and mission of the company and clear communication of the values guiding this company. Among the factors defining the organizational culture, there are

also the internal atmosphere of the organization, the level of employee engagement and satisfaction, employee habits, attitudes and the axiological context, i.e. the value system/axiological system prevailing in the organization. In general, organizational culture is defined by a set of internal organizational practices, especially activities that strengthen trust, as well as norms regulating cooperation. In order to build a non-oppressive organizational culture, „it is necessary to provide quality feedback to subordinates, support employees in their development and, as they self-improve, also increase their independence, which will also have a positive impact on employee self-esteem [...]. Strengthening partner relations and trust in the workplace [...], is an extremely important element of organizational culture that fosters the well-being of employees” (Tyszkiewicz, 2024).

3. Division of the organization according to the Frederic Laloux model

The well-being of an employee in the workplace depends on many factors, among which the dominant way of making decisions in the organization, consistency of values, as well as the style of communication and the ability to satisfy the need for self-fulfillment deserve to be distinguished. The distinguished factors depend on the prevailing paradigm in the organization. Most often, organizational paradigms, as patterns of thinking, are arranged gradually and indicate the value systems present in organizations. This is the case with the division proposed by Frederic Laloux. Laloux lists five such thinking patterns symbolically, marking each of these patterns with a specific color.

3.1. The paradigm of Impulsive Red

Frederic Laloux places red organizations at the bottom of the hierarchy. In organizations from the level of red, there is an oppressive style of communication. A characteristic feature of this level of communication is the impact of fear and the use of veiled, periphrastic mobbing behaviors towards co-workers. An employee of a red organization focuses on surviving in unfavorable conditions, including everyday functioning in a professional environment that does not inspire trust. This environment is unpredictable, even dangerous, because it uses ostracism without inhibition, as well as repressive measures in the form of open violence and threats. Examples of such oppressive behavior most often include suggesting dismissal, ignoring a subordinate employee combined with his or her professional isolation, incrimination, slander and blaming responsibility. Laloux claims that the Impulsive Red paradigm is dominated by a primitive emotional spectrum expressed in the use of force and violence in interpersonal relationships, including the demand for employee submission and the frequent tantrums of the superior.

The metaphor for red organizations is „a pack of wolves, because just as the alpha male uses force to maintain its position as leader in the wolf pack, the head of the organization belonging to the Impulsive Red level uses ruthless violence to subjugate others to his or her own will. Only in this way can they maintain their leadership status. When their power is questioned, immediately someone else will try to overthrow them using the method of force” (Laloux, 2022, p. 26).

Behaviors typical of the Impulsive Red organization today occur in economically disadvantaged regions, most often in confrontational societies, also in chaotic and primitive antagonistic, aggressive and adversarial environments. Examples of such places are areas of struggle for influence, zones of civil wars, bankrupt states, penitentiaries and urban districts of violence. Employees of the Impulsive Red paradigm organization focus on the present and immediate response to dangerous, uncertain, and threatening situations. Red Organizations openly give up building a permanent strategic base, while the employee of such an organization focuses on surviving in an untrustworthy and deceptive environment (Laloux, 2022, pp. 26-27).

3.2. The Paradigm of Conformist Amber

The second level in Laloux’s hierarchy is Conformist Amber. Amber-level organizations are also dominated by an unfriendly form of communication manifested in extremely directive management, for example, in management in the style of an overbearing satrap who gives orders and orders or a manager who motivates his or her subordinate employee by arousing a sense of guilt, shame and fear in this employee. An employee of an amber organization is driven by a strong need for internalization, i.e. absorbing the rules and principles of this organization. These rules and principles, as regular practices, are established by the authorities. They take the form of imperatives. They determine the *status quo* of the organization, they are constant and stable. As patterns of constant conduct, these imperatives constitute foreseeable circumstances/situations. According to the interpretation proposed by Frederic Laloux, employees of amber organizations „internalize the norms of the group, and their thinking is dominated by concern for appropriate appearance, behavior and thoughts in order to fit into the environment” (Laloux, 2022, p. 28).

The need for internalization in Conformist Amber organizations is clarified by coach and mediator Ewa Mazul, who claims that in organizations from the amber level, „the experience of security that comes from belonging to a group and the sense of connection that is created thanks to this is available. The goal is no longer just survival, but a relatively stable life in a group” (Mazul, 2020, p. 59). This Amber attitude is echoed by the statement of systems theorist Ken Wilber, who writes that in Conformist Amber „care and concern are extended from the individual to the group – but no further! So if you’re a member of a group – a member of my mythology, my ideology – then you’re also saved. But if you belong to a different culture, a different group, a different mythology, a different god, then you are damned” (Wilber, 1996, p. 273; Laloux, 2022, p. 29).

In the organization of the amber type, as in the organization of Impulsive Red, dualistic thinking dominates, but it is not – typical for the color red – egocentric thinking: I – you, mine – yours, but the dualism of ethnocentric thinking: us – them. Laloux believes that „amber’s conformist sensitivity develops a deeper sensitivity to other people’s feelings and to their points of view” (Laloux, 2022, p. 28). Among the amber organizations, Laloux distinguishes government agencies, public schools, religious institutions and military organizations (See: Laloux, 2022, p. 30).

3.3. Orange of Achievement as a paradigm of competence and purpose

The third level in the Laloux hierarchy are the Orange of Achievement organizations. Organizations from the orange level are characterized by a strong and assertive communication style related to the focus on achieving ambitious goals and competition. The competitive and competitive work environment of Orange of Achievement requires the acquisition of the ability to change the form of communication from submissive, aggressive and manipulative to polite, precise, firm and straightforward communication. In such conditions, the majesty of the authoritarian ruler falls in favor of science and empirical experience. Therefore, „in order to survive and not fall out of the race for goods in the structures of orange, it is necessary to be ready to compete and take on challenges, the ability to »play as a team«, a focus on development and openness to innovation” (Mazul, 2020, p. 47). In orange, the readiness to compete is therefore associated with the acceptance of change, as well as the rejection of violent and manipulative activities, and the fruitful cooperation of the rival parties (See: Janik, 2019).

According to Laloux, the orange paradigm of achievement allows meritocracy as a division based on skills and competences, while at the same time accepting the depreciation of authority, the questioning of the ethical norms of the group, and the critique of the inherited *status quo*. Nowadays, the Orange of Achievement manifests itself mainly in the circles of educated people, in business circles and politics. „The Orange of Achievement is the dominant paradigm of business corporations” (Laloux, 2022, p. 50). Unfortunately, the orange organizational culture also smacks of some shortcomings/flaws. So in no way should we trivialize the negative side of the orange pattern of thinking. These adverse aspects of Orange of Achievement manifest themselves in corporate greed, the corporate rat race, short-sightedness, over-borrowing, financial burdens, and ever-increasing debt, as well as hyperconsumption, ecosystem destruction, and irresponsible exploitation of the planet’s resources. Laloux adds that „this should not, however, obscure the enormous liberation that this stage has brought us; namely, the Orange of Achievement moved away from the view that only correct answers are the domain of power [...], brought a healthy dose of skepticism [...], allowed us to engage in the search for truth – regardless of dogma, political authorities and without risking our lives” (Laloux, 2022, p. 35).

3.4. The paradigm of Pluralistic Green

Communication processes in organizations from the green level are shaped and conditioned by a system of shared values. Among these values, family values deserve special attention, as well as the ability to listen empathically to oneself and others. In the paradigm of green, the community of family and empathic values determines the motivational processes of employees who are subordinate to a supportive and charismatic leader. Therefore, it is considered that „the green level is associated with a breakthrough in the approach to work organization – interpersonal relationships and the awareness that the needs of all people are as important at work as they are in the family begin to matter” (Mażul, 2020, p. 49). All activities at the level of the green color relate the sphere of human values, feelings and needs. Employees of green organizations are, above all, responsible and passionate people who should inspire each other. For this reason, any discussion at the green level takes into account a management strategy that refers to corporate social responsibility (CSR) (See: Demków, Sulich, 2018, pp. 73-84).

According to Laloux, the green culture of the organization is co-created by values and an inspiring purpose. „In many cases, green organizations put an inspiring purpose at the heart of what they do” (Laloux, 2022, p. 47). The perspective of a green organization is associated with interpersonal egalitarianism, appreciation of harmony, harmony, lasting relationships, cooperation and recognition of the values of community. In organizations, the tone of the green color is given by the empowerment of the employee, while the role of hierarchy is diminished, or both hierarchy and authority are consciously abandoned. Pluralistic Green is characterized by sensitivity focused on people and their feelings. Laloux believes that the axiological pluralism of the green organization „is strongly present in postmodern academic thinking” (Laloux, 2022, p. 43). According to Laloux, in addition to universities, specific examples of green organizations are also the American airline Southwest Airlines, the trading company Ben & Jerry, as well as DaVita – a leader in pro-health care and innovative forms of treatment (Laloux, 2022, pp. 47, 49).

3.5. The paradigm of Evolutionary Teal

The highest level in the hierarchy of the organization, according to Frederic Laloux’s scheme, is currently occupied by Evolutionary Teal. A characteristic feature of teal organizations is the form of communication based on empathy, related to the Nonviolent Communication (NVC) method. The NVC method is an excellent tool for building relationships and at the same time listening, used in companies using the method of two-way communication in the form of mediation or negotiation. Nonviolent communication (NVC), as a method of communication characteristic of teal organizations, „teaches how to build deep and honest relationships at work, listen to others with empathy, while honestly expressing one’s needs. »Don’t be nice or rude – be authentic« – this is an approach that we can implement by practicing

NVC principles in communication” (Mażul, 2020, p. 51; See: Berendt, Kozak, 2022, pp. 29-31, 43).

In addition to the empathetic form of communication, the teal turn in the organization of work manifests itself in self-improvement and self-management identified with the lack of external management. This means that „in the previous stages, there was always a »captain of the ship« – a satrap, a boss, and then a leader. Meanwhile, a teal company is fundamentally different from previous forms of organization in that it is based on the cooperation of independent and responsible people who have a highly developed need for self-fulfillment and want to satisfy it also at work” (Mażul, 2020, p. 50).

Laloux begins his characterization of the self-managing Evolutionary Teal by recalling the postulate of the American futurologist John Naisbitt (1929-2021), who stated that „we must learn to balance the material wonders of technology with the satisfaction of the spiritual needs of our human nature” (Naisbitt, 1997, p. 63), because „the most exciting turns of the twentieth and twenty-first centuries will happen not because of technology, but because of the expanding concept, what it means to be human” (Wzorek, 2024). The teal level, as the highest level in the hierarchy proposed by Laloux, captures a person holistically, taking into account his or her body, head, heart and mind. This level, also called the authentic or integral level, thus allows us to create a space to listen to „the wisdom that flows from the deeper parts of ourselves” (Laloux, 2022, p. 59).

Laloux claims that by functioning in the axiological perspective of teal, we are in a way reversing the existing order, because „we no longer strive for recognition, success, wealth and belonging to lead a good life, but we strive for a life well lived, and its result can be recognition, success, wealth and love” (Laloux, 2022, p. 60). Teal is therefore associated with the possibility of satisfying the need for self-fulfilment. According to Waldemar Kozłowski, self-fulfillment is one of the most important employee values today, giving a sense of agency, and giving a person the opportunity for self-fulfillment is winning their heart (See: Kozłowski, 2022, p. 94; See: Stanković, 2022). Suffice it to say that this need is at its highest level in the sequence of Abraham Maslow’s (1908-1970) needs¹. The teal need for self-realization is complemented by the sense of subdued fear of the ego, finding one’s own conviction of rightness as a compass, identifying life with the road and journey, the ability to gently cope with adversities, the ability to combine wisdom not only with analytical intellect and rationality, but also with emotional intuition, striving for wholeness, both in relation to oneself, in contacts with others, as well as in correlation with nature/nature and holistic building of oneself and one’s life based on one’s own potential (See: Laloux, 2022, pp. 59-68; Żukowska, 2023, pp. 74-111; See: Bugdol, Stańczyk, 2021).

¹ Abraham Maslow in his pyramid/hierarchy of needs, counting from the bottom up, takes into account: physiological needs, the need for security, the need for belonging, the need for recognition and the need for self-fulfillment.

4. Levels of communication – levels of organization

The described organizations, operating at different color levels, are characterized by language mechanisms prevailing in them, established and characteristic for a given level. The ability to diagnose communication styles is associated with the development of specific infiltration skills, i.e. reconnaissance, thanks to which we catch complex mechanisms of using a specific communication style by interlocutors. These reconnaissance abilities are associated with the proficiency in separating oppressive and non-oppressive statements, separating aggressive and subjugating linguistic mechanisms, present and overtly used in organizations, as well as the use of an effective antidote to the mechanisms/tools of exerting pressure systematically used in organizations (See: Mażul, 2020, p. 42).

The way you manage your organization depends on your communication style. In other words, the dominant communication style in an organization determines how the organization is managed. The style of communication depends on the level of development of the consciousness of the communicators. We reach the next stages of consciousness development by choosing not a revolutionary, but an evolutionary path of cyclical changes. In the process of systematic awareness, the ongoing evolution „is a guarantee of the development of consciousness and the related transition to the next, higher level of work organization. It should be added that this evolution goes from the most violent ways of using language in interpersonal relationships to non-violent mechanisms based on empathy” (Mażul, 2020, p. 42). These violent and oppressive forms of communication dominate in red and amber organizations. Assertive communication is at the forefront in orange organizations, while green and teal organizations focus on the value of empathy and an empathetic form of communication.

The path of empathic contact is consent to partner with another person, it is also about designing a space of consent and acceptance to see their life: feelings and needs behind the words of a specific person. „Being there for someone and their feelings doesn't mean we feel the same. This means that we give the other person our full attention and presence” (Berent, Kozak, 2022, p. 243). In the process of these evolutionary communicative transformations, or rather transformations of language mechanisms prevailing in organizations, systems of strengthening the motivation and inspiring of employees are created (See: Mażul, 2020, p. 42). A professional motivational process should therefore be in harmony with the norms and values that are, in a way, the backbone of the company. It should be realized that building an effective motivational process takes years, and it is determined, among other things, by the type of leadership (See: Sierackiewicz, 2016, pp. 18-23; See: Stańczyk, 2013, pp. 104-108); to no less, also employee potential, the level of communication, the organization's capabilities, changes in the organization's external environment, as well as the organizational culture described earlier (See: Kozłowski, 2022, p. 15).

5. Conclusion

The subject of analysis in this article are contemporary models of organization management according to the color division of organizations by Frederic Laloux. The research characteristics took into account the issue of building organizational culture and the horizon of values preferred in organizations. The analyses confirm the thesis that the value system preferred in the organization determines the level occupied by the organization in the Laloux hierarchy of levels. It was also verified that the level of awareness of an organization's employees is determined not only by the values preferred in the organization, but also by the decision-making styles associated with these values, the preferred thinking patterns in the company and the level of communication.

The considerations undertaken in the article also show the role of the humanities in the creation of organizations with a humanistic management style. The research shows that the humanistic management style to a certain, albeit small, extent is already revealed in the Orange of Achievement organizations, while it dominates in organizations from the level of Pluralistic Green and Evolutionary Teal. In these organizations, humanistic management becomes a source of inspiring transformations, focused on the person/employee and their well-being.

The ways of presenting the humanistic style of management are varied. There is no doubt that the humanistic style of management is always centered on an emancipated man, aware of his or her obligations towards other people. Therefore, it can be assumed that the basis of the humanistic style of management is the Kantian categorical imperative, according to which man should never become a means to ends, for example, „such as profit, economic growth or efficiency” (Kostera, 2015, p. 53). Man is an autotelic value, and therefore he is an end in himself. At the same time, it is a relational being. For this reason, management in the humanistic perspective should take into account both the individual and the social, especially the social, relational and community dimension of their existence. The socio-community dimension of life takes into account the cultural context and human „sensitivity to political, historical and ethical traditions” (Kostera, 2015, p. 54). Therefore, in order for this humanistic style of management to be fully realized, priority must be given to humanity and to man in their holistic approach.

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THE NEW TECHNOLOGIES IN MEDICAL MARKETING

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Purpose: New technologies impact marketing, specifically, new forms of interaction among consumers and firms, provides new types of data that enable new analytic methods, creates marketing innovations, requires new strategic marketing frameworks. It is important to keep in mind that different technologies can serve these multiple functions at the same time.

Healthcare marketing in 2024/25 will focus mainly on user experience. Medical facilities will be forced to incorporate new technologies into their offerings in order not to be left behind.

Design/methodology/approach: The literature review was used in research.

Findings: The first part of the research analyzes the limitation of health care marketing, especially by Polish legislation. Marketing for medicine 2024/25 will focus mainly on user experience and the quality of services. Advanced algorithms, machine learning, artificial intelligence. All this will turn the medical market upside down. Patients' expectations can now be diagnosed even more accurately. As a result, they will receive even more detailed answers to their questions. To succeed in marketing, it will be necessary to be flexible and ready to implement new technologies quickly.

Practical implications: The research results can help to understand how technology influences

Originality/value: Paper presents new attitude towards medical marketing. It is addressed to healthcare organizations, doctors, business and researchers.

Keywords: new technologies, medical marketing, quality, healthcare.

Category of the paper: viewpoint, literature review.

1. Introduction

Medical marketing is a relatively new field of marketing that focuses on promoting medical products and services. The goal of medical marketing is to reach out to patients, doctors and other medical professionals to increase awareness of available treatment options and medical products and services. Marketing specialists believe that marketing should not be treated as a separate field of activity of an organization. Organizations are characterized by the fact that a marketing approach can be applied in all areas of its functioning, and it is no different in healthcare facilities. The purpose is to show the importance of marketing of medical services,

but also to indicate the directions and methods of action of medical institutions not only to increase the quality of medical services but the satisfaction of the patient-customer of medical services (Nadziakiewicz, 2018).

When creating a quality policy, drawing up an offer, establishing procedures for serving the client-patient, etc., one should keep in mind the marketing, or in other words, pro-client aspect of the organization's activities. Marketing, in fact, fulfills the task of integrating all areas of management in health care institutions, where the main goal (subject) of activity is the customer - the patient. Therefore, the use of marketing activities without appropriate quality standards is unjustified and the time and budget allocated to marketing is then wasted. "Quality has also become the main challenge of modern marketing" (Brilman, 2002, p. 91).

The most important issue for modern marketing is not whether it can be implemented in healthcare facilities, but the extent of implementation. The peculiarities of healthcare make it impossible to uncritically transfer the rules of the classical concept of marketing. Marketing is a certain way of thinking and a certain sensitivity to what the patient thinks, what he expects, what is his level of satisfaction with the service provided to him. This approach to marketing provoked the emergence of the concept of patient-centered care, "patient - centered care" (Ginter, 1998), which assumes that the basis of all decisions in the institution is the patient, and not the functions or goals of individual organizational units. This leads to the thesis that today's healthcare unit offers the use value of its services, which is health and even life. Therefore, the marketing activities of any health care unit should begin with an analysis of the patient's behavior, understanding his decisions and choices, meeting his needs, related to health care (Nadziakiewicz, 2018).

2. Selected problems of the market for medical services.

In modern socio-economic realities, the market for medical services has become a competitive market. Medical facilities have to compete for contracts with both the National Health Fund and external customers. A competitive market is defined as a market in which the value of a service, commodity is determined as a result of free supply and demand (Nadziakiewicz, 2018). In a competitive market, all entities are subject to the same rules and operate in a similar environment. Transactions entered into on the competitive market are subject to civil-legal or customary regulations and information on the services offered is generally available (Kądzielawa, 2004).

The market for medical and health services can be called the processes that take place between providers of medical services - medical entities - and recipients - patients. Medical service is called a health service, i.e. a service aimed at preserving, restoring, saving or improving health, as well as other medical activity resulting from the process of treatment or

separate provisions regulating the principles of their operation (Laws. z dn. 15.04.2011 art. 2, item 10). The provider of medical activity shall make public information about the scope and types of health services provided. The content and form of such information may not have the characteristics of advertising (Law of 15.04 2011 art. 14, No. 112, item 654).

Experts believe the market for medical services not covered by reimbursement from the National Health Fund is growing. According to a recent study conducted by research firm PMR, Poles spent PLN 22 billion on private medical services in 2024. The growing popularity of private medical services is further influenced by online appointments. Research firm PMR has published a projected growth rate of 7 percent in the coming years. It is expected to grow from PLN 22 billion in 2017 to PLN 37 billion in 2024. We are most likely to use both benefits available under the National Health Fund and health services that are not covered by public funding. Under the terms of the Law on Health Care Services Financed from Public Funds, the relevant ministers or the National Health Fund are obligated to finance health care services from public funds. Health care services provided to insured persons are financed primarily through health insurance premiums. The treatment of persons other than the insured who have the right to publicly financed health care services is financed from the state budget. The health insurance premium is monthly and indivisible, amounting to 9% of the premium base (www.gov.pl, 2024).

A 2016 CBOS survey showed that 40 percent of Poles opted for such a “mixed” model. PMR, on the other hand, now estimates that the figure is as high as 60 percent. It is worth noting that those who rely exclusively on private medical services, paid for out of their own funds or through commercial health insurance, represent only a few percent of all patients. Traditionally, the most common use of private medical services is in the field of dentistry. This is, by the way, the only medical field in which those who use services contracted under the National Health Fund are in the minority. The main reason is quite simple - the National Health Fund finances a very limited range of dental procedures. The second most popular medical service outside of the National Health Service is consultation with specialists. The main factor that leads patients to choose the private health care system is the very long waiting time for an appointment under the National Health Service. The average waiting time to see a specialist under the NHF is more than three months, but it is not uncommon for it to be more than a year. When the same services are available almost immediately on a commercial basis, many patients choose the private sector (Nadziakiewicz, 2018).

A much shorter wait to see a doctor is the primary advantage of commercial medical services. For many people, the ease of making appointments through online platforms may be an additional motivation to choose non-NHS services. It is enough to find the right specialist in the search engine, fill in the form and confirm the appointment via SMS or make payment.

"Higher quality of offered services - in addition to economic efficiency and cost reduction, as well as better adaptation of facilities to the needs of the market - is the primary goal of the transformations currently taking place in our country's health care institutions" (Zeler, Kapala, 2004, p. 1).

The health care outlays will amount to PLN 225.2 billion. Taking into account the increase in the expenditure forecast for 2024 from PLN 200 billion to PLN 208.6 billion, as a result of the latest amendment to the National Health Fund's financial plan in July, in 2025.

Six of the most effective ways to market health services.

The development of marketing in the medical services sector is related to improving the quality and availability of medical care and increasing competitiveness in the market. The most important changes that have influenced this development are the improvement in the quality of medical care, the introduction of e-health, the health insurance market and the growing expectations of patients. Patients expect increasingly better medical care and communication with doctors and medical staff. Hence, more and more medical facilities are investing in the quality and marketing of medical services, as well as in education about physical and mental health.

Marketing efforts in the medical industry are primarily about communicating services and building the image of medical institutions. Here are six of the most effective ways to market health services.

1. Webside

Above all, marketing success on the web requires a modern site, designed in accordance with the latest standards of mobility, functionality and the so-called User Experience, or user experience. Many medical offices do not have their own websites or use outdated sites, and this negatively affects the image and trust towards the company.

A medical office's website should contain clear information about the offer, staff, price list, ways to contact and book appointments. An online enrollment system is an added advantage. It is also worth posting reviews of satisfied customers. It can also be useful to prepare a section of the most common questions and answers about the offer, treatments, visits and rules of use.

2. Google website positioning

Today, there is no effective marketing of the medical industry without SEO of a website on Google. The primary goal of SEO is to have your site on the first page of search results, and preferably in TOP3, for queries related to your offer and location, such as "root canal treatment Gliwice", "psychotherapist Gliwice" or "endocrinologist Gliwice". In practice, if a company's website does not appear on the mentioned first page of search results, the chances of a patient coming across it are close to zero.

The main benefit of SEO efforts on a medical institution's website is that it allows it to reach a large audience without the risk of infringement.

Local positioning, i.e. concerning phrases related to the location (city, district, province), is especially recommended for companies operating locally, among others medical offices. Its costs are relatively small, and the effects are visible quite quickly, even after just a few weeks of launching the site. The service involves optimization activities on the site, as well as acquiring valuable links leading to the site or managing customer reviews.

3. Google My Business profile

Improving the online visibility of a clinic or practice can also be achieved by setting up a Google My Business profile. This is a platform where you can choose what information about your business is available in the search engine and on Google Maps. For medical services, the profile includes contact information, hours of operation, photos, customer reviews, and short testimonials. A well optimized business card is an excellent support for local positioning.

4. Social media

The medical industry is no exception: creating clinics or practice profiles and effective social media marketing can bring huge benefits. However, it is worth choosing carefully which social media platforms to be active on. Depending on your target audience, a presence on Facebook, Instagram or YouTube would be a good idea.

Social media provides an opportunity to build a positive image of the physician, connect with patients and share valuable health-related knowledge as well as news about the operation of the facility. There are many formats to choose from: short videos, testimonials, posts.

In social media marketing of any industry, it is very important to be systematic and stay in touch with observers. The focus should be on publishing content regularly, responding to feedback and comments, and responding to messages received.

5. Medical content marketing

Medical content marketing is a tool that is still not widespread enough, but extremely effective and allows you to build a position of authority in the medical market. First of all, it is worth taking advantage of a well-known trend here: Poles are specialists in searching for advice from Dr. Google :). They seek treatment methods on their own, use search engines to find diagnoses and solutions to their health problems. Your medical brand's website and social networks can be a reliable source of answers to their questions.

One solution we recommend is blogging. It gives you the opportunity to publish articles on topics related to health and the services you offer. It will also allow better search engine optimization of the site. In addition, it is an ideal tool to build the image of the doctor as an expert.

6. Appointment booking systems

The most well-known booking and scheduling service is the Famous Doctor portal. It is a service that allows patients to search for doctors and medical facilities, as well as to post reviews and rate the quality of medical services provided. Every day it is used by thousands of people who are looking for information on selected medical specialists and services. Hence, the medical community does not underestimate this channel, and in fact uses it as one of the most important tools for promotion and communication. And since there are potential patients out there, who can easily reach the competition, it is worth choosing to be present and active on this site. Of course, it is not the only e-service system of its kind, but it is by far the most popular.

3. New Technologies in Marketing.

Technology is defined as scientific knowledge and its applications to useful purposes (John, Weiss, Dutta, 1999) so technology can be related both to the product or the service that follows from the scientific knowledge and to the knowledge itself, it avoids the necessity of distinguishing between the product or service (e.g., chatbots) and the technology (e.g., artificial intelligence [AI]) it encompasses, which is, at times, impossible to do (Glazer, 1991). Nowadays technology changes rapidly, the term “new” is referring to recent applications of scientific knowledge that have not been replaced by others. In other words, technology is “new” when it is early in the adoption cycle for organization and client of marketing services.

Integrating all these considerations, new technologies can be defined in marketing as scientific knowledge and its application in the early adoption cycle for firms or consumers with the potential to influence the activity, institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients-patients, partners, and society at large.

Four Ways New Technologies Impact Marketing

At a high level of abstraction, can be observed new technologies impact marketing: four specifically, new technology:

1. supports new forms of interaction among consumers and firms,
2. provides new types of data that enable new analytic methods,
3. creates marketing innovations,
4. requires new strategic marketing frameworks.

It is important to keep in mind that different technologies can serve these multiple functions at the same time.

Text Analytics

Text analytics involves the automatic extraction of information from unstructured written sources performed by a computer to discover new information. This technique combines multiple disciplines (including natural language processing), and through its use, unstructured data changes its format into one that both humans and computers can understand, which has a positive effect on streamlining many processes (Ranjan, Prasad, Mane, 2021) Text analytics can be used for both prediction and understanding (Berger, Humphreys, Ludwig, Moe, Netzer, Schweidel, 2019). In both cases, it can be used to gain knowledge related to individuals (for example, assessing a customer's satisfaction with a product or service, or the likelihood of using a company's services again), as well as a firm, or a market. By using text analytics for prediction, marketers can, for example, gain knowledge about what type of customer is most likely to perform a given activity.

Voice Analytics

The objective of voice analytics is to extract voice data and analyze it using speech recognition tools (Ngai, Wu, 2022). For this purpose, a speech recognition system is created that allows a machine to understand and execute voice commands after first identifying spoken words and converting them into another format (Kumaran, Rangaraj, Siva Sharan, Dhanalakshmi, 2020). During the voice recognition process, a microphone in the user's device registers input data (sound waves), which are then converted into a digital signal so that they can then be further analyzed by a computer (Rawat, Gupta, Kumar, 2014) The goal of an automatic speech recognition (ASR) system is to extract relevant data from the speech signal and to enable the computer to correctly interpret the spoken words and their meaning (Regulski, Nowak, 2013). The processes essential for speech recognition are feature extraction (removing unnecessary information from the data without losing relevant information), acoustic modeling (generating words based on sound waves), decoding (deciding on the sequence of words in an utterance), and pronunciation modeling (comparing the content generated by the acoustic model with the content of the dictionary and creating the final result) (Rawat, Gupta, Kumar, 2014). In marketing, speech recognition is used in voice assistants such as Amazon's Alexa (Hu, Gong, Lu, Ding, 2023). Voice assistants (VAs) are able to communicate with users using spoken language because they can both speak and listen - the natural language generation is responsible for the speaking function, and the natural language understanding is responsible for the listening function (Hu, Gong, Lu, Ding, 2023) VA is be used for so-called voice shopping, during which the consumer utters a request with information about what they would like to purchase, and the VA recommends products that meet their needs; if the purchase is approved, the VA can also help with the purchasing process, as well as tracking the shipment (Hu, Gong, Lu, Ding, 2023). It helps to find needed service or doctor appointment.

Image Analytics

The objective of image analytics is to extract information from digital images using various techniques (for example, classification or clustering), and its application can be found in marketing activities related to analyzing data such as human faces, or visual elements of brands. Areas of marketing where image analytics can be applied are product design, advertising, branding, the online shopping experience, and the consumer perspective. In the case of product design, the study can focus on creating novel designs, as well as on measuring the uniqueness of a given product compared to other average products, examining how a given product design can influence customers' perceptions, or how it can be personalized to individual customers (Dzyabura, Kihal, Peres, 2021) (In the case of advertising, image analytics can be a tool to measure the originality and effectiveness of an ad by comparing it to other successful ads, to assess which visual elements influence certain customer behaviors, or which advertising elements are more tailored to which customers (for example, potential customers or customers who make a subsequent purchase) (Dzyabura, Kihal, Peres, 2021). Image analytics in branding, on the other hand, can be used to examine how visual representations can influence brand perception, and what associations they evoke (Dzyabura, Kihal, Peres, 2021). It is often used by dentists and commercial plastic surgeon to show their results and using photos.

Visual identification

The process of visual brand identity involves a variety of activities aimed at differentiating a company through the use of distinctive visual elements. These elements include, for example, a logo, color palette or font. Its main goal is to create a consistent and easily recognizable image. This is important as part of a marketing strategy, as it contributes to building brand awareness, maintaining customer loyalty and differentiating ourselves from competitors. The brand visual identity is very important. For example: Color increases brand recognition by up to 80%. In order for the visual identity of a medical brand to be effective, it is necessary to develop it carefully and thoughtfully. A company's branding should reflect both its personality and its operating context. If the company wants client patients to be recognized it is essential to ensure good quality branding. Especially in 2024 where online presence is especially important.

Video Analytics

Video analytics is a tool that allows marketers to obtain meaningful information from videos that are needed for decision-making. Video analytics can be used as a tool for making decisions about store layout, staff scheduling, display location, traffic flow, or performance measurement. An example of a system used for video analytics is IVA (Intelligent Video System), which automatically processes and interprets live or recorded videos without the need for human intervention (Dzyabura, Kihal, Peres, 2021).

4. Improving the quality of medical services through marketing

Quality improvement requires marketing support (Nadziakiewicz, Mikołajczyk, 2019), which is evident from the very definition of quality, which is customer-oriented (Hamrol, 2018). A patient using medical services expects a product, i.e. a service that conforms to the parameters about which he or she has been previously informed and a reproducible level of quality of these services. Both quality and marketing are directed in their activities and goals towards the recipient, the user.

When establishing a quality system, information about the customer is essential. A facility is not able to define what the quality of its products or services is until it determines what patients' expectations of quality are. It cannot be considered in isolation from the patient's needs and preferences. It should be realized that the main element of management by quality is to make decisions based on data and not just opinions. Therefore, various methods of surveying patient opinion are used. In this sense: “[...] marketing is the “input of the quality system” – it helps to define customer expectations of quality and to identify differences in these expectations between different target groups of customers” (Opolska, 2002, p. 19).

Marketing also serves: “[...] as it were, at the <exit of the quality system>, to inform customers and other external entities about the quality standards of the medical services provided. It is not enough to create an efficient quality system, describe procedures, train staff. If there is a lack of efficient information conveyed by means of marketing tools that the company conducts certain activities in terms of adjusting the quality of its services to the customer's expectations, then the quality system will become only a dead entry in the strategy of operation” (Opolska, 2002, p. 109).

Marketing activities are aided by information about the existence in a given health care facility - management by quality, implemented ISO and accreditation systems. Marketing is present when defining the quality model for the medical services offered, when creating quality policies in these facilities, and when communicating the established quality policy to patients.

Marketing also proposes instruments for measuring the degree of patient satisfaction with the level of quality offered by a given healthcare facility. The feedback obtained contributes to shaping the organization's quality management. Marketing is a contributor to quality improvement in the institution. But marketing also benefits from good quality in an organization. Quality becomes an image, a market image of the institution and an important argument for the customer - the patient. Building and perpetuating the market image of a healthcare facility are tasks for marketing. It influences the patient's emotions, evaluation and opinion of a particular facility, which guides the decision to choose; this also applies to the services they may use. And all this is due to the existing and well-functioning quality sphere.

The concept of quality leadership strategy is emerging in healthcare units. It involves offering attractive services, that is, putting at the disposal of the patient an offer whose unique character will be noticed and appreciated by him. It can be said that nowadays, any service offered by a healthcare unit, and on top of that, equipped with a guarantee of fast delivery, will arouse the patient's interest and desire to use it. However, this strategy is based on the belief that a standard product cannot satisfy all patients, some of whom are willing to pay more for a service that will perfectly satisfy their needs (Nadziakiewicz, Mikolajczyk, 2019).

The attractiveness of services may be due to their availability or low cost. The implementation of this strategy requires certain measures to be taken by the health unit: creating a brand, taking care of the image of the facility and its services, investing in technology to innovate, a wide range of services in each sector, cultivating close contact with the patient. The aforementioned factors should serve to provide comprehensive service to the patient.

The differentiation strategy was developed to meet the needs of a segment of patients with exorbitant requirements and insensitive to the price of service. Despite a certain attractiveness, however, this perception of quality leads to pathology in the field of health care. A person strives to use a certain proposition in order to get the perfect result of his treatment – even when he cannot afford it.

In health care, the interaction of service providers at different levels of the system and between different participants at the same level is particularly important for achieving the desired treatment outcome. The concept of cooperation also appears in many documents of the World Health Organization, for solving problems, especially in primary health care. At this level, the involvement of both sides of the service process is essential for the development of partnerships.

Marketing has a direct relationship with the process of creating quality in a healthcare facility. Certain typical activities related to this strategy can be helpful in the pursuit of quality creation. The starting element for marketing analysis is patient surveys or a survey of potential patients. Communicate to patients in an understandable way about the way services are provided in the direct service line (registration) or indirectly (brochures, posters, web sides, social media). The actual quality of service, combined with the aforementioned promotional impact - in the long cycle will bring the desired success from the level of service (quality). Promotional treatments will contribute to receiving information on the requirements of patients for quality medical services. It can talk about the formation of quality standards, that is, the implementation of medical services in accordance with them. The basis for the existence of marketing is the idea of the creation of a promise. Taking it literally with regard to the service process, it can be said that in the field of health services it has not been realized. The patient will never be assured that he will be cured. In this situation, a contract cannot be written between the parties, guaranteeing the patient's protection against poor quality service. There could always be a human factor that fails or medical complications. Therefore, a health service can only be considered as a set of professional activities using available medical knowledge and

professional equipment. A broader understanding of the idea of the promise that the health service makes to the patient makes it possible to realize three marketing principles in health care. The first is to make the promise real (external marketing), the second is to create opportunities for medical personnel to keep their promises (internal marketing), and the third is the process of fulfilling the pledge (interactive marketing). The existence of marketing in healthcare facilities is possible when a philosophy of thinking and acting based on trust and commitment is shared by all members of the organization. The ability to create and maintain long-term relationships are strongly linked to the individual predispositions and motivations of staff. It is important to realize that as new market solutions emerge, the importance of marketing in medical facilities increases. The patient-provider relationship should be based on trust and commitment between the parties. To the patient's good perception of the quality of services, the implementation of a quality management system contributes. Promotion of patient education and effective communication are examples of recommendations. The implementation of marketing in the sphere of medicine is the launch of a mechanism, which is a certain concept of operation in the market realities of health care facilities. This will contribute to the move away from completely free services provided.

5. Summary

Commercialization of healthcare organizations is taking place, so a new marketing understanding of health care services is emerging. For health care facilities, a marketing understanding of service will involve the ability to combine concern for meeting patient needs with an economic approach to facility management. The concept of marketing is an increasingly common tool in healthcare. Today it is difficult to imagine functioning in the modern medical marketplace if such activities are not consciously undertaken. Facilities seeking to increase their advantage over competitors must develop and implement marketing strategies, and the constraints that exist cannot be an excuse for failing to take appropriate action. New technologies in marketing can help to win the competition.

The basis for the existence of marketing is the idea of the creation of a promise. Taking it literally with regard to the service process, it can be said that in the field of health services it has not been realized. The patient will never be assured that he will be cured. In this situation, a contract cannot be written between the parties, guaranteeing the patient's protection against poor quality service. There could always be a human factor that fails or medical complications. Therefore, a health service can only be considered as a set of professional activities using available medical knowledge and professional equipment. A broader understanding of the idea of the promise that the health service makes to the patient makes it possible to realize three marketing principles in health care. The first is to make the promise

real (external marketing), the second is to create opportunities for medical personnel to keep their promises (internal marketing), and the third is the process of fulfilling the pledge (interactive marketing). The existence of marketing in healthcare facilities is possible when a philosophy of thinking and acting based on trust and commitment is shared by all members of the organization. The ability to create and maintain long-term relationships are strongly linked to the individual predispositions and motivations of staff. It is important to realize that as new market solutions emerge, the importance of marketing in medical facilities increases. The patient-provider relationship should be based on trust and commitment between the parties. To the patient's good perception of the quality of services, the implementation of a quality management system contributes. Promotion of patient education and effective communication are examples of recommendations. The implementation of marketing in the sphere of medicine is the launch of a mechanism, which is a certain concept of operation in the market realities of health care facilities. This will contribute to the move away from completely free services provided. Commercialization of this area is taking place, so a new marketing understanding of health care services is emerging. For health care facilities, a marketing understanding of service will involve the ability to combine concern for meeting patient needs with an economic approach to facility management. The concept of marketing is an increasingly common tool in healthcare. Today it is difficult to imagine functioning in the modern medical marketplace if such activities are not consciously undertaken. Facilities seeking to increase their advantage over competitors must develop and implement marketing strategies, and the constraints that exist cannot be an excuse for failing to take appropriate action.

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ISSUES OF HUMAN CAPITAL ANALYSIS AND ASSESSMENT ON THE EXAMPLE OF REPORTS PUBLISHED BY LISTED COMPANIES

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Purpose: The aim of this article is to examine the information capacity (information policy) of publicly available reports published by enterprises from the point of view of various approaches to assessment of human capital, as well as its deeper analysis.

Design/methodology/approach: The listed companies' information policy assessment in the field of human capital carried out on the basis of annual reports and broadly understood ESG or CSR reports, published by 140 companies listed on the Warsaw Stock Exchange. In detail the research consisted in analysing the content and quality of the information presented in the reports in terms of the application of the criteria for assessing human capital by answering the 15 questions regarding different issues on this subject.

Findings: The research shows that the analysed companies listed on the Warsaw Stock Exchange are characterized by a rather diverse approach to information policy in the field of human capital, and in fact none of them conducts it in an unequivocally complete and transparent manner. Obtained results clearly indicate that their overall reporting in the field of human capital is quite average. The results for large companies and some industries are relatively better than the general average.

Research limitations: The research did not cover the entire population of companies listed on the Warsaw Stock Exchange but only companies from WIG-20, mWIG-40 and sWIG-80 indexes.

Practical implications: In order to improve the assessment and analysis of human capital in enterprises, a certain standard of data reporting in this area should be introduced.

Social implications: Improving enterprise reporting in the area of human capital would have a positive impact on the overall assessment of enterprises' involvement in socially responsible activities.

Originality/value: The conducted research, based on a relatively large (in comparison to other studies in this field) research sample and a detailed approach to the criteria for assessing human capital, allowed to verify the possibilities of practical application of the human capital assessment indicators postulated in the literature.

Keywords: human capital, ESG reports, human capital assessment, human capital ratios, information policy of listed companies.

Category of the paper: Research paper.

1. Introduction

Along with the changes in the socio-economic reality in recent decades, which were caused by, among others, globalization and the information and technological revolution, there has been a transition from an economy based on traditional material resources towards an economy based on intangible resources (the so-called knowledge-based economy). Thus, intangible resources are currently widely considered to be decisive for the competitive advantage of enterprises, pushing traditional material resources in the form of fixed assets into the background (Barney, 1991; DeNisi et al., 2003; Szwajca, 2012; Iwanowicz-Pałka, 2024). The role of the human (employee) has also increased, as one of the possible intangible resources, who began to be perceived as a component of various aggregate values related to the enterprise – intellectual capital, innovativeness, competitiveness, and finally value (Schultz, 1961; Becker, 1962; Dobija, 2005; Nawrocki, 2012). Several decades ago, the common opinion was that wages were only a payment for the work performed by employees, and the value of the enterprise was only increased by investments in fixed assets. Currently, which was largely influenced by the development of the resource-based view (RBV) concept, the forerunner of which is considered to be E. Penrose (1959), it is obvious that the employee is not only a workforce, but one of the most valuable resources of the enterprise. It is necessary for its proper functioning, and having a specific value verified on the market, it determines the economic potential of a given entity and allows for building its competitive advantage (Szopik-Depczyńska, Korzeniewicz, 2011) and improving its operational efficiency (Berk et al., 2010; Wang et al., 2014; Asare et al., 2017; Nawaz, 2019). Employees of an enterprise create developmental, creative assets that have the ability to continuously improve. For this reason, they contribute more than other resources to creating additional values for the enterprise (Wyrzykowska, 2008; Poczowski, 2008; Dokurno, 2017), which is reflected in the literature in the term "human capital" for employees of a given organization (Haq, 2016).

With the growing interest in the importance of employees for the development of enterprises and the improvement of their performance, the term "human capital" has received many interpretations and measurement concepts (Jabłoński, 2021). As a result, we can currently encounter numerous approaches to this issue, which are very diverse in terms of detail and recommended assessment criteria. The methods of assessing or measuring human capital presented in the literature are in most cases based on very detailed, including not only quantitative, partial criteria. This naturally raises questions about their possible source of data and the real possibilities of widespread use (Folloni, Vittadini, 2010). On the other hand, the number of publications addressing the issue of reporting non-financial information on human capital is also growing, especially those taking into account Polish conditions (e.g. Czaja-Cieszyńska, 2020; Nakonieczny, 2018; Bagieńska, 2014). At the same time, however, the research presented in these studies is quite general in nature and does not answer

the question: to what extent is the information on human capital presented in non-financial reports useful from the point of view of the criteria for its assessment presented in the literature?

Therefore, the aim of this article is to examine the information capacity of publicly available reports published by enterprises from the point of view of various approaches to assessment of human capital, as well as its deeper analysis. Due to the specific information openness (the obligation to publish periodic reports), as well as the great diversity in terms of the type of business activity conducted and its scale, companies listed on the Warsaw Stock Exchange were accepted as the research subjects.

The article consists of a theoretical introduction and its expansion in relation to the perception of human capital and methods of its assessment and analysis, methodological part, research results and summary.

2. The concept of human capital and approaches to its assessment and deeper analysis

Although the idea of human capital dates back to the seventeenth century and is associated with researchers dealing with economic and financial issues (including William Petty, Adam Smith, William Farr), the beginnings of the theory of human capital as an organized discipline of knowledge date back to the turn of the 1950s and 1960s (Kiker, 1996). At that time, some scientists stated that knowledge, education, skills, and human health have production potential (Mincer, 1958; Schultz, 1961; Becker, 1962).

Human capital can be classified as a difficult concept to define. There are many definitions in the literature, depending on the perspective of consideration, i.e. management, accounting, radical or neoclassical economics (Jabłoński, 2021). For the purposes of this article, it was assumed that human capital is a resource of knowledge, skills, abilities, qualifications, attitudes, motivation, and health of employees, which is of significant importance in economic activity and is a source of future earnings (OECD, 1998, Fisher et al., 2006, Łukasiewicz, 2009).

In one of the general approaches, the concept of human capital can be considered from a macroeconomic and microeconomic perspective. From a macroeconomic perspective, human capital is identified as one of the basic resources of the economy, determining economic growth. In the microeconomic approach, the concept of human capital concerns an individual employee and is treated as an element of the intangible resources of the enterprise (Kucharcikova, 2011).

A company can seek competitive advantage based on properly trained, highly motivated and loyal staff (Noe et al., 2006; Bloisi, 2007; Gabcanova, 2011). Activities aimed at increasing the value of human capital include in particular (Nellis, Parker, 2006; Ackroyd et al., 2005; Zieliński, 2006):

- acquiring human capital (employing properly trained staff, replacing staff),
- maintaining human capital remaining within the company's control (through an appropriate motivation system and creating development opportunities),
- developing human capital within the company (training).

Some authors divide human capital into general capital and specific capital. General (universal) capital can be used in all types of economic activity, while specific capital determines the productivity in a given enterprise (McConnell, Brue, 1986).

From the perspective of the company, human capital is an element of intangible resources, and according to Edvinsson and Malone (2001), it is also a component of intellectual capital, which includes knowledge, experience, technology, relationships with customers and professional skills, which are a source of competitive advantage for the organization. Intellectual capital, apart from human capital, also includes structural capital, which is defined as everything that supports employee productivity and relational capital concerning all relationships with external stakeholders as well as reputation resulting from these relationships (Sydler et al., 2014; Bombiak, 2016; Hussinki et al., 2017).

Human capital, in addition to the characteristics brought by an employee to the organization (skills, knowledge, experience resulting from seniority, health, attitudes, values, etc.), also includes the ability of employees to learn, motivation (including sharing information), striving to achieve goals, or the ability to work in a team (Kiker, 1966; Hanushek, Woessmann, 2008; Antonelli et al., 2010; Flabbi, Gatti, 2018). Additionally, apart from the individual human capital of each employee, the human capital of an enterprise also includes the creativity and innovativeness of employee teams (Czechowska-Świtaj, 2005; Sokołowska, 2005; Król, 2006). It should also be emphasized that all of the above-mentioned issues are particularly important from the point of view of the Industry 4.0 concept, which has been popularized in recent years, one of the key conditions for its implementation is the acquisition of appropriate education and skills by employees (Flores et al., 2020, Singh et al., 2021).

It should also be noted that for a company, human capital is higher than the simple sum of the human capital of all employees. People are co-creators of processes, norms, build social relations and organizational systems. By reacting to changes in the environment and influencing them, they increase individual knowledge and shape skills (Storberg-Walker, 2004).

Attempts to measure human capital are generally based on treating employees as assets of the enterprise and measuring changes in their value. Many authors raise doubts about the possibility of measuring human capital, which focus on questions (Phillips et al., 2003):

- Can human capital be treated as a business asset at all?
- What human capital costs should be capitalized?
- How reliable are the methods for determining the value of human capital and their relationship to costs?

At the same time, the most commonly used methods of human resource valuation are valuations based on (Rogowski and Panfil, 2015):

- costs related to personnel policy (cost approach),
- market transactions (market approach),
- income generated by the employee (income approach).

In the case of estimating the value of human capital in accordance with the “cost” approach, the most frequently recommended concepts in the literature are: the historical cost method and the replacement cost method. In the first one, the value of human capital is reflected in the expenditure incurred on acquiring and training an employee, and in the second one, the expenditure on replacing the currently employed employee with another one. The main measures allowing for estimating the value of human capital in the case of using the historical cost method are: recruitment and selection costs and training costs, and in the case of the replacement cost method, additionally the cost of leaving a previous employee (Łukasiewicz, 2009; Samul, 2011; Czajkowski, 2012). Generally, however, taking into account the differences in the openness of information policy of enterprises (Nawrocki and Zieliński, 2013), the practical application of the above-mentioned cost concepts of estimating the value of human capital is quite difficult, mainly due to the problematic access to the required data. For this reason, a simplified approach is often used for research purposes, in which the value of human capital is assumed to be the data on the amount of remuneration and benefits for employees disclosed in the financial statements of companies – such an approach was used, for example, in the value added intellectual capital (VAIC) coefficient (Pulic, 2004).

The “market” approach to estimating the value of human capital is based on the analysis of market transactions that involved assets similar to those being valued, i.e. employees (Rogowski, Panfil, 2015). However, the price included in individual contracts is not always equal to the equilibrium price, which is why it is not identical to the value of an intangible asset, e.g. an employee. The price is influenced by non-market factors (such as negotiation skills or expected synergy effects) that affect the parties to the transaction. Changes in market conditions also mean that historical prices are not always a good indicator of value in new realities. Therefore, an indispensable element of valuation is the analysis of market and non-market conditions and the identification of those factors that may cause a deviation from the equilibrium price (Reilly, Schweihs, 1999). The basic problem with the “market” approach is the availability of complete data on transactions involving assets similar to those being valued. Hence, its practical application is most often limited to selected industries.

When estimating the value of human capital using the “income” approach, it is assumed that it is equal to the present value of future revenues for each employee (Rostkowski, 2011; Flamholtz, 2012). Estimations using the income method are also made difficult by changes in tangible assets (raw materials, technology) and intangible assets (organization and management), which, on the one hand, are unpredictable over a period of several decades, and on the other hand, significantly affect employee performance (Król, 2006; Łukasiewicz,

2009). Changes in the employment structure and staff turnover may also make it difficult to value human capital (Zieliński, 2008). A departing employee may take with them experiences related to the mechanisms of operation, informal connections with customers, suppliers, and other employees (Sokołowska, 2005), which results in disruptions in the functioning of the organization (Probst et al., 2004).

In addition to the three approaches to the valuation of human resources in an enterprise (cost, market and income) indicated above, the literature on intellectual capital management also indicates a number of concepts for assessing human capital as one of the components of intellectual capital, including:

- The Intangible Assets Monitor (Sveiby, 1997).
- The Skandia Monitor (Edvinsson and Malone, 2001).
- A set of indicators for measuring individual components of intellectual capital according to J. Mouritsen (1998) and Lim and Dallimore (2004).
- Sopińska and Wachowiak's intellectual capital measurement model (2003).
- A set of guidelines for reporting intangible assets proposed as part of the MERITUM project (Guimon, 2009).

Synthesizing the above-mentioned concepts of assessing human capital, Sopińska, Wachowiak and Mierzejewska (2015) draw the following conclusions and propose an original multi-indicator model of assessing human capital based on intellectual capital (Table 1):

- it is not possible to indicate one universal tool for identifying and measuring human capital,
- in most measurement concepts, a multi-indicator approach is used,
- in many cases, the proposed indicators for measuring human capital are given without specifying the exact method of their calculation,
- in the proposed models, emphasis is placed on various areas of human capital,
- in some approaches, separate indicators are proposed for individual categories of human resources, distinguished due to: the position held in the organizational structure or the form of employment,
- in most proposed methods for measuring human capital, qualitative and quantitative indicators occur in parallel.

The list of indicators for measuring human capital presented in Table 1 shows that this measurement does not have to be limited to the most popular and obvious categories such as the number of employees and their wage and benefit costs, but can be much broader and more detailed.

Table 1.*A multi-indicator model for measuring human capital through the prism of intellectual capital*

Indicator Category	Indicator	Measurement method
Cost indicators	Employee acquisition cost index	Recruitment and selection costs per newly hired employee to the average total employee remuneration
	Training cost index	Training costs per employee
	Total wage cost ratio	Total salary costs per employee
	Employee leaving cost index	Employee leaving costs (e.g. employee severance pay) per employee
	Employee investment cost indicator	Training cost to Total wage cost ratio
	Employee replacement cost Indicator	Employee leaving cost index + Employee acquisition cost index
Time-quantitative indicators	Staff rotation rate	The number of employees leaving in a given period in relation to the total number of employees
	Human resource availability Indicator	Number of full-time employees in relation to the total number of employees
	Employee anchoring indicator	Number of employees employed for an indefinite period of time in relation to the total number of employees
	Training time indicator	Number of training days per employee
	Employee replacement time indicator	The average time needed to introduce a new employee to the tasks at positions in the company
	Professional development indicator	Number of employees covered by an individual professional development program in relation to the total number of employees
	Employee engagement rate in research and development activities	Number of employees in research and development departments in relation to the total number of employees
	Absenteeism rate	Average number of days of absence per employee in one year
Performance indicators	Employee creativity indicator	Number of reported initiatives per employee
	Employee creativity utilization rate	Number of implemented employee initiatives per employee
Financial indicators	Employee profitability indicator	Value added per employee
	Employee sales rate	The amount of sales revenue per employee
	Employee value generation indicator	Market value of the company per employee
Quality indicators	Industry experience index	Average number of years of work in the industry of employees employed in the enterprise
	Company experience index	Average number of years of work of employees in a given enterprise
	Age diversity index	Percentage of employees in each age group (e.g. every 10 years)
	Gender diversity index	Percentage of women and men in the total number of employees
	Education level indicator	Number of employees with higher education in relation to the total number of employees
	Competency match index	Number of employees employed according to their education in relation to the total number of employees
	Competence uniqueness index	Share of experts with a significant position in the industry in relation to the total number of employees
	Job satisfaction index	Number of satisfied employees in relation to the total number of employees
	Mentoring scope index	Number of employees mentored in relation to the total number of employees
	Employee attitude index	Number of employees showing high commitment to the employer in relation to the total number of employees

Source: Sopińska, Wachowiak, Mierzejewska, 2015, pp. 57-58.

At the same time, however, the question arises about the actual possibilities of practical application of all these indicators from the point of view of access to appropriate data. The desire to answer this question is both the main motivation and the main goal of this article. The following research hypotheses were also put into verification:

- H1: Due to the development and great popularity of the CSR and ESG concepts in recent years, companies listed on the Warsaw Stock Exchange implement an open information policy in the field of human capital, which allows for its comprehensive and detailed analysis based on a number of indicators.
- H2: The information policy of companies listed on the Warsaw Stock Exchange in the field of human capital varies depending on the size of the entity, which translates into greater information openness of large companies compared to medium and small companies.
- H3: The information policy of companies listed on the Warsaw Stock Exchange in the field of human capital varies depending on the sector and industry affiliation of the entity, which translates into greater information openness in sectors associated with a higher level of human capital (technology, medicine, industry, finance).

3. Research methodology

The listed companies' information policy assessment in the field of human capital was carried out in October 2024 on the basis of annual reports and broadly understood ESG or CSR reports, including reports on non-financial information, integrated reports or sustainable development, published by companies listed on the Warsaw Stock Exchange that are also included in the WIG-20, mWIG-40 and sWIG-80 indices. Due to the adopted data source and the limitation of the research entities to the composition of the three indices, the research sample consisted of a total of 140 entities (132 domestic and 8 foreign) representing 8 sectors and 50 industries according to the Warsaw Stock Exchange list (WSE, 2024), which is illustrated in Fig. 1 (due to the large number of individual representatives of industries and their similar nature, it was decided to combine them into larger groups, which resulted in reducing the number of industries considered to 30).

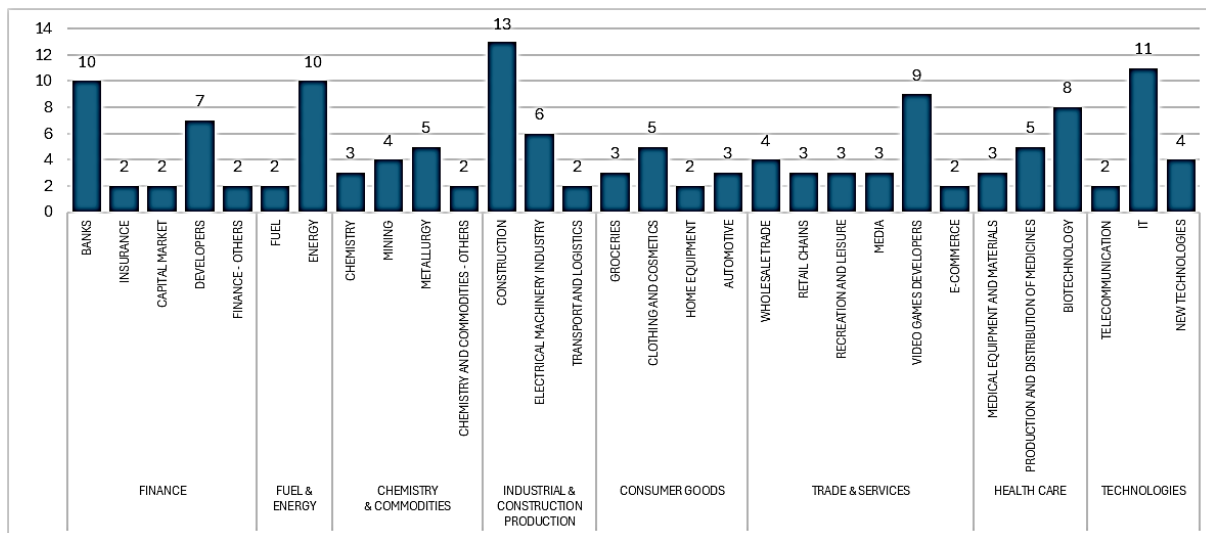


Figure 1. Division of the research sample into sectors and industries taking into account their quantity.

Source: Own work based on data of WSE: <https://www.gpw.pl/wskazniki>.

The subject of the research for the above-mentioned sample was the information value of the annual reports published by the analysed companies and broadly understood ESG or CSR reports in the field of human capital, and its implementation was based on the previously used approach regarding the assessment of the information policy of listed companies in the field of innovative activity (Nawrocki, Żabka, 2011) and human resources (Nawrocki, Zieliński, 2013). In detail, the research carried out consisted in analysing the content and quality of the information presented in the reports in terms of the application of the criteria for assessing/valuing human capital mentioned in the previous point (Table 1). This analysis was conducted by answering the following questions (a total of 15, taking into account different variants in question 4):

1. In addition to the mandatory annual report, does the company also publish a broadly understood ESG report, including a report on non-financial information, an integrated report or a sustainable development report? (R?)
2. Does the company provide information on the number of employees in published reports? (NE?) If so, in what form is this presented (status at the end of the year in persons, average employment in persons, status at the end of the year in full-time positions, average employment in full-time positions)?
3. Does the company provide data on employee rotation in published reports? (ER?)
4. Does the company provide the employment structure in published reports according to:
 - 4.1. positions? (ES-p?)
 - 4.2. education? (ES-e?)
 - 4.3. age? (ES-a?)
 - 4.4. work experience? (ES-we?)
 - 4.5. gender? (ES-g?)
 - 4.6. type of contract, i.e. full-time, part-time, other? (ES-tc?)

- 4.7. duration of the contract, i.e. indefinite, fixed-term? (ES-cd?)
- 4.8. region? (ES-r?)
5. Does the company provide information in published reports about employment costs incurred in a given period (salaries and benefits for employees)? (EC?)
 6. Does the company provide information in published reports about employee training? (ET?) If so, in what form is it provided (cost, time, people)?
 7. Does the company provide information in published reports about employee accident statistics? (EAS?)
 8. Does the company provide information in published reports about the feedback culture, i.e. periodic assessment of employees and assessments of their engagement and job satisfaction? (FC?)

Due to the form of the above questions, three possible answers were adopted for most of them: "no information", "general information" and "detailed information". At the same time, it should be noted that the answer option "general information" is actually only applicable to different variants of question 4 (employment structure) and 8 (feedback culture), because only in these areas there was a significant differentiation in the information provided by the analysed companies. In the remaining cases, the answers were on the basis of YES or NO, or it was in the form of a specific numerical value.

4. Results

The results obtained during the conducted research were presented in three perspectives.:

- the entire research sample,
- a distinction between large companies (WIG-20), medium companies (mWIG-40) and small companies (sWIG-80),
- a distinction between individual sectors and industries.

First, the percentage of responses to the questions indicated in the previous point was presented, which was obtained for all 140 listed companies analysed (Fig. 2).

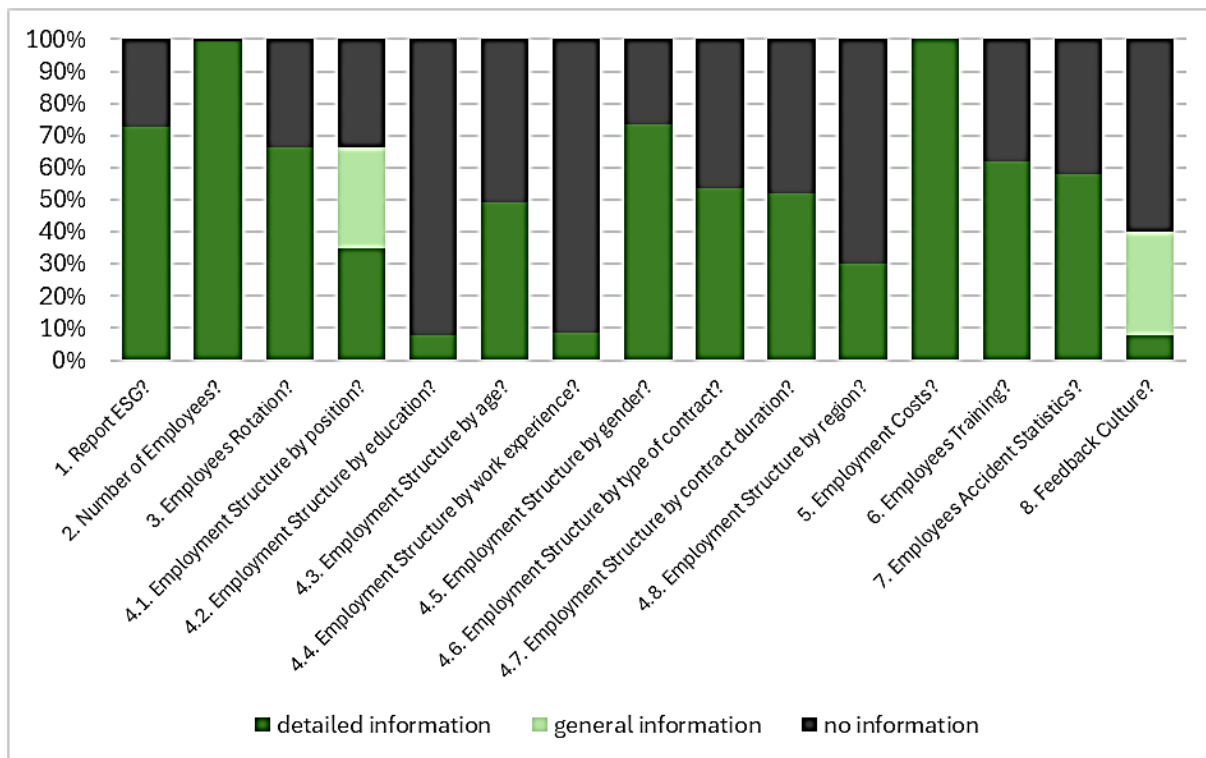


Figure 2. Results of the research on the information value of analysed companies listed on the Warsaw Stock Exchange reports from the point of view of specific issues related to human capital assessment.

Source: own calculations.

The presented results clearly indicate that despite the fact that approx. 73% of the analysed companies (102 out of 140) publish non-financial information, including information related to employees, in the form of broadly understood ESG reports, their overall reporting in the field of human capital is quite average, which also indicates only partial positive verification of the research hypothesis H1:

- Only detailed information on the size of human resources in the form of the number of employees (only in the case of 1 company out of 140 analysed there was a lack of information) and the costs of their maintenance, i.e. expenses and benefits for employees (full information for all 140 analysed companies) can be assessed as fully positive. It is also worth noting that the high percentage of positive indications regarding the above-mentioned categories results to a large extent from their obligatory nature, i.e. the requirement to disclose them in annual reports.
- Apart from the size of employment and its maintenance costs, only in the case of employment turnover, employment structure by job position and gender, as well as training and accident statistics, can one notice information openness clearly above average, i.e. over 50%, among the analysed companies. At the same time, it is worth noting that in relation to the employment structure by job position, only about 35% of them provide detailed information, and almost 31% limit themselves to general information in the form of a division into "blue-collar" and "white-collar" employees.

- At an average level, i.e. around 50%, the analysed companies disclose information on the employment structure by age, type of contract and its duration.
- As for the remaining types of information distinguished regarding human capital, the policy of their disclosure in the analysed companies is clearly weaker. Information on the employment structure by region is disclosed by about 30% of the analysed companies, on the feedback culture, i.e. employee opinion surveys on working conditions and place of work by about 40%, of which only 8% in detail (providing the results of the employee survey). The disclosure of information on the employment structure in terms of education (8%) and work experience (9%), which is one of the most important criteria for assessing human capital, is definitely the weakest in the analysed entities.

In addition, which is not visible in Fig. 1, it should be noted that in the case of 29 out of 140 companies analysed (21%), a minimalist approach to disclosing information on human capital was found, consisting in limiting only to mandatory information, i.e. the number of employees and the costs of their employment (14 cases, 10%) or at most one more category (15 cases, 11%), most often including the employment structure by position. The full scope of information on human capital, according to the list indicated earlier, was not provided by any of the analysed entities, and only 2 out of 140 (7%) could boast a single lack of information. At the same time, the largest group of entities in the research sample were those with 3 or 5 missing information (24 cases each, 17%), which certainly contributed to the fact that the average for the entire research sample was a fairly good 6.59 missing information, and in percentage terms 44% (i.e. on average in the case of the analysed companies, 8.41 out of a total of 15 questions from the list, i.e. 56%, had positive answers).

Taking into account the results regarding the assessment of the information policy of the analysed companies in the field of human capital (Fig. 2) and the list of indicators postulated for its analysis or assessment (Table 1), it can be concluded that the data on the area of employees published by companies listed on the Warsaw Stock Exchange would allow to a large extent, use indicators such as: Total wage cost ratio, Staff rotation rate, Gender diversity index, Training time indicator, Employee profitability indicator, Employee sales rate, Employee value generation indicator, and in a limited one: Training cost index, Employee investment cost indicator, Employee creativity indicator, Age diversity index, Human resource availability indicator, Employee anchoring indicator, Company experience index, Education level indicator, Job satisfaction index, Employee attitude index.

Concluding the conclusions regarding the approach covering the entire research sample, it is also worth paying more detailed attention to the way the analysed companies inform about the number of employees (Fig. 3) and their training (Fig. 4).

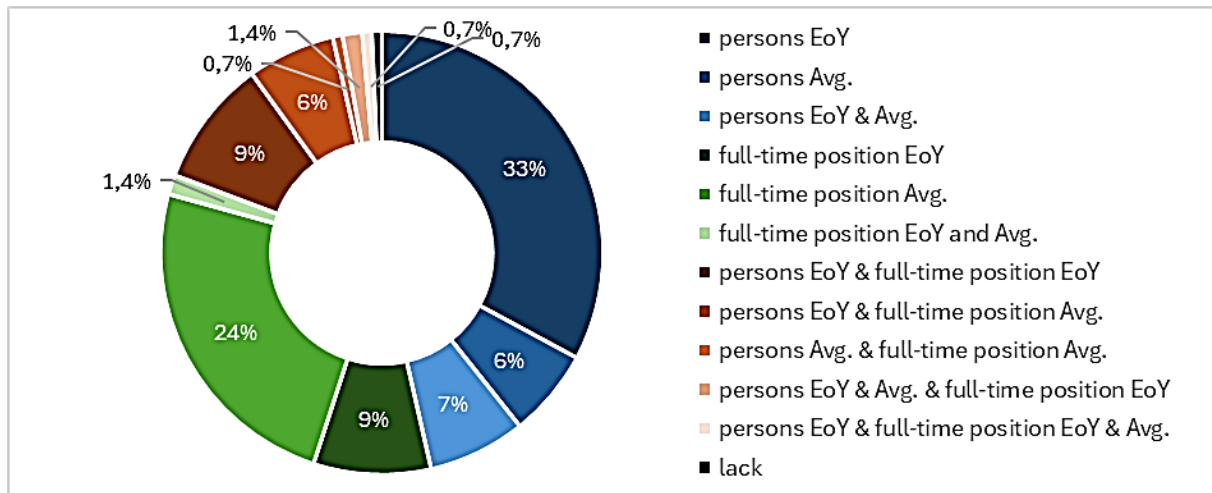


Figure 3. The method of reporting the number of employees by the analysed companies listed on the Warsaw Stock Exchange.

Source: own calculations.

As noted earlier, the analysed companies generally did not limit access to information on employment (only 1 entity in 140 did not disclose this information), and, as shown in Fig. 3, they did so in very different ways. In general, information on employment was provided in terms of persons or full-time positions and with regard to the end-of-year (EoY) or average (Avg.) status. Out of the 140 companies analysed, 80 (approx. 57%) disclosed information on employment in persons at the end of the year, 47 (approx. 34%) in persons on average, 27 (approx. 29%) in full-time positions at the end of the year, and 25 (approx. 18%) in full-time positions on average. It should also be noted that some entities provided employment in more than one way. At the same time the diverse approach to providing information on the size of employment creates certain problems with the comparability of some of the criteria for assessing human capital, where the number of employees is used as a component (e.g. work efficiency, employment costs per 1 employee). The differences between the appropriate approaches (persons and positions) and their status (end of the year and average) may not be particularly large (on average approx. 3%), but the change in the value of individual complex assessment criteria influences and distorts their comparability.

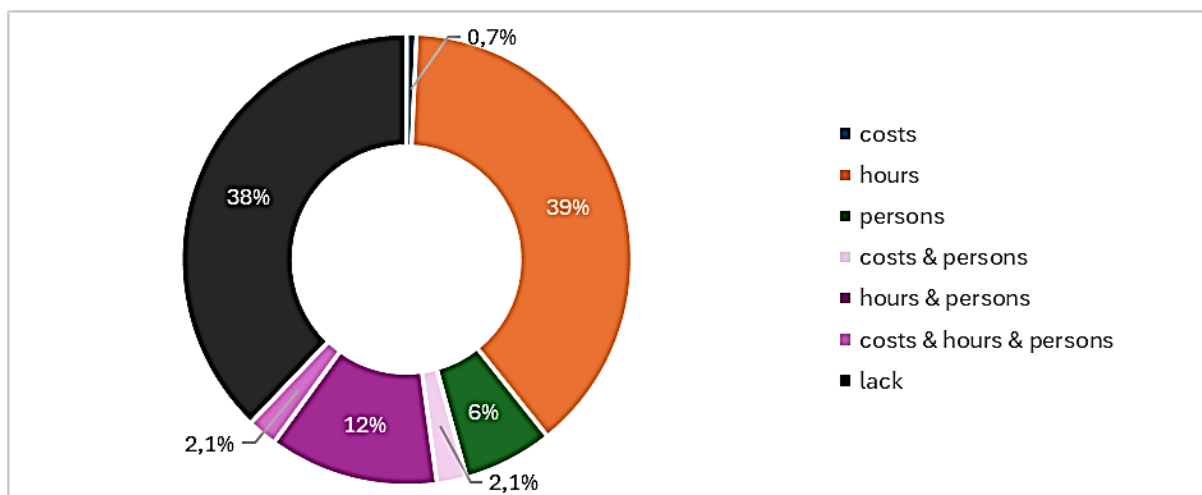


Figure 4. The method of informing about employee training by the analysed companies listed on the Warsaw Stock Exchange.

Source: own calculations.

In addition, in the context of employment data, attention should also be paid to the approach of various entities to the issue of identifying individual employees as employed persons. A review of the reports of the analysed companies shows that some entities include only persons employed under an employment contract in their employment data, while others also include co-workers employed under civil law or internship contracts. There are also often quite clear differences between employment data disclosed in the annual report and in the non-financial information report. The lack of a uniform approach in this area further affects the problems with the results comparability of some of the criteria for assessing human capital.

The situation is similar when it comes to informing by the analysed companies about employee training. The results of the information value among the analysed companies presented in Fig. 2 show that about 62% of them inform about employee training. At the same time, however, taking into account the different ways of providing this information (Fig. 4), it can be seen that this can also create problems in terms of comparability. Out of the 140 analysed companies, 74 (53%) inform about training in terms of hours, 32 (about 23%) in terms of people, and only 7 (about 5%) in terms of costs or value, i.e. how much PLN was spent on employee training. It should also be noted here that some entities provided information about employee training in more than one way.

Although the conclusions presented above are not particularly optimistic, when presenting the results obtained during the research divided into specific groups of companies, certain positive aspects can be seen.

Fig. 5 shows the percentage of responses to the formulated questions divided into large companies (WIG-20), medium companies (mWIG-40) and small companies (sWIG-80). Taking into account the presented results and comparing them with the overall results discussed earlier (Fig. 2), it should be noted that large companies (WIG-20) present themselves most favourably in terms of reporting on human capital, although at the same time this is not

reporting that could be described as "fully open" (on average approx. 4 information gaps in relation to the list of 15 examined issues concerning human capital, i.e. approx. 26%) - none of them provides the employment structure by age, only approx. 10% of them provide the employment structure by education, and approx. 50% by region. Large companies also "lose" to medium-sized companies in terms of information on the employment structure by position. At the same time, in terms of other issues related to human capital raised in the research, large companies in most cases present themselves clearly better than medium-sized companies (on average about 5 information gaps, i.e. about 34%), and especially small companies (on average more than 7 information gaps, i.e. about 49%). Therefore, the research hypothesis H2 can be verified as true.

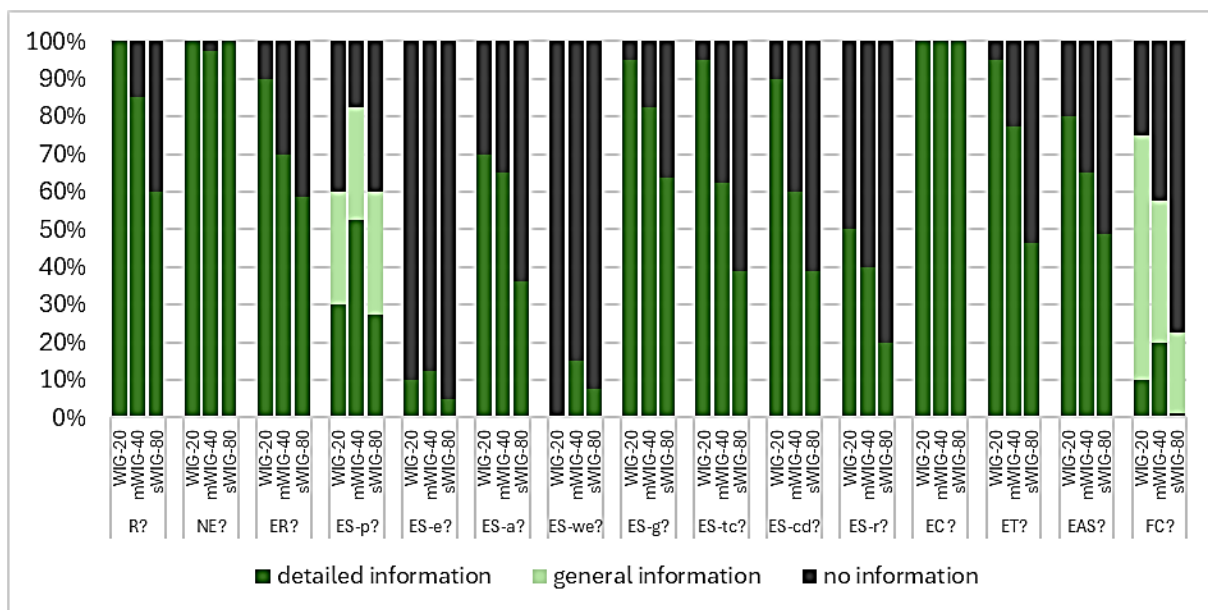


Figure 5. Results of the research on the information value of analysed companies listed on the Warsaw Stock Exchange reports from the point of view of specific issues related to human capital, divided into large companies (WIG-20), medium-sized companies (mWIG-40) and small companies (sWIG-80).

Source: own calculations.

In addition to the division presented above, significant differentiation in the reporting of human capital in the analysed companies can also be observed depending on their sector affiliation, as illustrated in Fig. 6.

Among the eight sectors considered, the information policy in the field of human capital should be assessed most favourably in relation to FINANCE (F), INDUSTRIAL & CONSTRUCTION PRODUCTION (I&CP) as well as FUEL & ENERGY (F&E), although it is not a fully open policy (slightly more than 5 information gaps, i.e. approx. 35/36%) and is characterised by some diversification in terms of the information disclosed.

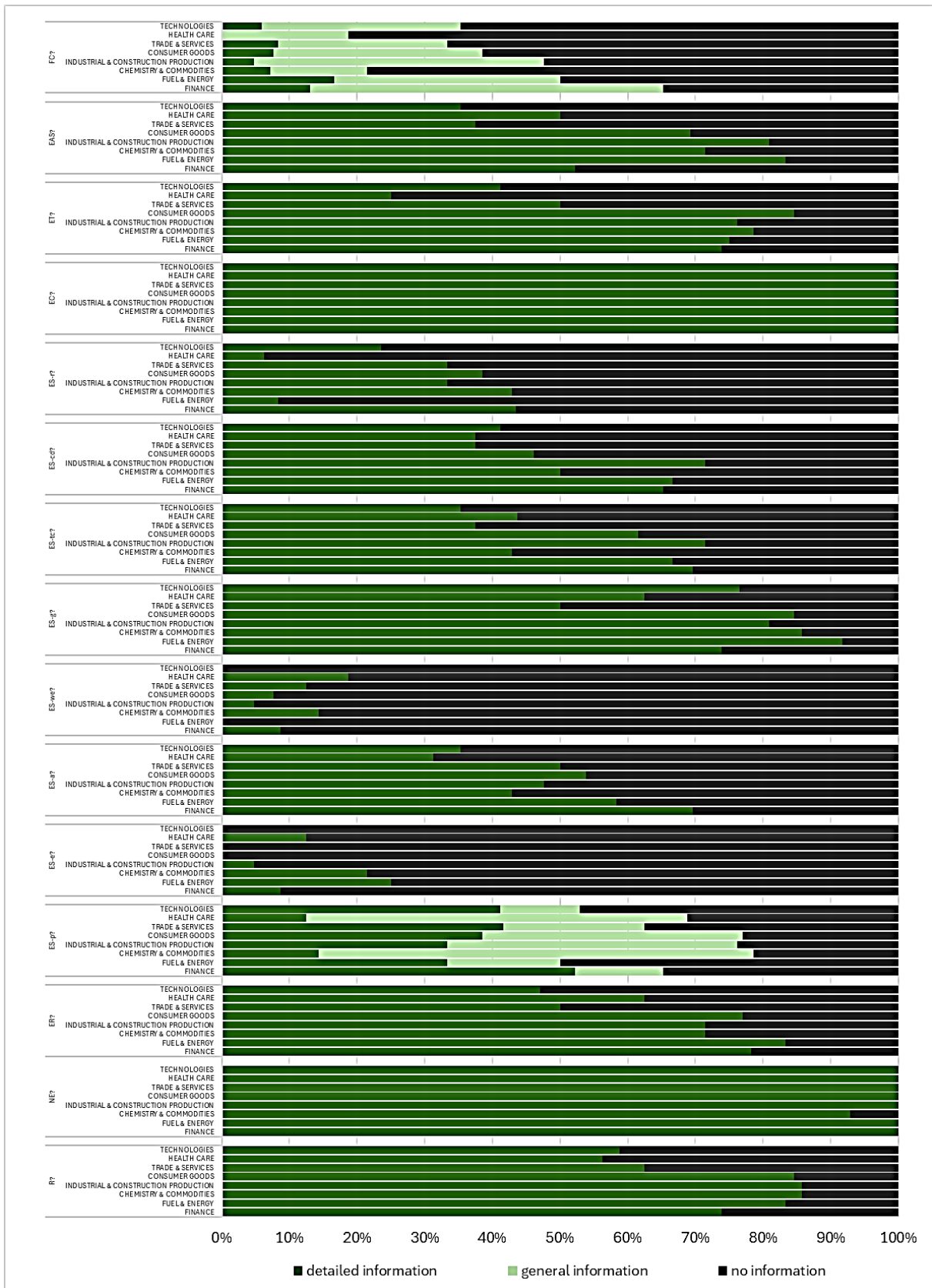


Figure 6. Results of the research on the information value of analysed companies listed on the Warsaw Stock Exchange reports from the point of view of specific issues related to human capital, depending on the sector.

Source: own calculations.

Apart from the size of employment and related costs (which all but one of the analysed companies fully report), entities from the above-mentioned sectors are in the lead in terms of issues such as: publication of non-financial reports (especially I&CP and F&E), employees rotation, employment structure by position (I&CP only), education (F&E only), age, gender (especially F&E), type and duration of the contract, as well as training, employees accident statistics (I&CP and F&E only) and feedback culture (especially F). Entities from the CONSUMER GOODS (CG) and CHEMISTRY & COMMODITIES (CH&C) sectors are only slightly behind the above-mentioned sectors in terms of openness of information policy regarding human capital – on average there are less than 6 information gaps, i.e. 37/38%. Entities from these sectors can also be considered among the leaders in terms of publishing non-financial reports and reporting on employees rotation, employment structure by position, education (only CH&C), age (only CH&C) and gender, as well as employees training (only CG). In the case of entities from the remaining three sectors, i.e. TRADE & SERVICES, HEALTH CARE and TECHNOLOGIES, information gaps exceeded 7 on average and in percentage terms ranged from 49-51%, with the weakest being in technology companies.

From a more detailed perspective, i.e. industries within individual sectors, the results of the analysis are presented only as the percentage of positive responses to questions from the list concerning human capital issues in terms of minimum (Min), maximum (Max) and average (Mean), as illustrated in Fig. 7.

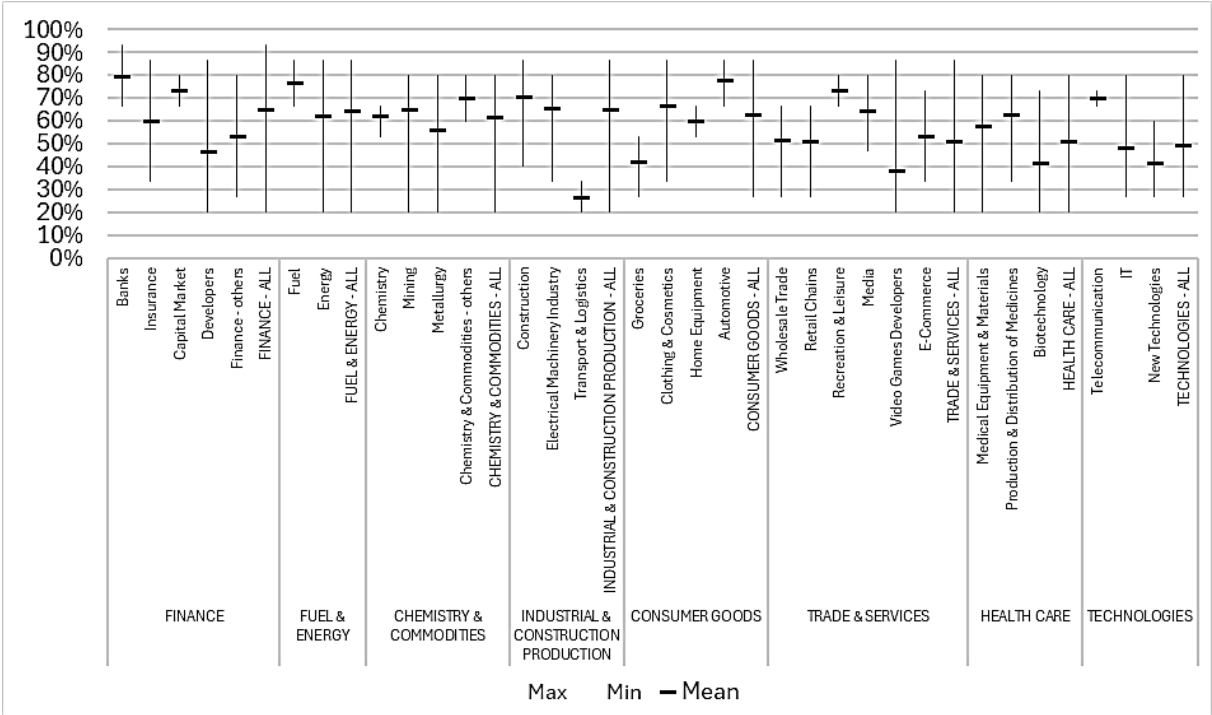


Figure 7. Results of research on the information value of analysed companies listed on the Warsaw Stock Exchange reports from the point of view of human capital assessment criteria divided into sectors and industries (Max, Min, Mean).

Source: own calculations.

As can be seen in Fig. 7, within each of the sectors considered, there is considerable variation in the assessment of information policy regarding issues related to human capital for individual industries. The clear leaders in this respect, with a percentage of positive indications to questions from the list regarding issues related to human capital of at least 70%, are banks and entities related to the capital market (FINANCE sector), fuel (FUEL & ENERGY sector), chemical (CHEMISTRY & COMMODITIES sector), construction (INDUSTRIAL & CONSTRUCTION PRODUCTION sector), automotive industry (CONSUMER GOODS sector), recreation & leisure industry (TRADE & SERVICES sector) and telecommunications entities (TECHNOLOGIES sector). On the other hand, the least information about human capital, with a percentage of positive indications to the questions from the list under consideration below 40%, is provided by entities from the transport & logistics industry (INDUSTRIAL & CONSTRUCTION PRODUCTION sector) and video games developers (TRADE & SERVICES sector). At the same time, it should be noted that in the case of several industries, there is an exceptionally high differentiation of entities in terms of information policy in the field of human capital (the range between the highest and lowest percentage of positive indications to the questions from the list under consideration is over 50 percentage points). This group includes insurers, developers, other financial companies (FINANCE sector), energy entities (FUEL & ENERGY sector), mining and metallurgical entities (CHEMISTRY & COMMODITIES sector), entities from the clothing & cosmetics industry (CONSUMER GOODS sector), video games developers (TRADE & SERVICES sector), entities from the medical equipment & materials as well as biotechnology industry (HEALTH CARE sector) and finally IT companies (TECHNOLOGIES sector).

Taking into account the above-mentioned results (Fig. 6 and Fig. 7), the research hypothesis H3 can be verified only as partially true. While entities from the financial and industrial sectors, i.e. FINANCE, FUEL & ENERGY, CHEMISTRY & COMMODITIES as well as INDUSTRIAL & CONSTRUCTION PRODUCTION, with minor industry exceptions (developers, transport & logistics, groceries), actually present themselves most favourably in terms of the openness of information policy regarding human capital, the poor results of companies from the HEALTH CARE and TECHNOLOGIES sectors, including in particular such industries as biotechnology, IT and new technologies, are somewhat surprising.

5. Summary and discussion

The research shows that the analysed companies listed on the Warsaw Stock Exchange are characterized by a rather diverse approach to information policy in the field of human capital, and in fact none of them conducts it in an unequivocally complete and transparent manner. In this respect, it can be said that the situation is quite similar to the state diagnosed

by the author in a similar research about 11 years ago (Nawrocki, Zieliński, 2013), as well as research results of other authors (Surowiec, Skowron-Grabowska, 2022; Czaja-Cieszyńska, 2020; Bagieńska, 2018). On the other hand, in the meantime, the concept of CSR – Corporate Social Responsibility has gained in importance and popularity, which then evolved into the ESG model – Environmental, Social, Governance (Włoch, 2021), along with which more and more entities listed on the capital market publish broadly understood reports on non-financial information, taking into account, among others, issues related to employees, where quantitative data are provided according to the unified standards of the Global Reporting Initiative (GRI, 2024). For this reason, the method of presenting information on employees or human capital has noticeably improved, which can be seen in the percentage of entities publishing reports or extended non-financial information (approx. 73% in 2024 vs approx. 8% in 2013), as well as disclosing data on employment (approx. 99% in 2024 vs approx. 89% in 2013), employee rotation (approx. 66% in 2024 vs approx. 12% in 2013), employment structure by work experience (approx. 9% in 2024 vs approx. 5% in 2013), or employee training (approx. 62% in 2024 vs approx. 10% in 2013). It is true that it should be remembered that the research presented here concerned 140 entities from the WIG-20, mWIG-40 and sWIG-80 indices, and the 2013 research concerned all 438 entities listed at that time, which certainly, due to the greater share of small entities, translated into lower percentages of positive answers to individual questions. However, in the case of questions regarding non-financial reporting, employee turnover and training, the difference in results is so large that even if we assume that the remaining listed companies in 2024 did not provide this information, the percentage of positive indications for the 2024 research would still be significantly higher than for the 2013 research. Additionally, it should be noted that in the currently published reports on non-financial information, new categories of information have also appeared, which were not previously provided, or if they were provided, then only sporadically, i.e. employee accident statistics and employee satisfaction assessments with the workplace and their engagement (feedback culture).

At the same time, however, despite the positive direction of changes in the information policy of listed companies in the area of non-financial issues, including in particular human capital, it is still quite average (an average of 6.59 information gaps in the analysed entities out of 15 categories considered, which gives a percentage of disclosed information of only about 56%), which resulted in the lack of confirmation of hypothesis H1. It is true that when considering the results of the study taking into account the division by company size or industry, one can find some positives, i.e. large companies from the WIG-20 index, which means confirmation of hypothesis H2, or in terms of industry, banks, companies related to the capital market, fuel, chemical, construction, automotive, recreation & leisure and telecommunications, which means partial confirmation of hypothesis H3.

In the information policy of the surveyed entities regarding human capital, certain shortcomings, that persist over time, should be noted, i.e. a large degree of freedom in the scope of information disclosed by companies and the manner of its provision, which makes it difficult to carry out an objective assessment and comparison of human capital for a larger number of entities according to the same set of indicators.. Undoubtedly, a major step towards solving this problem would be to introduce the obligation for companies to report according to a certain universal template.

Finally, it should be noted that the strengths of the conducted study include a relatively large, compared to studies by other authors, research sample and the detail of the subject of the study, i.e. the criteria for assessing human capital. In the context of further research directions, it can be indicated to expand the subjects of the study to include smaller companies, outside the WIG-20, mWIG-40 and sWIG-80 indices, and to verify, according to the applied methodology, the information policy in the area of human capital in companies listed on foreign markets.

Acknowledgements

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THE SCOPES OF DIGITAL COMPETENCES

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Purpose: The main purpose of this article is to describe the scopes of digital competences as a key type of skills from the point of view of satisfactory functioning in the professional and private domain in the technological environment of human life, characteristic of modern times.

Design/methodology/approach: From the invention of the computer, the Internet and the smartphone as foundational digital technologies to the emergence of their intensification such as cloud solutions, Iot, blockchains, and cognitive technologies, we know that the effective exploitation of these solutions requires the acquisition of competences to use them. As bibliometric research shows, issues of digital competence continue to gain importance. The main aim of this paper is to describe existing competences and models to conceptualise research related to them, identify possible gaps, and attempt to fill them. It is assumed that the models that already exist should be supplemented with a meta-level to ensure that they are constantly updated in accordance with the digital ontology. Due to the anticipatory nature of the investigation, a conceptual analysis was used in the study.

Findings: In this research, the two main concepts 'digital literacy' and 'digital competence' were defined, the notion of 'digital capital' is included, referring to Pierre Bourdieu's concept of capital, helping to realise the role of digital competences as a factor in building social status. Selected competence models are described, possible deficits are recognised, and a possible way of filling them is proposed.

Research limitations/implications: These considerations are merely a conceptual sketch and, as such, call for more in-depth theoretical analyses, which will then be subjected to empirical verification, for example, a pilot study of experts and users' views on the role of a critical attitude towards one's own and digital competences and the need for their further development.

Practical implications: The research carried out in this article has a very practical dimension, as the theoretical analysis undertaken was aimed at producing very concrete results related to education in both individual and systemic terms, as it can provide indications of the scope for self-improvement and the expansion of curricula to include specific competence dimensions.

Social implications: The article is conceptual in nature, which, in line with the research method used, allows for the development of theoretical reflection (basic research), in this case concerning digital competences, their scopes, and areas of development, and as such can provide indications on the substantive content of digital competence subjects recommended for educational systems.

Originality/value: The most significant achievement of the present reflections is the identification of a potential competence gap in existing digital competence models and the attempt to fill this gap by extending the model to include a meta-level, critical attitude towards scope of digital competence, constant updating of competencies.

Keywords: digital competences, digital literacy, data literacy, AI literacy, digital capital, meta-digital competences DigComp 2.0.

Category of the paper: Conceptual paper.

1. Introduction

The commonly formulated observations about the impact of digital technology on every aspect of our reality now seem to be a truism. For generations to come, the Internet, computers, smartphones, and AI are an integral part of the world as they know it. As with any technology, we design it with a specific intention, and with knowledge we use it to improve our functioning, enhance our quality of life, experiment with the limits of human agency, etc. As homofaber or tool-making animal (McLuhan, M., McLuhan, E., 1988, pp. 93-94), we view technology as an adaptive means to control the environment in which we live (Hall, 2001, p. 35).

We also know from the history of our species, as Yuval Harari succinctly put it, that humans have always been better at inventing tools than using them wisely (Harari, 2018, p. 7). But in order to use technology wisely, it is necessary to use it fully consciously. And this comes with time, born in experiments, successive attempts, and constant elimination of mistakes. This is how we improve our creations, this is how we increase their efficiency, and this is how we acquire the skills necessary to use them optimally. The same is true of digital technologies, their close integration into our daily lives necessitates a constant upgrading of the competences associated with them, and there is nothing new in this. However, in the case of digital technologies, we have to take into account a significant variable regarding their rate of development, which is aptly captured by the trend recognised by Gordon Moor (Moor's law) of an exponential increase in the number of processors used on a monthly basis (Gregersen, 2024). Leaving aside the debates surrounding the precision of Moor's findings, the trend he recognised illustrates the existence of a correlation occurring between the pace of technical back-end development and the growth of computing power and digital transformation.

Using a metaphor, one could say that it is a technology that "never sleeps", every month brings new technological developments, and in view of this fact, the question of the extent of digital competence cannot remain indifferent. This is, so speak, the first competence imperative - digital competences do not exist, they must be subject to constant development, and this, in turn, requires a critical assessment of their validity. In the present considerations, it is assumed that the competence requirements indicated above constitute a metalevel conditioning the others, concretising around specific digital functionalities.

Two research questions should be considered as the main focus of the deliberations:

1. What competence scopes are currently indicated as digital competencies?
2. Can these competences be regarded as exhaustive of the competences necessary for effective use of digital technology?

In the case of the second question, the assumption formulated earlier provides a partial answer, but it seems to need to be made more specific. Addressing the research questions posed requires, first, the identification of currently formulated competency scopes and, secondly, the identification of a possible competency gap. This research will be preceded by a bibliometric introduction, which will help to realise the general trend in research on digital competences. Conceptual analysis will be used to develop theoretical insights from existing knowledge, which can then be verified in the course of empirical work. At this stage of the research, this method seems to be fully justified.

2. Methods

The paper will use two research methods: a bibliometric method and a conceptual analysis.

- Bibliometrics - that is, statistical analysis of books, articles, or other publications, involving the collection of data on the number of scientific articles and publications, classified by author and/or institution, field of study, country, etc., in order to construct productivity indicators for research (OECD Glossary of Statistical Terms). This method will be used to assess researchers' current interest in digital competencies issues and to identify the contexts in which these issues are being studied including domain mappings. These findings are important as an indicator of the advancement of work related to digital competences. The study will include data extracted from one of the largest databases covering peer-reviewed and published articles, monograph chapters, and scholarly monographs – SCOPUS-based, Sciencedirect. Two key terms, 'digital competencies' and 'digital literacy', have been included in the study due to the fact that these terms are treated synonymously by some authors.
- The second method used for consideration will be one of the oldest scientific methods, i.e. conceptual analysis (Furner, 2004; Gilson, Goldberg, 2015; Stuart, 2015; Dickson et al., 2018), whereby further theoretical analyses are conducted on the basis of already existing knowledge. In this method, using the most classical research methods, such as deductive reasoning, initial assumptions, well grounded in theory, are made, and from these initial assumptions, conclusions are formulated that extend knowledge in the field or allow new hypotheses to be put forward, which are then subjected to verification in empirical research. This type of research is typical of the so-called basic research. Conceptual analysis is used to combine theories, adapt theories to new developments, categorise, establish logical relationships between phenomena, and build theoretical models (Jakkolla, 2020). Given the theoretical sophistication of the issues discussed in the considerations, this method seems appropriate. According to the conceptual analytical steps adopted, the study will undertake the following tasks:

- Defining basic concepts, describing the initial theoretical assumptions, in this case, defining terms such as: "digital capital", "digital competencies", "digital literacy".
- Establishing the relationships existing between the different concepts, in this study, answering the question: Which competences are currently indicated as digital competences?
- Conclusions – in this study, an answer to the question – Can these scopes be considered to exhaust the competencies necessary for effective use of digital technology?

The theoretical knowledge obtained in this way can form the basis for empirical research, as hypotheses developed that should be verified in the course of further research work.

3. Results

3.1. Bibliometrics

According to the methodological assumptions described above, it is initially necessary to establish to what extent the proposed topic is currently a relevant research topic. Below are the results of a search in the SCOPUS database from the Science Direct website, covering terms such as: "digital competences"; "digital literacy". Data was collected on 14.08.2024. The number of publications by year, type of publication, and scientific discipline was taken into account. The article considers data from when the topics appeared in the SCOPUS database, i.e. 2010 to the current year – 2024. The largest increase in interest in these topics was recorded in 2023. This will allow us to trace the research interest in the problems proposed in the article and to indicate the contexts of existing research, such as the predominant type of publication or the discipline in which digital competences are addressed. The results obtained are presented sequentially in Figure 1 (by year), Figure 2 (by type of publication), Figure 3 (by scientific field).

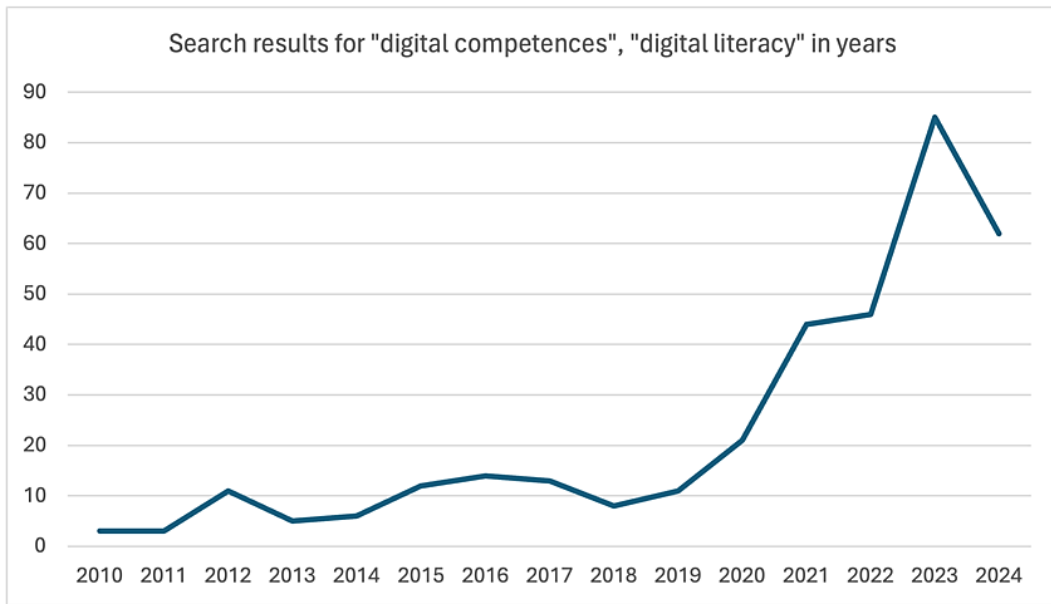


Figure 1. SCOPUS-based Science Direct – number of published articles search for "digital competence" and "digital literacy" in years.

Source: Own elaboration.

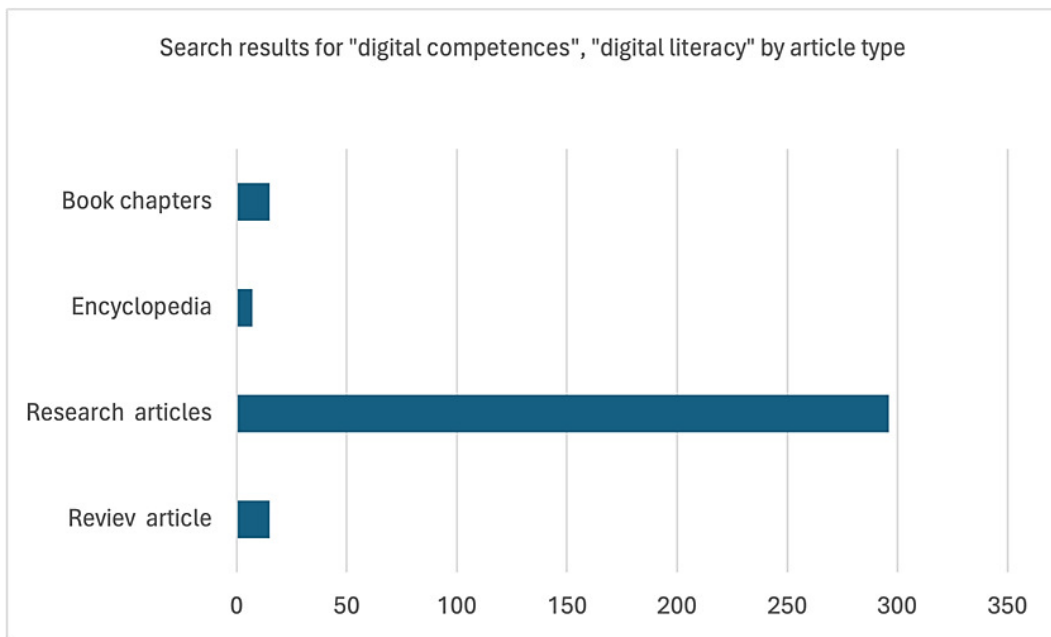


Figure 2. SCOPUS-based Science Direct – number of published articles search for "digital competence" and "digital literacy" by article type.

Source: Own elaboration.

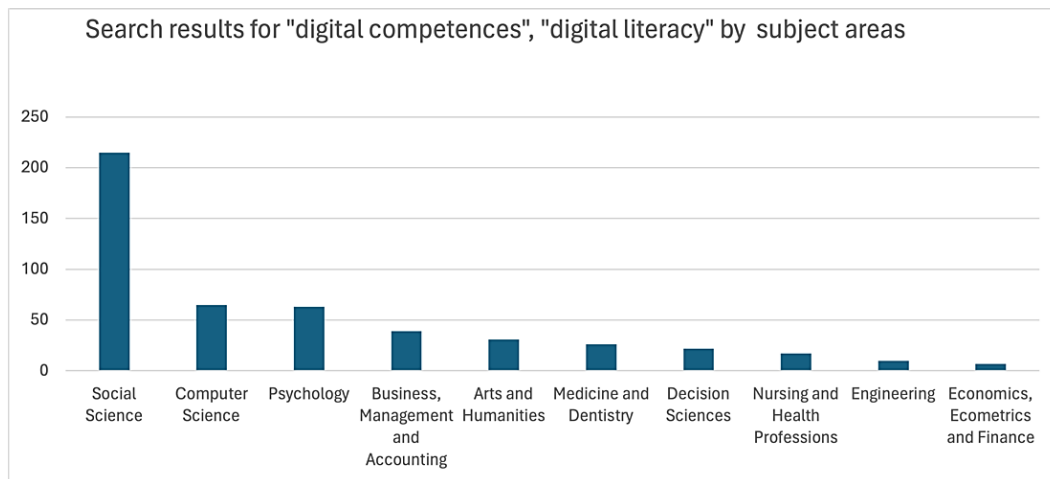


Figure 3. SCOPUS-based Science Direct – number of published articles search for "digital competence" and "digital literacy" by subject areas.

Source: Own elaboration.

The data obtained from the bibliometric study allow several conclusions to be drawn, indicating the existence of certain trends related to scientific analyses of issues concerning digital competences. First, an increase in interest in this issue is clearly discernible over the past decade. The decrease in the number of publications in 2024 is the result of a lack of complete data; there are still four months left until the end of the year, and the current number of publications rather indicates a continuation of the trend. The increasing interest of researchers usually indicates that the subject matter is problematised, i.e. that it is becoming the focus of attention, as an issue of importance, and this in turn is the result of increasingly perceived gaps in current knowledge. Secondly, the type of publications that predominate, research articles, tells us that we are at the stage of collecting data that, in time, can be transformed into more general theoretical conclusions. That is, in a sense, we are at the beginning of a research journey. Third, most of these publications are produced within the social sciences, which may indicate a growing understanding of the importance of digital competence for our social functioning, or more radically, an understanding that social life in its various dimensions is now impossible without digital competence. All the above mentioned findings are a basis for further research.

3.2. Conceptual analysis

3.2.1. Definition of digital competences and relationships existing between the different concepts

When we ask about competence, we are by definition referring to the quality of our performance; this is due to the etymology of the term itself. The Latin term *competentia* means conformity, suitability, readiness for something; *competere*, in turn, means to be in tune with something, suitable for something, and *competentes* means suitable, capable. These terms were used in specific contexts related to professional activities. For example, in craftsmanship to emphasise mastery of one's craft, in the judiciary toward officials who were entitled to speak on a given matter, also in the case of gladiators when, after long preparation, they were ready

to fight in the arena (Filipowicz, 2016, pp. 11-12). These hermeneutic analyses reveal three important aspects of the concept of competence:

- they concern a specific action; we are competent in something specific,
- to be competent is to know the methods and to know what their theoretical background is, and it means that to be competent is to have specific ways of making decisions and acting,
- achieving competence requires a conscious process of improvement and time.

According to this scheme, in the case of competences concerning the use of digital technologies, one would have to consider:

- What specific areas of competence might be involved?
- What methods and knowledge should be acquired and what knowledge should be available?
- What kind of reflection should be developed in relation to a specific time frame?

Two terms to describe digital literacy dominate the research already conducted on digital competence: 'digital literacy' and 'digital competence', some authors advocate treating these terms as synonyms (Pangrazio et al., 2020), but it is worth trying to distinguish their potential designations, this can contribute to a clearer picture of the scope of the issue under analysis (Fallon, 2020). In the case of 'digital literacy', it is helpful to trace the etymology of the term 'literacy' itself. According to the Oxford Dictionary and Oxford Reference, literacy is 'the ability to read and write, contrasted to illiteracy.' In looser usage, this also includes basic arithmetical competence' (Oxford Dictionary, Oxford Reference, 20.08.2024). In a similar vein, the OECD defines the term 'literacy' as the ability to understand, evaluate, use and engage with written text to participate in society and achieve goals' (OECD, 20.08.2024). As can be seen, these original meanings refer to competencies related to communication through a specific medium; in this case writing, over time the term came to refer to media literacy in a broad sense - 'media literacy' in the context of the ability to understand, evaluate, use and engage in the use of media to participate in society and achieve one's goals, and in the digital media age transforming to 'digital literacy'(Buckingham, 2007; Burke, 2008; Rintaningrum, 2009; Roodney, Hafner, 2012; Pilgrim, Martinez, 2013; Kamerer, 2013; Wilson et al., 2015; Potter, Mcdougall, 2017; Ptaszek, 2019; Ross et al., 2024). Some authors point out that the concept of 'digital literacy' describes reading and writing tasks utilising technology-powered media. Digital literacy is the ability to find, evaluate, utilise, share, and create content using information technologies and the Internet (Pilgrim, Martinez, 2013, p. 63), whereas, in the view of others, it is about the optimal use of media in general, not just reading and writing (Glister, 1997; Kamerer, 2013; Pangrazio et al., 2020; Osika, 2021b; Ross et al., 2024). Whereas one of the strands developing within 'media literacy' is the critical approach, which places a strong emphasis on three components: the first is 'metaknowledge' of 'meaning systems and the sociocultural contexts in which they are produced and embedded'; the second involves the

technical skills to negotiate these systems; and the final ‘involves the capacity to understand how these systems and skills operate in the interests of power’ (Pangrazio, 2016, p. 164). The critical trend with the development of digital technologies also emphasises the importance of ‘critical data literacy’ (Hinrichsen, Coombs, 2013; Maybee, Zilinski, 2015; Kleppman, 2017; Osika, 2021a, 2022a), which includes skills such as: ‘(1) Awareness: understanding data and their role in society; (2) Access: understanding how to identify, locate and appropriately use structured data in datasets and databases; (3) Engagement: evaluate, analyse, organise and interpret data to make evidence-based decisions; (4) Management: organise and manage data; (5) Communication: synthesise and create visualisations and representations; (6) Data Ethics: identify diversified data sources, considering the risks of managing such data and the issues implicit in the use of data; (7) Preservation: awareness of long-term practices of storing, using and reusing data (Atenas et al., 2020, p. 7). And recently, the importance of AI literacy is increasing, which is defined as ‘a set of competencies that enable individuals to critically evaluate AI technologies, communicate and collaborate effectively with AI, and use AI as a tool online, at home, and in the workplace’ (Long, Magerko, 2020; Hjorth, Chrysostomou, 2022; Knoth et al., 2024; Stolpe, Hallström, 2024).

Studies also talk about more specific types of literacy, such as ‘information literacy’, i.e., ‘the ability to recognise when information is needed and to have the ability to locate, evaluate, and effectively use the needed information’ (Pilgrim, Martinez, 2013, p. 67). Multiliteracies – namely ‘the multiple ways of communicating and making meaning, including such modes as visual, audio, spatial, behavioral, and gestural (Pilgrim, Martinez, 2013, p. 67) and web literacy, i.e. ‘the knowledge and use of specific skills needed to locate, analyse and communicate information found online (Pilgrim, Martinez, 2013, p. 67).

However, as researchers point out (Janssen et al., 2013; Fallon, 2020), the term ‘literacy’ does not fully capture the entire spectrum of competences required to make optimal use of digital technology. ‘Digital competency clearly involves more than knowing how to use devices and applications [...], which is intricately connected with skills to communicate with ICT, as well as information skills. Sensible and healthy use of ICT requires particular knowledge and attitudes regarding legal and ethical aspects, privacy, and security, as well as understanding the role of ICT in society and a balanced attitude towards technology (Fallon, 2020, p. 2451, from: Janssen et al. 2013, p. 480). Rather, our focus should therefore be on developing holistic models of digital competence that allow us to delineate the ranges necessary to assimilate as equipment to enable us to function in a reality heavily influenced by digital technologies.

One of the proposals for a broader approach to digital competence is to define it as a set of competences composed of information competences including the ability to search for information, understand it, assess its reliability and usefulness, and digital competence, which includes the ability to use a computer and other electronic devices (hardware literacy), use the Internet, use various types of applications (applications literacy) and software (software literacy), and create digital content. There is also mention of functional competences related to

the use of digital and information literacy in eight key areas of life - work and professional development, relationships with relatives, pursuing interests, health, finances, religion and spiritual needs, everyday life, civic engagement (Plebańska, 2021; Kompetencje cyfrowe 4.0). The competence model described above is part of the Polish Digital Competence Development Programme, which was developed in 2020. Its aim was to identify a framework covering competences to be developed from pre-school and early school education to senior age. By design, the strategy aims to significantly reduce areas of digital exclusion.

The Development Agenda for the EU, in turn, has developed a DigComb 2.2. The oldest version of this competency model is version 1.0, which was created in 2013, with subsequent updates being DigComp 2.0 (2016), 2.1 (2017), 2.2 (2022). DigComp 2.2 covering five competence areas: **information and data literacy** (browsing, searching and filtering data, information and digital content, evaluating data, information and digital content, managing data, information and digital content), **communication and collaboration** (interacting through digital technologies, sharing through digital technologies, engaging in citizenship through digital technologies, collaborating through digital technologies, netiquette, managing digital identity), **digital content creation** (developing digital content, integrating and re-elaborating digital content, copyright and licences, programming), **safety** (protecting devices, protecting personal data and privacy, protecting health and well-being, protecting the environment), *problem solving* (solving technical problems, identifying needs and technological responses, creatively using digital technologies, identifying digital competence gaps) (Vourikari et al., 2016). Another proposal for a set of digital competences is adopted by the UK Department for Education: *Essential digital skills framework*, developed in 2018, in this case the key is to set a baseline level that allows the use of digital technology.

In the competence models cited, the ranges of skills that need to be acquired have been accurately identified, so it can be said that they provide object-orientated indications of particular types of competence. However, the acquisition of competences also requires the adoption of a specific attitude towards these object-related references, which is why this discussion proposes as a basis for analysis the model by José Janssen, Slavi Stoyanov Anusca Ferrari, Yves Punie, Kees Pannekeet, Peter Sloep, its visualisation showing **Figure 4**.

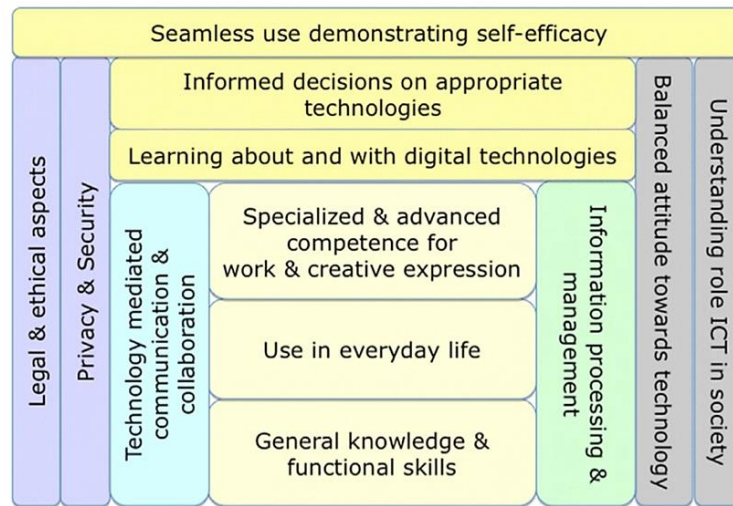


Figure 4. Areas of digital competence.

Source: Janssen, 2013, p. 478.

In this model, alongside the subject scopes described, there is also an indication of a balanced attitude towards the technology itself, the role of this attitude being crucial as a support for informed decision-making in relation to the use of certain functionalities. Protecting privacy, for example, requires knowing the contexts associated with the technological backdrop of its violation, when we know this, we can try to build our own privacy policy, but this requires a more distanced attitude towards the technology, because we have to want to take such a step. Similarly, deciding to turn off notifications puts me back in control of my digital device use habits. As indicated earlier, these considerations are decisive in the choice of this model for further analysis.

3.2.2. *Meta-digital competence*

Javeir A. Rodriguez-Camacho et al. referring to Pierre Bourdieu's concept of capital argue that the digital transformation of contemporary society has resulted in the increased status of those with knowledge and skills in the use of digital technologies. In this sense, we can consider digital competences as digital capital, i.e. a value that is socially attributed to members of society because of the level of knowledge and skills they possess in this area (Rodriguez-Camacho et al., 2024, p. 1). However, we know, as mentioned in the 'Introduction', that one of the characteristics of digital technology is that it develops at an exponential rate, requiring constant updating of software and sometimes even hardware, so the mere fact of mastering a certain range of competences at a given time, from the point of view of digital capital, seems insufficient. Therefore, it is worth adding a meta-level to the already existing competency scopes mentioned with the models described extending digital competences not so much by additional types of competences, but rather by a certain attitude one takes towards the competences one already has, i.e. that they are only temporary.

In general, therefore, it is about adopting a critical attitude towards the already identified skills that make up digital capital, and this, in turn, will make it possible to constantly update them, i.e., what we consider to be digital competences and what is included in their scope. For example, two decades ago it was very important to operate specific programmes; now we rather talk about the ability to perform tasks, and in which programme it will be performed has become secondary. The inclusion of a meta - level of competence will allow an ontological adaptation to the nature of digital technology, and this will help to develop a conscious attitude to the need to continuously work on one's digital capital, carried out in the spirit of 'lifelong learning'. This competence complementation can also help to overcome various types of digital exclusion, as it helps to realise that, in a sense, everyone has a competence deficit, so everyone needs to learn something. Figure 5 shows a visualisation of the completed digital competency model below.

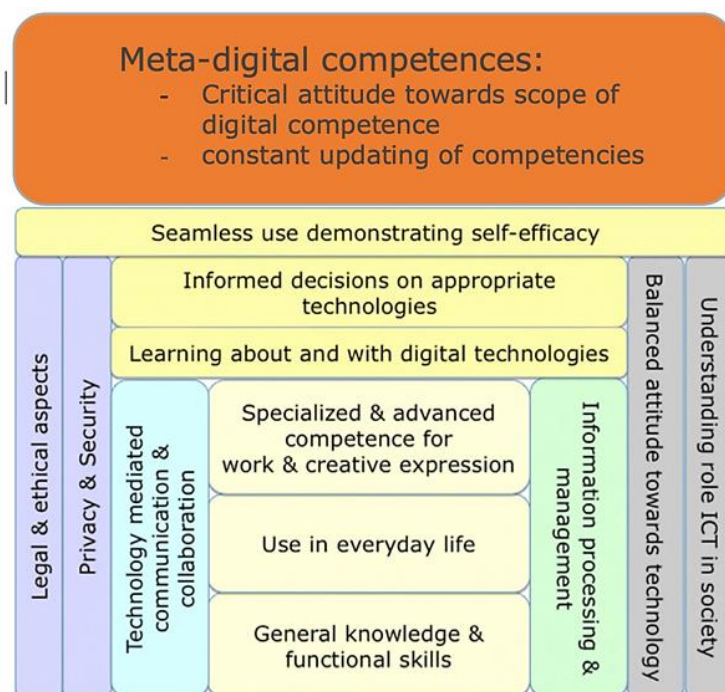


Figure 5. Concept of new areas of digital competence.

Source: Own elaboration based on Janssen, 2013, p. 478.

3.3. Application potential of the extended competence model

The proposed extended model of digital competence is intended to raise awareness of the level of skills we have and the skills we need to add, and this applies to both educators and suggestions for self-development. While the extent of what we need to use digital technology is to a greater extent verified in everyday life, to put it succinctly, life imposes on us what we need to learn, the attitudes we adopt towards technology and our own skills remain in the background, hence the need to take into account the meta-level of competence.

At the same time, we know that the scopes described must become elements of development strategies that consider digitality as an integral part of reality. In Poland, the *Digital Competences Development Programme* has been under development since 2020, which is a direct reference to the EU Digital Education Action Plan 2021-2027, together with the more general *Path to the Digital Decade* programme, which is part of the digital transformation policy for the EU. Under these programmes, it is envisaged that at least 80% of 16-74 year olds will have basic digital skills and at least 20 million working people in EU countries will be ICT specialists (Path..., 2022). Given the specificity of digital technology, the realisation of these assumptions implies the need for a continuous update of the competency scopes, allowing to keep the strategies up to date and the educational assumptions adapted to them helping to create curriculum frameworks for all levels of education. The addition to the competency model proposed in the article can be seen as an expert voice to improve the expected scopes, which is how its application potential is understood.

4. Discussion

Digital technology has become an integral part of our lives, and this applies to all forms of life (Webb, 2019; Lee Kai-Fu, 2019; Śledziewska, Włoch, 2020; Osika, 2022a; Rogacka, 2022). Therefore, everyday life, both professional and private, requires members of society to have a high level of proficiency in using this technology. As is pointed out, it is the extent of our competence in this regard that builds our social status, hence the term digital capital (Rodriguez-Camacho et al., 2024), which consists of both knowledge and skills. The development of technology necessitates the acquisition of competences related to it and analyses concerning their optimal scope from the point of view of its application. In the case of digital competence, these analyses are carried out around the two key terms 'digital literacy' and 'digital competence', although some researchers treat them synonymously (Pangrazio et al., 2020). The term 'digital literacy', according to its etymology, is related to literacy and directs research attention to the proficient use of a particular medium in the communication process (Oxford Dictionary, 20.08.2024; Oxford Reference, 20.08.2024; OECD, 20.08.2024; Buckingham, 2007; Burke, 2008; Rintaningrum, 2009; Roodney, Hafner, 2012; Pilgrim, Martinez, 2013; Kamerer, 2013; Wilson et al., 2015; Potter, Mcdougall, 2017; Ptaszek, 2019; Ross et al., 2024). Within this research strand, critical analysis is also undertaken () and is currently trying to develop with new scopes such as 'data literacy' (Hinrichsen, Coombs, 2013; Maybee, Zilinski, 2015; Kleppman, 2017; Osika, 2021a, 2022a) or 'AI literacy'. The term 'digital literacy', according to its etymology, is related to literacy and directs research attention towards the proficient use of a specific medium in the communication process, hence its further elaboration on 'media literacy' or 'digital literacy', in relation to digital media. Within this

research strand, critical analysis is also undertaken (Glister, 1997, Kamerer, 2013; Pangrazio et al., 2020; Osika, 2021b; Ross et al., 2024) and is currently attempting to develop with new scopes such as ‘data literacy’ or ‘AI literacy’ (Long, Magerko, 2020; Hjorth, Chrysostomou, 2022; Knoth et al., 2024; Stolpe, Hallström, 2024). The second concept, which has a slightly broader meaning (Janssen et al., 2013; Fallon, 2020), is ‘digital competence’ in this case; the research carried out is concerned with the wider use of digital technology and the conditions that guarantee proficiency in this area. Three competency models are highlighted in this discussion, one of which was chosen for further analysis due to its more holistic approach (Plebańska, 2021; Kompetencje cyfrowe 4,0; DigComb 2.0 reference model; José Janssen, Slavi Stoyanov Anusca Ferrari, Yves Punie, Kees Pannekeet, Peter Sloep).

In the course of further research work, the Janssen et al. model has been extended to include meta-competences concerning the attitudes we should adopt towards the digital competencies we already possess. It seems that this addition will allow us to continuously update our competence base and maintain a high level of digital capital, in line with the digital technology ontology. Of course, theoretical analyses must be verified by empirical research, for example, in the form of pilot studies to test the solutions developed, in the opinion of experts or users themselves.

5. Conclusions

According to the assumptions made in the ‘Introduction’, as beings living in a world shaped by digital technologies in all its aspects, to function optimally in such an environment, we must have the competences needed to use them. This fact has been indisputable since the very beginning of the emergence and spread of digital technologies. Therefore, with their development, we began to ask questions about the scope of digital competences. Research in this area has focused on the two key concepts of ‘digital literacy’ and ‘digital competence’, the first directing analyses towards media competence and the latter toward a greater use of digital technologies in accordance with their full functionality.

In the present discussion, following a bibliometric analysis indicating a continuous growth of interest in this issue over the past decade, both key concepts and selected competence models were examined according to the research questions posed.

1. What competence scopes are currently indicated as digital competencies?
2. Can these competences be regarded as exhaustive of the competences necessary for effective use of digital technology?

In response to the questions, the three selected competence models are briefly described, one of which was chosen for further analysis and extended to a meta-level covering not so much the subject areas, but relating to the postures that foster competence development and,

at the same time, the building of digital capital, crucial from the point of view of shaping one's position and role in society. This strand should be considered as a contribution to research dedicated to this issue. The theoretical solutions developed were sketchy in nature and, as such, should be subjected to further analysis including empirical.

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LOGISTICS MODELS OF CRITICAL SITUATIONS, THEIR USE DURING WARFARE

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Purpose: The purpose of the research is to create models for applied information technology research of logistics processes of transporting goods and people during the period of the country's martial law.

Design/methodology/approach: To achieve the specified goal, the following tasks must be solved: creation of optimization models for planning the transportation of weapons and military equipment to the front line; creation of optimization models for planning the evacuation of the population to the rear. Research methods are based on optimization and simulation models, which allow planning and choosing rational ways of transporting goods and people in the conditions of martial law. Used mathematical methods and models: system analysis, methods of transport logistics, integer (Boolean) optimization, multi-criteria optimization, methods of expert evaluation. The subject of research is the models, methods and applied information technology of virtual distributed control of carriage transportation in conditions of threats.

Findings: In the work, a research of the logistics processes of transportation during the period of the country's martial law was carried out. Current areas of research related to the transportation of military cargo to the front line, as well as the evacuation of the population from the front-line zone to the rear, are separated. The main logistic indicators that must be used to evaluate transportation processes under the conditions of military threats have been formed (transportation time, transportation risks, transportation cost, the number of the population being evacuated). Optimization models have been created for choosing rational routes of transportation to the front line and to the rear. Local optimization of logistics indicators was carried out, taking into account limitations on the permissible time and risk of transportation. Multi-criteria models were created for finding compromise solutions for transportation logistics.

Originality/value: The scientific novelty of the research is related to the creation of a complex of original optimization models, which can be used to analyze and plan the logistics of transporting weapons and military equipment to the front and evacuating the population to the rear. The proposed approach is the basis for the creation of applied information technology for the planning of transportation logistics during the period of the country's martial law.

Keywords: model, logistic indicators, optimization, multi-criteria formulation of the optimization problem.

Category of the paper: Research paper.

1. Introduction

The state of war in the country forced to review the logistics processes of transportation (Алексієв, О., Алексієв, В., Неронов, 2023; Федорович, Гайдєнко, Пуїденко, 2017; Федорович, Западня, Іванов, 2016; Федорович та ін., 2023; Федорович та ін., 2022а; Федорович, Прончаков, 2020; Федорович, Сломчинський, Пуїденко, 2018; Федорович та ін., 2020; Федорович та ін., 2022b; Федорович та ін., 2022c). There are new areas in logistics that need to be explored for effective transportation planning in the face of military threats. Especially important are the directions of logistics, which are related to the transportation of weapons and military equipment (WME) to the front line and the transportation (evacuation) of the population to the rear from the front-line areas. Therefore, the topic of the proposed publication is relevant, in which optimization models are created for the rational choice of transportation routes under martial law conditions. The purpose of the research is to create models for applied information technology research of logistics processes of transporting goods and people during the period of the country's martial law. Tasks that are solved in the work:

- creation of optimization models for planning transportation of WME to the front line,
- creation of optimization models for planning the evacuation of the population to the rear.

2. Methods

Research methods are based on optimization and simulation models, which allow planning and choosing rational ways of transporting goods and people in the conditions of martial law. Used mathematical methods and models: system analysis, methods of transport logistics, integer (Boolean) optimization, multi-criteria optimization, methods of expert evaluation. The subject of research is the models, methods and applied information technology of virtual distributed control of carriage transportation in conditions of threats.

3. Results

3.1. Optimization model for planning transportation of weapons and military equipment to the front line

One of the urgent tasks, which is related to the implementation of effective operational and tactical actions on the battlefield, is the formation of the necessary reserves of weapons and military equipment (WME) for the front line. The front line includes actual military local zones (MLZ) in which active combat operations are conducted. It is necessary to form the necessary stocks of anti-terrorist weapons in the MLZ for conducting successful operational and tactical actions. Therefore, the task of finding relatively safe ways of supplying WME to the frontline in conditions of military threats is urgent. To solve the given problem, we will use the integer (Boolean) programming method. Let's enter a variable x_{ijk} :

$$x_{ijk} = \begin{cases} 1, & \text{if the } j\text{-th way of supplying WME to } i\text{-th MLZ with } k\text{-th warehouse} \\ & \text{of logistics components (transshipment, storage, distribution,} \\ & \text{temporary stop, etc);} \\ 0, & \text{otherwise.} \end{cases} \quad (1)$$

At the same time, it is necessary to: $\sum_{j=1}^{n_i} \sum_{k=1}^{m_j} x_{ijk} = 1$, which means the mandatory choice of specific way of supplying WME to i -th MLZ from k -th composition of logistics components, where N is the number of MLZ on the front line; m_j is the number of possible warehouses of logistics components per j -th way of supply; n_i is the number of possible ways of supplying military goods to i -th MLZ.

Let's introduce the main logistics indicators for evaluating and choosing a possible option for transporting MLZ to the front line:

1. R are the risks of supplying MLZ to the frontline, in conditions of military threats.
2. T is the time required for the supply of MLZ to the front line.
3. W are the stockpiles of weapons, which are formed on the front lines to fulfill the actual operational and tactical tasks of the military leadership.

Let's present the indicators R , T , W taking into account the variables x_{ijk} :

$$R = \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} r_{ijk} x_{ijk} , \quad (2)$$

where r_{ijk} is the risk of delivering military cargo to i -th MLZ on j -th way of supply from k -th composition of logistics components.

$$T = \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} t_{ijk} x_{ijk}, \quad (3)$$

where t_{ijk} is the time required for the transportation of military cargo to i -th MLZ for j -th way with k -th possible composition of logistics components.

$$W = \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} w_{ijk} x_{ijk}, \quad (4)$$

where w_{ijk} is the number of batches of WME that can be moved by j -th possible way of delivery from k -th composition of logistics components to i -th MLZ.

We will create optimization models for solving the task of forming WME stocks on the front line for effective combat operations on the battlefield.

1. Minimization of the risks of the formation of WME stocks in the conditions of the actions of military threats:

$$\min R, \quad R = \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} r_{ijk} x_{ijk}, \quad (5)$$

while fulfilling the restrictions:

$$T \leq T^*, \quad T = \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} t_{ijk} x_{ijk}, \quad (6)$$

where T^* is the permissible (planned) time of delivery of WME to the front line.

$$W \geq W^*, \quad W = \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} w_{ijk} x_{ijk}, \quad (7)$$

where W^* is a stockpile of anti-aircraft weapons, which must be formed to fulfill the actual operational and tactical tasks of the military leadership.

2. Maximization of WME stocks on the front line for successful combat operations:

$$\max W, \quad W = \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} w_{ijk} x_{ijk}, \quad (8)$$

while fulfilling the restrictions:

$$R \leq R^*, \quad R = \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} r_{ijk} x_{ijk}, \quad (9)$$

where R^* is the acceptable risk of the supply of WME in the conditions of the actions of military threats.

$$T \leq T^*, \quad T = \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} t_{ijk} x_{ijk}. \quad (10)$$

It is possible to formulate a multi-criteria optimization problem using indicators R , T , W .

In this case, it is necessary to form a complex indicator:

$$K = \alpha_R \overset{\vee}{R} + \alpha_T \overset{\vee}{T} + \alpha_W \overset{\vee}{W}, \quad (11)$$

where α_R , α_T , α_W , are the "weights" of indicators R , T , W , $\alpha_R + \alpha_T + \alpha_W = 1$.

$\overset{\vee}{R}$ is a normalized indicator R :

$$\overset{\vee}{R} = \alpha_R \frac{R - R_{\min}}{R^* - R_{\min}}, \quad (12)$$

where R_{\min} is the minimum value of the indicator R after its optimization.

$\overset{\vee}{T}$ is the standardized indicator of delivery time:

$$\overset{\vee}{T} = \alpha_T \frac{T - T_{\min}}{T^* - T_{\min}}, \quad (13)$$

where T_{\min} is the minimum time value T after its optimization.

$\overset{\vee}{W}$ is a normalized indicator W :

$$\overset{\vee}{W} = \alpha_W \frac{W_{\max} - W}{W_{\max} - W^*}, \quad (14)$$

where W_{\max} is the maximum value of the WME stock after its optimization.

It is necessary to find:

$$\begin{aligned} \min K &= \alpha_R \overset{\vee}{R} + \alpha_T \overset{\vee}{T} + \alpha_W \overset{\vee}{W} = \alpha_R \frac{R - R_{\min}}{R^* - R_{\min}} + \alpha_T \frac{T - T_{\min}}{T^* - T_{\min}} + \alpha_W \frac{W_{\max} - W}{W_{\max} - W^*} = \\ &= \frac{\alpha_R}{R^* - R_{\min}} \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} r_{ijk} x_{ijk} + \frac{\alpha_T}{T^* - T_{\min}} \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} t_{ijk} x_{ijk} - \frac{\alpha_W}{W_{\max} - W^*} \sum_{i=1}^N \sum_{j=1}^{n_i} \sum_{k=1}^{m_j} w_{ijk} x_{ijk} - \\ &- \frac{\alpha_R R_{\min}}{R^* - R_{\min}} - \frac{\alpha_T T_{\min}}{T^* - T_{\min}} + \frac{\alpha_W W_{\max}}{W_{\max} - W^*}. \end{aligned} \quad (15)$$

3.2. Optimization models for planning evacuation transportation to the rear

The modern war led to the evacuation of the population from the front-line zone to the rear. Migration processes have arisen, for which it is necessary to create logistical evacuation chains. Therefore, the study of evacuation flows is relevant to assess the ability of the transport network to carry out the planned transportation of people to temporary places of residence (TMR). While planning evacuation processes, it is necessary to form a set of places (M), which are capable of receiving the population, with their capabilities to meet social needs. Then, it is necessary to form ways of transporting people, in conditions of risks (R) military threats, estimate the cost (W) and plan time (T) evacuation. Let's create an optimization model, which can be used to

determine rational ways of evacuating the population (F) from the front-line zone to possible places of temporary residence in the conditions of the country's martial law. Let's enter an integer (Boolean) variable x_{plk} :

$$x_{plk} = \begin{cases} 1, & \text{if the transportation of people to the } p\text{-th place of residence will be carried out} \\ & \text{using the } l\text{-th transportation route with the } k\text{-th warehouse of logistics} \\ & \text{components (temporary stop, transition from one route to another, distribution of} \\ & \text{evacuation flows, etc.);} \\ 0, & \text{otherwise.} \end{cases} \quad (16)$$

As the main logistical indicators of the evacuation process, we will consider:

1. The time required to evacuate people (T).
2. The cost of the population evacuation process (W).
3. Risks of military threats (R).
4. Number of population to be evacuated (F).

Taking into account the variables x_{plk} , the logistic indicators of population evacuation are as follows:

$$T = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} t_{plk} x_{plk}, \quad (17)$$

where m_p is the number of possible ways to evacuate the population to p -th place TMR; n_l is the number of possible warehouses of logistics components for their use on l -th way of transportation; t_{plk} is the time required to move people to p -th place of the TMR taking into account l -th selected evacuation route and k -th composition of logistics components.

$$W = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} w_{plk} x_{plk}, \quad (18)$$

where w_{plk} is the cost of transporting people to p -th possible place of TMR, taking into account the chosen one l -th way of transportation and k -th composition of logistics components.

$$R = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} r_{plk} x_{plk}, \quad (19)$$

where r_{plk} is the risk of transporting people, in conditions of military threats, in p -th possible place of TMR taking into account the chosen one l -th way of transportation and k -th composition of logistics components.

$$F = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} f_{plk} x_{plk}, \quad (20)$$

where f_{plk} is the number of the population that will be directed to p -th place of the TMR taking into account the chosen one l -th way of transportation and k -th composition of logistics components.

The following formulations of the optimization problem are possible, which are related to the evacuation of the population to the rear:

1. Minimize the time required to evacuate the population:

$$\min T, T = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} t_{plk} x_{plk}, \quad (21)$$

taking into account the limitations:

$$W \leq W^*, W = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} w_{plk} x_{plk}, \quad (22)$$

$$R \leq R^*, R = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} r_{plk} x_{plk}, \quad (23)$$

$$F \geq F^*, F = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} f_{plk} x_{plk}, \quad (24)$$

where:

W^* is the planned cost of the population evacuation process;

R^* is the permissible risk of the evacuation process, which is associated with possible actions of military threats;

F^* is the planned number of the population that will be evacuated from the front-line zone to the rear.

2. To maximize the number of the population that will be evacuated from the front-line zone to the rear:

$$\max F, F = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} f_{plk} x_{plk}, \quad (25)$$

taking into account the limitations:

$$T \leq T^*, T = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} t_{plk} x_{plk}, \quad (26)$$

$$W \leq W^*, W = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} w_{plk} x_{plk}, \quad (27)$$

$$R \leq R^*, R = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} r_{plk} x_{plk}, \quad (28)$$

where T^* is the planned time for population evacuation.

3. Minimize the risks of population evacuation:

$$\min R, R = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} r_{plk} x_{plk}, \quad (29)$$

taking into account the limitations:

$$T \leq T^*, T = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} t_{plk} x_{plk}, \quad (30)$$

$$W \leq W^*, W = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} w_{plk} x_{plk}, \quad (31)$$

$$F \geq F^*, F = \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} f_{plk} x_{plk}. \quad (32)$$

A multi-criteria formulation of the population evacuation optimization problem is possible. To do this, we will introduce a complex criterion in the form of an additive composition of logistic indicators T, W, R, F :

$$Q = \alpha_T \overset{\vee}{T} + \alpha_W \overset{\vee}{W} + \alpha_R \overset{\vee}{R} + \alpha_F \overset{\vee}{F}, \quad (33)$$

where:

$\alpha_T, \alpha_W, \alpha_R, \alpha_F$ are the "weights" of indicators T, W, R, F , $\alpha_T + \alpha_W + \alpha_R + \alpha_F = 1$;

$\overset{\vee}{T}, \overset{\vee}{W}, \overset{\vee}{R}, \overset{\vee}{F}$ are the normalized values of indicators T, W, R, F :

$$\overset{\vee}{T} = \frac{T - T_{\min}}{T^* - T_{\min}}, \quad (34)$$

$$\overset{\vee}{W} = \frac{W - W_{\min}}{W^* - W_{\min}}, \quad (35)$$

$$\overset{\vee}{R} = \frac{R - R_{\min}}{R^* - R_{\min}}, \quad (36)$$

$$\overset{\vee}{F} = \frac{F_{\max} - F}{F_{\max} - F^*}. \quad (37)$$

It is necessary to minimize the complex criterion Q :

$$\begin{aligned} \min Q, Q = \alpha_T \overset{\vee}{T} + \alpha_W \overset{\vee}{W} + \alpha_R \overset{\vee}{R} + \alpha_F \overset{\vee}{F} = & \frac{\alpha_T}{T^* - T_{\min}} \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} t_{plk} x_{plk} + \\ & + \frac{\alpha_W}{W^* - W_{\min}} \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} w_{plk} x_{plk} + \frac{\alpha_R}{R^* - R_{\min}} \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} r_{plk} x_{plk} - \frac{\alpha_F}{F_{\max} - F^*} \sum_{p=1}^M \sum_{l=1}^{m_p} \sum_{k=1}^{n_l} f_{plk} x_{plk} - \\ & - \frac{\alpha_T T_{\min}}{T^* - T_{\min}} - \frac{\alpha_W W_{\min}}{W^* - W_{\min}} - \frac{\alpha_R R_{\min}}{R^* - R_{\min}} + \frac{\alpha_F F_{\max}}{F_{\max} - F^*}, \end{aligned} \quad (38)$$

where T_{\min} , W_{\min} , R_{\min} , F_{\max} are the extreme values of indicators after their optimization.

3.3. Optimization models for taking preventive measures against the influence of military threats during the transportation of goods and people

The outdated transport infrastructure has a large number of vulnerabilities that affect the disruption of the transportation of goods and people, especially during the period of martial law, under the conditions of military threats.

The following main existing vulnerabilities can be identified:

- physical and moral aging of components of the transport network (bridges, intersections, viaducts, highways, etc.),
- bottlenecks that lead to the accumulation of goods and people (transport queues, temporary stops, redistribution according to transportation directions, etc.),
- places where climatic phenomena occur more often (flooding, mud avalanches, soil disturbances, etc.).

During the period of martial law, the country may become vulnerable due to possible actions of military threats (arrivals of missiles, drone attacks, bombings, etc.), which leads to disruptions in transportation, occurrence of emergency situations, disasters with loss of life.

Therefore, the topic of the proposed research is relevant, in which the influence of military threats on the vulnerability of the transport infrastructure, which is used for transportation to the front and to the rear in the period of the country's martial law, is simulated.

The purpose of the research is to create models for assessing the impact of military threats on the vulnerability of transport infrastructure (TI), for the formation of preventive actions aimed at reducing the risks of the impact of threats on planned transportation both to the front and to the rear.

To research the influence of military threats on IT, we will form a chain of sequence of actions in the form of: modeling the emergence of a military threat \rightarrow excitation of possible vulnerabilities \rightarrow modeling of the scale of TI violations in the form of damages (material and human) \rightarrow formation of a set of preventive actions to reduce or neutralize the effects of military threats.

A set of preventive actions (M) depends on: the scale of violations; losses (P), which arise; from military threats (V); set of vulnerabilities that are excited (W). To assess the effect of military threats, we will form a set of indicators:

1. The risks of military threats – R ,
2. Expenses for the elimination of possible losses from the action of military threats – Z ,
3. The time required to carry out preventive measures to minimize or neutralize the actions of military threats – T .

We will use integer (Boolean) programming to simulate the impact of military threats on IT. Let's enter a Boolean variable x_{epk} :

$$x_{epk} = \begin{cases} 1, & \text{if the occurrence of the } e\text{-th threat triggers the } p\text{-th set of TI vulnerabilities,} \\ & \text{for which it is necessary to form the } k\text{-th set of preventive actions;} \\ 0, & \text{otherwise.} \end{cases} \quad (39)$$

Then, taking into account the variables x_{epk} indicators R, Z, T have the form:

$$R = \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} r_{epk} x_{epk}, \quad (40)$$

where:

V is the number of possible threats;

r_{epk} is the risk of e -th military threat, which excites p -th composition of vulnerabilities that lead to use k -th composition of necessary preventive actions;

n_p is a set of preventive actions for neutralization p -th composition of vulnerabilities;

m_e is a set of possible compositions of vulnerabilities that can be excited upon occurrence threats.

$$Z = \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} z_{epk} x_{epk}, \quad (41)$$

where z_{epk} are the costs of carrying out k -th component of preventive actions to eliminate possible damages that occur during excitation p -th composition of vulnerabilities from the action of e -th threats.

$$T = \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} t_{epk} x_{epk}, \quad (42)$$

where t_{epk} is the time required for implementation k -th composition of preventive measures necessary to eliminate possible damages that occur during excitation p -th composition of e -th threats.

In the conditions of the state of war in the country, it is extremely necessary to minimize the time (T) to carry out preventive actions regarding the possible influence of military threats on transportation both to the front and to the rear. Therefore, it is necessary:

$$\min T, T = \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} t_{epk} x_{epk}, \quad (43)$$

taking into account the limitations:

$$Z \leq Z^*, Z = \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} t_{epk} x_{epk}. \quad (44)$$

Acceptable risks to prevent military threats:

$$R \geq R^*, R = \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} t_{epk} x_{epk}, \quad (45)$$

where R^* is the assessment by experts of risks for the emergence of military threats to IT.

In conditions of limited capabilities of the country, it is necessary to minimize costs Z to carry out preventive measures against possible actions of military threats.

In this case, it is necessary:

$$\min Z, Z = \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} z_{epk} x_{epk}, \quad (46)$$

taking into account the limitations:

$$T \leq T^*, T = \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} t_{epk} x_{epk}, \quad (47)$$

where T^* is the planned time of the risks of preventing military threats for the implementation of preventive measures against the possible impact of military threats.

$$R \geq R^*, R = \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} t_{epk} x_{epk}. \quad (48)$$

A multi-criteria formulation of the task of planning preventive actions to the influence of possible military threats is possible.

Let's introduce a complex indicator Q :

$$Q = \alpha_R \cdot \check{R} + \alpha_z \cdot \check{Z} + \alpha_T \cdot \check{T}, \quad (49)$$

where $\alpha_R, \alpha_z, \alpha_T$ are the "weights" of indicators R, Z, T ; $\check{R}, \check{Z}, \check{T}$ are the values of indicators R, Z, T :

$$\overset{\vee}{R} = \frac{R - R^*}{R_{\max} - R^*}, \quad (50)$$

where R_{\max} is the experts' pessimistic assessment of the risk of military threats affecting IT.

$$\overset{\vee}{Z} = \frac{Z - Z_{\min}}{Z^* - Z_{\min}}, \quad (51)$$

$$\overset{\vee}{T} = \frac{T - T_{\min}}{T^* - T_{\min}}. \quad (52)$$

It is necessary to minimize the complex indicator (Q) to find a compromise solution among indicators R, Z, T :

$$\begin{aligned} \min Q, Q = & \alpha_R \cdot \overset{\vee}{R} + \alpha_z \cdot \overset{\vee}{Z} + \alpha_T \cdot \overset{\vee}{T} = \frac{\alpha_R}{R_{\max} - R^*} \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} r_{epk} x_{epk} + \\ & + \frac{\alpha_z}{Z^* - Z_{\min}} \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} t_{epk} x_{epk} + \frac{\alpha_T}{T^* - T_{\min}} \sum_{e=1}^v \sum_{p=1}^{m_e} \sum_{k=1}^{n_p} t_{epk} x_{epk} - \frac{\alpha_R \cdot R^*}{R_{\max} - R^*} - \frac{\alpha_z \cdot Z_{\min}}{Z^* - Z_{\min}} - \\ & - \frac{\alpha_T \cdot T_{\min}}{T^* - T_{\min}}. \end{aligned} \quad (53)$$

4. Summary

In the work, a research of the logistics processes of transportation during the period of the country's martial law was carried out. Current areas of research related to the transportation of military cargo to the front line, as well as the evacuation of the population from the front-line zone to the rear, are separated. The main logistic indicators that must be used to evaluate transportation processes under the conditions of military threats have been formed (transportation time, transportation risks, transportation cost, the number of the population being evacuated). Optimization models have been created for choosing rational routes of transportation to the front line and to the rear. Local optimization of logistics indicators was carried out, taking into account limitations on the permissible time and risk of transportation. Multi-criteria models were created for finding compromise solutions for transportation logistics.

Used mathematical methods and models: system analysis, methods of transport logistics, integer (Boolean) optimization, multi-criteria optimization, methods of expert evaluation.

The scientific novelty of the research is related to the creation of a complex of original optimization models, which can be used to analyze and plan the logistics of transporting weapons and military equipment to the front and evacuating the population to the rear.

The proposed approach is the basis for the creation of applied information technology for the planning of transportation logistics both to the front and to the rear, taking into account possible military threats, during the period of the country's martial law.

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IMPACTS OF CONTEMPORARY CRISES ON THE EU ECONOMY: RETHINKING OUR APPROACH TO POLICYMAKING

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Purpose: This paper analyzes the economic impacts of different significant economic crises on the EU (European Union) economy. We will use the 2008 financial crisis, the COVID-19 pandemic, and the Russia-Ukraine War. We will also mention how some specific policies, such as green or migration policies, can complicate the management of the negative/harmful impacts on the EU economy. We advocate for a holistic approach to economic policies that prioritizes resilience and stability to foster a more prosperous economic environment. The top priority of EU policymakers should be avoiding severe socio-economic consequences that would hinder potential future focus on implementing green policies or rational migration quotas without shifting the focus from the priority of stabilizing the economy.

Design/methodology/approach: We use academic articles and official documents regarding the impacts of crises on the EU economy. We analyze the negative/harmful effects (short-term or long-term) and focus on contemporary studies because they provide us with the most recent data.

Findings: Analysis has shown us that many negative/harmful effects of recent crises are similar in nature and often expand as new crises emerge. We must be cautious while adopting long-term policies (green policies, migration policies, etc.) as they can be controversial for the most vulnerable countries hit by the ongoing crisis.

Research limitations/implications: Many of the effects of contemporary economic crises are still unknown because they have occurred in the last two decades. Our research mainly suggests some of the currently known effects and challenges we are facing.

Social implications: The paper is helpful for organizations and institutions that are focusing on economic analysis and could be useful as an inspiration for adopting future national and international policies.

Originality/value: The study focuses on compiling recent data and studies that demonstrate similarities between different economic crises we have faced in the EU.

Keywords: economy – crises – EU (European Union) – policy.

Category of the paper: Research paper (political philosophy/economy).

Introduction

In the last couple of years, we have experienced many changes in our world—the impact of modern technology on our culture, individuals, politics, and culture. We can observe how economics has changed with modern technology, as we can conduct business more efficiently, manage our finances, or promote financial independence from traditional forms of employment. We have lived through different conflicts, wars, cultural clashes, migration issues, global warming, and other global-impacting events. Our modern world is deeply interconnected as various regions of the world produce different commodities or specialize in different services, which all impact the global economy.

Our primary analysis method will consist of various academic sources (economic and financial studies) and official documents (especially from the European Union) that demonstrate how different forms of aforementioned crises impacted the society, especially economic and financial stability, ergo inflation, unemployment, and similar factors. This form of analysis should give us a more comprehensive overview of the expected impacts of the big crises that have occurred in the last 20 years, especially given that our modern society has changed and is changing so drastically. We will create a coherent explanation of how to use past mistakes, impacts, and consequences to mitigate future crises more effectively and without causing so many long-term harmful impacts. It is impossible to claim that one approach would identify all the possible situations, outcomes, and effects; nevertheless, by creating a comprehensive and coherent analysis of different crises and their impacts through thorough academic studies and official documents (especially from institutions working with financial and economic topics), we can prevent future policies from failing on the same mistakes.

As we can conclude from just a few examples mentioned above, economic and financial stability are very sensitive areas when even the most minor changes in the global world, whether related to the material, environmental, cultural, or political sphere, can significantly impact prices with high inflation, high unemployment rate, slow GDP growth, or investments.

The Global Financial Crisis of 2008: lasting consequences and implications

This section will analyze the similar economic factors that were most present during the aforementioned crises. From our short analysis of various sources, studies done by international institutions, and multiple academics, it is clear that several were present, such as significant global economic disruption, halting growth, or regional inequalities. Supply chains were severely disrupted, leading to shortages and delays in goods. Inflation surged in the wake of each crisis, driven by supply constraints and increased government spending.

Response by governments and central banks intervened with measures such as stimulus packages, monetary easing, and subsidies. These crises exacerbated economic inequality, as vulnerable populations and small businesses bore the brunt of the impact. Geopolitical and social uncertainties heightened, with conflicts straining global stability. Additionally, energy markets experienced extreme volatility, and rising debt levels became a common challenge. This is also related to the issue of new green policies and regulations that drastically impact the energy sectors, causing new challenges that often come in the wrong period, especially during more significant crises. Financial markets saw heightened volatility, and the risk of recession increased, reflecting these global disruptions' profound and far-reaching effects.

In a study from 2012, written by Atanas Kolev for the European Investment Bank, called “The impact of the recession in 2008-2009 on EU regional convergence”, Kolev argued that the EU regional convergence was slowing down and different factors during the big crises impacted the regional inequalities between different economies. He also argues that data shows that before 2007, the EU economies were closer to their level than before the big financial crises (Kolev, 2012, pp. 1-4). According to Kolev's research, the economic downturn of 2008 and 2009 had an effect on the European Union's aim to enhance cohesion among economies, leading to the need for new policies to assist and finance the most severely affected countries.

Similarly, in another study related to the 2008 financial crisis¹, the authors argue that one of the most significant impacts of the crisis on the EU economy was the regional disparities and stunts in developing EU countries. Authors argue that poorer and remote regions were particularly affected by the global financial crises, especially with intermediate effects compared to rural regions close to cities, which showed greater resilience at the beginning of the crises. Even though it seems like rural regions and major cities were less impacted initially, later development showed that they were also heavily impacted by the global economic crises (Dijkstra, Garcilazo, McCann, 2015, pp. 939-948). In another study called “A decade on from the crisis: Main responses and remaining challenges”, the author argues that the main economic impact was a collapse in growth, massive job losses, a decline in investments, or increased public debt. It took a lot of time for the EU economy to start to recover from the pre-crisis conditions (Szczepański, 2019, pp. 1-2). Many challenges remained after the crises, especially with the lack of deeper collaboration within the EU and its future with the Economic and Monetary Union (Szczepański, 2019, pp. 2-5). There is also the issue that some of the countries are still more in debt than others and clearly show signs of battling with the impacts of the global financial crises (Szczepański, 2019, pp. 2-5). These authors illustrated how deep the 2008 financial crisis was. In our case of the EU, it was taxing on regional inequalities, severe impacts on already poorer regions, job losses, decline in investments, or increase in public debt. In the next section, we will analyze how the COVID-19 pandemic impacted the economic development in the EU and observe if the challenges are similar to those of the 2008 financial crisis.

¹ For more studies about the impact of the global financial crisis on the EU and its economy, see Belka, 2009.

The effects of the COVID-19 pandemic on the EU economy:

The article “The Covid-19 Crisis: The EU Recovery Fund and its Implications for European Integration – a Paradigm Shift” by Chih-Mei Luo highlights how the EU started to focus more on integration and stricter economic policies instead of relying on neoliberal principles. He summarizes the impacts of COVID-19 on the EU economy: “COVID-19 hit the EU at a precarious time for its health and social policies – the legacies of the EU’s economic governance in the post-euro crisis years. The interplay between political leadership, damaged health systems and precarious labour markets helped form the ‘patient zero of the coronavirus’ in the EU’s centres of infection – Italy and Spain. Necessities for game-changing in the ideology and methodology of the post-COVID-19 EU economic governance became justified on grounds that reflected both practical pressures and moral obligations. Judging by these yardsticks, the EU’s policy responses, the revolutionary recovery fund, echoed preferences outlined by this paper in terms of policy direction, focuses and methods. It was evaluated as a welcomed paradigm shift in the EU’s economic governance, from the long-held neo-liberalist orthodoxy emphasizing supply-side reforms to the investment-driven, demand-side management“ (Luo, 2021, p. 14). Luo’s analysis depicts that the EU before relied on less direct policies that would try to mitigate the impacts of the crisis and implemented new mechanisms that tried to lessen the pandemic's negative effects.

Luo, in his article, concludes, "Only through precise policy implementations can the correct policymaking be felt and conveyed. If well implemented, the recovery fund would usher in a new chapter of European integration and re-polish European values by promoting the well-being of ordinary Europeans. Conversely, poor implementation would risk further fragmentation of European integration, leading to ever-stronger anti-EU populism” (Luo, 2021, p. 15). Similarly to our position, it is critical to adopt new policies with a more holistic approach that would consider our past experiences with the effects of previous economic crises.

Authors Maarten Verwey and Allen Monks argue that “The COVID-19 pandemic resulted in an unprecedented economic contraction in 2020, with EU real GDP falling by 6.1%, more than during the global financial crisis“ (Verwey, Monks, 2021, para. 2). They argue that long-term structural challenges remain, most of these also pre-date the pandemic, such as aging population, weak productivity growth, climate change, income, and wealth inequality, or territorial disparities within Member States (Verwey, Monks, 2021, para. 6). They continue and argue that pandemic added other pressing problems such as lack of investments, damage to the public finances, or increase to the number of pre-existing vulnerabilities. They say, „Internal imbalances related to high government and private debt have increased, driven by the recession and measures taken to address the COVID-19 crisis. Pre-pandemic dynamic house price trends persisted and mortgage debt continued to grow significantly in some countries. Current account deficits widened in countries dependent on tourism revenues and the correction of current

account surpluses has stalled. Moving forward, new risks may emerge as a result of structural transformations accelerated by the COVID-19 crisis“ (Verwey, Monks, 2021, para. 9). As we can observe, numerous economic issues existed before the COVID-19 pandemic, many still lingering after the global financial crisis of 2008. As we have said before, we must adopt a more holistic approach (considering the wider picture of the EU economy) to create policies that consider possible long-lasting negative effects and avoid unnecessary short-term burdens on the poorest, small businesses, or other vulnerable groups.

In a document created by the World Bank called “World Development Report 2022”, they argue, “The economic impact of the pandemic has been highly unequal within and between countries. As the COVID-19 crisis unfolded in 2020, it became clear that many households and firms were ill-prepared to withstand an income shock of the length and scale of the pandemic. In 2020, more than 50 percent of households globally were not able to sustain basic consumption for more than three months in the event of income losses (World Bank, 2022, p. 5). They continue and claim that the crisis clearly impacted more disadvantaged groups in emerging and advanced economies (World Bank, 2022, p. 5). Smaller businesses were also impacted, as the report states, “Smaller firms, informal businesses, and those with more limited access to the formal credit market were harder-hit by income losses stemming from the pandemic. Larger firms entered the crisis with the ability to cover expenses for up to 65 days, compared with 59 days for medium-size firms and 53 and 50 days for small firms and microenterprises, respectively” (World Bank, 2022, p. 5) There are studies² that point out similar problems and impacts of the COVID-19 pandemic on the EU economy and its citizens. For our purposes, this illustration of the negative/harmful effects of COVID-19 on the economy is sufficient as it demonstrates many similar effects on the EU economy as the 2008 financial crisis did.

Impact of Russia’s invasion of Ukraine on the EU economy:

Russia’s invasion of Ukraine is a very sensitive topic, as there are many different factors to consider while discussing any future economic policies. Many experts agree that our dependence on Russia’s fossil fuels is making it more difficult to provide support to Ukraine. There are also other factors to consider while discussing possible economic independence. For instance, experts on this topic argue that “A large share of energy-intensive manufacturing and a strong import dependency on Russian energy reduce the room for adjustment and make

² The Economic Bulletin published by the European Central Bank also analyzes the economic impacts of the COVID-19 pandemic. The authors argue that the pandemic was a great shock to the already wounded economy. They warn against the long-term effects as most people and businesses are unprepared for this new threat. The authors also warn that we must look at past crises to better understand possible long-term effects (Martín Fuentes, Moder, 2021).

the risk of a prolonged recession greater. Diversification of energy sources and composition, in particular renewables, will only work in the medium term. Equally serious is dependence on Russian and Ukrainian key raw materials and intermediate goods (e.g. iron, cereals, fertilisers): The risks of bottlenecks and supply restrictions feed sector-specific inflationary shocks, which are easily transmitted to the whole economy” (Celi, Guarascio, Reljic, Simonazzi, Zezza, 2022, pp. 141-142). They continue their argumentation and add that “Russia’s invasion of Ukraine, and the consequent sanctions, have unleashed supply and demand shocks, slashing growth, fueling inflation and raising new challenges for the EU’s fiscal and monetary³ policy. The member countries more dependent on fossil fuels are going to suffer more – which explains their opposition to including oil and gas in sanctions. These economies are the EU’s “manufacturing heart”, therefore their hardships will be inevitably passed on, in varying degrees, to the whole Union” (Celi, Guarascio, Reljic, Simonazzi, Zezza, 2022, p. 146). As we can observe, again, there are similar negative effects on the economy as during the 2008 financial crisis and the COVID-19 pandemic. Energy prices will increase as a result of a shortage of fossil fuels or changes in distribution, which will increase the price. This will most likely negatively impact the people and small businesses in the poorest regions.

Other experts also agree on the severity of the consequences for the EU economy, “the economic and financial consequences for Europe will be profound. The economies of Russia and Ukraine will suffer by far the most. Ukraine’s economy will shrink badly, a large part of its infrastructure will be destroyed, and millions of people are leaving the country. Russia will suffer a major recession and a sharp increase in inflation, and there will be a severe drop in living standards. The rest of Europe, and especially the countries of CESEE, experience significantly higher inflation and some financial contagion. The inflationary impact across the EU will furthermore depend on the willingness (or otherwise) to cut off oil and gas imports from Russia. If that happens, EU growth would suffer significantly” (Astrov et al., 2022, p. 378). As was the case with other crises, the impact on inflation, financial stability, or market economy is significantly and unevenly felt within EU countries. We, therefore, need to adopt solutions and policies that would understand the regional differences in the EU without punishing the vulnerable, who are often left out when designing contemporary solutions. Similarly, this official document from the European Investment Bank claims that “Inflation triggered by the war could reduce real private consumption in the European Union by 1.1%, although the impact will vary across countries. The impact will be felt more in countries where consumption is more sensitive to energy and food prices and where a relatively large share of the population is at risk of poverty. Countries in Central and South-Eastern Europe tend to be more affected. The increase in food and energy prices will hit low-income households disproportionately, but to varying extents across EU Member States. Lower-income households

³ For more information see the textbook *Economics of Monetary Union* (2022) provides insight into the challenges of monetary union within Eurozone. Textbook makes it easier to understand the institutional and economic aspects of different types of crises, placing special emphasis on European integration.

in the richer countries of Northern and Western Europe are better able to absorb the price rise than households in Central and South-Eastern Europe, largely because savings rates and incomes overall tend to be higher” (European Investment Bank, 2022, para. 5-6). They also point out that certain recommendation after experiencing the COVID-19 pandemic. “During the COVID-19 crisis, policy measures were key in keeping poverty at bay. In the current crisis, policies need to be deployed to reduce risks for vulnerable households and to maintain social inclusion” (European Investment Bank, 2022, para. 7) We should be careful when creating future economic or social policies without the EU. We have learned from the past that many harmful effects can be lessened by adopting policies that would directly target the specific negative effects⁴ (inflation, unemployment, regional inequalities, poverty, etc.).

Economic crises and their influence on migration and green policy:

In this final section, we will briefly discuss how future policies can clash with the negative impacts of contemporary crises. We have chosen migration and green policies as different parties often regard them as problematic for many reasons. For instance, there would be more burdens on some countries with migration support or certain countries having more industry in their economy, which green policies would impact. In the article “The green economy transition: the challenges of technological change for sustainability” by Patrik Söderholm, the author warns us in his conclusion that we need to be careful while devising any policies regarding the green economy as there are many undiscovered challenges that have multifaceted character. We need to have an interdisciplinary approach that would consider different factors and scenarios without endangering the future implementation of green policies (Söderholm, 2020, pp. 9-11).

Other experts warn us that green policies need to be implemented in a serious manner to avoid causing damage to the poorer regions. For instance, authors Andrés Rodríguez-Pose and Federico Bartalucci argue that “The territorial impact of the green transition is bound to be uneven from a geographical perspective. Some regions are more exposed than others to the major shifts prompted by the European Green Deal. In many of these more vulnerable regions, the green transition vulnerability falls on top of other, pre-existing, cleavages that are at the root of social and political discontent. Many economically left-behind regions could be further left behind by both the effects of climate change and the measures to combat it. Regions with a high level of carbon emissions from fossil fuels and high reliance on transitioning sectors,

⁴ For further reading on the COVID-19 pandemic and economic crises, see *Mitigating the COVID Economic Crisis: Act Fast and Do Whatever It Takes* (2020), as the book provides a critical analysis of the implications of the COVID-19 pandemic on global and European economic stability, offering valuable lessons on crisis management and policy responses.

such as road transportation, heavy industry, tourism and agriculture, are far more vulnerable to the green transition” (Rodríguez-Pose, Bartalucci, 2024, p. 354). As we can observe, the market economy is very sensitive to drastic changes without providing sufficient support to transform the economy. The authors argue that the negative impacts⁵ can be seen in the poorest and most vulnerable regions with heavy reliance on fossil fuels or industry.

We will briefly mention the migration quotas as this topic is more of a political discussion than solely an economic issue. However, even such pressing political matters can have dire consequences on the stability of the EU economy, given that the countries have opposing views on handling the migration issue. For instance, expert Klaus F. Zimmermann argues that “Driven by questions raised about the economic consequences of migration, the research community has provided a number of insights which are important for policy-making. Among those are that Germany has long been a country of immigration and could do so much better by means of improved management through well-considered immigration legislation. Public debates often focus on the inflow of people and ignore the large outflow of migrants. Effective flexibility of labor increases the economy's output and people's welfare. Restricting free labor mobility may force people to stay and bring family members, which is against what policies were intended to achieve. More migrants in jobs can increase the employment of natives when they act as complements and not as substitutes. There is also no convincing evidence that migrants overly exploit the welfare state. Hiring economic migrants and finding jobs for asylum seekers help to reduce tensions in the native population and strengthen the chances for successful economic integration” (Zimmermann, 2019, p. 122). Similar arguments are present in a publication by the International Monetary Fund, “The Refugee Surge in Europe: Economic Challenges”, authors argue that we should take inspiration from international past experiences regarding migration and what we should anticipate for the economic dimension. They also warn that migration⁶ can have a negative effect on the GDP per capita if the refugee workers are not properly integrated into society. Authors emphasize that by doing so, the impact on the economy and social expenses would be reduced as the refugees would be able to partake more actively in the market economy (Aiyar et al., 2016, pp. 32-33). For our analysis, it is crucial to note that implementation is a key factor here. The impact of these controversial topics rests on exemplary implementation. We are advocating for a more cohesive and holistic approach that would look at the complex situation in the EU economy and implement policies that would prevent poorer regions from becoming more poor, vulnerable from becoming more vulnerable, and stop profound regional differences.

⁵ For more on the impacts of the green transition on the EU and its labor market, see Vandeplass, A., Vanyolos, I., Vigani, Vogel, 2022. The possible implications of the green transition for the EU labor market. The authors in this study created a detailed analysis of how to carefully implement the green transition without causing too many severe implications on the labor market.

⁶ For more information about migration trends, see Czaika, de Haas (2014) as they analyze global migration patterns from 1960 to 2000. They challenge the notion of a universally increasing volume, diversity and geographical scope of migration and highlight the directional shifts in migration.

Conclusion⁷

We have demonstrated that the three crises (the 2008 financial crisis, the COVID-19 pandemic, and the Russia-Ukraine war) have similar adverse economic effects and challenges. We have shown that regional inequalities, inflation, higher unemployment, and an increase in debt (and more) are all present through the different economic crises. Each crisis adds new challenges that require mitigation in the long term. We also debated controversial or hard-to-agree policies, such as migration or green policy, which often cause huge debates at the EU and national levels. To avoid further damage caused by the Big Three crises, we recommend that the EU implement more cohesive and holistic strategies that would consider the broader picture of impacts on the EU as a whole, especially on the vulnerable and poorest regions. Also, different states have differently oriented economies. Therefore, the EU should not propose policies that would harm the economy of specific countries as that would create additional measures for the EU to adopt in the future. The table below summarizes the key findings in the article.

CATEGORY	KEY FINDINGS	POLICY RECOMMENDATIONS
Common Adverse Effects	<ul style="list-style-type: none"> - Regional inequalities. - Inflation. - Higher unemployment. - Increased public debt. 	<ul style="list-style-type: none"> - Allocate targeted financial assistance to regions most affected by inequalities and unemployment.
Long-Term Challenges	<ul style="list-style-type: none"> - Controversial policies (green, migration) create additional strain. 	<ul style="list-style-type: none"> - Ensure green policies are flexible for vulnerable regions and stagger implementation. - Implement migration quotas that reflect regional economic needs.
Impact on Vulnerable States	<ul style="list-style-type: none"> - Disproportionate effects on poorer EU countries. 	<ul style="list-style-type: none"> - Customize EU-wide policies to minimize harm to specific economies (e.g., agricultural, energy-dependent regions).
Policy Complexity	<ul style="list-style-type: none"> - Simultaneous adoption of multiple policies can overburden struggling economies. 	<ul style="list-style-type: none"> - Prioritize economic stabilization before advancing controversial or resource-intensive long-term policies.
Holistic Policy Needs	<ul style="list-style-type: none"> - Lack of cohesiveness exacerbates socio-economic divides. 	<ul style="list-style-type: none"> - Foster stronger inter-EU coordination for crisis mitigation. - Integrate crisis-management strategies into future policy planning.

Note. This table presents the author's synthesis of research findings and conclusions drawn from the analysis of major economic crises affecting the EU economy.

⁷ For more information and in depth description of economic aspects of financial crises and more global perspective on economy and historical challenges, see the book *Manias, Panics, and Crashes: A History of Financial Crises* (2023).

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SECTOR-SPECIFIC IMPACTS OF ADVANCED TECHNOLOGIES ON MANAGEMENT PRACTICES: CASE STUDIES

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Purpose: purpose of this paper is to explore the profound impacts of advanced technologies—such as AI, blockchain, IoT, and robotics—on management practices across various sectors. By examining sector-specific case studies, this paper seeks to uncover the nuanced ways in which advanced technologies influence management practices and to identify the competencies required for effective organizational leadership in this evolving landscape. The analysis highlights how different sectors adapt to technological advancements and the critical managerial skills needed to navigate these changes successfully.

Design/methodology/approach: To achieve the objectives, the paper employs a qualitative research approach, incorporating a comprehensive review of existing literature and case studies from diverse sectors including healthcare, finance, manufacturing, retail, and transportation. The approach includes a detailed analysis of the integration and impact of advanced technologies on management practices.

Findings: The adoption of advanced technologies across sectors reveals the need for specific managerial competencies. In healthcare, managers must excel in data analysis and ethical AI integration. The finance sector requires expertise in blockchain, AI, and cybersecurity. Manufacturing demands skills in technology management, workforce retraining, and cybersecurity. Retail managers need to integrate AI and IoT solutions while safeguarding data privacy, and those in transportation and logistics must oversee autonomous systems, real-time data, and workforce adjustments. Overall, managers need technological proficiency, analytical skills, cybersecurity awareness, and change management expertise. Continuous learning and adaptability are also crucial for navigating technological advancements and maintaining a competitive edge.

Originality/value: This paper provides a novel examination of how advanced technologies influence management practices across different sectors, offering insights into both the benefits and challenges associated with these innovations. The value of the paper lies in its comprehensive analysis and sector-specific case studies, which contribute to a deeper understanding of the intersection between technology and management. The research is addressed to academics, industry professionals, and policy-makers interested in the evolving landscape of technology-driven management.

Keywords: advanced technologies, management competencies, technology integration, sector-specific impacts.

Category of the paper: Literature review.

1. Introduction

In the 21st century, the advent of advanced technologies has profoundly transformed how industries operate. Suchacka et al. (2023) provide an in-depth examination of Industry 4.0 technologies, illustrating their transformative impact on industries and socio-economic structures. This analysis emphasizes the urgency for businesses to integrate these technologies to stay competitive and meet the demands of the modern market. Technologies such as AI, blockchain, IoT, and robotics have become integral to organizational strategies, leading to significant shifts in management practices across various sectors. These technologies offer unprecedented opportunities for efficiency, accuracy, and innovation, but they also present challenges that require new approaches in leadership, strategy, and human resource management. Additionally, Bilan et al. (2022) found that AI's application in organizational contexts extends beyond simple automation; it plays a crucial role in complex areas like decision support systems and knowledge management, fostering innovative organizational cultures.

The integration of advanced technologies across diverse sectors is influenced by a multitude of factors that extend beyond mere leadership, encompassing strategic planning, quality management, and organizational competencies. Empirical evidence suggests that revitalized management practices are essential for the effective adoption and application of information technologies within various environments. These practices, which promote increased openness, mutual support, and risk-taking by employees and managers, have been shown to significantly impact the utilization and effectiveness of information technologies in organizations (Teece, 2007; Stefan et al., 2022). For instance, the adoption of big data technologies in inter-organizational settings can optimize collaboration processes and enhance cooperative dynamics when organizations pursue complementary motivations of learning and efficiency (Mikalef et al., 2019; Alaskar et al., 2024). Similarly, the strategic adoption of new technologies in firms is influenced by dispersed information and learning dynamics, which can lead to phenomena such as strategic delay and herding behavior, thereby affecting the timing and efficiency of technology adoption.

Strategic planning and strategic quality management play a pivotal role in augmenting technology transfer competence. Research has indicated that strategic quality management may serve as a mediator in the relationship between strategic planning and technology transfer competence, underscoring the significance of synchronizing quality management practices with strategic objectives to promote technology adoption and transfer (García-Fernández et al., 2022). This synchronization enables organizations to more effectively navigate the intricacies associated with technology integration, thereby enhancing their competitive advantage in emerging markets (Stefan et al., 2022).

In the manufacturing industry, the implementation of technology management practices – such as technology transfer, acquisition, process optimization, and absorption – has been shown to have a substantial effect on innovation performance. These practices contribute not only to advancements in process and product innovation but also stimulate methodological innovation, ultimately enhancing the overall performance and creativity of firms. This highlights the critical need for a comprehensive technology management strategy that encompasses multiple aspects of technological adoption and utilization.

The interaction among information technology (IT), knowledge management, and human resource management capabilities represents a significant determinant of organizational performance. The enhancement of human resource management and knowledge management capabilities through IT capabilities subsequently leads to improved business performance within organizations (Agarwal et al., 2022). This interrelatedness of these capabilities indicates that organizations must cultivate and integrate these dynamic capabilities to succeed in the digital age.

Furthermore, empirical evidence suggests a positive correlation between advanced human resource management practices and manufacturing flexibility. Organizations that adopt sophisticated human resource management systems generally demonstrate elevated levels of flexibility, a critical attribute for adapting to fluctuating market dynamics and technological innovations (Agarwal et al., 2022). This association underscores the importance for organizations to allocate resources towards human resource management practices that enhance flexibility and responsiveness. The digitalization of human resource processes is increasingly recognized as a key driver for enhancing sustainability and ethical practices within organizations (Kuzior, Kettler, Rąb, 2021). This shift aligns with the broader sector-specific impacts of advanced technologies on management practices, promoting efficiency and transparency. The integration of artificial intelligence into sustainability practices can significantly enhance resource management and environmental preservation. However, it also raises crucial ethical concerns, such as data privacy and algorithmic bias, which must be carefully addressed to ensure responsible AI deployment (Kuzior, Sira, Brożek, 2023).

Knowledge management practices are crucial for enhancing innovation performance. Research indicates that a combined strategy involving "soft human resource management practices" alongside "hard IT practices" significantly fosters both product and process innovations within manufacturing organizations (Santoro et al., 2018). This integrated approach enables firms to adeptly manage their knowledge assets and utilize them to achieve innovative results.

Within the framework of visual performance management, the implementation of visual strategies and performance management methodologies has been demonstrated to improve practices related to performance measurement and management. Such methodologies contribute to the continuous evolution of strategic initiatives, streamline performance evaluations, and cultivate an environment conducive to ongoing improvement and innovation.

This suggests that visual management systems can serve as a potent instrument for organizations aiming to enhance their operational efficiency and promote innovation (Furman, Malysa, 2023).

Moreover, the implementation of formal management protocols and systematic frameworks in new product development initiatives has been associated with enhanced success rates in high-technology enterprises. The establishment of structured management practices offers essential oversight and organization, effectively addressing the intricate challenges inherent in new product development, thereby leading to improved results (Cornwell et al., 2021).

In summary, although leadership is undeniably significant, it is essential to recognize that other elements, including revitalized management practices, strategic planning, quality management, technology management, human resource management, knowledge management, and design management, are crucial for the successful adoption and integration of advanced technologies within diverse industries. Collectively, these factors enhance organizational efficiency, accuracy, innovation, and overall performance.

This article aims to provide an in-depth analysis of how these advanced technologies impact management practices within different sectors. By exploring both the positive and negative effects, and examining real-world case studies, the nuanced ways will be uncovered in which technology reshapes management and what this means for the future of organizational leadership.

2. Methodology

This study employs a qualitative research methodology incorporating literature analysis and case studies. The research approach was designed to provide a comprehensive understanding of how advanced technologies impact management practices across different sectors.

The study focuses on the period 2019-2024 to capture the most recent technological developments and their impact on management practices. This timeframe was chosen to analyse the latest implementations of advanced technologies, include both pre- and post-pandemic technological transformations, and ensure relevance and currency of findings.

The literature review process involved analysing academic publications from Web of Science, Scopus, and Google Scholar databases. The use of these complementary databases enabled access to both established research published in journals and the latest developments in the field. Additional industry reports and technical documentation were used to supplement academic sources, particularly for recent technological implementations.

The selection of sectors for analysis was based on three main criteria: level of technological transformation, economic impact, and diversity of technology applications. Healthcare, finance, manufacturing, retail, and transportation were chosen as they represent areas where advanced

technologies have demonstrated significant impact on management practices. These sectors also provide diverse examples of technology implementation and associated management challenges.

Each sector was analysed through several key dimensions that are explicitly presented in the study. The analysis framework examined: technology implementation patterns (specific technologies and their applications), management challenges and responses to technological changes, required management competencies, and sector-specific barriers and benefits of technology adoption. Validation of research findings was conducted through use and comparison of information from various scientific sources as well as analysis of published case studies and industry examples. The combination of theoretical analysis and sector-specific examples provides insights that are valuable for both academic understanding and practical implementation.

3. Sector-Specific Impacts

3.1. Healthcare Sector

The incorporation of the IoT and robotics has notably increased operational efficiency. IoT devices, such as wearable health monitors, allow for continuous patient monitoring, minimizing the need for in-person visits and enabling real-time data collection (Luo et al., 2024). Robotics assist in surgical procedures, offering precision and reducing recovery times, which in turn improves patient outcomes and boosts hospital throughput (Chatterjee et al., 2024; Haidegger et al., 2022). The advent of advanced technologies has significantly enhanced the healthcare sector. AI and machine learning, for example, have revolutionized decision-making processes (Topol, 2019). AI-powered diagnostic tools improve the accuracy of medical image interpretation, facilitating earlier disease detection and enabling more personalized treatment plans (Chibugo et al., 2024). Predictive analytics further enhance patient management by forecasting health trends and optimizing resource allocation (Razzak et al., 2019).

Nonetheless, the implementation of these technologies introduces several challenges. The use of AI in diagnostics raises ethical questions regarding transparency and accountability in decision-making, particularly when AI-generated recommendations conflict with human judgment (Nelson, Madiba, 2020). Additionally, integrating these new technologies with existing systems can be both expensive and complex, necessitating substantial investments in technology and training (Daugherty, Wilson, 2018).

To exemplify the impact of these technologies in healthcare, consider the application of AI in personalized medicine at the Mayo Clinic, where AI algorithms analyse patient data to tailor treatment plans (Mayo Clinic, 2024).

The key impact areas and corresponding management responses in healthcare technology implementation are summarized in Table 1.

Table 1.

Impact Areas and Management Responses in Healthcare Technology

Impact Areas and Corresponding Management Responses	
key impact areas	management response
AI-Enhanced Diagnostics	Ethical AI integration and staff training
Telehealth	Expansion of remote care services
Data Privacy	Strengthening of data protection measure

Source: developed by the author.

As shown in Table 1, healthcare organizations are implementing various management responses to address technological changes. The implementation of these technologies brings both significant benefits and challenges to the sector. The healthcare sector has realized substantial benefits from technological advancement. AI-powered diagnostic tools have improved the precision of medical diagnoses, while IoT devices have revolutionized patient monitoring by enabling continuous observation. The integration of robotics in surgical procedures and automation in administrative tasks has increased operational efficiency, leading to improved patient care and resource utilization, while advanced analytics support better treatment planning and resource allocation.

However, several significant barriers challenge technology adoption in healthcare. The high initial implementation costs and complex integration with legacy systems present financial and technical challenges. Additional barriers include the substantial investment required for staff training, ethical concerns regarding AI decision-making transparency, and the ongoing challenge of maintaining patient data privacy while leveraging advanced analytics for improved care delivery.

3.2. Finance Sector

In the financial sector, the integration of advanced technologies has resulted in significant enhancements. A notable example is blockchain technology, which has optimized operations, especially in trade finance, by delivering secure, transparent, and immutable records of transactions. This technological innovation has mitigated instances of fraud, bolstered trust, and accelerated transaction processing times (Mohd et al., 2024). Furthermore, artificial intelligence-driven financial services, such as robo-advisors, have enriched the customer experience by providing tailored investment recommendations and portfolio management solutions (Zhu et al., 2024).

Notwithstanding the advantages associated with the incorporation of these technologies within the financial sector, the transition has not been devoid of challenges. Although blockchain technology is recognized for its security features, it remains susceptible to vulnerabilities, including hacking and fraudulent activities, particularly at the junctures where transactions intersect with conventional systems (Olaseni, Familoni, 2024). Furthermore,

the automation brought about by artificial intelligence and robotics may result in workforce displacement, especially in repetitive functions such as data entry and customer service (Adeyeri, 2024).

The application of blockchain technology in trade finance by HSBC exemplifies its transformative potential within the financial sector. This implementation has notably decreased the duration necessary for processing letters of credit (SBC Bank Middle East Limited, 2020). In the domain of artificial intelligence, the financial advisory firm Betterment utilizes AI-driven platforms, providing clients with customized financial guidance at a cost that is significantly lower than that of conventional advisory services (Betterment LLC, 2024).

Table 2 presents the main impact areas and management responses observed in financial technology adoption.

Table 2.

Impact Areas and Management Responses in Financial Technology

Impact Areas and Corresponding Management Responses	
key impact areas	management response
Blockchain for Transactions	Compliance and cybersecurity management
AI in Wealth Management	Balancing automation with personalization

Source: developed by the author.

Building upon the management responses outlined in Table 2, it is important to analyze both the advantages and challenges that these technologies bring to the financial sector. The implementation of advanced technologies in the financial sector has yielded notable advantages. Blockchain technology has enhanced transaction security through immutable record-keeping, while AI-driven solutions have enabled personalized financial services. The sector has achieved improved operational efficiency through automation, better risk management through advanced analytics, and enhanced market responsiveness through real-time data analysis.

The financial sector faces several implementation challenges in adopting these technologies. Cybersecurity risks and complex regulatory requirements pose significant barriers, while the integration of new systems with existing infrastructure presents technical challenges. Additionally, institutions must address the needs for comprehensive staff retraining and robust data management systems, particularly when handling sensitive financial information.

3.3. Manufacturing Sector

The manufacturing industry has experienced significant advantages due to the integration of advanced technologies. The implementation of robotics in production lines has enhanced both the speed and accuracy of manufacturing processes, while simultaneously lowering operational costs (Campilho, Silva, 2023). Additionally, the IoT has facilitated predictive maintenance, utilizing sensors to monitor equipment performance in real time. This capability

allows for the anticipation of potential failures prior to their occurrence, thereby reducing downtime and minimizing maintenance expenditures (Schymanietz et al., 2022).

Nonetheless, the incorporation of these technologies within the manufacturing sector has also given rise to various challenges. The deployment of robotics, for instance, has generated workforce-related issues, particularly the disparity between the skill sets of existing employees and the requirements of an increasingly automated workspace, thereby necessitating comprehensive retraining and educational initiatives (Bárcia De Mattos et al., 2020). Additionally, the dependence on technological systems introduces potential vulnerabilities, including the risks associated with system malfunctions or cyber-attacks, which can lead to considerable disruptions in operational continuity (Ameta et al., 2024).

Tesla's Gigafactory serves as a prominent example of the integration of robotics within the manufacturing sector, showcasing how automated processes have not only enhanced production capacity but also upheld product quality (Universal Robots, 2022). In a comparable manner, Siemens has implemented IoT technologies for predictive maintenance across its manufacturing facilities, illustrating the potential for such innovations to decrease operational downtime by 20% and generate significant savings in operational expenditures (Siemens, 2024). The principal impact areas and management responses in manufacturing technology integration are outlined in Table 3.

Table 3.

Impact Areas and Management Responses in Manufacturing Technology

Impact Areas and Corresponding Management Responses	
key impact areas	management response
Predictive Maintenance	Shift to data-driven decision-making
Automation	Workforce retraining and technology integration
Cybersecurity	Development of robust security protocols

Source: developed by the author.

The management responses presented in Table 3 reflect the complex nature of technology integration in manufacturing. This complexity is further illustrated by examining the sector's benefits and challenges. The manufacturing sector has experienced significant advantages through technological integration. Robotics implementation has enhanced production precision and speed, while IoT-enabled predictive maintenance has reduced equipment downtime and maintenance costs. Advanced automation systems have improved production efficiency, quality control, and workplace safety, leading to increased productivity and reduced operational costs. These technologies have also enabled more flexible production processes and better inventory management.

However, manufacturers face substantial challenges in technology implementation. The high costs of automation systems and the need for extensive workforce retraining present significant financial and organizational challenges. Integration with existing production systems, cybersecurity concerns for connected devices, and the need to maintain production continuity during technological transitions remain key barriers. Additionally, manufacturers

must address the social implications of automation and maintain workforce morale during technological transformation.

3.4. Retail Sector

In the retail industry, the integration of advanced technologies has significantly improved both customer engagement and operational efficiency. The advent of AI has transformed customer interactions by facilitating personalized marketing strategies. AI algorithms are employed to analyse consumer data, enabling the prediction of preferences and the customization of marketing messages, which subsequently results in increased conversion rates (Mele, Russo-Spena, 2023). Additionally, the IoT has enhanced inventory management processes by allowing for real-time monitoring of stock levels and the automation of reordering systems, thereby mitigating issues related to both overstock and stockouts (Mashayekhy et al., 2022).

The integration of technology in the retail sector presents several pressing concerns. The issue of data privacy becomes increasingly significant, as the extensive collection of consumer data may result in breaches if not adequately safeguarded (Filani, 2024). Furthermore, an excessive dependence on automated systems may lead to service interruptions in the event of technological failures, thereby detrimentally affecting customer satisfaction (Zhang, 2023).

Amazon exemplifies the application of AI in the retail sector through its personalized recommendation system, which has demonstrably enhanced sales by customizing the shopping experience for individual consumers (Manasa, Jayanthila Devi, 2022). Concurrently, Walmart's adoption of the IoT for inventory management has led to the optimization of stock levels throughout its extensive global network, thereby minimizing waste and ensuring the consistent availability of products (Mashayekhy et al., 2022). Table 4 summarizes the key impact areas and management responses in retail technology implementation.

Table 4.

Impact Areas and Management Responses in Retail Technology

Impact Areas and Corresponding Management Responses	
key impact areas	management response
IoT-Driven Supply Chain	Optimization of logistics and inventory management
AI for Customer Personalization	Enhancing customer experiences while ensuring data privacy
Technology Integration	Managing legacy systems and new tech solutions

Source: developed by the author.

The management approaches outlined in Table 4 demonstrate the retail sector's adaptation to technological change. This adaptation process has resulted in both significant benefits and challenges. The retail sector has gained substantial benefits from technological adoption. AI-driven personalization has enhanced customer experience and increased sales conversion rates, while IoT applications have improved inventory management and supply chain efficiency. Advanced analytics have enabled better understanding of consumer behavior and

demand patterns, leading to optimized pricing strategies and reduced waste. These technologies have also facilitated the seamless integration of online and offline retail operations.

Nevertheless, retailers encounter several implementation challenges. The need to protect customer data privacy while leveraging personalization technologies presents a significant challenge. Integration costs, especially for smaller retailers, and the complexity of implementing omnichannel solutions pose substantial barriers. Additionally, retailers must balance automation with maintaining personal customer service and manage the technical challenges of real-time inventory systems.

3.5. Transportation and Logistics Sector

The integration of advanced technologies such as autonomous vehicles, the IoT, and AI-driven logistics solutions is profoundly reshaping management practices within the transportation and logistics sector. These innovations have facilitated unprecedented levels of operational efficiency, contributed to the reduction of operational costs, and improved capabilities for real-time tracking and data analysis (Mohsen, 2023). Consequently, managers in this domain are increasingly responsible for supervising highly automated operations, making informed strategic decisions based on extensive real-time data, and ensuring the seamless incorporation of new technological advancements with pre-existing systems (Baimukhanbetova et al., 2023).

The integration of autonomous vehicles and IoT devices within the realms of transportation and logistics presents a multitude of challenges for managers. Key issues include the necessity of ensuring the safety and reliability of autonomous systems, safeguarding against cybersecurity threats in an increasingly interconnected landscape, and managing the substantial capital expenditures required for the implementation of these technologies (Biswas, Wang, 2023). Furthermore, managerial responsibilities extend to addressing the potential displacement of the workforce resulting from automation, necessitating the formulation of strategies for workforce retraining and redeployment (Ferreira, Reis, 2023).

DHL has effectively utilized IoT technology to enhance its logistics operations, with a particular focus on shipment tracking and the optimization of delivery routes. The integration of IoT necessitated the development and implementation of new systems aimed at facilitating real-time data analysis and informed decision-making (DHL, n.d.). This transition also required the establishment of comprehensive training programs for employees to ensure they could proficiently utilize IoT tools and accurately interpret the data produced. Managers encountered the challenge of aligning IoT systems with existing logistics software, in addition to maintaining data integrity and security. Nevertheless, the deployment of IoT has resulted in marked improvements in delivery efficiency and heightened customer satisfaction (DHL, n.d.). The main impact areas and management responses in transportation and logistics technology adoption are presented in Table 5.

Table 5.
Impact Areas and Management Responses in Transportation and Logistics Technology

Impact Areas and Corresponding Management Responses	
key impact areas	management response
Autonomous Vehicles	Development of new monitoring protocols and compliance strategies
IoT-Driven Logistics	Real-time tracking and operational efficiency
Workforce Retraining	Managing the transition to automated systems

Source: developed by the author.

Building on the management responses shown in Table 5, it is essential to understand the comprehensive impact of these technological implementations on the sector. The transportation and logistics sector has realized considerable advantages through technological implementation. IoT and AI applications have improved route optimization and real-time tracking capabilities, while autonomous systems have enhanced operational efficiency. Advanced analytics have enabled better fleet management and predictive maintenance, leading to reduced operational costs and improved service reliability. These technologies have also facilitated more accurate delivery time predictions and better resource allocation.

The sector faces several significant implementation challenges. The high cost of autonomous vehicle technology and the need for extensive infrastructure upgrades present substantial financial barriers. Regulatory compliance, especially for autonomous systems, and cybersecurity concerns for connected vehicles pose ongoing challenges. Additionally, the sector must address workforce concerns regarding automation and ensure reliable system performance under various operational conditions.

4. Role of the managers through the sectors

In various sectors, the implementation of advanced technologies yields several common advantages, including heightened efficiency, cost reductions, and improved decision-making capabilities. Nonetheless, the adoption of these technologies also presents significant challenges, particularly regarding ethical implications, potential job displacement, and the complexities associated with integrating new systems into existing legacy infrastructures.

Each industry demonstrates distinct adaptations to these technologies. It is imperative for managers across various sectors to cultivate new competencies and strategies to adeptly respond to these transformations. This necessitates an emphasis on lifelong learning and the capacity to effectively manage both technological and human resources. The role of managers is transitioning from the traditional oversight of operations to that of strategic leaders who can leverage technological advancements to drive organizational success.

Healthcare managers must embrace a collaborative leadership approach that fosters close cooperation with IT departments, data analysts, and healthcare professionals. This collaboration is essential to ensure that technological advancements serve to enhance patient care rather than impede it. Additionally, managers should formulate strategies for ongoing learning and professional development, thereby equipping their teams to effectively navigate the continually evolving technological landscape. Healthcare managers must embrace a collaborative leadership approach that fosters close cooperation with IT departments, data analysts, and healthcare professionals. This collaboration is essential to ensure that technological advancements serve to enhance patient care rather than impede it. Additionally, managers should formulate strategies for ongoing learning and professional development, thereby equipping their teams to effectively navigate the continually evolving technological landscape.

Finance managers must embrace a proactive stance concerning technological advancements. This entails cultivating a comprehensive understanding of emerging technologies, remaining abreast of regulatory developments, and promoting an innovative culture within their teams. Additionally, it is essential for them to prioritize the establishment of trust with clients by ensuring that AI-driven services are transparent, secure, and closely aligned with the needs of their clientele.

Manufacturing managers are required to formulate a strategic vision for the integration of technology that emphasizes long-term advantages rather than immediate profits. This approach necessitates investments in employee training initiatives, the cultivation of a culture dedicated to continuous improvement, and the establishment of robust partnerships with technology suppliers. Kuzior (2022) highlights that Industry 4.0, while driving efficiency, can cause technological unemployment, necessitating education reforms that combine technical and ethical training. Furthermore, managers must exhibit agility, remaining prepared to adapt to emerging technologies to ensure that their organizations maintain a competitive edge.

In the retail sector, managers must adopt a collaborative leadership approach that emphasizes close cooperation between sales, marketing, inventory, and IT departments. This collaboration is crucial for ensuring that technological advancements and strategies align with customer needs and operational efficiency. Managers should work with IT teams to implement advanced systems for inventory management, customer relationship management (CRM), and data analytics, enhancing the customer experience and streamlining operations. Additionally, managers need to develop strategic visions that address market trends, consumer behaviour, and competitive pressures, leveraging data insights to optimize inventory, pricing, and sales strategies. Continuous learning and professional development are essential, with managers promoting ongoing training in new technologies, sales techniques, and customer service skills. Staying informed about industry trends and innovations allows managers to keep their teams agile and responsive. Furthermore, a customer-centric approach is vital, ensuring that technological implementations and strategies focus on improving the shopping experience. Retail managers must also demonstrate adaptability to shifting market conditions, seasonal

changes, and emerging technologies, embracing new tools and practices to enhance operational effectiveness and customer satisfaction.

Professionals in the transportation and logistics sector are required to cultivate proficiency in the oversight of automated systems and the analysis of extensive datasets. It is imperative for these managers to remain abreast of technological innovations and regulatory developments to ensure their organizations maintain a competitive edge and adhere to compliance standards. Furthermore, management should prioritize the establishment of a culture centred on continuous improvement, wherein employees are motivated to adopt emerging technologies and acquire the skills essential for success within an industry characterized by rapid evolution.

Table 6.
Relevance of Competency Areas to Management

Managers' Competencies	
competency area	relevance to management
Technical Proficiency	Understanding and implementing advanced technologies
Analytical Skills	Leveraging data for strategic decision-making
Cybersecurity Awareness	Protecting organizational data and systems
Change Management	Leading teams through technological transitions
Innovation Management	Fostering and managing technological innovation
Cross-Functional Collaboration	Integrating diverse perspectives and expertise

Source: developed by the author.

In the contemporary technological environment characterized by rapid advancement, the incorporation of sophisticated technologies across diverse sectors necessitates that managers cultivate a novel set of competencies. Technical proficiency serves as a fundamental skill for managers, as they must possess a comprehensive understanding of the technologies being deployed within their organizations. Such knowledge equips them to proficiently supervise the integration of new tools and to ensure that technological innovations are congruent with organizational objectives.

Analytical skills are becoming increasingly important, as the ability to interpret and use large data sets is essential to making informed decisions. Managers must be skilled at analysing data to uncover insights, predict trends, and drive strategies that enhance organizational performance. As digitalization continues to expand, cybersecurity awareness is another important area of competency. Managers are responsible for prioritizing data security, developing robust cybersecurity strategies, and ensuring that all levels of the organization are aware of potential risks and how to mitigate them.

Considering ongoing technological advancements, effective change management emerges as an essential competency for facilitating team transitions. It is imperative for managers to promote a culture that values adaptability and continuous learning, thereby enabling employees to accept and integrate new technologies and processes. Furthermore, innovation management is critical to steering technological change. Managers are tasked with fostering creativity, mitigating the risks associated with the adoption of new technologies, and ensuring that innovations are congruent with the organization's long-term strategic goals.

In conclusion, cross-functional collaboration is paramount in a technology-oriented environment, where effective management necessitates the integration of varied perspectives and expertise from multiple departments. It is imperative for managers to foster collaboration and communication among diverse teams, thereby ensuring that the organization's collective knowledge and competencies are utilized to optimize the advantages of technological integration.

The emergence of advanced technologies has significantly transformed the managerial landscape, prompting a reevaluation of the competencies deemed essential for effective management. Traditionally, managers depended on conventional competencies, notably technical expertise, which entailed a comprehensive understanding of specific industry practices and processes. Additionally, effective people management was fundamental, focusing on leadership, motivation, and team-building capabilities. Furthermore, problem-solving skills, characterized by analytical reasoning and decision-making proficiency, along with financial acumen – encompassing the interpretation of financial statements and budgeting – were integral components of the conventional managerial role.

In contrast, the contemporary digital landscape necessitates a more extensive and varied skill set. Digital literacy has emerged as a fundamental competency, requiring managers to demonstrate proficiency in the use of digital tools and platforms. Furthermore, data analytics has become a critical capability, empowering managers to analyse data effectively and make informed, data-driven decisions. The ability to manage change has gained paramount importance, as managers are now required to be adaptable and adept at guiding their organizations through ongoing transformations. Additionally, fostering innovation – characterized by creativity and a readiness to experiment with novel ideas – has become integral to driving organizational growth. Moreover, customer centricity, which emphasizes the understanding and fulfilment of customer needs, has transitioned into a core component of digital strategy and experience design.

An analysis of managerial roles in traditional versus digital contexts indicates notable transformations in the requisite competencies. Technical proficiency, which was once a fundamental necessity, has transitioned into a domain of specialized knowledge situated within a more expansive digital framework. While personnel management continues to be vital, it now encompasses an augmented emphasis on cultivating digital talent and promoting collaborative efforts. The significance of problem-solving, inherently essential, has been enhanced through the incorporation of data analytics and a more strategic approach. Moreover, financial literacy has broadened to encompass digital financial management practices and the assessment of return on investment (ROI).

Significant transformations have taken place in managerial competencies, mirroring the changing requirements of the digital era. It is imperative for managers to transition from a reliance on technical proficiency to a foundation in digital literacy, thereby acquiring a more comprehensive skill set that extends beyond industry-specific expertise. The emphasis has

shifted from routine operational responsibilities to a focus on strategic planning and innovation, compelling managers to adopt a long-term perspective and prioritize sustainability initiatives. Furthermore, the traditional focus on individual performance has evolved into an essential recognition of the importance of fostering teamwork and collaboration as vital components of driving digital transformation. Consequently, contemporary managers are required to be adaptable, technologically competent leaders capable of navigating complexity, spearheading innovation, and generating value within an increasingly interconnected global landscape.

5. Conclusions

As organizations continue to integrate advanced technologies, the application of combinatorial models of artificial intelligence will be crucial for sustainable development, enabling more nuanced and effective decision-making processes that align with both organizational goals and external environmental changes (Kuzior et al., 2021). The incorporation of advanced technologies across diverse sectors has fundamentally altered management practices, yielding considerable advantages while also posing significant challenges. These transformations necessitate a reevaluation of conventional management methodologies and the cultivation of new skills and strategies.

As we look to the future, the impact of advanced technologies on management practices is expected to intensify. Consequently, managers will be required to exhibit greater agility, technological proficiency, and ethical awareness to effectively navigate the complexities inherent in a technology-driven landscape.

To maintain a competitive edge, it is imperative for managers to prioritize ongoing education and to remain abreast of technological innovations pertinent to their industries. As Industry 4.0 continues to reshape our world, we must address the ethical challenges it presents. As noted in contemporary studies, proactive ethical frameworks will be essential to ensuring that these advancements benefit society (Fobel, Kuzior, 2019). Additionally, a proactive stance toward addressing ethical considerations and the implications for the workforce should be adopted. This entails ensuring that the integration of technology is conducted in a manner that yields benefits not only for the organization but also for society.

The future of management in an increasingly technology-driven environment necessitates a nuanced equilibrium between the adoption of innovative practices and the effective management of the human dimensions associated with organizational transformation. Collaboration between academic institutions and industry stakeholders must be fostered to adequately prepare future managers for this dynamic landscape, thereby equipping them with the essential skills and knowledge for success.

Further research could explore the application of AI in additional sectors, such as education, energy, agriculture, finance, and public administration, where its impact has already shown significant promise. For instance, Skrynnyk et al. (2022) highlight the transformative impact of AI on education, demonstrating how AI technologies can personalize learning, provide immediate feedback, and streamline administrative processes. In the energy sector, AI can optimize energy consumption and improve grid management. In agriculture, AI aids in precision farming, crop monitoring, and yield prediction. In finance, AI enhances fraud detection, risk management, and customer service. Public administration can benefit from AI through improved service delivery, resource management, and data-driven decision-making. Expanding research into these areas could reveal substantial benefits, driving innovation, efficiency, and adaptability across a wide range of industries.

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TRANSIT OF CULTURAL HERITAGE IN SILESIA AS AN ELEMENT OF CITY PROMOTION. ON THE EXAMPLE OF BOLESŁAWIEC CERAMICS

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Purpose: Representatives of various nations and cultures have marked their influence on the multicultural heritage of Silesia. In the centuries-long intricate history of this region, which is special because of its location, various cultural options clashed, which left their mark on its diversity, creating a specific cultural mosaic.

The present area of Lower Silesia was subjected to a particular influence of German culture, until a new balance of power and division of political influence in Europe took place after World War II, which involved the shift of Poland's borders westward and the incorporation of lands referred to from then on as "recovered".

Both the period of resettlement and the settlement of the incorporated western lands led to a great deal of socio-cultural turmoil, which is described in recent publications by Zbigniew Rokita (Rokita, 2023) and Karolina Kuszyk (Kuszyk, 2019), among others.

One of the elements of the changes taking place in the area was the issue of the transit of the cultural heritage found there. The purpose of the article, therefore, is to show the process of acquisition and use, and therefore the transit of such heritage, which has now become the basis for the creation of a brand that is associated almost worldwide with Polish culture. The brand, which at the same time is a key element in the promotion of one of the historic Lower Silesian cities - Bolesławiec, and thus the promotion of the entire Lower Silesian region, and even the whole of Poland, is the Bolesławiec Ceramics.

The article will present examples of building a regional product brand and creating a contemporary image of the city based on this "adapted" cultural heritage.

Project/methodology/approach: The article is explanatory and descriptive in nature.

The research methods adopted in this paper indicate a qualitative type of research. These include, both the technique of observation and content and document analysis, i.e. on the basis of observed phenomena and facts occurring in urban space, as well as the analysis of the literature on the subject and found factual data (desk research), the process of creating the image of the city based on a specific regional product will be shown.

Findings: Modern cities are increasingly using the following to build their image in an innovative way: cultural heritage, special qualities or symbols of the landscape, but also the creative industries that characterize them.

Originality/value: The innovation of the article is to analyze the ways in which the city carries out promotional activities, conducive to promotion and development, using the attributes that distinguish the city and thus make it original, attractive and interesting, with a particular focus

on creative industries. The results of the analysis and formulated conclusions may allow the use and implementation of similar solutions in other cities to stimulate their future development and build their own image.

Keywords: cultural heritage, cultural transit, image of the city, branding, creative industries.

Category of the paper: empirical research (observation) and desk research.

1. Wstęp

“[...] The identity of a city is the sum of the elements that identify it. It is a set of features, characteristic of a city, that distinguish it from others and is expressed by all the activities that are undertaken in the city, creating its personality and character. (Stanowicka-Traczyk, 2008, p. 14).

The area of Silesia as a whole is a “multicultural” region, mainly due to its intricate history and belonging throughout history to three nations: Polish, Bohemian and German.

Silesia, due to various cultural influences, has shaped and preserved to this day not only a specific mentality of border people or a characteristic ethnic dialect, but also a specific culture, the genesis of which often does not have a uniform pedigree. This means that the image of cultural heritage, both tangible and intangible and intangible, present in the contemporary social space of the whole of Silesia, consists of the achievements of various nations and cultures.

This particular form of heritage, which consists of a mosaic of different cultural influences, creates a specific cultural wealth of the region, which at the same time constitutes a significant economic potential, as an important element of the region's creative industries and an engine for the development of cultural tourism.

The purpose of the article is to present an example of the use and promotion of cultural heritage, bearing clear signs of multiculturalism, also referred to as “heritage in transit” (this term is used in Kurpiel, Maniak, 2020)”.

The purpose of the article is also to show the process of acquisition and use, and therefore transit, of such heritage, which has now become the basis for creating a brand associated almost worldwide with Polish culture.

One of the Lower Silesian cities of historical origin - Boleslawiec - was used as the research area, while the subject of analysis is, one of the most recognizable both in the country and abroad, creative industries, which includes the Boleslawiec ceramic industry, known and operating in the market under the brand name - Ceramics Boleslawiec.

The uneasy post-war fate of the so-called “recovered lands,” also referred to by some as “obtained” (Rokita, 2023), necessitated facing the tangible and intangible heritage found there.

The basic research question posed is therefore: How does multicultural heritage create and enrich the contemporary image of the city?

The research method used for this study is a contribution to the study of multiculturalism and branding of the city selected for analysis, which is the Lower Silesian city of Boleslawiec.

This publication also refers to theoretical issues related to the sense of belonging, identity and forms of adaptation of found cultural elements associated with a specific social space of the city.

2. Materials and Methods

2.1. The identity of a multicultural city

On the grounds of territorial marketing, the identity of a city is defined as “a set of characteristics that distinguish a city from others and are expressed by all the activities that are undertaken, creating its peculiar personality and character” (Łuczak, 2005, p. 46).

In cities with a monocultural character, i.e. those whose historical pedigree is mainly associated with a relatively culturally homogeneous community (nationality), identity in the form of a totality of cultural heritage, both tangible as well as intangible, is relatively easy to identify. Identification with a culture that maintains its coherence and continuity over long centuries becomes obvious. The characteristic features of such a culture, as well as its historically shaped symbols and “emblems” belong to a single space and community that identifies with them.

However, a significant part of the current territories of western and northern Poland, for long centuries belonged to culturally foreign powers, which obviously left their mark on these areas. Often this was a trace that became permanently inscribed in the social space and townscape, despite the fact that after World War II, with the change of statehood, they underwent a profound social transformation, associated with an almost complete replacement of the population.

This clearly raises the question of how and under whose influence the contemporary “cultural landscape” of western Poland's territories, today referred to as the “recovered lands”, was shaped. That is, those territories where multiculturalism refers not so much to the simultaneous overlapping of multiple cultural influences, which also took place in other Polish cities of the pre-war period, but rather the transit and preservation of the “cultural capital of the place” with the simultaneous replacement of its social tissue.

As Andrzej Sadowski writes: “Cultural capital consists of relevant meanings, symbols, values, ideas, ideologies, myths, rituals, behavioral patterns, prestige criteria, etc., that is, those normative values which, being on the equipment of individuals and collectivities, result from their participation in the socialization processes of the family, local communities, peer groups, schools, parishes, regional, national and civilization collectivities. They become capital when

they are brought, communicated in the collectivity, when they acquire a certain meaning in the conditions of the interpersonal relations taking place, when they can serve to assimilate other forms of capital or power” (Sadowski, 2009, p. 39).

The tradition of manufacturing Boleslawiec Ceramics (German: Bunzlauer Keramik) in the Boleslawiec (German: Bunzlau) region, dates back to the 14th century, while the decisive development of production, first by craftsmen, then by industry, is dated to the turn of the 18th and 19th centuries. Hence, the development and popularization of the brand is inextricably linked to German cultural heritage.

The specificity of the Boleslawiec ceramics industry also lies in the fact, that in contrast to other types of industry, such as although heavy industry, which developed mainly in Upper Silesia, and until the period of the division of Silesia in the 1920s, also remained in German hands, the ceramic industry in the Boleslawiec area, is counted among the so-called creative industries, and is one of the forms of applied art, especially in the form of ornamentation, created by skilled artists.

Despite the presence of traditional, classic designs of German origin, with which this ceramics is most often associated (cobalt and white dots or peacock eyes), today there is a multitude of different designs on the market, signed with the logos of the artists or manufacturers who create them.

Like any “work of art”, even one with applied art qualities, Boleslawiec pottery has a pedigree, and in this respect it is certainly part of Germany's cultural heritage.

Anna Kurpiel and Katarzyna Maniak, cite in their publication (Kurpiel, Maniak, 2020, p. 165) an excerpt from a video, in which they say: “Boleslawiec ceramics play an important role in the memories of many Silesians of German origin. For many of them, it is a piece of their “little homeland”. Very many of them have amassed a small collection over time. Among the souvenir items [...] there has always been Boleslawiec Ceramics”¹.

2.2. Social memory – continuity and change

“Social memory is socially created, transformed, relatively unified and accepted knowledge, relating to the past of a given collective. This knowledge encompasses various contents, performs various functions, persists through various cultural carriers, and comes into the consciousness of individuals from various sources. Its relative unification occurs precisely thanks to the mechanisms of social life. Thus, there is a relative unification in a given group of perceptions relating to the past” (Golka, 2009, p. 15).

The process of taking over and at the same time transforming the collective memory, concerning the place, undoubtedly took place in the so-called “recovered” territories.

¹ The film “Boleslawiec Ceramics from the Reinhold Factory” (<https://vimeo.com/5389849>, 29.10.2019).

As we read in an entry on the subject of the Recovered Territories, by Zbigniew Rokita (Rokita, 2023, p. 3): “It was here, in the Recovered Territories, that one of the most spectacular events in 20th-century European history took place after the war. [...] Poland faced one of the greatest civilizational challenges - the transformation of Germany into Poland. But you can still see the stitches with which they sewed together prewar and postwar Poland. [...] some people continue to weave a tale that someone interrupted some years ago to the now dead residents of their tenements.”

As the future has shown, places that are carriers of collective memory, forming the contemporary fabric of the city, meld with the present into a single urban organism.

These significant buildings, squares and places, but also material and spiritual heritage, form the core of the cultural identity of today's participants in the city's social space as well. Taking over the existing heritage, as well as continuing its history, by writing “our own continuation” of these histories, turns out to be one of the forms of building identity anew and seeking rootedness in the history of the place where one has come to live.

“Collectivities usually know the importance of maintaining social memory in various - mainly public, but also private - places, hence the sometimes visible struggle to influence both the content of that memory and the places associated with it” (Saryusz-Wolska, 2006, p. 216).

The post-war fate of Boleslawiec pottery is one example of the preservation of the continuity of the cultural heritage of a place, despite the process of “uprooting” elements of German culture, which had shaped the area for many centuries, that has begun.

“Boleslawiec pottery and the practice of making it - partially abandoned but not abandoned, attracting new circles of heirs, generating conflicts, but also providing a link between heirs - seems to be the heritage of many heirs rather than an orphaned heritage” (Kurpiel, Maniak, 2020, p. 167).

Since 1946, the production of ceramics in Boleslawiec was taken over by the Boleslawiec Pottery and Ceramics Works, thanks to Tadeusz Szafran, a Cracow-based artist, who made efforts to resume the plant's work. The previous plant, founded in 1889 by German merchant Herman Hoffman, operated under the name Reinhold & Co.

In 1980, Ceramic Works “BOLESŁAWIEC” Sp. z o.o. was spun off, and was allowed to use the city's name.

The distribution of Boleslawiec ceramics in the post-war period was carried out by Cepelia, actually: Headquarters of Folk and Artistic Industry (Centrala Przemysłu Ludowego i Artystycznego – CPLiA) - a former organization of cooperatives of folk and artistic handicrafts, which ran trading outlets that sold goods produced in the associated cooperatives, made or inspired by the work of **Polish** folk artists.

Henceforth, Boleslawiec pottery was already to be associated exclusively with Polish folk culture and serve to promote Poland abroad, as a significant brand presenting Polish cultural heritage. This is evidenced by the fact that in July 2017 the President of the Republic of Poland

Andrzej Duda and his wife presented Prince William and Duchess Kate with, among other things, a coffee service from Boleslawiec².

As Agata Zborowska writes: “In many analyses of the post-war reality of the so-called Recovered Territories, the concept of *taming* has been used as an accurate description of the practices of settling the annexed territories. It can be helpful, for example, in describing the individual practices and behaviors of people resettled from the Borderlands, still believing for a long time in the in returning to their local homelands. However, at the level of analysis of official discourse, it seems more accurate to use precise language indicating the processes of polonization, colonization, takeover or appropriation. In our view, this terminology captures the nature of the mechanisms of incorporating Lower Silesia into Poland's borders, as it includes an emphasis on forced and sometimes violent displacement, seizure of property, the practice of looting and erasure of the region's history (Zborowska, 2019, p. 124).

Marian Golka calls this process *false memory*, writing: “[...] False memory is a negation of the previous memory and constitutes a kind of implant in relation to that one. A long-held false memory, after several generations have passed, can be considered reliable and even fully true”. [...] A common manifestation of selective forgetting is memory filtering, which involves selecting certain fragments of memory and keeping silent or even deleting others that are inconvenient” (Golka, 2009, pp. 143-144).

The post-war history of the Lower Silesian city of Boleslawiec and its associated ceramics, illustrates the course of this process.

3. Results, discussion and conclusions

“Adapted” and ‘tamed’ the cultural legacy of the city and region, in the form of Boleslawiec pottery, proved to be a significant asset during the political and economic changes that occurred in the 1990s.

“The end of this top-down policy of polonization of the northwestern lands, came with the political transformation, which opened the field to new local narratives, based on the heterogeneous cultural heritage of the region. In the 1990s, Lower Silesia and its individual cities, eager to dissociate themselves from the communist propaganda, began to ‘reinvent’ themselves, looking for an identity dominant for themselves, including - a regional product” (Kurpiel, Maniak, 2020, p. 170).

Already Max Weber claimed that: “A city is a market, we can say: a city is diversity. Together with its architecture, the shape of the space, the features of the social environment and supra-local functions. The city, which is the personification of diversity, at the same time forms

² Durka, A. We know what the presidential couple gifted to Duchess Kate and Prince William, *wp.pl*, 2017.07.18, 2024.06.09.

a certain whole, which is the basis of the cultural identity of its inhabitants” (Majer, 2010, p. 122).

With the restoration of the market economy and the move away from a centralized economy, cities and local governments, as a special kind of enterprise, faced the need to define their character, their image, based on what constitutes their originality, what defines and distinguishes them from other cities. Depending on the profile of the city's dominant economy or existing character, they began to bet on a certain type of industry, tourism or culture in the broadest sense.

As the experience of Western economies has shown, the most effective in the era of the dominance of services, characterizing post-modern societies, turned out to be image building based on the development of the so-called creative industries, related to culture in the broadest sense, including art (including applied arts) or historical or tourist values of places. As part of the promotion of cities based on cultural potential, they have begun to also started to create cultural tourist routes, including those related to places that until now have not been associated with tourism at all, such as post-industrial areas³.

“Cultural and creative industries already make a significant contribution to the national product of many European countries, as does cultural tourism. These are elements interactively co-creating the next phase of humanity's development towards a knowledge-based economy based on the tertiary sector” (Janikowski, 2010, p. 52).

The modern city, in order to exist, needs to define itself and thus promote its potential. Hence, many cities have also begun to create their own “brands” (branding), exposing and “exporting” its greatest assets.

In the case of Boleslawiec, the choice of “brand” seemed obvious. The heritage that has characterized and distinguished the region for centuries, regardless of its national origins, has become its most appropriate symbol, and thus its greatest economic asset.

The development of the brand that Boleslawiec ceramics has become is today inextricably linked to the with the promotion of the city itself and the Lower Silesia region.

The name of today's most well-known ceramics in the country, but also abroad, also “commands” attention to the city itself, whose historical and architectural qualities are as interesting as the ceramics produced here (photo 1).

This is also mentioned by Charles Landry, writing: “City leaders simultaneously need to understand how changes of a material nature alter the emotional and symbolic perception of space and the subtle systems of a city's social ecology” (Landry, 2013, p. 38, Kinal, 2015, p. 19).

³ For example: Szlak Zabytków Techniki Województwa Śląskiego (The Industrial Monuments Route of the Silesian Voivodeship) www.wikipedia.org/wiki/Szlak_Zabytk%C3%B3w_Techniki_Wojew%C3%B3dztwa_%C5%9A%C4%85skiego



Figure 1. Market Square in Bolesławiec.

Source: www.flyrecord.pl/boleslawiec-z-lotu-ptaka-1624

The development of the brand's promotion has resulted, among other things, in the organization of one of the largest ceramic events in the country, this is the Bolesławiec Ceramics Festival (photo 2), which has been held annually in mid-August for 30 years. The festival gathers more and more exhibitors every year (in and around Bolesławiec, new, smaller factories engaged in ceramics production are established, also taking advantage of the brand's status) and a growing number of interested parties, from almost all over the world.



Figure 2. Bolesławiec Ceramics Festival.

Source: www.facebook.com/umboleslawiec

The ceramics festival is, of course, accompanied by other events, characteristic of the city's festivities, whose logo has become a white dot on a cobalt background (photo 3).



Figure 3. Classic design of Boleslawiec Ceramics

Source: own photo.

4. Summary

The cultural heritage of the city is formed by both elements of tangible culture, as well as intangible.

In the case of tangible heritage, we most often have in mind the layout and architectural fabric of the city consisting of interesting, usually historic buildings, squares, historical places or social spaces of special significance, imbued with symbols and meanings, which the Polish sociologist of space Aleksander Wallis (Wallis, 1980, p. 71) referred to as cultural areas.

Intangible heritage, on the other hand, most often takes the form of a kind of spiritual “superstructure” of the city, which consists of a totality of cultural achievements, such as literature, music, art, including applied art, but also customs, traditions or culinary heritage.

This heritage is developed and promoted in the form of so-called creative industries, which often form one of the important pillars of the urban economy, which is why in many cities and regions are creating local or regional brands (“branding” of regional products) to promote this cultural potential, but also to promote the city or region itself (Smołka-Franke, 2019, p. 542; Evans, 2015, pp. 135-158; Anholt, 2005; Smołka-Franke, 2022).

In 2023, the city of Boleslawiec also applied for the inclusion of Boleslawiec ceramics in the National List of Intangible Cultural Heritage (photo 4).

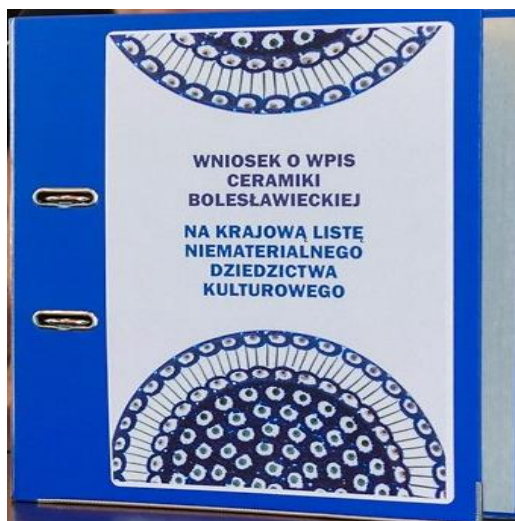


Figure 4. Application for the entry of Bolesławiec ceramics on the National list of intangible cultural heritage.

Source: www.muzeum.boleslawiec.pl/boleslawiecka-ceramika-ubiega-sie-o-wpis-na-krajowa-liste-niematerialnego-dziedzictwa-kulturowego

Creative industries, are a significant pillar of economic development of countries, hence their value is emphasized, for example, through the creation of a network of UNESCO creative cities, specializing in particular areas of the arts⁴.

The research undertaken for the purpose of the study, was explanatory and descriptive.

The city of Bolesławiec, described in the article, is an example of multicultural heritage, which, despite its difficult and intricate history, associated with the shift of Poland's post-war borders to the west, the resettlement of the native population and attempts to appropriate (in the process of Polonization) and falsify history, saved the region's cultural heritage, taking over and developing the creative industry that is the ceramics produced here for centuries.

And despite the fact that nowadays this heritage is understandably used to build the image of an already Polish city and promoted as Polish folk art, arousing widespread appreciation and admiration among users almost all over the world, thus constituting one of the main products of Poland's promotion, it should not be forgotten that it is nevertheless an example of multicultural heritage - heritage in transit. Hence, one should also bear in mind the genesis and importance that the people living in Lower Silesia in the pre-war period contributed to its development.

The use of various forms of multicultural heritage, in order to promote a city or region, should be done with a clear indication and respect for the participation of all authors and creators of this heritage.

⁴ <https://www.unesco.pl/kultura/690/>

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EMPLOYMENT OPPORTUNITIES FOR PEOPLE WITH INTELLECTUAL DISABILITIES

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Objective: The objective of this article is to organize the knowledge regarding disability and to initiate a discussion on the necessary changes in societal perceptions of individuals with intellectual disabilities, with the aim of preparing them for self-determination.

Approach: In the text, I refer to my own research conducted during my doctoral studies. The research consisted of the following stages: preliminary studies: Assessing the level of skills, primarily in the area of independence (research tools used: PAC - H.C. Gunzburg's Progress Assessment Chart for evaluating social development in individuals with intellectual disabilities, HKI - Heidelberger Kompetenz-Inventar for individuals with intellectual disabilities); analysis of the causes of observed differences (research tool: questionnaire); pedagogical experiment lasting 4 years: Conducted with an experimental group and a control group. Both groups were assessed every 6 months (research tools used: PAC - H.C. Gunzburg's Progress Assessment Chart for evaluating social development in individuals with intellectual disabilities, HKI - Heidelberger Kompetenz-Inventar for individuals with intellectual disabilities). Follow-up study conducted 6 years after the experiment (research tools used: PAC - H.C. Gunzburg's Progress Assessment Chart for evaluating social development in individuals with intellectual disabilities, HKI - Heidelberger Kompetenz-Inventar for individuals with intellectual disabilities).

Findings: I would like to demonstrate that by providing students with appropriate and, importantly, practical opportunities to learn certain skills, they are capable of learning much more.

Practical implications: As changes in a developing society occur more and more rapidly, it is necessary to constantly update the methods of working and educating people with disabilities to prepare them to function independently.

Originality/value: The concept of an individual with an intellectual disability deviates from commonly applied standards. Many people perceive such individuals only as recipients of help and support. However, it is essential to remember that they are also members of the community, with associated duties, mandates, and prohibitions.

Keywords: intellectual disabilities, employment, society.

Category of the paper: Viewpoint, general review.

1. Introduction

Money as a Means of Payment was invented by the Phoenicians around 1000 B.C.

For centuries, money has fulfilled its purpose, initially being used in exchange for tangible goods (food, clothing, etc.) and later for more abstract items (stocks, savings). It might seem that contemporary society uses and handles money effortlessly and without difficulty. With a credit card in your pocket—which, it should be noted, is itself becoming obsolete in favor of smartphones and other similar gadgets—one might believe that we have full control over our finances. At any moment, we can check our account balance, savings, expenses, and so forth. Society 5.0 seeks to meet these demands by fully integrating the latest technologies into people's daily lives, aiming to improve the functioning of society, the economy, and the environment. I believe that the vast majority of people utilize these capabilities in this way.

However, what about those who, for various reasons, are unable to master technology? In my discussion, I would like to focus on individuals with intellectual disabilities. For these individuals, adaptive functioning does not proceed as it should; they face difficulties in understanding abstract concepts, and the notion of money and its purchasing power is not fully comprehended by them.

Intellectual disability is classified based on the severity of symptoms and intellectual and adaptive functioning. To organize my discussion, I would like to briefly describe the existing levels.

Mild intellectual disability: Individuals with mild intellectual disabilities may have learning difficulties but typically achieve an educational level equivalent to the end of elementary school. They often require support with complex tasks such as managing finances or career planning, but they are generally capable of leading relatively independent lives. They frequently work in simple jobs that require minimal skills. I would like to emphasize that with proper training, they are capable of using money safely and effectively. **Moderate intellectual disability:** Individuals with moderate intellectual disabilities have limited academic learning abilities and may achieve an educational level similar to the early grades of elementary school. They require support in daily life, both in self-care and social interactions. They may perform simple tasks under supervision.

Severe intellectual disability: Individuals with this level of disability have significant learning difficulties, often limited to the most basic skills, such as recognizing letters and numbers. They require constant assistance with daily activities, such as eating, dressing, and personal hygiene. Their ability to communicate independently is limited.

Profound intellectual disability: Individuals with profound intellectual disabilities have very limited cognitive and communication abilities. Their mental development is comparable to that of a very young child. They often have serious health and physical issues that further complicate their functioning.

In this article, I will focus solely on the first and second levels of intellectual disability.

2. Benefits

In Poland, individuals with disabilities face various financial challenges, most often related to their health condition and the various limitations that arise from it (such as the inability to plan due to potential disease relapse, additional injuries, or even "ordinary" colds). It is also important to remember that these individuals generally have lower immunity, which is especially dangerous and potentially life-threatening in the event of subsequent COVID-19 outbreaks.

Individuals with disabilities, including those with intellectual disabilities, can rely on the following forms of financial support:

Social benefits (pensions, care allowances, rehabilitation supplements, caregiver allowances)

Employment – either in the open labor market with the help of an assistant or in sheltered employment conditions

Various support programs (partial reimbursement of medical treatment costs, purchase of medications, home adaptations, or vehicle modifications).

Support from organizations: They can also receive assistance from organizations, associations, and foundations whose charters include the provision of such support.

Tax relief: They are also entitled to tax deductions.

Aside from individual circumstances (such as when the parents of a person with a disability are very well-off, or conversely, are forced to rely on social assistance), the average family of a person with a disability tends to be lower-functioning financially. This is primarily due to the need for one parent to give up their professional career to care for the child.

In the years 2007-2017, I conducted research among 200 families with children with intellectual disabilities. In the controlled shares of 100 families whose children attend special schools in Gliwice and Bytom (Poland), and 100 families whose children attend appropriate schools in Bernkastel-Kues and Cochem (Germany). For an individual with an intellectual disability (in my discussion, I focus only on mild and moderate levels) to understand such abstract concepts as money, its purchasing power, saving, interest, etc., they require systematic training. Mastering the use of a payment card or mobile app also depends on frequent use of technology. Initially, this should be done under the supervision of parents or teachers, but eventually, the individual should be able to do it independently.

It is difficult to provide such training when the family's financial situation is challenging. This is understandable, given that many families need to plan their expenses very carefully. I understand the concerns and reluctance of parents to allow their children to use money independently.

The school is not always able to meet this challenge either. When analyzing the Polish teaching guide, I noticed that taking students to the store is recommended only four times, and the student's role is always limited to "assisting the teacher during shopping".

In contrast, during the same period, students with a comparable level of intellectual disability in the German education system went shopping once a week as part of their school activities.

The shopping trips were integrated into preparing lunch for the group. The students' tasks included:

- Deciding what they would cook,
- Checking promotional flyers to ensure they had enough money,
- Making a shopping list,
- Going to the store,
- Finding items on the shelves,
- Paying at the checkout, and
- Returning to the school.

I would like to emphasize that even the most advanced technology cannot replace the type of training that equips individuals with the skills necessary for independent functioning. Learning to recognize fraudulent offers—such as scams or taking out loans with unreasonable interest rates, etc.—is crucial. Work on these skills should begin as early as possible, ideally in the younger school years, and should be continued after school through training, workshops, or participation in projects.

In analyzing the research I conducted, I observed that students in the experimental group achieved a higher level of competencies than the control group. Unfortunately, the highest level of skills was observed at the end of their schooling. However, there was a systematic decline in competencies afterward. Despite their skills, none of the students were able to maintain employment. Social interaction increasingly became limited to their own rooms, and new acquaintances ceased to appear (with the remaining family growing older). Even in cases where there were no articulation issues, a decline in communication competencies could be observed.

The German peer developed relatively steadily, was employed, lived independently or in care homes, and led an active social life. He often had a partner.

The subjects covered during the 12 years of schooling in the German system include:

- Scope of Work and Vocational Training:
 - The range of work and vocational education.
- Scope of Aesthetics:
 - Fundamentals of aesthetic development.
 - Music, dance, rhythm.
 - Drama, play, theater.
 - Visual arts.
 - Beauty of nature.

- Scope of Leisure and Personal Life Creation:
 - Leisure time.
 - Openness to others, readiness to engage.
 - Housing.
 - Partnerships.
- Scope of Domestic Activities:
 - Basic skills in handling food.
 - Basic “hygienic” and care skills.
 - Basic knowledge needed for managing a household.
- Scope of “Self and Others”:
 - Development of self-awareness (Sexual life).
- Scope of Communication:
 - Readiness for communication, components of communication.
 - Symbolism.
 - Eye contact, facial expressions, body language.
 - Verbal speech.
 - Sign language, facilitated communication, "computer-based" communication.
 - Foreign languages.
 - Reading.
 - Writing.
- Scope of Sports, Movement, Games, and Activities:
 - Body awareness, signals from one’s own body.
 - Orientation in indoor and outdoor spaces.
 - Effort and rest.
 - Water activities, swimming.
 - Games and sports competitions.
 - Sports and movement games.
 - Athletics – running, jumping, throwing.
 - Competitions and artistic gymnastics.
 - School sports offerings related to leisure time.
- Scope of Respect for Public Goods:
 - Concepts of numbers, sizes, money, and time.
 - Nature and ecology.
 - Technology and DIY.
 - Public services and institutions.

3. Employment

Preparation for work begins during schooling. Each year, the number of internships and interactions with workplaces increases. Referring to my research, I would like to note that in Germany, all individuals with mild and moderate intellectual disabilities were engaged in professional work upon reaching the required age. Of course, the scope of their tasks was fully adapted to their abilities. I observed workplaces such as those producing license plates, packaging components (e.g., shower cabins), printing and sorting materials (e.g., car manuals), and a specialized company that professionally destroyed documents. It is worth noting that in these facilities, the margin of error was 0.2%, exactly the same as in other facilities employing fully abled workers. The exception was the document destruction company, where the margin of error was "0" – just like in any such firm. Therefore, it can be said that products made by individuals with disabilities must be "just as good" as those from other facilities.

Topics related to work and vocational training discussed in German schools include:

- Basics of work and production.
- Acquisition of general practical skills.
- Understanding the relationship between work and the economy.
- Developing a personal attitude towards work.
- Addressing inappropriate behavior towards other colleagues.
- Coping with work difficulties (problem-solving).
- Participating in creating workplace safety, adhering to health and safety regulations.
- Forms of work and production.
- Independent and group work.
- Preparation of individual components.
- Creating products from components (assembly).
- Participation in preparing semi-finished products.
- Working with machines.
- Operating computers and computerized machines.
- Planning, preparing, and selling from an economic perspective.
- Working with wood.
- Working with metal.
- Working with textiles.
- Working with leather.
- Working with paper.
- Restaurant work (renovation, restoration).
- Gardening.
- Working with clay.

- Industrial work – assembly and installation.
- Sorting, packaging, and shipping.
- Preparation and completion of vocational training.

Data from the Central Statistical Office, approximately 2.3 million people with the exclusion of having no criminal record, the amount of incapacity or average incapacity for work are included in the ZUS files. In the examined category of people with the exclusion of disability, the amount of incapacity or the amount of incapacity for work, which constitute 51.1%. Most of them were men aged 64 (50.5 thousand), while women were aged 73 (31.8 thousand). The median age of men is 62 years, and the median age of women is 64 years.

In Poland, the employment system is highly varied. Often, individuals are employed for three months (during which there are discounts for hiring such employees). It is quite common for people to work without a formal contract and receive reduced wages. Their monthly income typically does not allow for independent living and self-sufficiency. There are prevailing concerns that the actual costs associated with employing individuals with intellectual disabilities (such as damaged equipment, goods, and the need for constant supervision for safety) result in losses rather than gains.

The most common form of employment offered to adults with intellectual disabilities is participation in Occupational Therapy Workshops. Once again, we are faced with a situation where the intentions are good, but the practice is not always effective. Even though workshop participants perform a variety of subjects, these workshops should be classified as hands-on therapy rather than actual paid employment. The workshops were created to prepare adults for the labor market, but research shows that they do not fulfill this task.

According to expectations, a graduate of a special primary school for students with moderate or severe intellectual disabilities should be able to:

- Communicate with their immediate surroundings.
- Listen to and follow simple instructions.
- Understand the layout of their own body.
- Signal and manage physiological needs.
- Maintain personal hygiene.
- Wipe their nose with a tissue.
- Comb their hair.
- Dress and undress independently, adjust clothing to weather conditions, prepare a simple meal on their own—set the table, make a sandwich, clean up, eat in an aesthetically pleasing manner using utensils.
- Function well in a group.
- Establish and maintain appropriate social contacts.
- Handle new situations.

- Spend free time in a culturally acceptable and generally accepted manner.
- Behave appropriately in public places.
- Move around their immediate and broader surroundings while ensuring safety.
- Know their own name, surname, age, and address.

The analysis of this program indicates that the focus is primarily on self-care, personal hygiene, and safety. Functioning within the child's surrounding world is limited to motor skills and sensory integration. Social competencies (such as waiting their turn, accepting criticism, losing in group interactions) are insufficiently emphasized. There is a noticeable tendency toward vague and general descriptions, which can lead to superficial or impoverished implementation.

I would also like to share my own reflection here. An individual with moderate or severe intellectual disabilities who is only, or mainly, trained in basic hygiene activities is, in my view, being prepared for the role of a resident in a social care facility, rather than for self-determination. One might wonder if the graduate will possess sufficient skills to, given current changes in the perception of the place of individuals with intellectual disabilities in society, take an appropriate role in it. A socially expected graduate is someone who can take control of their life and interact with others. They might need assistance from a personal assistant or family assistant but will be capable of making decisions and facing their consequences.

4. Support Organizations

Fortunately, both countries have numerous organizations supporting individuals with intellectual disabilities. These include local and national associations and foundations, as well as state, religious, and private entities. Some focus on supporting parents, others on children, and yet others on adults with intellectual disabilities. I have analyzed several organization statutes and can confirm that financial training is often conducted through the implementation of EU projects. Many organizations employ dedicated staff whose role is to secure funding by writing proposals specifically targeted at supporting people with disabilities.

5. Incapacity

I would also like to highlight that, as a country, we are "catching up" with certain European solutions aimed at individuals with intellectual disabilities.

The Universal Declaration of Human Rights was adopted by individual countries in 1948, and Poland joined this group in 1993.

The European Social Charter was signed in 1961, but Poland did so only in 1991/1997.

The Standard Rules on the Equalization of Opportunities for Persons with Disabilities were recognized by all parties in 1993.

The Madrid Declaration was also adopted in 2002.

The UN Convention on the Rights of Persons with Disabilities was ratified by Poland only a year later than other countries, in 2007.

In general terms, the documents can be summarized as follows:

- Nothing about disabled people without disabled people.
- People with disabilities seek equal opportunities, not pity.
- Creating a society for all.
- Creating an accessible environment.
- Full equality and participation in all areas of life.
- Independent living.
- Respect for diversity.
- People with disabilities as active citizens.

However, in Poland, there is a troubling trend of abuse regarding the use of legal incapacitation. Parents and guardians often claim that it is for the benefit of the person concerned, but I personally have some doubts.

Incapacity is a legal tool used in situations where a person, due to mental illness, intellectual disability, or other psychological disorders, is unable to direct their actions and make decisions independently in a conscious and responsible manner. The purpose of incapacity is to protect the interests of such a person, as well as to safeguard society from potentially harmful actions by that person. There are two types of incapacity: full and partial.

Full Incapacity: This applies to individuals who, due to mental illness, intellectual disability, or other psychological disorders, are unable to direct their actions at all. **Legal Consequences:** A person with full incapacity loses the ability to perform legal acts, meaning they cannot independently enter into contracts, manage their property, or make legal decisions. A legal guardian, appointed by the court, acts on their behalf.

Partial Incapacity: This applies to individuals who, due to the aforementioned reasons, are able to direct their actions only to a limited extent. **Legal Consequences:** A person with partial incapacity has restricted legal capacity. They can make decisions in simple daily matters independently but need the consent of a court-appointed guardian for more significant issues.

The process of declaring incapacity is relatively straightforward. An application must be submitted, and the court reviewing the application conducts evidentiary proceedings, including appointing experts who assess the psychological condition of the person in question. The person has the right to be heard, unless their health condition prevents it. Based on the collected evidence, the court issues a ruling on full or partial incapacity or dismisses the application if it deems incapacity unnecessary.

Application and Controversies: While incapacity aims to protect individuals who are unable to act independently, it also raises controversies due to the restriction of freedom and rights of the incapacitated person. Therefore, decisions regarding its application must be made cautiously, with full respect for human rights and consideration of the best interests of the person concerned.

The theory related to incapacity suggests a fully professional approach to the matter. One must not forget that it is about protecting individuals with disabilities. However, research conducted by PSOOU (Polish Association for People with Intellectual Disabilities) more than twenty years ago revealed that, out of 400 cases of incapacity:

- 98% were ruled based on a single contact.
- 91% were declared as full incapacity regardless of the degree of disability (including mild cases).

Despite everything, one must hope that changes in the social living standards will gain appropriate momentum and maintain the right direction.

6. Conclusion

The educational offer for students with intellectual disabilities should be significantly expanded to include content related to vocational preparation.

Maintain systematic opportunities for further education or training for adults with intellectual disabilities. There should be increased activity in raising awareness of employers and cooperation with local workplaces. Promote examples of local "Good Practices".

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THE EXPERIENCE OF ERASMUS PLUS STUDENTS ON STUDYING IN POLAND – IMPLICATIONS ON HIGHER EDUCATION INSTITUTIONS INTERNATIONALISATION

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Purpose: Internalization of higher education is one of the key challenges Polish education faces since the accession to the EU. Although the volume of international students systematically increases, Poland still lags behind, even in relation to countries in the region. Analysis of the experiences of foreign students regarding their stay in Poland can provide valuable answers in the broader context of factors of success of educational migration in a given country or region.

Design/methodology/approach: To achieve the objectives of this paper, the online survey method was appointed. The questionnaire was delivered to the Erasmus Plus students realizing the exchange programs in one of the HEI's in Poland. The research was conducted in December 2023, 30 correctly completed questionnaires were obtained. The presented study is of pilot nature.

Findings: The results indicate that people visiting Poland within the framework of Erasmus Plus Programme generally positively evaluate their mobility experience. Students from non-European countries are more lenient in their assessment. Respondents point to certain administrative problems, e.g. the need to fully translate the university's system applications into English or the cancellation of courses due to a lack of participants. According to the respondents, Poland has great potential and is interesting due to the low cost of living compared to other European countries, although establishing relationships with Poles is not easy in the opinion of the survey participants.

Research limitations/implications: The presented study is based on a survey completed by 30 people, however there is a balance between student from EU countries and non-European countries. No general conclusion can be drawn hence the research sample is small. Nevertheless, conducted research may contribute to develop hypothesis for more in-depth analysis devoted to the growing role of internationalization in higher education and the growing number of foreign students in Poland.

Practical implications: Referring to the educational, institutional and socio-cultural contexts of the experience of Erasmus Plus students in Poland the paper outlines the implications on the internationalization of higher education, but also invites for the wider discussion about considering Poland as a target country for a long-term migration.

Social implications: The study contributes to understanding institutional and social factors influencing positive experiences of foreigners studying in Poland.

Originality/value: International mobility is one of the important factors for young people in career planning nowadays. Accordingly, the number of students deciding to demonstrate their

ability to work in multicultural environments increases. Due to the growing scale of globalization of education and business it is important to bring the light on the internationalization of higher education in countries that only lately started the path to internationalization as well as analyze the issues related to the adaptation of newcomers in the host countries.

Keywords: internationalization of higher education institutions, international mobility, cultural differences.

Category of the paper: research paper.

1. Introduction

Internationalization of higher education institutions is the “process of including the international, intercultural and global dimension in the process of providing educational services at the academic level” (Chan, 2013, in: Domański, 2017, p. 63).

Internationalization is one of the key strategic challenges for Polish universities at the beginning of the 21st century as data from OECD reports indicate a large distance separating Polish universities from European and Anglo-Saxon universities (Domański, 2017, p. 63).

The essential manifestation of the internationalization of higher education is mobility, considered from the perspective of the subject (mobility of students, academic and administrative staff, mobility of the institution itself) and the object (mobility of the educational programs) (Dymyt, 2018, p. 120). Internationalization means integrating into academic institutions multi-facet changes directed to acquire competences and exchange experience taking place in cultural, linguistic and geographical change by all participants of academic community (Dymyt, 2018, p. 118).

The mobility of foreign students towards Poland as a destination country for an internship, exchange or completion of the entire cycle of studies is systematically increasing. In the academic year 2022/2023, nearly 89.5 thousand foreign students from 180 countries studied in Poland. In 2023 for the first time, according to the data of Central Statistical Office, Polish universities have managed to overcome the significant number of 100,000 foreigners including students arriving in Poland on exchange programs (Stat.gov.pl, 15.06.2023). In the academic year 2023/2024 the number of students from abroad has exceeded 107,000. Most foreigners came from European countries. The largest group were people from Ukraine (46.2 thousand), from Belarus (12.7 thousand) and Turkey (4.8 thousand) (Stat.gov.pl, 17.06.2024). Following the increasing number of foreign students, both the number of foreign lecturers and the number of programs conducted in English in Polish universities increased.

Poland demonstrates many of features of a destination country for immigrants, making migration one of the major challenges for this society over the next few decades – considering Poland having been one of Europe’s most homogeneous societies in terms of ethnicity, race

and religion over the last few decades. The process of turning into a destination country for immigration constitutes a research problem worth to be analyzed.

The main objective of the undertaken research was to analyze the experience of Erasmus+ students on studying in Poland. The concept of “experience” is often used inattentive, as an ordinary language unit however in scientific discourse this concept is multidimensional and complex (Wyka, 1993, p. 5). By experience we will understand here the skills, knowledge and social competences gained through participation in international exchange and the general feelings of the respondents regarding their stay in Poland. Results obtained could bring interesting perspective on the internationalization of HEIs in Poland.

2. Methods

The main question posed in the paper address the experience of Erasmus Plus students of studying in Poland. The components of the experience include both institutional aspects such as the diversity and quality of courses offered by the academic institution, contact with teachers and administrative support, as well as non-institutional factors of a socio-cultural nature – e.g. the affordability, of the ease of establishing contacts and relations with locals, living conditions, cultural offer of the region, etc.

To achieve this objective the online survey method was used. The questionnaire was sent to participants of the Erasmus+ program, who were enrolled in exchange program at the Silesian University of Technology in the winter semester of the academic year 2023/2024. The research was prepared and conducted in December 2024 with the assistance of Erasmus students as part of seminar devoted to intercultural queries conducted by the author in the fall semester 2023. The questionnaire was completed by 30 people from European and non-European countries, 2/3 of respondents were females. The questionnaire included the questions concerning the motives for choosing Poland and the Silesian University of Technology as a place for academic exchange, satisfaction with the offer and level of courses, satisfaction with the campus infrastructure, meeting expectations regarding the stay in Poland, and considering Poland as a target country for long-term migration. No general conclusion can be drawn hence the research sample is small. Despite the small research sample, the answers provide interesting implications on the process of internationalization of higher education institutions in the Polish context an may contribute to development of hypothesis for more in-depth study of quantitative character.

3. Erasmus Programme as a community mobility instrument

For many years, the European Union has been pursuing an educational policy that promotes the growth of student mobility in the spirit of “Europe without borders” - internationalization allows building bridges between European countries and cities. The flagship instrument of this policy is the Erasmus Programme – European Community Action Scheme for the Mobility of University Students established in 1987. In the first year of operation, as many as 3200 students from 11 European countries participated in the international exchange, and the programme has constantly been evolving: today, it is one of the European Union's most visible success stories with 15 million people participating since 1987 (Erasmus-plus.ec.europa.eu, 2024). “International student exchange implemented within the Erasmus program is one of the most important elements of the modern model of higher education” (Walesiak 2009, p. 105).

The original goals of the program announced in 1987 were aimed at achieving long-term close cooperation at the community level. The objectives of the Programme specified in Article 2 of the Council Decision include: 1) achieving a significant increase in the number of students from universities spending an integrated period of study in another Member State, while ensuring equality of opportunity for male and female students as regards participation in such mobility; 2) promoting broad and intensive cooperation between universities in all Member States; (3) improving the full intellectual potential of the universities in the Community by means of increased mobility of teaching staff, thereby improving the quality of the education and training provided by the universities with a view to securing the competitiveness of the Community in the world market; (4) strengthening the interaction between citizens in different Member States with a view to consolidating the concept of a People's Europe; (5) ensuring the development of graduates who obtained direct experience of intra-Community cooperation, thereby creating the basis upon which intensified cooperation in the economic and social sectors can develop at Community level (Brown, Guereño-Omil, Hannam, 2014, p. 13). The main objective of this educational programme was to improve the level of education and strengthen European countries.

Since the establishment, the programme has expanded both in terms of methods of cooperation as well as the number of countries engaged. Erasmus Plus – an extension of the European Community Action Scheme for the Mobility of University Students – supports mobility in education, training, youth and sport in Europe and beyond (Erasmus-plus.ec.europa.eu, 2024).

The importance of the international mobility for future professional development is one of the factors contributing to the systematical growth of this phenomenon. “Participation in international student mobility for a period of studies abroad constitutes an important element of university education and has clear implications for professional careers of graduates” (Bryła, Domański et al., 2014, p. 7). International mobility can benefit to the professional career

development in various aspects, including expanding of skills and knowledge, development of international network, improvement of adaptability and flexibility, improvement of language skills or personal development.

4. Research results

Thirty people attending Erasmus Plus international exchange programme filled in the online questionnaire; 46,7% of the respondents were residents of European Union countries (7 females and 7 males), while 53,3% of students came from non-European countries (13 females and 3 males). A detailed breakdown of students by country of origin is presented in Figure 1.

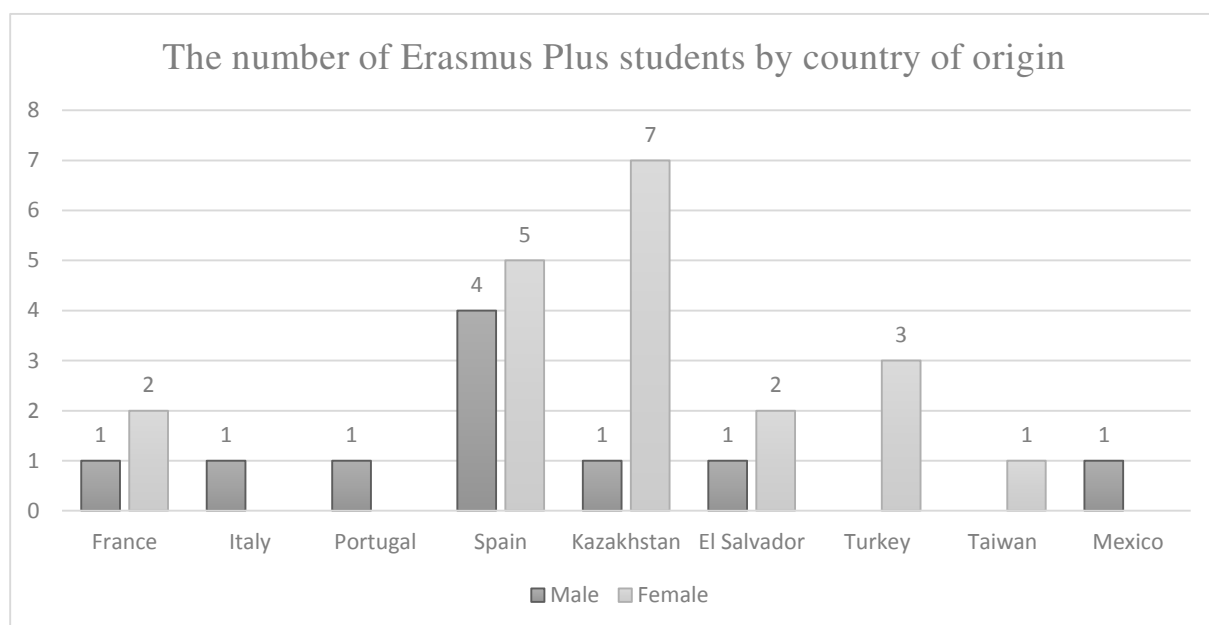


Figure 1. The number of Erasmus Plus students by country of origin.

The reasons for choosing Poland as a location for an international exchange were primarily affordability of living (9 answers), variety of educational offer in Poland (9 answers), obtaining a Schengen visa and the possibility of traveling outside Poland (8 answers), as well as recommendations from close people (6 answers) (the question was of multiple choice). As far as the choice of the university was concerned, for almost half of the students (14 people) it was the only one available to complete an international exchange under the framework of the Erasmus Plus Programme (*I didn't have other options, (...) it was the only partner university, it is the only Polish university that has an agreement with my home university etc.*). For 26% of respondents (8 people), the main reason was study offer available at the partner university – courses in line with the curriculum of the studies at the home university, more diverse offer than in other HEI's available, subjects related to the educational specialties. Personal

recommendation was the reason for choosing the university for 10% of the respondents (3 persons), while other answer was given by 13% of the respondents (4 persons).

The overall assessment regarding the fulfilment of expectations regarding the stay in Poland is rather positive in this group of respondents (Figure 2).

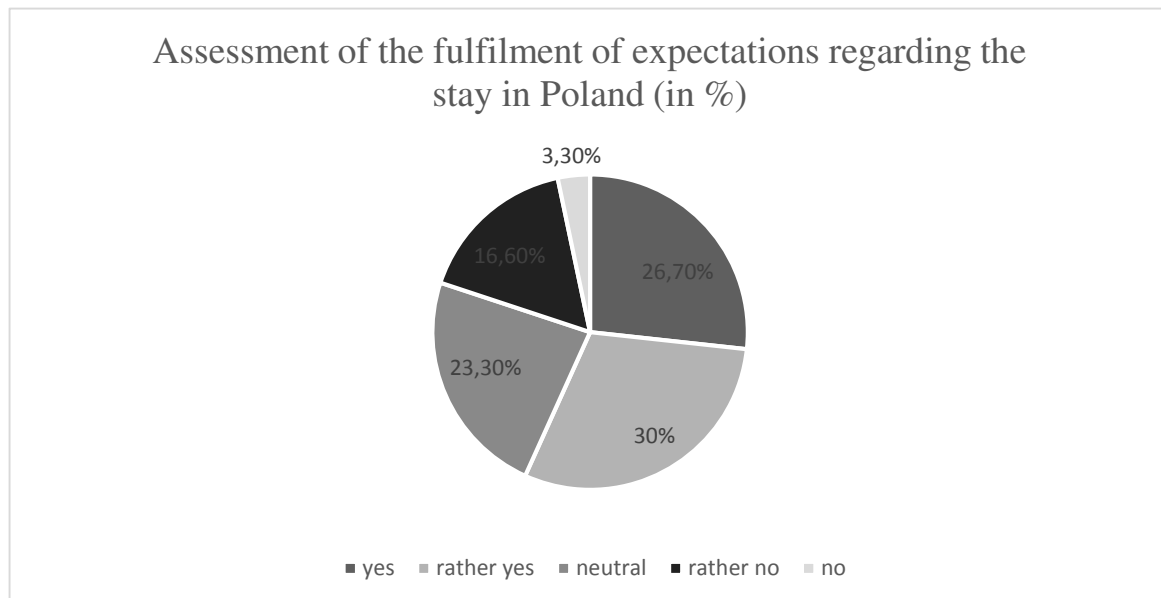


Figure 2. Assessment of the fulfilment of expectations regarding the stay in Poland (in%).

More than half of the respondents (57,6%) believe that their expectations regarding the mobility experience in Poland have been fulfilled. Only one person is dissatisfied with stay, complaining mainly about the organization issues, courses cancelled due to the lack of participants, deficit of information about course content, the quality of conducting classes in English. Eight students (26,7%) indicated a “definitely positive” experience of studying in Poland, 4 of whom came from EU countries and 4 from non-European countries. In justifying their answers, the respondents specified, among *others*, that: *the courses were very interesting and had new information* (non-EU resident); *It is very comfortable here, I really like the study programs and people are kind* (non-EU resident); *I feel that both universities and Poland are underrated* (EU resident); *I'm having a great time here, everyone is so nice, and teachers are very understanding with Erasmus students* (EU resident); *I had no real expectation, but it was far better than I could have expected in term of student life and travel etc.* (EU resident). The respondents who assess their stay in Poland as rather meeting expectations mainly point to certain organizational deficiencies, like not many courses available due to the lack of participants (non-EU resident), lack of sufficient information about the organization of the campus and individual departments (non-EU student), slow administration (EU resident). Students who chose a neutral answer (staying in Poland neither meets nor fulfills expectations) drew attention primarily to organizational issues - e.g. the lack of a full translation into English of all university applications, a long waiting period in connection with the circulation of documents, or the low standard of dormitories in relation to the price. Yet rather negative experiences also pointed to organization – e.g. the need to independently manage with the

organization of the academic year, class schedule or travel arrangements to faculties located in other cities, cancellation of courses due to the lack of participants, etc. As far as the assessment of teaching staff is concerned, 70% of students is satisfied with the competencies and qualifications of academic teachers (including 33.33% who expressed high satisfaction about this issue). It is worth noting that as many as 80% of students appreciate the language skills of academic staff (Figure 3).

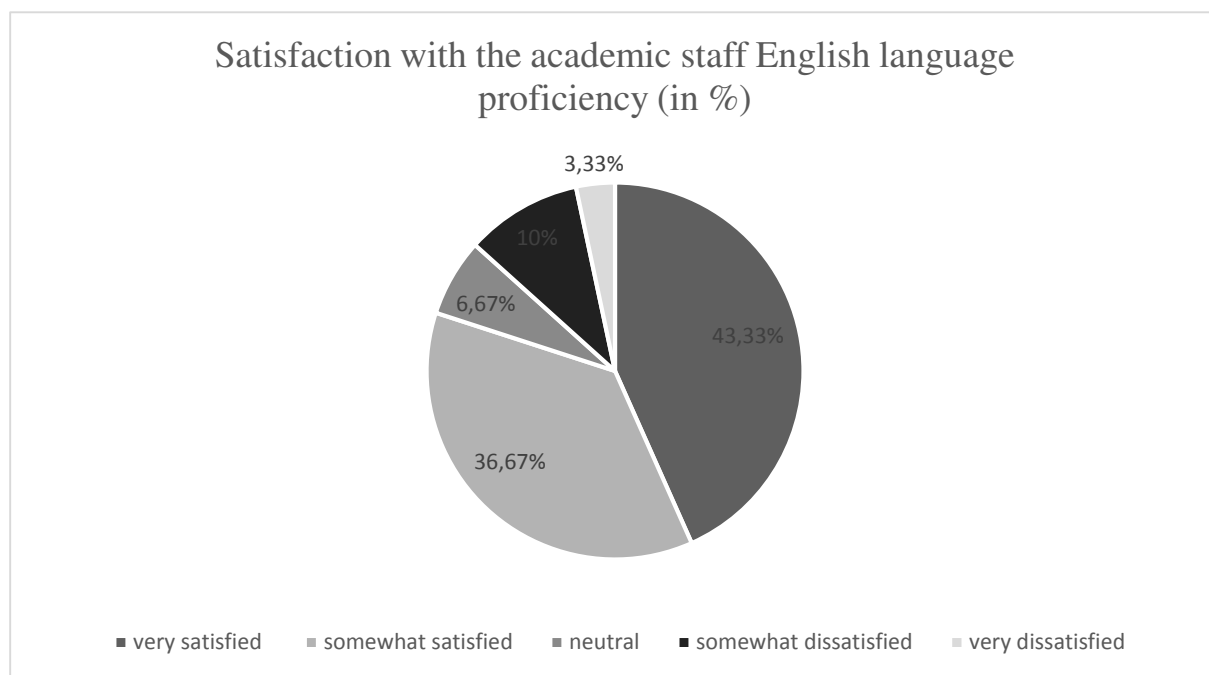


Figure 2. Satisfaction with the academic staff English language proficiency (in%).

Erasmus Plus students also positively evaluated the course offer – 80% of respondents expressed a moderate or high degree of satisfaction with the educational proposal. Respondents are more critical of modern teaching methods – as many as 16.7% found the teaching methods somewhat unsatisfactory and very unsatisfactory, and for another 16.7% the methods were neither satisfactory nor unsatisfactory. It should be noted that students from EU countries were less satisfied with the methods. In turn, almost 60% of students positively and very positively assessed the attitude of academic staff towards students studying at the university under the framework of Erasmus Plus Programme.

Living conditions and infrastructure were rated definitely very high: as many as 80% of respondents expressed satisfaction with the campus and its infrastructure, with 60% declaring a high level of contentedness. As for the region and opportunities for spending free time - here the ratings are also high: as for 60% of respondents the offer of Upper Silesia region is very good or rather good. When asked "If you had the opportunity, would you stay to study and work in Poland?" 53% of respondents answered affirmatively, while 23% gave a negative answer – all the respondents who answered negatively came from EU countries (France, Spain, Portugal). In support of their positive responses, the respondents indicated: *Poland has great opportunities not only academically but also professionally, where is easy to progress in both*

fields; I love Poland and I see it as ideal to be able to maintain a normal and calm life, the only bad thing is the language; I really like this country, and I found that studying here less stressful than in my home country; It is a very good place and Poland have a lot of opportunities; I like the fact that Poland is very cheap and safe country rather than other European countries. Maybe If I had more friends here, I would have stayed; After this experience I have realized that Polish students are very qualified in their studies. I am sure that there is a good working future. In justifying negative answers, respondents mentioned: Even though has a lot of good things, there's still a lot of barriers that don't make Poland workable and livable; (...) the zloty is very weak compared to euro and polish is one of the hardest languages so I would much rather go to another European country to study or work; Study yes, live and work here no. We have far better living conditions in France and countries around it (Germany, Switzerland). It is also worth noting that 90% of respondents (27 students) positively assessed their experience of staying in Poland, which is clearly a good result in the context of the ongoing internationalization of higher education in Poland.

5. Conclusion

The aim of the presented study was to examine the experience of foreign students participating in the international mobility under Erasmus Plus Programme at one of the universities in the Silesian Voivodeship. In terms of foreigners' interest in the region as a location for part or all of their studies, the statistics show that Upper Silesia is still inferior to the Masovian or Lesser Poland Voivodeships, where cultural and tourist aspects are an additional motivator (Stat.gov.pl, 17.06.2024). However, in Upper Silesia the number of foreigners participating in the students' exchange under the framework of Erasmus Plus Programme, or students deciding to complete the full cycle of education is systematically growing.

Although the research sample was small and the study is of preliminary character, conducted research may contribute to the development of more in-depth study, wheatear the results show some important aspects of studying in Poland in the opinion of foreigners. Erasmus Plus students assess the institutional and social aspects of education in Poland quite well, while also drawing attention to administrative shortcomings (e.g. lack of sufficient information in English). The respondents mostly positively assess both the academic staff, the educational offer and the infrastructure of the campus. Certain differences were observed in the assessment of the experience of staying in Poland between students from EU and non-European countries – the latter see great potential in Poland and the region in terms of affordability of life and opportunities for professional development, while the former perceive worse conditions than in their home countries. People from EU countries were also more critical

of organizational issues and the educational offer. In open-ended responses, the respondents also drew attention to problems resulting from the organization of HEI system – including the student's independent responsibility for familiarizing themselves with the class schedule or getting to classes in another city etc. Nevertheless, 90% of respondents considered their stay in Poland as fulfilling.

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MODEL OF PROJECT CLASSES IN PRIMARY SCHOOLS IN WODZISŁAW ŚLĄSKI

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Purpose: The aim of this work is to present a practical example of the process of defining and implementing project-based classes in primary schools in Poland, allowing students of these schools to become familiar with the idea of project-based problem solving.

Design/methodology/approche: The materials analyzed include developed work models, notes from meetings of the team organizing the implementation, and collected post-project comments. Surveys were collected and interviews were conducted with teachers and school principals.

Findings: The publication presents a model that was developed for the organization and implementation of project-based classes in primary schools in Wodzisław Śląski.

Practical implications: The process of creating and verifying the developed solution was presented. The original model of team preparing and then implementing the project, was subjected to practical verification, which enabled the indication of good and bad experiences that were identified during the entire process.

Originality/value: The presented experiences were written from the perspective of the team preparing and implementing the developed solution, and not, as is usually the case, from the point of view of a teacher or student participating in the classes. The developed and verified solution, despite its limitations, can be widely used to organize project classes in primary schools both in Poland and abroad.

Keywords: project management, educational projects, primary education, project management model.

1. Introduction

The education of primary school students is one of the basic obligations of local governments. This is an activity carried out on the basis of the "Education Law" Act. This activity is aimed in particular at educating, raising and caring for students, at the same time, the activity of local government in this area is not only related to statutory provisions. In addition to knowledge and skills resulting from the implementation of the school program, there are often attempts to provide content that is intended to give students the opportunity for

broad development, including functioning at subsequent levels of education or the labor market after completing education. Many activities related to education and training are the result of the activities of local governments themselves which (independently or in agreement with other entities) try to improve and develop the educational process they are responsible in their administrative area. These are common activities throughout the country (they do not occur individually), although they are implemented with varying intensity - it can be said that they concern, in principle, the majority of the student population in Poland. All these activities are perceived as an attempt to strengthen competences and result from the need to prepare school graduates to function in society after completing the educational process (Adamowicz, 2017; Jachimczak et al., 2023).

In the context of changes taking place in our environment, initiatives aimed at improving the situation of school graduates are gaining importance, and the presented publication contains a collection of organizational experiences gathered during the project of systemic implementation of project classes for all primary school students in the city of Wodzisław Śląski in the 2022/23 school year.

2. The project approach in education

In principle, the role of the school is to provide fundamental knowledge, accompany development and build social relations. Conducting education and educating children and young people is carried out in various ways, but it is often a project-based method – consciously or not. Many schools and organizations use the project approach in the didactic process, and over the past 15-20 years, the implementation of project activities by schools has become common. Transferring this education takes place even at the level of preschool or early school age.

The use of the project approach results from many premises (Strojny et al., 2015; De Bono, 2010 or Chojnacki, 2018). These are most often:

- the possibility of developing the teaching staff,
- inviting other entities to implement joint projects,
- own activity of the teaching staff,
- activation of the teaching staff by the school management.

Usually, described educational projects are presented from the point of view of the experiences gained by students or guardians, who are managed by teachers. There are many publications on research in the field of supporting the development of key competences, such as cooperation, critical thinking and time management, e.g. (Okońska-Walkowicz et al., 2009). Those indicate the effectiveness of the project method in developing skills such as planning activities and solving problems. Sysło (2021) emphasizes that Information Technology

education within projects shapes not only technical skills, but also logical thinking and creativity. Gąsior M. (2022) analyzes the preparation of students for the labor market, where key competences are essential, while Trzmielewska (2021) describes educational projects implemented as part of volunteering, that strengthen students' social competences. Okońska-Walkowicz A. emphasizes the importance of the project method in developing modern competences. A specific type of project approach in education is the Project Based Learning (PBL) approach, which has been used in Poland in a practical way for over 10 years. Its idea – boiling down to building interdisciplinary teams that find solutions to specific problems - was presented, for example, in (Zdonek, 2017; Karpińska-Musiał, 2018) or (Tykarska, Jarzemińska, 2018). These publications also indicate the interdisciplinary, developmental effects of such an approach to student education.

Another area where we can find publications referring to educational projects is the evaluation and monitoring of the effects of the project approach. W. Wańkiewicz discusses efficiency indicators enabling the results analysis of projects implemented in schools. Lenart (2014) proposes benchmarking as a tool for comparing educational effects in different institutions. Dębowski et al. (2013) in the "Reference Report" analyze the effectiveness of implementing educational standards in Poland in comparison to Europe, and (Hernik et al., 2014) present the results of the TALIS study, which show the state of project management in Polish education.

The implementation of the project approach itself is often an innovation. Marek-Kołodziej (2015) presents an example of implementing an organizational innovation, showing the benefits for schools. Zuziak et al. (2017) describe engineering techniques as a support for project-based learning.

The publications listed above refer to the issue of using the project approach (i.e. interdisciplinary, team approach), most often show direct benefits or the method of operation in individual project teams, at most the implementation of a project solution in a single organizational unit - e.g., a school or university. There are no publications that would concern the systemic model of implementing such a solution in a group of entities. This publication tries to fill this gap by presenting a solution that is of course imperfect, but indicates possible practical application in a systemic way.

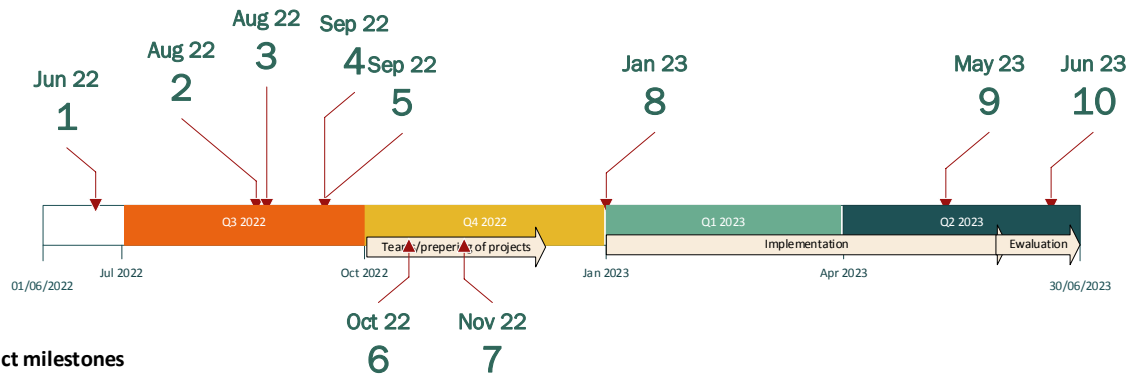
3. Preparation for implementation, developed model

Due to the general demographic trends and changes in the labour market observed by the authorities of the city of Wodzisław Śląski (Hrynkiewicz et al., 2017; Skibiński 2016), a decision was made to introduce classes into the primary school curriculum that would allow their students to learn the principles of a project-based approach to the implementation of problem-solving strategies. This would allow them to acquire the competences necessary in the rapidly changing labor market. This is an action carried out by the local government, whose duty, according to the act, is both to organize education in their own area, but also to inspire didactic activity. The following actions have been taken

1. Workshop initiating the project – meeting of teachers and principals of schools that were to implement the solutions – 6th grades.
2. Preparation for launching project classes began in the first quarter of 2022 with a workshop aimed at developing.

The aim of the project was not to obtain the results of the projects the students carried out in itself, but to increase their practical competences through their participation in project work, a real attempt at teamwork. The primary aim, which was defined by the city authorities, was to supplement the curriculum with elements that give students the opportunity to learn the basic principles and practical way of project teams functioning, which was perceived by the initiators as one of the competences needed and attractive in the future for effective functioning on the labor market.

During the workshops preparing for the implementation of the solution, equal models of implementing project classes in schools were discussed. They resulted from the size of a given school - the number of classes it runs and the number of teachers employed. Due to the awareness of the experimental solution, on the scale of the city and its schools, the variants of the work method between individual schools were finally abandoned and the solution presented in Figure 1 was developed.



Project milestones

June 2022

1 – Information for the Pedagogical Council

August 2022 (after 15)

2 – Workshops – principles of conducting classes, refining the project card template

September 2022

3 – Blocking subjects

4 – Training/workshops for teachers conducting classes

5 – Information for parents

October - November - 2022

6 – Building teams

7 – Preparing workshops – developing project cards (scope, schedule, costs)

January - May 2023

8 – Implementation of project activities

June - 2023

9 – Summary of experiences from the 2022/23 edition (students' presentations)

10 – Evaluation of the assumptions and principles of conducting classes

Figure 1. A model of conducting project classes in the perspective of one school year.

Source: own study.

This solution defined the following framework for implementing the idea of project classes:

1. It was assumed that the first half of the year would be devoted to preparing schools, teachers and parents to implement project classes. In particular, this meant taking the following actions:
 - a. Developing the content of the project card that the student teams would prepare before starting the actual project implementation.
 - b. Blocking subjects, allowing students to work on content common to these subjects, while providing a basis to issuing grades for the results obtained.
 - c. Trainings for teachers, allowing them to equalize their knowledge in the field of conducting classes using the project method.
 - d. Meeting with parents to explain the principles of conducting classes using the project method and drawing attention to the future independent work of the student teams, also outside of school.
 - e. Building 5-6-person student teams that are to carry out projects, so that the work in the team is balanced (and this is, according to the team supervisors, one of the biggest challenges).
 - f. Preparing a list of possible project topics, in case the student teams are unable to find their own.

2. Project classes were carried out in the second half of the school year. In particular, this meant taking the following actions:
 - a. First, student teams were created, they independently proposed topics for the projects they would implement.
 - b. Student teams, with the support of their supervisors, prepared project cards containing the basic parameters of the project (goals, simple work schedule, division of work, necessary aids- stationery or other).
 - c. In the period from January to May, under the team supervision of teachers, students implemented their ideas while preparing for their final presentation, which took place at the turn of May and June.
3. Project team supervisors were given some freedom in setting the start and end dates of individual stages, with the assumption that the final deadline (the turn of May and June – resulting from the end-of-year assessments) must be met.

Team of supervisors - teachers, acting as a kind of leading committee for the implemented project, was indicated on the project card of each student team. The rule was: students work independently - supervisors - lead to solutions. In particular, the support of supervisors referred to help in preparing a work schedule and signaling its expiry.

Even before the implementation, during the preparation of the project, the teaching team agreed that in the case of working with a team that is making a little progress, the topic should be quickly changed to one that the students can handle. In addition, the students were informed that the implementation of the project is an activity for which they will receive grades, and the teachers were to assess the progress of the work by giving partial grades.

4. Experiences from the implementation

To sum up the team's year-long work, descriptive surveys were sent to schools, allowing for an inventory of good and bad practices that appeared during the project. Responses were obtained from 7 out of 13 schools located in the city. Figures 2 to 5 present basic quantitative information on the implementation and results obtained during the implementation of the projects.

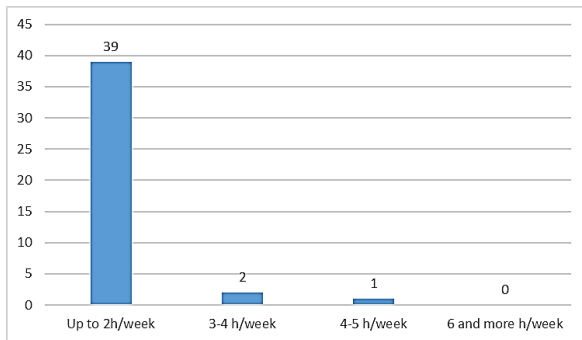


Figure 2. How much time per week was spent on tasks related to project activities per group.

Source: own study.

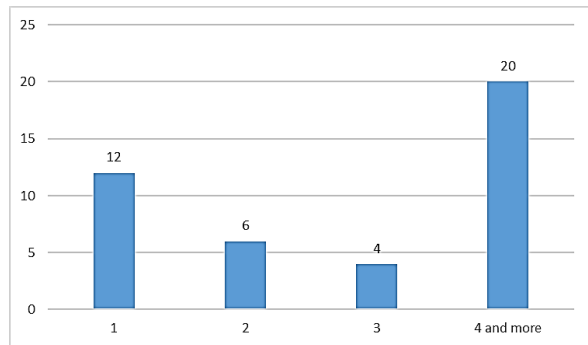


Figure 3. Number of student groups under the supervision of one teacher.

Source: own study.

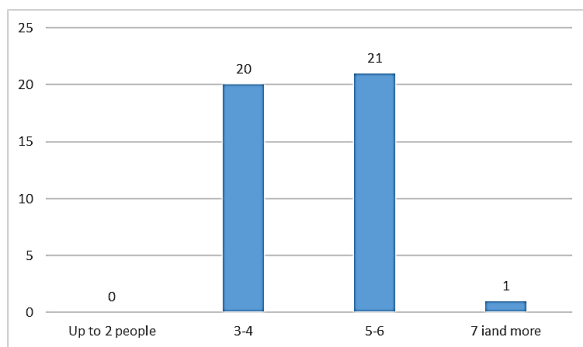


Figure 4. The size of student groups.

Source: own study.

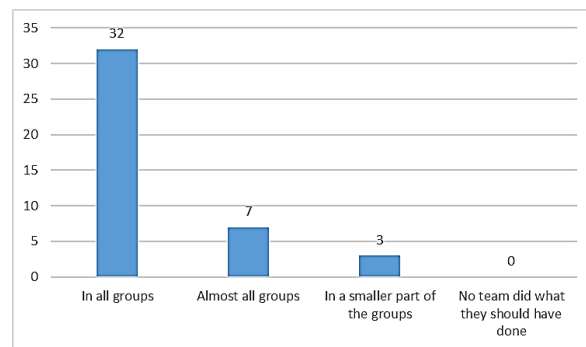


Figure 5. Number of groups in which the project classes ended with the presentation of the results.

Source: own study.

The data presented in the figures show that in most cases the classes were conducted in accordance with the assumptions developed together with the teachers - in most cases the number and size of the student groups that were under the supervision of the teachers did not exceed the number agreed during the preparation of the project. Moreover, in most groups the results obtained can be considered a success of the team's work.

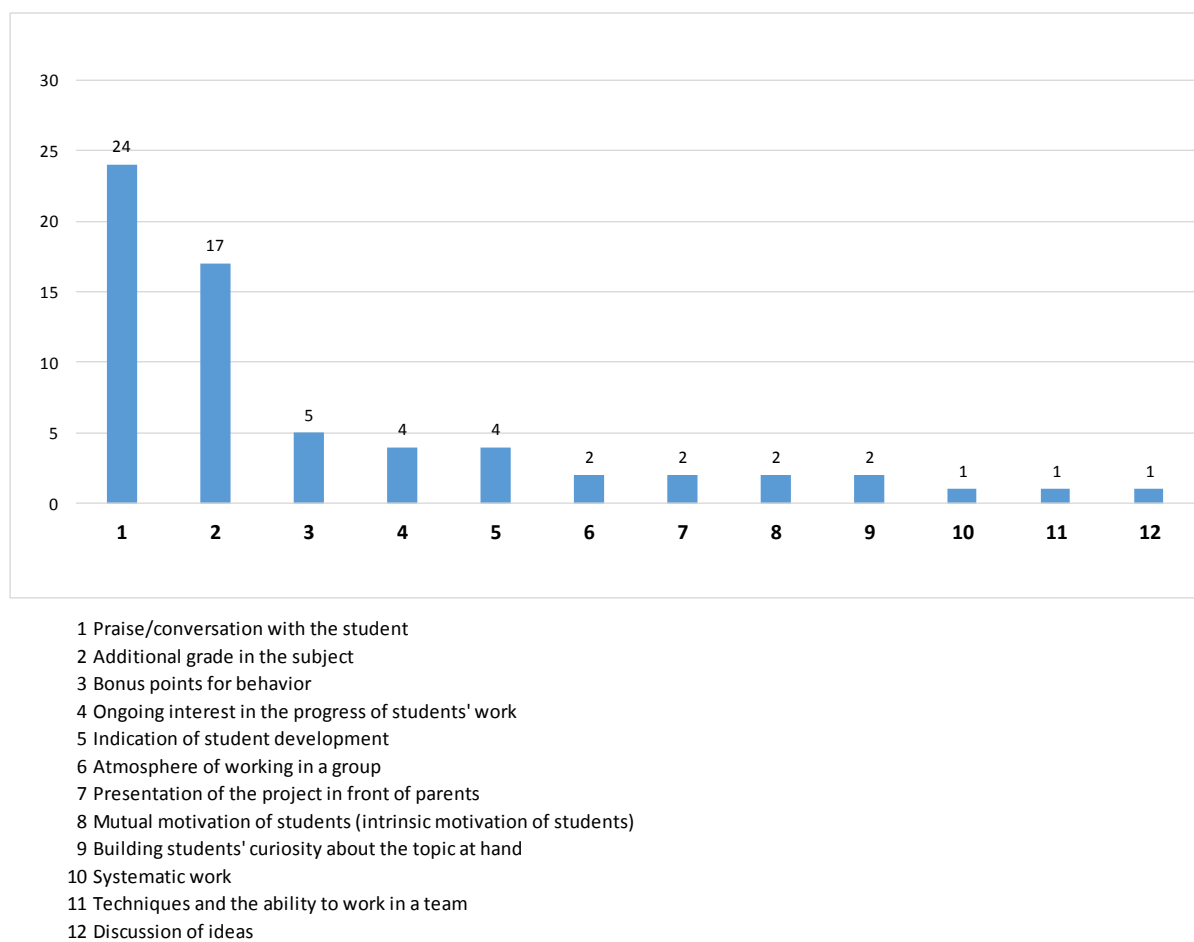


Figure 6 Type of motivation used when working with a team of students.

Source: own study.

Figure 6 presents methods of motivating students to work in project teams. Group supervisors were to indicate the methods used. Of course, the end-of-year assessment is at the forefront, but the method most often used was a conversation with students - praise, which, considering the number of projects that ended in success, may indicate the effectiveness of such a seemingly simple motivational method. At the same time, according to the authors, this emphasizes the need of devoting time to work with students and building a relationship with them that allows such cooperation. Simultaneously, teachers first pay attention to the lack of time as a problem related to the implementation of the project (Fig. 7).

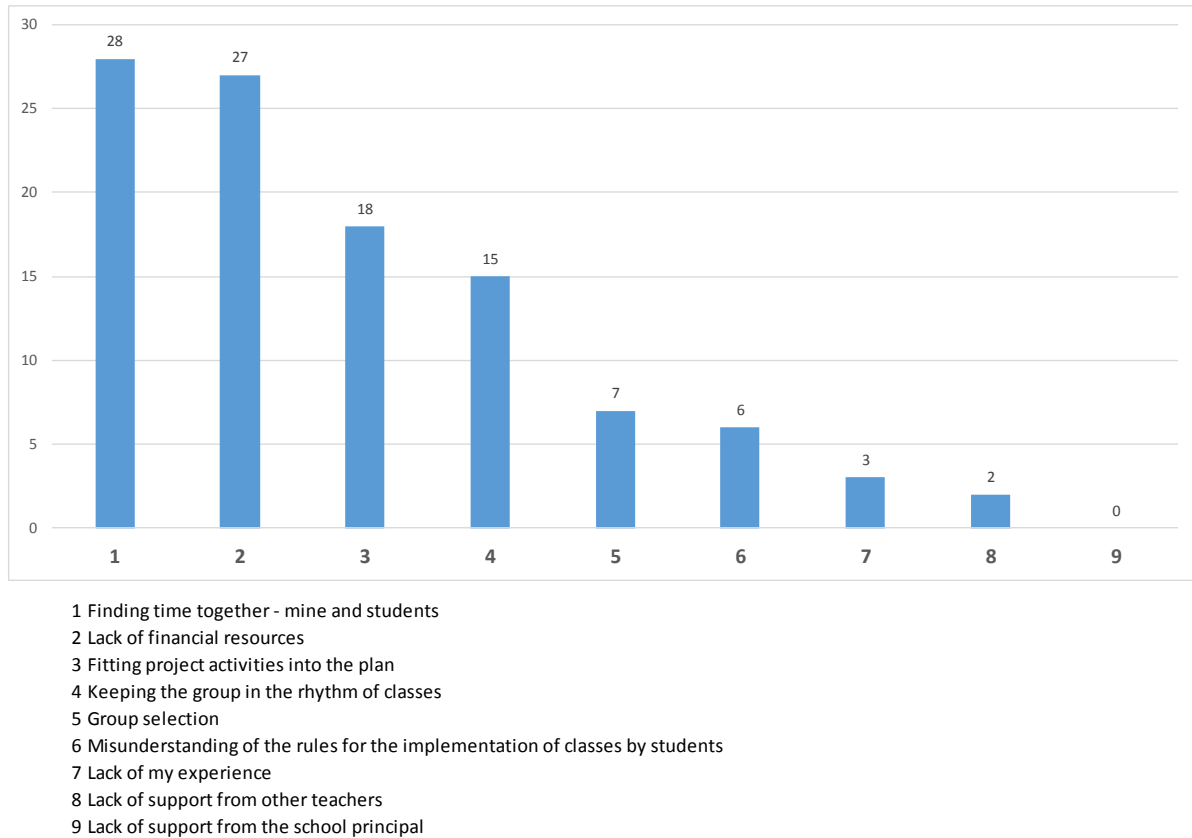


Figure 7. Types of problems during classes with students. Source: own study.

It is also clear that the implementation of student projects is hampered by the lack of budget for the tasks being carried out. Other problems include the appropriate arrangement of classes in the schedule and uneven work of groups. It can therefore be assumed that the key issues are the organization of classes in schools and the ability to work with a group.

Below are the descriptive results of a survey conducted among teachers who implemented project-based classes in the 2022/2023 school year. All statements are presented, and importantly, in some cases they are contradictory, which is most likely due to the different nature of schools or the experience of teachers responsible for implementing the project. The last of the listed comments, “Continue to implement”, is optimistic, as it clearly indicates the good reception and potential of the adopted idea. The responses presented below are almost 100% quotes from the received statements. They have been slightly edited to ensure their consistent grammatical form.

Question: What positive experiences occurred during the project implementation and how to strengthen them – if possible?

- a. Integration of the class group, cooperation between teachers, inter-subject correlation around a specific topic (in our case, getting to know our city), getting to know the history, infrastructure and cultural zones of the city.
- b. The children were eager to cooperate and share their ideas. It would be worth organizing a workshop for teachers working in projects with children.

- c. Developing responsibility and independence in most students and integrating students within the groups formed.
- d. Students develop the ability to work in a group, they become better at creating films/presentations in Canva, group leaders emerge.
- e. Group integration, weaker students can learn more from more capable peers, mutual motivation. Students discover their abilities and skills, gain the approval of their peers, their self-esteem increases.
- f. Group integration, strengthening cooperation among students, broadening knowledge and intellectual horizons, gaining new experiences.
- g. Group integration, student engagement, improving key competences.
- h. The project topic, very well thought out and tested in advance by the teacher. The topic was imposed on the groups from above, but the students had the opportunity to choose the area that interested them the most, modify many aspects of the topic, decide on the form of implementation of individual points. Generally, each group has the same issue to implement. By imposing a topic and listing the most important elements, it is easier for students to organize and plan their work. The possibility of choosing a specific area and the way of implementing the imposed points gave them a sense of decision-making and allowed them to adjust the form of performing the tasks, in accordance with their interests and skills.
- i. The project topic was previously "tested" by the leading teacher on a group of high school students. Therefore, it was easier to anticipate possible problems and modify activities.
- j. Integration of the group, there was cooperation between students.
- k. Strengthening relationships in the classroom, good cooperation between students, parents support throughout the process.

Question: What was/is a barrier to the project implementation, and what measures were used to overcome the barrier/problem? (if it could not be used, please indicate this as well)

- a. Lack of funds and lack of time in the lesson plan (specific hours allocated) for the implementation of the project. Concerns about how the twelve-year-olds will implement what we have planned, fear of the unknown, blocking subjects, difficulties in arranging the lesson plan, uneven pace of work of the project groups.
- b. Students come from different families with different financial status, have different financial resources that they can use to purchase the necessary materials (solution - checking information on the Internet, creating ICT tasks - Kahoot, etc.), some commute to school from outside the district and it is difficult for them to meet at a time other than project classes when combining classes.

- c. Blocking the subjects from the project on one day so that students could complete the project at school turned out to be unrealistic; implementing the project during classes caused difficulties in completing the core curriculum.
- d. The barrier is the small number of lessons with the class, sometimes missed classes (own illness, illness of the children, outings of the whole class or teacher).
- e. There is no additional hour or project classes to complete the project. Classes are held as part of lessons or as substitutes. All necessary materials are financed by parents or the teacher.
- f. Teachers have no experience in conducting long-term projects, poor motivation among children, lack of independence among students in taking actions to complete the project.
- g. Lack of financial resources to implement individual activities.
- h. Failure to take into account the specifics of individual schools.
- i. Organization of time for project implementation. Despite blocking the subjects covered by the project, it is difficult to implement it smoothly and effectively when you have to "sacrifice" lessons and the core curriculum at the same time. The long project implementation time is also a challenge for primary school students. From my experience working with people of this age, the most effective projects are those that do not last longer than 1-2 months. Stretching the work means that students forget what they have already done, are unable to return to their original ideas, come up with too much or too little and are not fully engaged in such long-term activities. The second problem is the total lack of funding, even for stationery needed by children to complete tasks. There is also a lack of funds for salaries for teachers leading the project. In school conditions, access to a computer room, printers and other necessary equipment also proved to be a problem. In order for the project group to be able to work, the other classes had to move their computer science lessons to regular classrooms that day.
- j. Different levels of student involvement.
- k. Time. Possibilities of meetings, providing advice and indicating the direction of activities. Students' lack of skills to work with long-term projects, they are only just learning this style, project work. Hence a number of questions and concerns on the part of students. It was necessary to divide tasks well, set precise deadlines, constantly monitor whether the work was progressing and the activities were carried out by students in the appropriate scope and according to the arrangements.
- l. Lack of financial resources. Students used their own resources.

Question: What comments do you have on the organization of the project?

- a. A systemic solution would be additional lesson hour(s) allocated to the implementation of the project (grade VI).
- b. The project method itself is a method that has many advantages. Students learn to work independently and solve problems creatively. However, I do not like the form of combining subjects. In the sixth grade, it is difficult to bring students' invented topics

into line with the core curriculum at this level of education, and it is even more difficult to combine three or more core topics from different subjects - sometimes completely unrelated. Projects should be based on either humanities or science topics. Students could choose from a range of proposed topics, which teachers would prepare in advance in subject teams - of course, the topic could be modified in consultation with the students.

- c. In the future, leave the possibility of formulating topics to teachers - students can decide on a topic that interests them; implement a project within a group of related subjects (humanities, mathematics and science).
- d. It is difficult for students to meet outside of school, most participate in various additional extracurricular activities (outside of school). An additional hour per week in the schedule, intended only for project work would be very useful.
- e. Maybe in the future volunteers can be recruited to implement the project, not the entire class.
- f. Lack of funds for organizing project plans, e.g. culinary products, financing scheduled trips.
- g. Lack of common principles for implementing the project for all schools.
- h. The project was not entirely thought through (maybe it was introduced too quickly), mainly in practical and organizational terms.
- i. The final effect was very satisfactory, the students had the opportunity to present the results of their work to the whole school and to their parents. Topic: Silesia and neighboring regions. The students presented voivodeships in numbers, interesting facts, important information, they did not even forget about regional costumes and traditional dishes. The coats of arms of the provinces and local music were also made. Visible were different points of view and various ideas on how to present their province. I consider the whole thing a very successful undertaking.
- j. No additional hours allocated for the implementation of the project.

Question: What areas/project elements should be improved and how?

- a. First of all, we should allocate specific hours for the implementation of the project, assign a certain amount of money for it, so that parents do not complain that they are supporting schools in the city (see LP). In grades 1-5 children should be taught to work in groups, so that in grade 6 there will be no issues with this in project classes.
- b. The project should be a separate subject for the class, written into the class plan (teacher gets compensation for the hour); financial resources for each school to implement the projects: necessary materials; apart from that, my opinion was presented in the point above.
- c. Allocate additional hours for the implementation of the project, e.g. from principal's hours.
- d. Providing funds for the implementation of projects.

- e. Preparation of the project - lack of financial resources for materials needed to implement the activities. Financing the activities of supervisors and coordinator.
- f. Financing - funds to be used in the implementation of the project as well as salaries for teachers. Organization of project classes for students, shortening the time of work on the project. More intensive work, but in a shorter time (e.g. project month).
- g. Planning division into project groups.

Any other comments/conclusions on the course of the project?

- a. We need to consider whether in times of crisis and financial constraints we can afford to implement all strategic tasks. I am sure that every person living in Poland will understand the lack of finances and failure to implement strategic tasks, especially in such an unfashionable area as education is lately.
- b. Additional funds for materials needed to implement the project.
- c. Providing at the beginning of the task the amount of funds that the project group has at its disposal to implement the project.
- d. Continue to implement.

5. Discussion of the model and summary of experiences

The first edition of project classes in schools brought a number of experiences gathered during work with students. The general model of classes, dividing the work in the school year into a period of preparing teams and topics, and then a period of implementation, proved effective. Teams used the prepared Card to plan their own activities, and then executed them.

The issues that required modification were primarily elements related to the organization of teachers' work - it was not always easy to find time for them to work together with students, especially in situations where they worked in two schools. Another challenge was to define the work topics of student teams so that they could implement elements of the curriculum appropriate for the subjects in which the project was conducted.

Finances, as usual, remain a separate issue. The project was implemented without a dedicated budget for student projects, which required tasks to be implemented based on non-financial resources, such as a bus provided by the city, access to the city's educational center, materials owned by schools or financed by parent councils. For the further development of the project, it is necessary to consider the financial resources needed to implement subsequent topics. This is not about large amounts - during the work, the budget of a single team was estimated at PLN 500 to, in rare cases, PLN 2000.

It should be emphasized that despite initial objections, the majority of the team implementing classes according to this model assessed it positively, indicating the possibility of using it in the future.

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Attachment 1 – template of the project card prepared by students with the support of their supervisors

Wodzisław Śląski, date

Project Card

1. Project topic:

2. Project team

First name and last name	Class

3. Team leader:

4. A team of supervisors with the coordinator

5. Team work rules 1/week, full week, etc. – and what cooperation with supervisory teachers should look like

6. Why this topic:

7. Method of presenting the results:

8. Methods of implementing the ideas for achieving the results listed in point 7:

9. What problems may occur during the implementation of the project?

Model of project classes...

10. Main tasks to be completed (presentation, trip, leaflet)

Project task	Task leader	Implementation period



11. Other information about the project:

12. Materials and tools needed to complete the project

Type	Quantity

Team leader and the team (signature)

Appendix 2 – list of topics proposed before implementation and selected topics that were implemented in the full cycle.

Proposed topics¹

1. Travel educates. Plan a 5-day trip to a European country of your choice.
2. The world seen through a camera lens.
3. Silesia full of charming spots.
4. In the footsteps of our school graduates?
5. Polish regional dishes.
6. Our Silesian traditions - a guide.
7. In the footsteps of Fryderyk Chopin.
8. What installations are hidden in our houses?
9. Is Wodzisław Śląski an attractive city?
10. Extraordinary residents of Wodzisław Śląski.
11. Tourist attractions of the world's largest islands.
12. Flavors of Italy.
13. My school - my place.
14. My dream kitchen.
15. The history of Wodzisław through the history of ordinary people.
16. „Komu w drogę, temu...” [Time to hit the road]
17. „Taniec łagodzi obyczaje?” [Dance softens manners]
18. The fascinating world of reptiles.
19. „Jeż zdrobniale, który lata doskonale” [The common swift]
20. Seasons - nature changes the landscape.
21. A journey to our Solar System.
22. What do we know about Poland's neighbors?
23. My region - my small homeland.
24. Every country has its customs.
25. “WITAJ MAJOWA JUTRZENKO...” - celebrations of the Constitution Day on May 3.
26. Silesia and neighboring voivodeships.
27. „Wszędzie dobrze, ale...” [There's no place like home]
28. In the footsteps of regional poets.
29. Do you know your roots?
30. The daily life of an athlete.
31. Following the lives of forest creatures.

¹ The equivalents of specific Polish sentences/proverbs are presented in brackets.

EVALUATION OF POLAND'S ENERGY TRANSITION PROCESS BETWEEN 2012-2022

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Purpose: The primary objective of this study is to empirically assess the progress of Poland's energy transition from 2012 to 2022.

Design/methodology/approach: The study employs a multidimensional approach using multi-criteria analytical methods. Specifically, the CRITIC and TOPSIS methods were utilized. The CRITIC method was applied to determine the weights of selected indicators that characterize Poland's energy transition process. These indicators include key parameters such as energy efficiency, the share of renewable energy sources in total production, greenhouse gas emissions, and electricity costs. Subsequently, the TOPSIS method was used to develop an index for assessing Poland's energy transition from 2012 to 2022. This index allows for the evaluation of the changes implemented in each year within the study period.

Findings: The results indicate that Poland has made significant progress in the energy transformation of its economy. The value of the Energy Transformation Assessment Index has markedly increased in 2022 compared to 2012. This improvement reflects the consistent and effective implementation of pro-environmental policies and measures aimed at the sustainable development of both the energy sector and the national economy as a whole.

Practical implications: The developed evaluation methodology offers a universal approach to determining a country's energy efficiency, which can be successfully applied to any country. By utilizing advanced multi-criteria decision analysis methods, this approach considers a broad range of criteria, including energy efficiency, the share of renewable energy sources, greenhouse gas emissions reduction, economic costs, and societal impact. Its versatility allows it to be used for evaluating both individual countries and groups of countries.

Originality/value: This paper introduces a novel approach by using MCDM-type methods to assess the effectiveness of a single country's energy transition process. This comprehensive approach provides a holistic assessment of the energy transition, encompassing dimensions of energy security, economic performance, environmental impact, and social outcomes.

Keywords: energy transition, process efficiency, energy policy, MCDM methods, multi-criteria analysis.

Category of the paper: Research paper.

1. Introduction

Global climate change, including increases in average temperatures, changes in precipitation patterns, and increasingly frequent extreme weather events, has become a serious threat to the entire Earth's ecosystem, including humans (Bolan et al., 2024; Kumar et al., 2021). To mitigate these effects, many countries and regions, including the EU-27, have committed to an energy transition that involves reducing greenhouse gas emissions, increasing the share of (RES) energy sources, and improving energy efficiency.

In recent years, energy transition has emerged as one of the key challenges for many countries, including Poland. This process, which involves transforming energy structures and implementing sustainable development strategies, is a crucial component of global efforts to combat climate change and protect the environment (Mehmood et al., 2024). The energy transition is a complex and multifaceted endeavor aimed at modernizing the energy sector to make it more sustainable, environmentally friendly, and resilient to various fluctuations in the energy market (Miller et al., 2015; Razzaq et al., 2023). This process primarily entails changes in the fuel mix used for energy production and the technologies employed in the power industry. Today, the energy transition encompasses much broader areas and affects all relevant aspects of life. It is generally understood as a shift from an energy system based on conventional sources to one that is based on zero-carbon, primarily RES. Simultaneously, this process is intended to foster economic growth, be environmentally sustainable, and avoid deteriorating the quality of life (Brodny et al., 2024).

The energy transition process thus involves a fundamental transformation in the way energy is produced, distributed, and consumed. Traditionally, many countries have relied on fossil fuels such as coal, oil, and natural gas for their energy systems (Hailes, Vinuales, 2023). While these sources are relatively cheap and accessible, they have serious negative environmental impacts due to the large emissions of carbon dioxide and other harmful substances they produce (Yang et al., 2024). A key objective of the energy transition is therefore to increase the share of renewable energy sources, such as wind, solar, hydroelectric, and biomass, which are less harmful to the environment and help reduce greenhouse gas emissions (Rahman et al., 2022).

In the energy transition process, the European Union is playing a key role in becoming a global leader. The ambitious goals and initiatives it has adopted are designed to reduce the environmental impact of the energy sector without compromising economic development and citizens' quality of life. As part of its energy and climate policy, the EU aims to significantly increase the share of RES in the energy mix and improve energy efficiency. To achieve these goals, it is introducing a range of regulations and strategies to promote investment in green technologies and innovative solutions. This also applies to Poland, an EU member state,

which is undergoing an intensive transformation of its energy sector. This transformation is essential to meet the EU's energy and climate policy objectives and to ensure energy security.

Therefore, given the timeliness and complexity of this issue, as well as the long-term nature of the energy transition process, it is crucial to assess the progress made in this area in Poland. This is particularly important since Poland is one of the largest EU countries and falls within the group of developing nations. Evaluating Poland's energy transition process from 2012 to 2022 is a vital step in assessing the effectiveness of the measures implemented during this period and in identifying areas that require further development.

The purpose of the research, the results of which are presented in this paper, was to develop and implement a multidimensional research methodology and conduct an assessment of the progress of Poland's energy transition from 2012 to 2022. The study employed the CRITIC and TOPSIS methods from the MCDM group. The CRITIC method was used to determine the weights of selected indicators characterizing the energy transition process in Poland. These indicators included key parameters such as energy efficiency, the share of RES in total production, greenhouse gas emissions, and electricity costs. Based on the TOPSIS method, an index for assessing Poland's energy transition during the 2012-2022 period was then determined.

2. Materials and methods

The study, which aimed to assess Poland's energy transition process between 2012-2022, was based on a set of 17 key diagnostic variables that characterize the process. The selection of these variables was based on their importance in the context of the energy transition and their ability to reflect the changes taking place in the Polish energy sector. The chosen variables reflect crucial aspects of energy production, consumption, and security, as well as the environmental, economic, and social dimensions of the transition. The selected indicators had to meet the following criteria:

1. **Relevance to the Energy Transition.** The primary criterion for selecting indicators was their direct link to energy transition goals, such as reducing carbon emissions, increasing energy efficiency, and shifting to renewable energy sources. Variables like the share of renewables in the energy mix, energy sufficiency ratio, and Greenhouse Gases (GHG) intensity of energy provide insights into the pace and progress of this transformation.
2. **Comprehensive Coverage of Key Aspects.** To capture a holistic picture of the energy transition, the selected variables span across different domains. This includes economic indicators such as GDP per capita and energy productivity, environmental indicators like GHG emissions and their intensity, and social indicators such as energy poverty (e.g., the population unable to keep homes adequately warm). This broad approach

ensures a balanced assessment of both the achievements and challenges of the energy transition.

3. **Reflecting Key Drivers of Energy Policy.** Several variables, such as energy imports dependency, diversifying the energy mix (HHI), and the energy intensity of production, were included because they are critical to understanding energy security, independence, and the resilience of the energy system. These indicators are essential in evaluating whether Poland is reducing its reliance on external energy sources and promoting a more sustainable, diversified energy mix.
4. **Data Availability and Reliability.** The data for all the selected variables were sourced from the EUROSTAT database, ensuring consistency, reliability, and comparability over the 2012-2022 period. EUROSTAT's comprehensive and standardized datasets allow for a consistent approach in analyzing energy-related trends across the years, enabling a robust and objective evaluation.
5. **Ability to Reflect Change.** Each selected indicator was chosen based on its capacity to reflect measurable changes in the energy sector. For example, energy productivity (measured in euros per kilogram of oil equivalent) offers an insight into how efficiently energy is being utilized in relation to economic output, while energy intensity and GHG intensity show the effectiveness of energy policies in reducing carbon emissions relative to energy consumption or Gross Domestic Product (GDP).

These variables included:

- total primary energy supply per capita, tons of oil equivalent (TOE);
- primary energy consumption per capita, tons of oil equivalent (TOE);
- energy imports dependency, %;
- diversifying the energy mix - the Herfindahl-Hirschman Index (HHI);
- energy sufficiency ratio;
- share of non-renewables in energy mix, %;
- share of renewables energy mix, %;
- GDP per capita, Euro;
- energy productivity, euros per kilogram of oil equivalent (KGOE);
- energy intensity, kilograms of oil equivalent (KGOE) per thousand euros;
- electricity prices for non-household consumers (consumption from 500 MWh to 1,999 MWh, all taxes and levies included), euros/kilowatt;
- electricity prices for household consumers (consumption from 2,500 kWh to 4,999 kWh, all taxes and levies included), euro/kilowatt;
- total GHG per capita, (tons CO₂ eq.);
- GHG Intensity of Energy, (kg CO₂ eq./toe);
- total GHG - GDP Intensity (tons CO₂ eq./M€);
- RES share in gross final energy consumption, %;
- population unable to keep home adequately warm by poverty status, %.

All data used in the study came from the EUROSTAT database and covered the years 2012-2022.

The essential calculations required to determine the value of the Index of Assessment of the Energy Transformation Process (IAETP) for Poland were conducted using multi-criteria analysis methods. This advanced technique considers multiple dimensions, or diagnostic variables, simultaneously, which is crucial for evaluating complex processes like energy transformation. To determine the weights of the indicators, the CRITIC method (Criteria Importance Through Intercriteria Correlation) was employed. These calculated weights were subsequently integrated into the core assessment using the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method.

The CRITIC method is a well-regarded approach in multi-criteria decision analysis, utilized for determining the relative importance of criteria in evaluation and decision-making processes. This method bases its calculations on an analysis of the correlation between criteria and the standard deviation of each criterion's values. Consequently, the CRITIC method considers both the data dispersion (standard deviation) for each criterion and the strength of interdependencies (correlations) between criteria (Diakoulaki et al., 1995). The calculation steps involved in this method are as follows:

- To construct a decision matrix:

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

- To normalize a decision matrix:

$$r_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}; \text{ for benefit criterion} \quad (2)$$

$$r_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}; \text{ for cost criterion} \quad (3)$$

- To determine the standard deviation (SD) values for the criteria (diagnostic variables) included in the assessment:

$$SD = \sqrt{\frac{\sum_{i=1}^n (r_{ij} - \bar{r}_{ij})^2}{n-1}} \quad (4)$$

- To determine the values of correlation coefficients between the criteria (diagnostic variables) included in the assessment:

$$r_{jk} = \frac{\sum_{i=1}^n (r_{ij} - \bar{r}_{ij})(r_{ik} - \bar{r}_{ik})}{\sqrt{\sum_{i=1}^n (r_{ij} - \bar{r}_{ij})^2 \sum_{i=1}^n (r_{ik} - \bar{r}_{ik})^2}} \quad (5)$$

- To determine the value of the Information Capacity measure (C_j):

$$C_j = SD \sum_{i=1}^n (1 - r_{jk}) \quad (6)$$

- To determine the weights of the evaluation criteria:

$$w_{ij} = \frac{C_j}{\sum_{i=1}^n C_j} \quad (7)$$

The TOPSIS method is a popular technique for multi-criteria decision analysis. It involves evaluating and comparing different alternatives (in the paper, the alternatives are the years under study) based on the distance from the ideal solution (the best possible solution) and from the anti-ideal solution (the worst possible solution) (Brodny, Tutak, 2023; Hwang et al., 1993). The process of determining the evaluation index involves the following steps:

- To construct a decision matrix (equation 1);
- To normalize data:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad (8)$$

- To construct a normalized weighted matrix:

$$v_{ij} = r_{ij} \cdot w_j \quad (9)$$

- To identify the ideal (A^+) and anti-ideal (A^-) solution:

$$A^+ = \{v_1^+, v_2^+, \dots, v_m^+\};$$

$$v_j^+ = \left\{ \left(\max_i v_{ij} | j \in S \right), \left(\min_i v_{ij} | j \in D \right) | i = 1, 2, \dots, n \right\} \quad (10)$$

$$A^- = \{v_1^-, v_2^-, \dots, v_m^-\}; v_j^- = \left\{ \left(\min_i v_{ij} | j \in S \right), \left(\max_i v_{ij} | j \in D \right) | i = 1, 2, \dots, n \right\} \quad (11)$$

- To calculate the distance from the ideal (D_i^+) and anti-ideal (D_i^-) solution:

$$D_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^+)^2} \quad (12)$$

$$D_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2} \quad (13)$$

- To calculate the measure of proximity to the ideal solution:

$$P_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (14)$$

- To make a ranking of alternatives based on the evaluation index (a measure of closeness to the ideal solution). The alternative with the highest value is the best alternative.

The methodology developed in this way was used to assess changes in Poland's energy transition process from 2012 to 2022.

3. Results and discussion

Based on the methodology developed and described (in Section 2), a study was conducted, the results of which are presented and discussed in this section.

3.1. Preliminary statistical analysis of the diagnostic variables adopted for the study

Table 1 shows the basic statistical parameters of the indicators (diagnostic variables) adopted for the study.

Table 1.

Basic descriptive statistics of the adopted indicators (diagnostic variables)

Indicators	Mean	Min	Max	Standard deviation	Coefficient of variation	Skewness	Kurtosis	Index of rate of change, %
X1	2.69	2.48	2.94	0.15	5.67	0.16	-1.13	110.00
X2	2.56	2.35	2.80	0.15	5.83	0.20	-1.07	109.63
X3	36.81	26.29	46.00	7.29	19.81	-0.08	-1.86	145.23
X4	0.33	0.28	0.37	0.03	9.15	-0.00	-1.57	83.76
X5	0.67	0.58	0.77	0.07	10.99	0.17	-1.98	78.57
X6	0.90	0.87	0.91	0.02	1.93	-0.37	-1.87	95.47
X7	0.10	0.09	0.13	0.02	16.58	0.37	-1.87	146.50
X8	12375.18	10000.00	15447.00	1966.97	15.89	0.32	-1.38	154.47
X9	4.44	3.91	5.29	0.41	9.22	0.67	0.41	135.26
X10	226.72	189.04	255.71	20.19	8.91	-0.25	-0.17	73.93
X11	0.12	0.10	0.15	0.02	14.26	1.30	0.97	133.22
X12	0.15	0.14	0.18	0.01	7.10	2.04	5.07	119.00
X13	10.40	9.83	10.86	0.31	3.02	-0.15	-0.25	98.92
X14	3857.02	3624.80	4089.96	179.78	4.66	-0.09	-2.01	89.58
X15	852.70	672.85	1017.21	111.86	13.12	-0.10	-1.07	66.15
X16	0.13	0.11	0.17	0.02	17.58	0.32	-2.03	154.07
X17	6.80	3.20	13.20	3.28	48.19	0.86	-0.11	37.12

Source: Own elaboration.

When analyzing the results, it can be concluded that the average primary energy consumption per capita in Poland during the analyzed period was 2.56 TOE, while the availability per capita was 2.89 TOE. The lowest primary energy consumption per capita occurred in 2013, at 2.35 TOE, while the highest was in 2022, at 2.80 TOE. On average, Poland imported about 37% of its energy between 2012 and 2022. The energy mix averaged 90% non-renewable sources and 10% renewable sources. The highest share of renewable sources in the energy mix was 13% in 2022, while the lowest share was 8.8% in 2013. The average share of renewable energy sources in final energy consumption was 13%.

During the review period, the average value of energy productivity was 4.44 euros per KGOE, and energy intensity was 226.72 KGOE per 1000 euros. From 2012 to 2022, average per capita greenhouse gas emissions were 10.40 tons of CO₂ equivalent, with the highest

emissions recorded in 2018 at 10.86 tons of CO₂ equivalent and the lowest in 2020, during the SARS-CoV-2 pandemic, at just under 9.9 tons of CO₂ equivalent.

3.2. Weight values of the indicators included in the study

In the next stage of the research, calculations were conducted to determine the values of the weights assigned to the indicators used in the empirical evaluation of Poland's energy transition process from 2012 to 2022. The analytical objective method, specifically the CRITIC method, was employed for these calculations. By determining these weights, the impact of individual indicators on Poland's energy transition process during the study period was accurately assessed. The results of these calculations are presented in Figure 1.

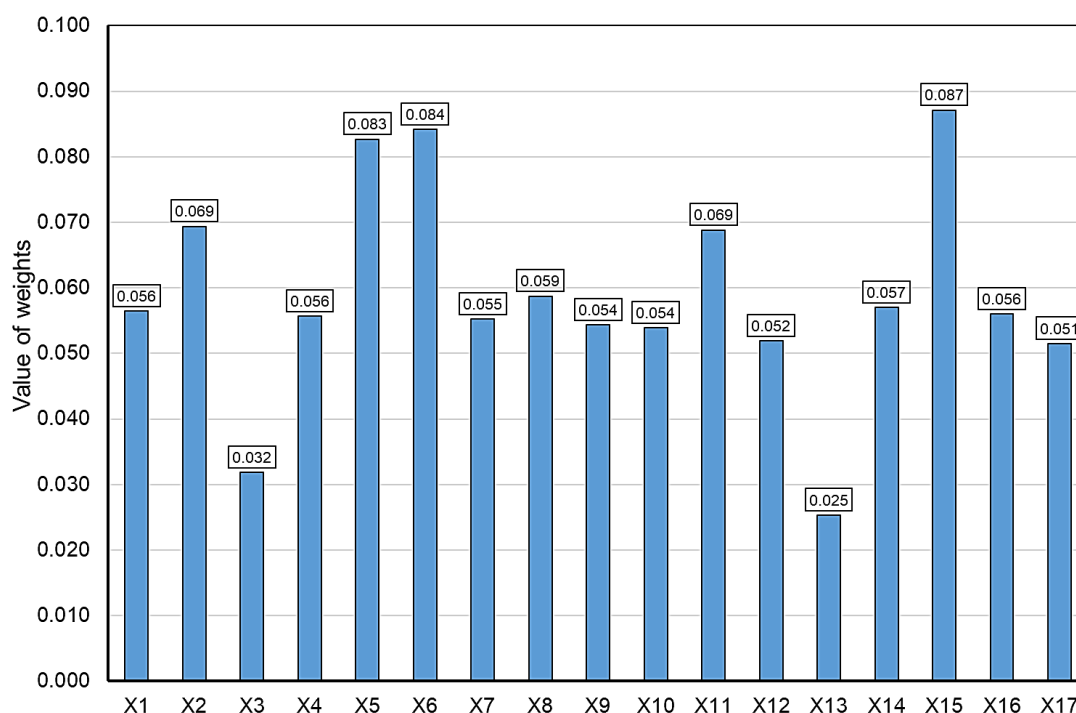


Figure 1. The values of the weights of indicators characterizing the energy transition in Poland determined by the CRITIC method.

Source: Own elaboration.

The analyzed indicators have varying weights, reflecting their relative importance in evaluating the energy transition process. Indicators such as GHG intensity to GDP (X15), share of non-renewable sources in the energy mix (X6), and energy self-sufficiency (X5) carry the highest weights, underscoring their significance to the research. Conversely, indicators like dependence on energy imports (X3) and total GHG per capita (X13) have the lowest weights among all indicators, though they remain important for assessing the process.

3.3. Assessment of Poland's energy transition process in 2012-2022

Using the determined weights for the indicators and applying the TOPSIS method, an index for assessing Poland's energy transition process (IAETP) from 2012 to 2022 was calculated. This period was chosen for analysis because it encompasses the most significant transformations in the energy sector. Between 2012 and 2022, Poland experienced substantial changes in energy policy, including increased use of renewables, alterations in the energy mix, and the implementation of new regulations aimed at improving energy efficiency and reducing greenhouse gas emissions. These factors contribute to the complexity of the energy transition process.

From 2012 to 2022, Poland's total primary energy supply per capita (Fig. 2) exhibited a generally rising trend, starting at 2.56 tonnes of oil equivalent in 2012, peaking at 2.94 tonnes in 2021, and then falling to 2.81 tonnes in 2022. This increase suggests a growing energy demand driven by economic development and increased industrial activity. Similarly, primary energy consumption per capita (Fig. 2) rose from 2.44 tonnes in 2012 to 2.80 tonnes in 2021, before decreasing to 2.67 tonnes in 2022. The rise in primary energy consumption reflects increased energy needs due to economic growth, higher productivity, and improved living standards. The noticeable rise in energy consumption up to 2021, followed by a decline in 2022, may indicate influences such as fluctuating energy prices, changes in economic structure, or the effects of policies aimed at improving energy efficiency.

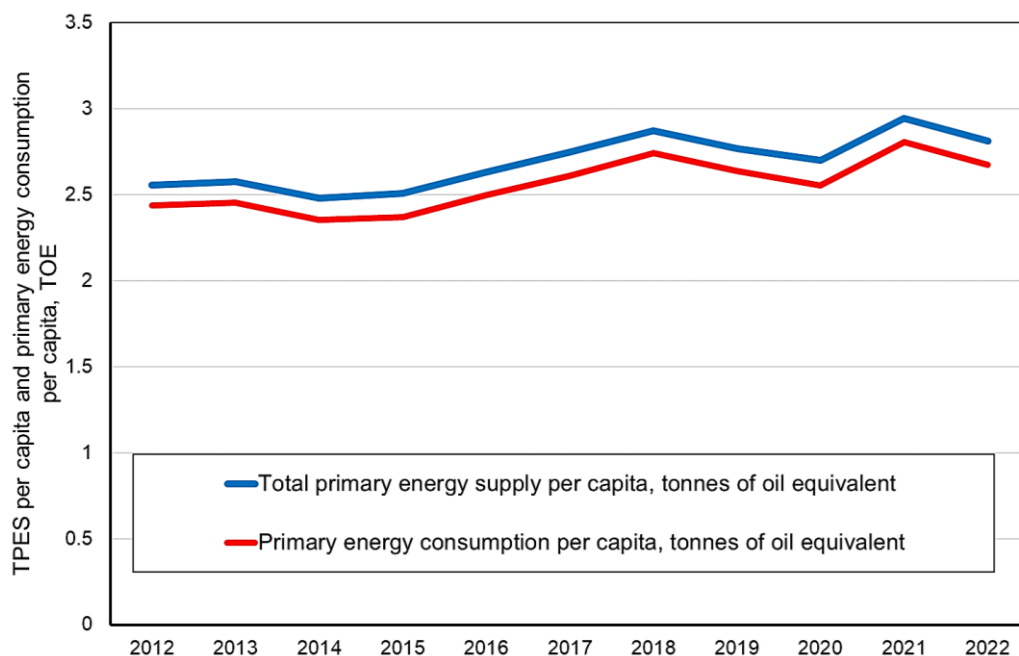


Figure 2. Changes in primary energy supply per capita and primary energy consumption per capita from 2012 to 2022.

Source: Own elaboration.

The decrease in both total primary energy supply per capita and primary energy consumption per capita in 2020 compared to 2019 can be attributed to the COVID-19 pandemic. In 2020, many economic sectors, including industry, transportation, and services, experienced significant reductions in activity due to the pandemic. Restrictions such as factory closures, travel limitations, and decreased industrial activity led to a drop in overall energy consumption. In 2021, with the easing of pandemic restrictions and a gradual recovery in economic activity, both indicators rose, reflecting an increase in energy demand and economic recovery. The decline in 2020 underscores the pandemic's impact on the energy sector and highlights the vulnerability of energy consumption to global crises and changing economic conditions.

The energy import dependency ratio (Fig. 3) increased from 31.67% in 2012 to 46.00% in 2022. This rise signifies a greater reliance on energy imports due to increased demand and a decline in domestic energy production from local resources. It also reflects the growing importance of foreign energy sources in Poland's energy balance. The share of non-renewable sources in the energy mix (Fig. 3) decreased slightly from 91.13% in 2012 to 87.00% in 2022. Despite this reduction, non-renewable sources continue to dominate Poland's energy mix, indicating the challenges of a rapid transition to a more sustainable energy system. Conversely, the share of renewable sources increased from 8.87% in 2012 to 13.00% in 2022, demonstrating Poland's progress toward energy transition. Notably, between 2018 and 2020, the share of renewable sources exceeded 11%, reflecting growing efforts to develop renewable energy.

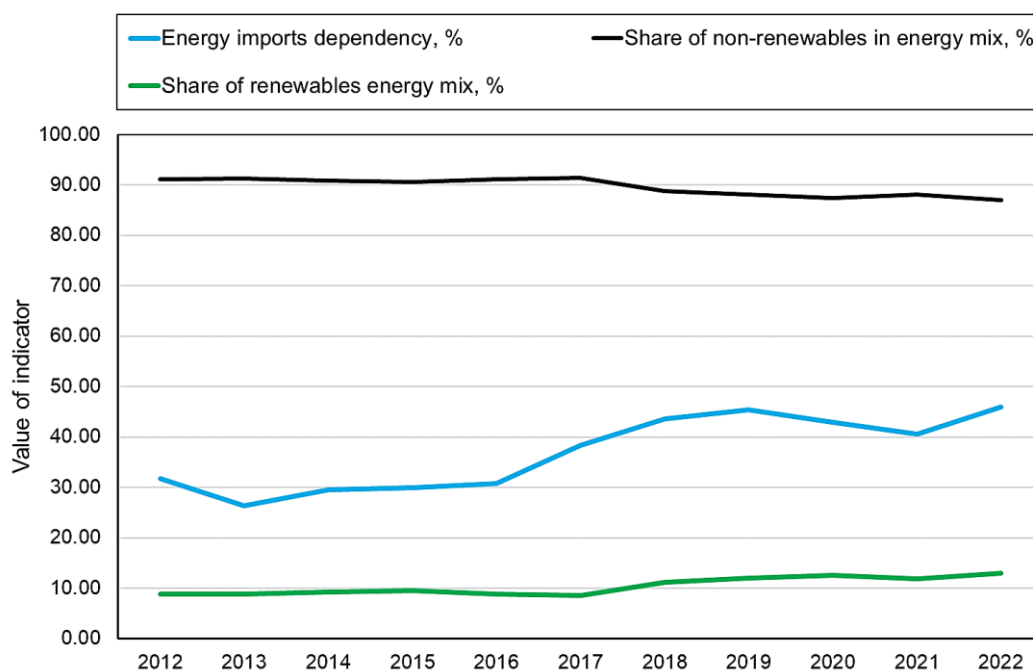


Figure 3. Changes in dependence on energy imports and the share of non-renewable and renewable sources in Poland's energy mix from 2012 to 2022.

Source: Own elaboration.

Analysis of data on the diversification of the energy mix, as measured by the Herfindahl-Hirschman Index (HHI) from 2012 to 2022 (Fig. 4), reveals changes in Poland's energy structure. The HHI, which reflects the concentration of energy sources in the energy mix, indicates the degree of diversification. Over the analyzed period, the HHI value decreased gradually from 0.36 in 2012 to 0.30 in 2019, remaining at 0.30 until 2022. This decline suggests that Poland's energy mix has become more diversified, reflecting an increased use of different energy sources.

Concurrently, the energy self-sufficiency index (Fig. 4), which is the ratio of energy production to consumption, demonstrated a declining trend throughout the period. Its value decreased from 0.766 in 2012 to 0.578 in 2021, before rising to 0.602 in 2022. The decline in the energy self-sufficiency index indicates a reduction in Poland's energy production capacity relative to its consumption.

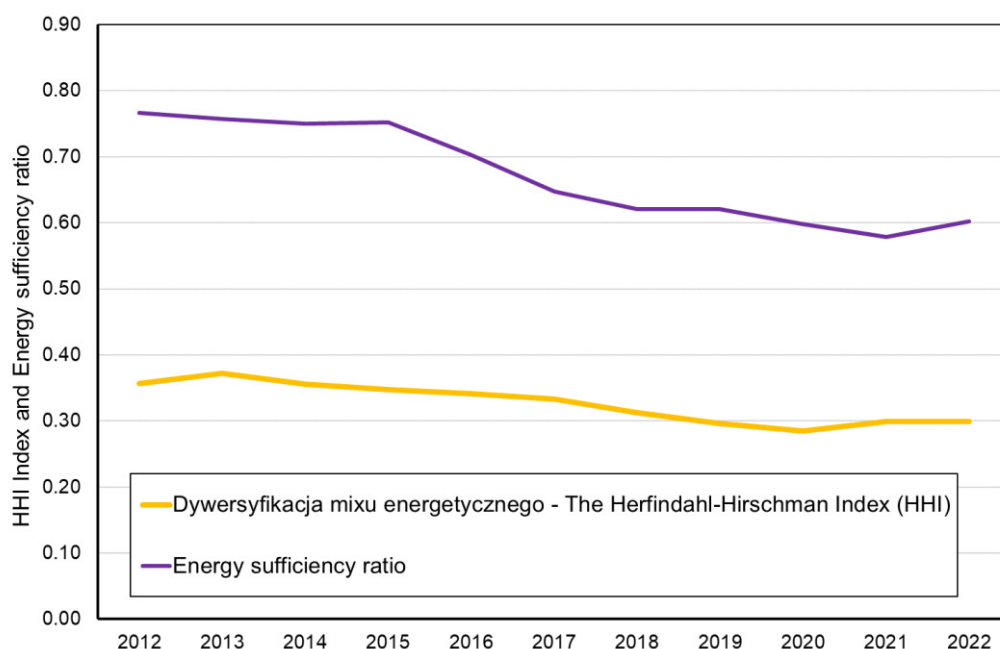


Figure 4. Changes in the diversification of Poland's energy mix and its energy self-sufficiency in 2012-2022.

Source: Own elaboration.

During the period under review (2012-2022), GDP per capita increased from €10,000 in 2012 to €15,447 in 2022 (Fig. 5). This over 50% increase reflects the country's overall economic development, improved living standards, and higher per capita income. This growth suggests that the energy transition has not disrupted the country's economic progress.

At the same time, energy intensity (Fig. 5), measured as kilograms of oil equivalent per thousand euros of GDP, exhibited a downward trend. In 2012, it was 255.71 kg/k€, and by 2022, it had decreased to 189.04 kg/k€. This decline indicates improved energy efficiency, with less energy consumption required per unit of economic output. This positive trend may result from the implementation of more efficient technologies, a shift to less energy-intensive production processes, or an increase in the share of more efficient energy sources.

It is notable that the decline in energy intensity was not uniform throughout the period. Between 2014 and 2019, energy intensity decreased gradually, reflecting ongoing efforts to enhance efficiency. However, in 2020, despite a decline in GDP due to the COVID-19 pandemic, energy intensity remained low. This suggests that the reduced energy demand was related to the economic context of the pandemic rather than a reduction in energy efficiency.

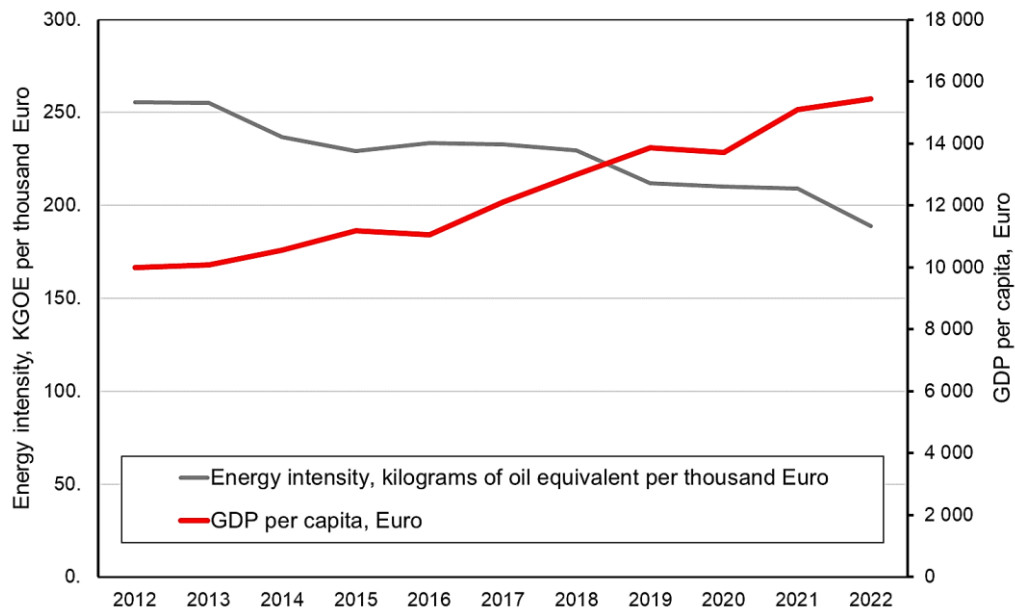


Figure 5. Changes in the value of GDP per capita and energy intensity from 2012 to 2022.

Source: Own elaboration.

The next indicators that were included in the energy transition assessment were energy prices for domestic users and industrial consumers (Fig. 6).

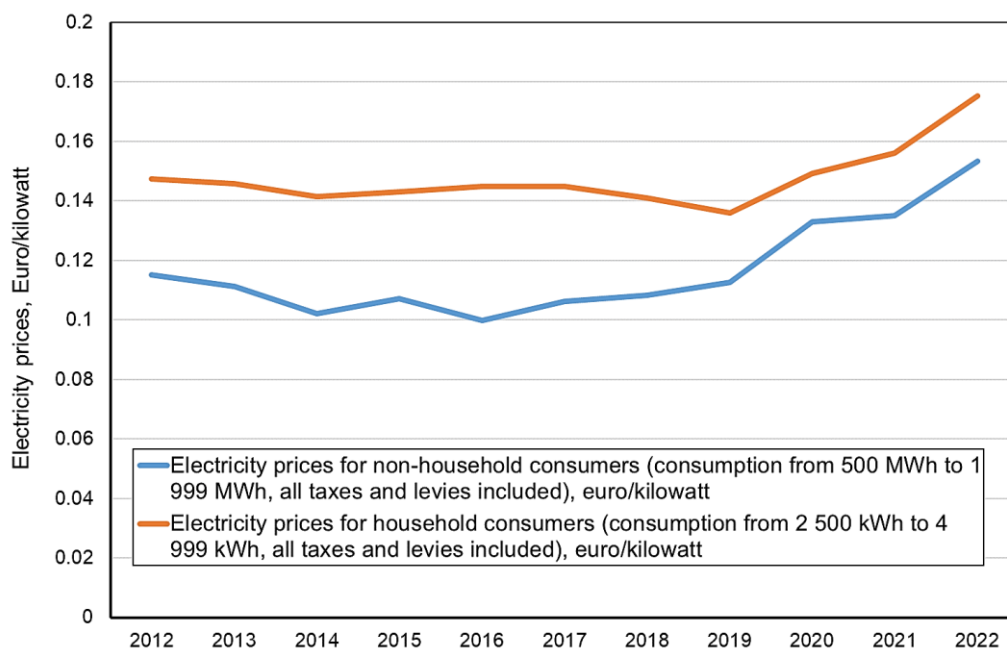


Figure 6. Formation of average electricity prices for residential and industrial consumers in 2012-2022.

Source: Own elaboration.

In the case of electricity prices for industrial consumers (those consuming between 500 MWh and 1,999 MWh per year), prices were relatively stable in the early years of the period under review. In 2012, the average price was €0.12 per kilowatt-hour. This price fluctuated in the following years, with a downward trend in the first part of the period, reaching a low of €0.10 in 2016. Prices then began to rise, reaching €0.13 in 2020, €0.14 in 2021, and €0.15 in 2022. For household electricity prices (consuming between 2,500 kWh and 4,999 kWh per year), prices were initially higher and more volatile. In 2012, the price was €0.15 per kilowatt-hour, which decreased to €0.10 in 2014. Prices then rose to €0.145 in 2016 and remained at that level until 2018, when they fell to €0.14. Starting in 2019, prices began to increase again, reaching €0.14 in 2020, €0.16 in 2021, and €0.18 in 2022. The increase in electricity prices in recent years is attributed to rising raw material costs, regulatory issues related to CO₂ emissions, the European Union's climate policy (including the Emissions Trading Scheme), and the geopolitical situation.

Analysis of data on greenhouse gas emissions per capita, GHG emissions intensity per unit of energy, and GHG emissions relative to GDP in Poland from 2012 to 2022 (Fig. 7) reveals varied trends and developments within the context of the country's energy transition.

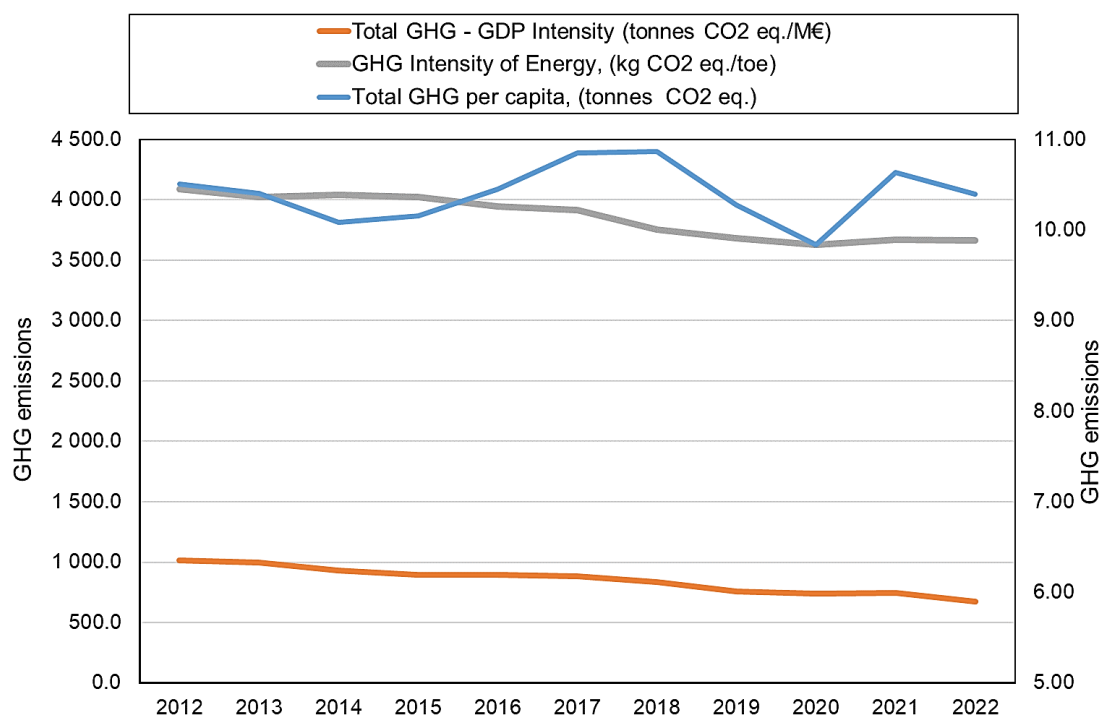


Figure 6. Shape of greenhouse gas emissions in Poland in 2012-2022.

Source: Own elaboration.

From 2012 to 2022, per capita greenhouse gas emissions showed a downward trend. Emissions decreased from 10.51 tons of CO₂ equivalent per capita in 2012 to 10.39 tons in 2022. The lowest per capita emissions were recorded in 2020 at 9.83 tons, a reduction attributed to lower energy consumption during the COVID-19 pandemic and its associated economic constraints.

The intensity of GHG emissions per unit of energy, expressed in kilograms of CO₂ equivalent per ton of oil equivalent (kg CO₂ eq./toe), also exhibited a downward trend. This intensity decreased from 4,089.96 kg CO₂ eq./toe in 2012 to 3,663.69 kg CO₂ eq./toe in 2022. This decline indicates progress in improving energy efficiency and reducing emissions within the energy sector. The most significant reduction in GHG emission intensity occurred between 2018 and 2019, likely due to the adoption of more advanced technologies and an increase in the share of renewable energy sources in the energy mix.

The intensity of GHG emissions relative to GDP, measured in tons of CO₂ equivalent per million euros of GDP, fell from 1,017.2 tons in 2012 to 672.85 tons in 2022. This substantial improvement reflects significant progress in the decarbonization of Poland's economy, attributable to both increased energy efficiency and structural changes within the economy. The most notable decrease in emissions intensity relative to GDP was observed between 2018 and 2020, suggesting improvements in overall efficiency and shifts in the industrial and service sectors.

From 2012 to 2022, the share of renewable energy sources in gross final energy consumption exhibited an overall upward trend (Fig. 7). In 2012, this share was 10.955%, and it increased to 16.879% by 2022. The most significant rise occurred between 2017 and 2018, when the share jumped from 11.059% to 14.936%.

Additionally, the percentage of the population unable to maintain adequate heat at home due to poverty decreased markedly during the review period, reflecting improved living conditions. In 2012, 13.2% of the population faced this issue, but by 2022, this percentage had dropped to 5% (Fig. 7). The most substantial decrease in this percentage was observed between 2013 and 2015, falling from 11.4% to 7.5%. This reduction was likely due to improved economic conditions during this time.

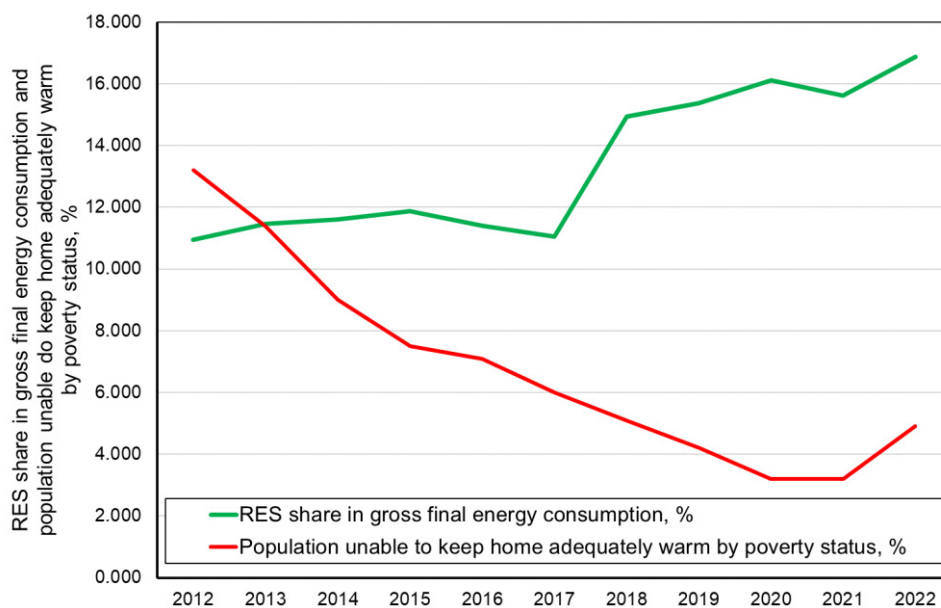


Figure 7. Changes in renewable energy in gross final energy consumption and the development of the energy poverty index in Poland from 2012 to 2022.

Source: Own elaboration.

The values of the indicators and the values of their weights, presented in Figures 2-7 (Figure 1), had a direct impact on the values of the index for assessing Poland's energy transition process (IAETP), in 2012-2022. The values of this index for this period are summarized in Figure 8.

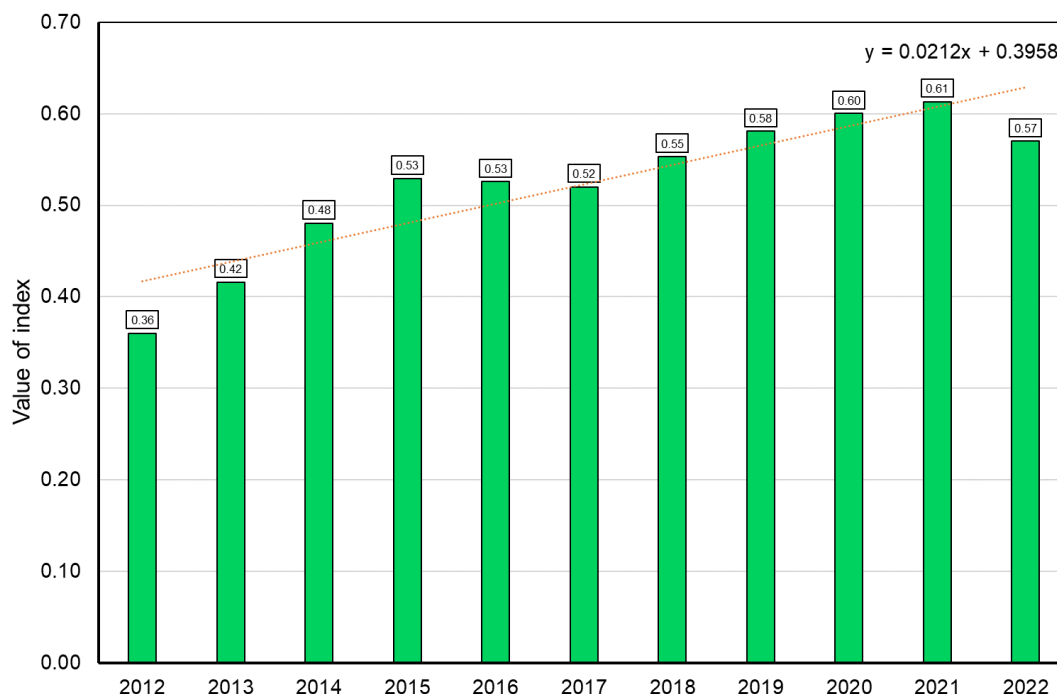


Figure 8. Values of the index for assessing Poland's energy transition process (IAETP) in 2012-2022.

Source: Own elaboration.

Analyzing changes in the index for assessing Poland's energy transition process from 2012 to 2022 reveals significant developments in the country's progress. In 2012, the index stood at 0.36, indicating that Poland was at the initial stage of implementing its energy transition policy. The index increased to 0.42 in 2013 and 0.48 in 2014, reflecting a growing commitment to improving energy efficiency and expanding renewable energy sources (RES).

By 2015 and 2016, the index value rose to 0.53, suggesting some stabilization and consolidation of the achievements in the energy transition. From 2017 onward, the index continued to grow, reaching 0.55 in 2018 and 0.58 in 2019, indicating an accelerated pace in the energy transition, driven by a higher share of RES in the energy mix and overall energy use. The highest index value was achieved in 2021 at 0.61. However, in 2022, the index value dropped to 0.57, signaling new challenges in the implementation of transformation policies. This decline can be attributed to factors such as increased GHG emissions in 2021, rising energy poverty, and higher electricity prices.

Despite this decline, the overall upward trend observed in previous years highlights positive progress in the energy transition process. Between 2012 and 2022, Poland achieved substantial advancements in its energy sector, contributing to noticeable progress in decarbonizing the national economy. However, the progress could have been more pronounced if not for Poland's

heavy reliance on conventional energy resources. The availability and low costs of fossil fuels have historically dampened public and political enthusiasm for transitioning away from them.

Although Poland continues to face challenges related to its reliance on coal and other fossil fuels, it is making steady progress toward diversifying its energy mix. The development of RES, such as wind and photovoltaic power, along with numerous initiatives to improve energy efficiency in industrial, transportation, and residential sectors, demonstrates ongoing efforts toward a more sustainable energy system (Kochanek, 2022; Rabbi et al., 2022). Importantly, these transformations have not negatively impacted the country's economic development or energy security.

Nevertheless, some studies suggest that energy transitions can temporarily affect energy security and economic growth rates (Li, Jang, 2019). Rapid shifts to renewable energy sources often involve high investment costs and technical challenges, potentially leading to temporary energy supply issues and higher energy costs (Hassan et al., 2024). This has been evident in Poland since 2019, with rising costs in energy production from traditional sources, increased energy commodity prices on international markets, and geopolitical factors contributing to higher energy costs.

4. Conclusions

Based on the developed methodology, a study was conducted to assess the effectiveness of the energy transition process in Poland from 2012 to 2022. The assessment considered key aspects of the process, including energy security, economic issues, climate impact, and social aspects.

The research revealed the following findings:

- The energy transition process in Poland is relatively slow. Despite positive effects, changes have been gradual compared to global standards, national needs, and EU-27 requirements.
- There has been a noticeable increase in the share of renewable energy sources, but it remains insufficient to fully address the country's growing energy needs and meet greenhouse gas emission reduction targets.
- Energy security issues, while relatively stable, require further action to ensure long-term energy independence.
- The energy transition process has not negatively impacted economic development. The value of GDP per capita increased by nearly 50% compared to the base year.
- There have been no significant social costs associated with the energy transition, as indicated by the Energy Transition Social Index, which shows no increase in the problem of energy poverty.

In light of these results, it is necessary to accelerate Poland's energy transition and invest further in environmentally friendly technologies. This approach will better address the challenges related to energy security, climate change, and social needs. Utilizing the results to manage transformation processes more effectively should lead to improved outcomes, both in terms of the overall IAETP index and the individual sub-indices.

5. Research limitations and directions for future research

The conducted research provided significant insights into the energy transition process in Poland; however, it is associated with certain limitations that must be considered when interpreting the results.

Firstly, the analysis was conducted exclusively for Poland, limiting the ability to compare the results with the situation in other countries. Energy transition is a global process, and the economic, social, and political diversity of individual nations can significantly influence the pace and effectiveness of this process. In light of the identified limitations, future research could be expanded and complemented by new approaches that enable a more comprehensive assessment of the energy transition process.

Expanding the research to include other countries, particularly those with similar levels of development and energy challenges, would allow for a comparative analysis of Poland's results with other regions. Such a comparative study would enable the identification of best practices and more effective transition strategies.

Another limitation is the relatively short time frame of the research, covering the years 2012–2022. While this ten-year period is sufficient to analyze the initial effects of the transition, it may be inadequate for capturing long-term trends and assessing the full impact of the transition on the economy, society, and environment.

An essential direction for future research is extending the time frame to capture long-term trends and evaluate the impacts of the transition in the context of changing economic and technological conditions.

The results obtained from this study can guide policymakers and industry stakeholders in shaping future energy strategies. The methodology proposed in this study offers a flexible framework that can be adapted to various national contexts and used to evaluate the progress of energy transition processes.

List of abbreviations

C_i	–	Information Capacity
CO ₂	–	Carbon Dioxide
CRITIC	–	Criteria Importance Through Intercriteria Correlation
€	–	Euro
GDP	–	Gross Domestic Product
GHG	–	Greenhouse Gases
HHI	–	the Herfindahl-Hirschman Index
IAETP	–	Index of Assessment of the Energy Transformation Process
kg	–	kilogram
KGOE	–	kilogram of oil equivalent
MWh	–	Megawatt-hour
RES	–	Renewable Energy Sources
SD	–	standard deviation
TOE	–	tons of oil equivalent
TOPSIS	–	Technique for Order Preference by Similarity to Ideal Solution
w_{ij}	–	the weights of the evaluation criteria

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APPLYING GENERATIVE ARTIFICIAL INTELLIGENCE TO SUPPORT INVENTION PROCESSES: AN ANALYSIS OF THE SYSTEMATIC INVENTIVE THINKING (SIT) METHODOLOGY

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Purpose: This paper aims to explore the integration of Systematic Inventive Thinking (SIT) methodology with Large Language Models (LLMs) to enhance innovative processes. It seeks to assess how LLMs can support analytical and creative processes in design teams and how hybrid human-LLM collaboration can contribute to more dynamic and unconventional problem-solving approaches.

Design/methodology/approach: The study employs a theoretical analysis of SIT methodology and LLM capabilities, synthesizing existing literature on both topics. It proposes a framework for integrating SIT with LLMs, including structured prompt patterns for each stage of the SIT process. The approach includes a comparative analysis of human and LLM capabilities in inventive processes.

Findings: Research reveals that LLMs can significantly enhance the SIT process by providing rapid information synthesis, generating diverse ideas, and systematically applying SIT principles. However, human creativity, intuition, and holistic assessment remain crucial for breakthrough innovations. The study identifies specific prompt patterns and techniques for effective human-LLM collaboration within the SIT framework.

Research limitations/implications: As this is an initial theoretical framework, empirical validation through case studies or experimental research is needed to assess its practical effectiveness.

Practical implications: The proposed framework offers practitioners in the fields of innovation and design a structured approach to integrating AI into their creative processes. Provides specific guidelines for the use of LLM to enhance each stage of the SIT methodology, which could lead to more efficient and innovative outcomes.

Social implications: Integration of SIT with LLM could significantly influence public attitudes toward AI, potentially increasing its acceptance as a collaborative tool in creative and problem-solving processes. This approach may lead to more efficient and sustainable innovation practices in various industries, potentially addressing social challenges more effectively. However, it may also raise concerns about job displacement in creative fields, necessitating a focus on reskilling and education to prepare the workforce for collaboration with AI systems.

Originality/value: This paper presents a novel approach to integrating SIT methodology with state-of-the-art AI technology, offering new perspectives on increasing human creativity with machine capabilities in structured innovation processes. It contributes to the emerging field of AI-assisted design thinking and provides a foundation for further research in this area.

Keywords: Systematic Inventive Thinking, Large Language Models, Innovation, Human-AI Collaboration.

Category of the paper: Conceptual paper, Research paper.

1. Introduction

In November 2022, a new entity emerged in our world, the first general-purpose artificial intelligence system, designed to pass as human and perform creative, innovative work previously exclusive to human capabilities. Direct inspiration for this article was Ethan Mollick's influential book 'Co-Intelligence' (Mollick, 2024), in which the author advocates collaboration with AI in the roles of co-worker, co-teacher, and trainer.

Systematic Inventive Thinking (SIT) is a methodology developed to support the innovation process by utilizing creative techniques and tools that aid in generating new ideas. This methodology is based on five fundamental principles that allow a systematic approach to problem solving and the creation of innovative solutions. While there is already a considerable body of scientific literature on integrating Design Thinking methodology with generative artificial intelligence, the SIT approach has not yet been considered in this context, creating new opportunities for researchers and practitioners in the field of innovation.

The main objectives of this paper include assessing how Large Language Models (LLMs) can support the analytical and creative processes of design teams, and how hybrid human-LLM collaboration can contribute to more dynamic and unconventional thinking about problems. In this way, the article contributes to the development of theoretical and practical foundations for the use of AI in SIT methodology, offering new perspectives and tools for practitioners in the field of innovation.

In the remainder of this article, Section 2 presents the SIT methodology and its distinctiveness from other design approaches. Section 3 presents the necessary knowledge about large language models and a selection of reports on the integration of AI technology with design processes. Section 4 presents structured patterns of design prompts. Section 5 describes in detail a design experiment that examines the impact of different rapid syntheses on the effectiveness of LLMs in generating concepts. Section 6 contains conclusions and future work.

2. Systematic Inventive Thinking (SIT)

The Systematic Inventive Thinking (SIT) methodology, and its later variant ASIT (Advanced Systematic Inventive Thinking), originate from the TRIZ theory (Theory of Inventive Problem Solving), which was developed by Soviet engineer and inventor Genrich Altshuller in the 1940s. TRIZ was originally created to identify regularities and patterns in innovative technical solutions (based on existing patent descriptions), making it possible to take a systematic approach to creating new inventions (Horowitz, 1999).

SIT was developed in the 1990s by a group of Israeli researchers and consultants who decided to simplify and adapt TRIZ for applications beyond the technical industry. They aimed to create a tool that would be easier to implement in various fields such as marketing, management, and product development. The key goal was for the SIT methodology to be simple, understandable, and universal, so that it could be used by individuals with varying levels of technical understanding (Horowitz, Maimon, 1997).

Systematic Inventive Thinking (SIT) is a methodology that distinguishes itself from other approaches to problem-solving and innovation design, such as Design Thinking, Lean, Six Sigma, or TRIZ, through its unique structure and principles. While other methodologies focus on identifying problems or optimizing processes, SIT concentrates on creatively utilizing available resources and assumes that creativity stems from restrictions and limitations, rather than infinite freedom, as posited by Design Thinking, which is oriented towards empathy and user understanding. Lean and Six Sigma methodologies focus on process optimization and waste elimination, often through data analysis and precise metrics. SIT differs from them in that it focuses on creative exploration of the constraints and available resources, promoting thinking “inside the box” instead of striving for process excellence. In the case of the approach from which SIT evolved, TRIZ, it is based on a systematic approach to innovation, but uses a knowledge base of previously solved technological problems to inspire new ideas. SIT is more intuitive and universal, focusing on transforming existing resources without referring to external patterns.

Although SIT is not as widespread as Design Thinking, which has reached the stage of solid critical analyses (Verganti et al., 2021), it appears to be an important candidate for wider application not only in organizations but also in education (Barak, 2013; Barak, Albert, 2017).

2.1. Structure of the SIT Methodology

The Systematic Inventive Thinking methodology consists of several key stages that ensure the systematic generation of innovative ideas, based on the application of five thinking patterns that are intended to lead to non-obvious but effective solutions. The process is similar to many problem-solving approaches, such as Design Thinking, Lean, Six Sigma, or TRIZ; it is structured and iterative (Barak, Bedianashvili, 2021).

For the purposes of this paper, the following stages of the SIT process have been adopted based on the publication by Barak & Bedianashvili (2021) and materials from SIT – Systematic Inventive Thinking Ltd. (2024).

Stage 1. Problem Definition

The first step is to thoroughly understand and define the problem to be solved. It is important to define both the goal and the context of the problem, which in SIT terminology we call the ‘closed world’, and further steps will be ‘thinking inside the box’. At this stage, it is also necessary to define the constraints and resources available to the team.

Stage 2. Functional Analysis

This stage involves analyzing the system, product, or service in terms of its functions. The aim is to identify what functions the individual elements perform and how they affect the whole. This analysis helps to understand which aspects are crucial and what potential starting points there are for innovation.

Stage 3. Application of SIT Patterns

At this stage, specific SIT thinking patterns are applied to generate innovative ideas. SIT is based on five main patterns that serve as tools for creative thinking.

1. **Division** - breaking down an object or system into parts and then reassembling them in a new way.
2. **Multiplication** - replicating an element of the system with certain modifications that lead to a new function or effect.
3. **Subtraction** - removing an essential element of a product or system to identify new applications or functions.
4. **Task Unification** - combining two or more elements in one system, leading to new functions or capabilities.
5. **Attribute Dependency** - changing the relationship between different attributes of the system, which can lead to new solutions.

Stage 4. Evaluation and Selection of Ideas

Generated ideas are evaluated in terms of their feasibility, innovativeness, and potential value. The team selects the best solutions that align with the project goals and can be implemented. Visualization of the new configuration is often recommended, imagining how the product or process looks after applying the chosen technique. This leads to the identification of potential benefits: analysis of what new values or functions have emerged as a result of the transformation, considering who might be interested in such a solution, and why.

Stage 5. Implementation

Selected ideas are further developed and prepared for implementation. It starts with assessing feasibility and identifying potential obstacles and ways to overcome them. At this stage, it may be necessary to develop prototypes, conduct tests and prepare a plan to bring the innovation to market.

Stage 6. Evaluation and Optimization

After implementing the solution, its effectiveness is evaluated. The team analyzes whether the intended goals have been achieved and identifies areas for further optimization.

These stages are iterative, meaning that if necessary, the team can return to previous steps to refine their solutions. This approach helps SIT in searching for innovative solutions systematically and organizedly in various fields.

2.2. Key Differences of SIT from Other Methodologies

SIT focuses on finding solutions within the ‘closed world’, or the immediate environment of the problem, instead of seeking external solutions. This approach contrasts with the idea of ‘thinking outside the box’, which often leads to less practical and less innovative solutions.

SIT emphasizes reversing the traditional problem-solving process, where a solution concept is first created and then a problem it solves is sought. This approach, known as ‘function follows form’, often leads to more innovative solutions than the traditional ‘form follows function’ approach.

The structural and systematic approach to problem-solving allows for increasing the chances of finding creative and practical solutions compared to methods based on spontaneity and randomness.

Advantages of SIT over other problem-solving methodologies

SIT does not focus on finding compromises, but on discovering new, surprising, and valuable problem solutions.

SIT offers a systematic and systematized approach to idea creation, introducing a sense of structure and order, in contrast to brainstorming, which often leads to chaos.

The ‘closed world’ principle in SIT encourages finding solutions using existing elements, which is particularly valuable with limited budgets or time.

SIT methods help identify and overcome the tendency to perceive problems and solutions in traditional ways.

The effectiveness of SIT is based on the analysis and manipulation of elements of the ‘closed world’. If a problem does not have clearly defined boundaries or components, applying SIT may be difficult, although collaboration with LLM can introduce new perspectives and simulations still within the concept of the ‘closed world’.

Although SIT can be applied in various fields, most of the problems analyzed require deep expert knowledge that the methodology itself cannot provide. SIT can be a support for experts but will not replace their knowledge.

The Systematic Inventive Thinking methodology is the right choice for the following tasks:

- Creating new products and services.
- Improving existing products and services.
- Solving technical and engineering problems.

- Generating innovative marketing and advertising ideas.
- Optimizing business processes.
- Solving complex organizational problems.
- Breaking thought patterns and overcoming functional fixation.
- Creating new business models.
- Solving product design problems.
- Generating creative solutions with limited resources

Problems that should not be solved with the help of SIT include:

- Ethical and moral issues, SIT is not a tool for making ethical decisions.
- Problems requiring extensive scientific research or gathering new data; SIT relies on using existing knowledge.
- Crisis situations requiring immediate action; SIT requires time for thought and application of techniques.
- Purely logical or mathematical problems; SIT is more suitable for conceptual and practical problems.
- Interpersonal issues and conflicts - SIT is not a tool for solving social or psychological problems.
- Problems requiring a radical paradigm shift or complete departure from existing frameworks - SIT works best within existing constraints.
- Simple problems with obvious solutions: SIT is most effective for complex challenges requiring a creative approach.

Of course, Systematic Inventive Thinking, like any tool (SIT can be treated as a set of tools), in the hands of an experienced moderator, can also be used for quick solutions, including those of a social nature.

3. Large Language Models (LLM)

Large language models, one of the main achievements in the field of artificial intelligence (AI), have transformed the way we process natural language. Generative artificial intelligence (GenAI) using LLMs now forms the foundation of many applications, ranging from natural language processing and machine translation to supporting creativity and innovation in inventive processes. The development of LLM technology since 2018, when the *transformer architecture* was presented (Vaswani et al., 2017), has allowed for an enormous increase in the capabilities of these models, both in the context of data processing and content generation. LLMs are models trained on enormous text datasets, using neural networks to analyze data sequences, which allows for predicting subsequent words in sentences. Due to the advanced

architecture and the availability of vast data resources, these models are able to understand and generate text in a way that resembles human language, making them useful in a wide range of applications.

3.1. Specifics of GenAI Models

One of the most well-known examples of applying this architecture is the GPT (Generative Pretrained Transformer) model, developed by OpenAI, whose successive versions, from GPT-3 to GPT-4, have revolutionized the approach to generative artificial intelligence. The basic mechanism of LLM operation is the so-called next token prediction, where ‘token’ means the smallest linguistic element (on average, one token is about 3/4 of a word in English). The model, based on previous tokens, tries to predict what should appear next. To achieve this, the model relies on its knowledge gained during training on enormous text datasets, which include diverse sources such as books, scientific articles, blog posts, or comments on internet forums.

In practice, LLMs do not possess semantic understanding in the traditional sense, as humans do. Instead, they use statistical associations between words and phrases that occur in the training data. Despite the fact that these models do not ‘understand’ text, their ability to model natural language is impressive. Correct content generation is based on the analysis of language patterns and contexts, which allows LLMs to create both short answers and long and complex texts.

Although LLMs are presented as autonomous reasoning engines, there is much research showing that they reliably fail in reasoning when left to their own devices (Kambhampati et al., 2024). These systems are best viewed as gigantic, approximate sources of knowledge that use incredible pattern-matching abilities to generate the next token, resulting in words and sentences.

3.2. The Concept of Context Window

The context window defines how many tokens the model can analyze at a given time, which affects its ability to understand and generate coherent and contextual responses. For example, if a model has a context window of 4096 tokens, only these tokens will be taken into account when generating a response, and any earlier information outside this range will be ignored. The size of the context window can significantly affect the performance of a language model. A larger context window allows the model to consider more information, potentially leading to more accurate and context-relevant results. Currently, the largest values are offered by the Gemini 1.5 Flash model – 1 million tokens, and Gemini 1.5 Pro has a context window of 2 million tokens. The most popular ChatGPT-4 model offers a context window of 128k tokens, while Llama 3 and Mistral allow the use of only 8,192 tokens, but it should be remembered that they can be run locally on a computer, ensuring data confidentiality. However, it should be noted that this parameter is not directly related to the quality of the response of the model.

3.3. Model Parameters

In AI-based language models, the key parameters affecting the quality and character of generated responses are temperature and top-p. Adjusting these parameters allows for precise control over the style and creativity of the response models, which is applicable in tasks that require coherent and predictable results, as well as those that need more diversity in the generated content. *Temperature* is a parameter responsible for controlling the degree of randomness in responses. Higher values, such as 1.0, lead to more diverse and creative responses, whereas lower values, for example 0.2, result in more predictable and repetitive answers. Lowering the *temperature* makes the model generate more conservative content, while raising this parameter increases the potential risk of less coherent but more original responses. *Top-p*, also known as nucleus sampling, regulates how ‘deep’ a pool of tokens the model can consider when generating responses. In this mechanism, the model selects tokens with the highest probability until their cumulative sum exceeds the value specified by the parameter *top-p*, for example, 0.9. This means that the higher the *top-p* value, the wider the set of potential responses is considered, which can lead to more diverse but less coherent results. On the other hand, lower *top-p* values limit the choice to the most probable tokens, which increases the predictability of responses.

Unfortunately, these parameters are set in the API (Application Programming Interface - a set of rules and protocols that allow different applications to exchange data and integrate functions) interface, not directly in the prompt content. However, by using the API (which is widely described on the internet), users can adjust the parameters of the LLM models to the specific needs of their applications, gaining control over the behavior of the model when generating responses.

3.4. Hallucinations

In the context of language models and generative artificial intelligence, ‘hallucination’ refers to the phenomenon where the model generates information that is not based on input data or factual reality. This can manifest in several ways. Fabricated information - the model may include details or facts that are completely made up, which can mislead users if considered accurate. Non-existent references - the model indicates data, suggests importing packages or libraries that do not exist. Contextual errors are content that is contextually inappropriate or irrelevant.

Addressing the problem of hallucinations is crucial to ensuring the accuracy and reliability of AI-generated content, especially in applications where precision is critical, and this can be achieved through specific prompting techniques. However, in this human-LLM collaboration model, whether the system response is correct or not is not such a big problem because if the LLM system hallucinates, humans will fairly easily detect it. Hence, any erroneous paths that generative artificial intelligence may take do not negate the sense of using it in the entire process

of systematically supporting inventiveness. Therefore, it is advisable to create prompts according to a model that contains examples. Of course, without examples, the currently functioning largest language models can perfectly function giving desired answers. However, examples make it easier for the system to orient itself through analogy to what we demand in more complex situations. Removing examples from prompts can be effective when we want a more open statement from the model and when the used model handles too low a context window in relation to the assumed needs.

3.5. Specific Applications of LLM

LLMs have found wide application in many fields, from automatic translation, summarizing long content, to business analytics. The following publications can help the reader deepen their knowledge about the integration of AI technology into organizations and processes that lead to innovation.

The authors (Gama, Magistretti, 2023) in a systematic literature review distinguish 6 stages of AI introduction in organizations, from making AI available in the organization (basic competencies and procedures required for effective technology implementation), to automating basic tasks and expanding decision-making processes. This work refers to the integration of AI technology and design processes, indicating the possibilities of including generative artificial intelligence in teamwork in a way that puts user needs first and does not aim to automate the design process.

In the context of this work, supporting creative and inventive processes, large language models can provide new ideas and solutions that were previously difficult to imagine. And so, generating novel and useful concepts is one of the important stages of design, the authors (Zhu, Luo, 2023) defined three concept generation tasks to utilize different knowledge and reasoning: domain knowledge synthesis, problem-based synthesis, and analogy-based synthesis. Evaluation experiments conducted on humans and data showed good performance in generating new and useful concepts.

Group ideation processes were studied in the work of (Shaer et al., 2024), which proposed forms of collaboration with GenAI at the stage of idea generation and evaluation. Researchers suggest that LLMs can support idea evaluation and improve the results of the ideation process. This indicates the potential to integrate LLM with design thinking processes to enhance creativity and decision making.

Another noteworthy example of integrating LLM with the Design Thinking process is the work of (Asadi, 2023), in which the author discusses the benefits, challenges, and transformative potential of ChatGPT and Google Bard in facilitating idea creation, prototyping, and user-centered design.

AutoTRIZ is an idea creation tool that uses LLM to automate and enhance the TRIZ methodology (Jiang, Luo, 2024). Using the broad knowledge and advanced reasoning capabilities of LLMs, AutoTRIZ offers an innovative approach to design automation and

interpretable ideation with artificial intelligence. The system takes a problem description from the user as the initial input and automatically generates a solution report upon completion of the reasoning process.

Unprecedented possibilities are provided by the use of GenAI for information analysis. In his work, (Buehler, 2024) transformed a dataset covering 1000 scientific articles devoted to biological materials into a comprehensive ontological knowledge graph. Through in-depth structural analysis of graphs, useful frameworks for innovation open up by revealing hidden connections.

There are also works that introduce generative artificial intelligence to applications for many users (He et al., 2024), pointing to concerns of several participants regarding the transparency of content ownership, private digital spaces, and specialized AI capabilities.

4. Prompt Patterns for Working in SIT

It should be emphasized that a necessary step for satisfactory cooperation with large language models is a brief information for team members about what they are, how they generate responses, how to build commands, and how to continue the dialogue. Sometimes, indicating even more technical details, such as context window size and response temperature, allows for breaking fears of using LLM. Using a few entertaining examples of using generative artificial intelligence, showing surprisingly precise responses from GenAI, seems to be an essential step to initiate team work with this technology.

Six families of use cases for artificial intelligence to support design teams have been identified:

1. Intelligent assistance, using artificial intelligence for quick information retrieval, explaining concepts, to creating specialized assistants (i.e., bots) for various tasks or design stages.
2. Research and analysis - using artificial intelligence to quickly gather and synthesize information on the topic we are designing for, from a huge number of sources, including those attached as local documents.
3. Creative ideation - using artificial intelligence to evoke novel ideas and challenge assumptions.
4. Data-Driven Insights - using artificial intelligence to extract meaningful patterns and forecasts from datasets, including multimedia ones.
5. Content generation, i.e., using artificial intelligence to design, write, and create multimodal materials, ranging from simple conversation with LLM, through generating complex reports, to graphic visualizations, including video.

6. Adaptation and localization, that is, using artificial intelligence to adapt content to different cultures and individual needs.

By applying these use cases, the moderator and/or members of design teams can unlock an unprecedented level of both efficiency and effectiveness.

4.1. Prompt Construction for LLM

Generative artificial intelligence systems are being implemented in many industries and environments. Developers and end-users interact with these systems using prompts or prompt engineering. The quality of prompt input into LLMs has a significant impact on the relevance and accuracy of their responses in terms of answering general purpose questions and problem solving (Liu et al., 2023). Currently, the most comprehensive meta-analysis (Schulhoff et al., 2024) summarizes knowledge about prompt techniques, introduces a taxonomy of prompt techniques, and analyzes their use.

4.2. Basic Prompt Structure for Generative AI Models

When designing basic prompts for commonly used models such as Gemini, Claude, LLaMA, or ChatGPT, the following elements should be considered.

Clear instructions. The prompt should clearly define the task or question. For example, "Explain the component removal technique in SIT methodology".

Contextual information. Providing context can help the model generate more relevant responses.

"You are a human resources management consultant in a technology company undergoing restructuring. Propose a strategy to improve internal communication, taking into account the growing number of employees working remotely and the need for integration of international teams".

Output format. Describe the desired output format; you can include it as an example file.

"To evaluate ideas, use a rating scale of 1-5 (1=strongly disagree, 5=strongly agree), present the summary in a table".

Style instructions. To obtain a specific tone or style, include style instructions. For example:

"Use clear, concise, and jargon-free language understandable to nontechnical audiences.

Maintain an objective and data-driven approach, avoid personal opinions or interpretations. British spelling".

Examples and templates - using model text can help in getting the model's response. For example, providing a marketing email template can help the model generate content that fits the desired structure.

One of the somewhat surprising capabilities of LLM is the ability to ask the model to write its own prompt. Example prompt:

"I want you to [provide details of what we want GenAI to do for us]. Write an optimal prompt to instruct a large language model to perform this task in the best possible way. Make sure that the prompt has the following structure: Role, Recipients, Goals, Style".

Moreover, we can be quite imprecise in our request, as artificial intelligence is good at working out what we want and creating the best prompt. If we run the prompt it creates and the result is not what we wanted, we should send this result back to the AI and ask the LLM to redo the prompt, explaining why the result was not appropriate, trying to explain doubts in a similar way as we would to another person.

Another important technique helpful in clarifying our needs is to add a request for questions to the prompt.

"Then ask me [number of questions here, usually three to five] questions that will allow you to better [understand e.g. the problem, do your job]".

4.3. Sample Patterns for SIT

It is worth starting work with the chosen model by presenting the role that the LLM will fulfill:

"You are an experienced Systematic Inventive Thinking (SIT) facilitator and will be working with a team of people. Remember that you are a specialist in the SIT method and serve as an advisor and helper - you provide knowledge, accumulated experience, and are curious by asking the team questions that can improve the SIT process. At the same time, you are a large language model (LLM), and your analytical capabilities are very important".

The system's response will assure us that the chosen GenAI technology understands the assigned role, and we can proceed to the actual work.

Stage 1 - Problem Definition

There are many techniques for defining a problem, but in the case of LLM, you can start with a simple prompt:

"Present a problem description consistent with the first stage of the SIT method (closed world definition), which is a wheelchair being too heavy for a person with low physical ability, but with a large mass. This wheelchair should not be electrically assisted due to problems with maintenance and battery charging. Ask me three questions that will allow you to better perform the task".

As shown in the above example, the initial description can be quite incomplete and may even be unclear. However, dialogue with LLM will allow for specifying requirements and generating a problem definition with a description of the goal, context, constraints, scope, and key success indicators.

Another approach to this stage is to treat LLM as a system that guides the team step by step.

"Guide the design team through the problem definition stage (thinking inside the box), step by step, asking individual questions. At the end, summarize the problem definition in points".

Of course, nothing prevents (except for the time that needs to be devoted to dialogue with LLM) from using both versions, as the results can be significantly different.

Stage 2. Functional Analysis

Here is an instruction on how to give me information so that we can collaborate effectively.

"Let's move on to the product world analysis for our wheelchair. Here is the information we have previously established:

[Here we place the entire text from the previous answer, containing the problem description]

Taking into account this information, please help me conduct a product world analysis. Let's start by listing all the main components of the wheelchair in points, and then analyze their functions, mutual relationships, and potential areas for improvement".

Of course, the prompt can be more elaborated by instructing it to generate descriptions of elements, reminding about the possibility of asking questions to the team, specific formatting of the answer, etc.

Stage 3. Application of SIT Patterns

Here are proposals for patterns to use SIT tools.

Prompt for **Subtraction**:

"Identify the key components of [product]. Which of them can be removed while maintaining or improving the main function? How will this change affect [project goal]?"

Prompt for **Multiplication**:

"Choose one element of [product]. How can we replicate or increase its number in an unusual way? What new functions or benefits could this bring?"

Prompt for **Division**:

"Consider the main functions of [product]. How can we separate them into smaller, more specialized elements? What new possibilities does this create?"

Prompt for **Task Unification**:

"Identify unique features of [product]. Which of them can we combine in a non-obvious way? How can this combination solve [problem]?"

Prompt for **Attribute Dependency**:

"What are the key attributes of [product]? How can we create new, beneficial dependencies between them to better address [user needs]?"

For each SIT tool, the following process is proposed, referring to **Stage 4 - Idea Evaluation and Selection**:

- a) Application of prompt to [product].
- b) Generation of at least 3 ideas.
- c) Evaluation of each idea in terms of [goal] realization and project constraints.
- d) Selection of the most promising idea for further development.

These universal prompts can be adapted to different products and problems, while maintaining the structure of the SIT method. It's worth remembering about the possibility of using the knowledge accumulated in the language model itself and treating LLM as a facilitator of the process.

4.4. Techniques Improving Results in Prompting

Knowledge of rapid prompt engineering allows for more precise control of LLM, and hence familiarity with the following techniques can greatly enhance human-LLM collaboration.

Zero-shot is a technique used in natural language processing, in which the model receives a task without prior examples or task-specific training, which can help in shaping results for open-ended tasks.

Rephrase and Respond (RaR) in the zero-shot technique, instructing the model to rephrase and expand the question on its own before providing an answer. This method can lead to better results, as demonstrated in many comparative tests.

Least-to-Most Prompting - this technique involves dividing the problem into sub-problems and solving them sequentially. It is particularly effective in tasks that require symbolic manipulation and mathematical reasoning.

Chain of Thought (CoT) involves constructing a reasoning path that leads the model through a series of logical steps to arrive at an answer. This can be done in various ways, for example using natural language or symbolic languages such as Python, depending on the task requirements. Example variants:

- Zero-Shot CoT - this variant does not use any examples. It typically involves appending a thought-provoking phrase to the prompt, such as "Let's think step by step" to encourage the model to generate its own reasoning path.
- Few-Shot CoT - this approach presents the model with multiple examples that include chains of thought, significantly improving performance by providing examples of problem-solving reasoning.
- Self-criticism and self-improvement - encouraging models to critique their own outputs and iteratively refine responses based on feedback can increase accuracy and confidence in results.
- These techniques are systematic approaches that take advantage of the strengths of language models to improve the quality of their outputs in various tasks.

5. Risks and Problems

This paper will not develop the issue of risks associated with the use of AI, and there are many. A detailed list is contained in a paper developed by a team of researchers mainly from MIT and The University of Queensland (Slattery et al., 2024) - a comprehensive living database of over 700 AI risks categorized by their cause and risk domain.

From a business point of view, the confidentiality of information is important. Many problems can be avoided by using locally run models (the most popular are LLaMa, Minstral), which can generate responses at an acceptable pace on personal computers with efficient graphics cards. It is also a great technique to be able to analyze confidential documents; a locally run LLM model can work without an internet connection.

However, another element of human-LLM collaboration that needs to be considered is the sense of psychological safety among team members using generative artificial intelligence. Although the direct impact of GenAI on psychological safety has not yet been widely studied, the existing literature on emotional and psychological safety provides valuable insights. The sense of safety is subjective and can vary depending on individual perceptions and experiences. Therefore, supporting a sense of safety in interactions with artificial intelligence requires considering both real threats and psychological factors that affect users' perceptions. An interesting approach is presented in the work of (Li et al., 2024) that maps patterns of human interaction with GenAI. The study identified four main areas of human-LLM interaction: processing tool, analysis assistant, creative companion, and processing agent. These categories help to understand the different roles that LLMs can play in human interactions.

6. Future Research Directions

The integration of LLM systems with SIT methodology opens several promising research directions, although designing empirical studies presents significant methodological challenges. Three key areas emerge as particularly valuable for future investigation:

- Team Dynamics and Creativity Assessment:
 - Investigating how LLM integration affects individual and collective creativity in SIT sessions.
 - Examining changes in team members' perception of their creative capabilities when working with AI.
 - Analyzing the impact of AI collaboration on team dynamics and innovation processes.

- Acceptance and Adaptation Studies:
 - Evaluating team members' acceptance of LLM systems in creative processes.
 - Studying the evolution of human-AI interaction patterns during SIT sessions.
 - Assessing how different levels of AI literacy affect collaboration effectiveness.
- Process Effectiveness Measurement:
 - Developing metrics for evaluating the quality and innovativeness of solutions generated through human-AI collaboration.
 - Comparing problem-solving efficiency between traditional SIT and AI-enhanced approaches.
 - Creating frameworks for measuring the impact of different prompt patterns on solution generation.

These research directions require careful consideration of multiple variables that can influence outcomes, including team composition, prior experience with AI systems, and problem complexity. Future studies would benefit from developing specialized agent-based systems using LLM with standardized prompt sets, allowing for more controlled measurement of collaboration effects while maintaining the flexibility inherent in creative processes.

The challenge lies in balancing the need for standardized measurement with the inherently unique nature of creative problem-solving processes. This suggests a mixed-methods approach combining quantitative metrics with qualitative assessment of team experiences and solution quality.

7. Conclusions

This paper presented a comprehensive framework for using generative artificial intelligence (AI) in the context of supporting inventive processes, with particular emphasis on the Systematic Inventive Thinking methodology.

Due to the initial stage of work on integrating SIT methodology with LLM systems, no research was conducted, e.g., on the effectiveness of the developed framework. This was also not the intention of the author, who at this stage does not see the need to look for ways to prove the effectiveness of integration but rather sees the need to support people than create automatic systems designing innovations. Of course, we should appreciate the efforts of researchers to provide more automated solutions that, however, will not limit human creativity. For example, (Tian et al., 2024) provides an OpenAI-based assistant called the 'Design Prompt Assistant' (Liu, 2024).

One of the potentially important applications is the role of LLM as a tool to support facilitators in working groups. It can provide suggestions for team management, helping to eliminate tensions and avoid stagnation. Additionally, GenAI can support the building of

a sense of safety in the team by providing appropriate inspiration in real time. Although LLM can partially replace facilitators in terms of access to knowledge and familiarity with moderation techniques, it is not able to fully recreate human relationships, which are crucial in building an atmosphere of trust. GenAI generates excellent content, but relationships based on emotions, empathy, and deep interpersonal understanding remain the domain of humans.

One of the significant limitations of generative artificial intelligence is its dependence on the quality of the input data. If users do not specify or force an analysis of the emotional state of people working on solutions, AI may show ‘deafness’ to these subtle signals. It must be remembered that LLMs are trained mainly on textual data and their ability to analyze moods and emotions is based solely on what can be inferred from linguistic data, although recently we can use multimodal models.

A comparative analysis of human and LLM system capabilities in inventive processes reveals both complementarity and areas of potential advantage for each side. Humans demonstrate an unmatched ability to contextually understand problems, using intuition, and combining seemingly unrelated fields of knowledge in an innovative way. This ability to ‘think outside the box’ is crucial in the initial stages of the inventive process, where defining the problem and identifying potential directions for solutions requires a deep understanding of the social, economic, and technological context.

Moreover, humans possess a unique ability to understand user needs and empathy, which is invaluable in designing human-centered innovations. Their ability to adapt to unforeseen circumstances and deal with ambiguity allows for a flexible approach to the inventive process, often leading to breakthrough discoveries.

However, LLM systems demonstrate impressive effectiveness in certain aspects of the inventive process. Their ability to quickly process large amounts of data and identify patterns exceeds human capabilities. In the context of SIT methodology, LLMs can be particularly effective in generating a large number of potential solutions based on principles such as unification, multiplication, or division.

LLMs also show an advantage in systematically applying heuristics and creative thinking methods. They can generate hundreds of solution variants in a short time, consistently applying SIT principles to various aspects of the problem. This ability to ‘exhaustively search the solution space’ can lead to the discovery of non-obvious but potentially revolutionary ideas.

However, the advantage of LLMs in generating a large number of ideas must be balanced with the human ability to assess their real value and feasibility. Humans are better at assessing the practical, ethical and social implications of proposed solutions, which is crucial for the effective implementation of innovations.

Ultimately, optimal utilization of potential in inventive processes requires a synergistic combination of human and machine capabilities. While LLMs can significantly expand the range of possibilities considered and accelerate certain stages of the process, human creativity, intuition, and the ability to evaluate holistically remain essential for truly breakthrough

innovations. The key to success is therefore not so much replacing human invention with AI, but rather its augmentation, leading to new, hybrid forms of creativity and innovation.

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CMMS CLASS SYSTEM IN INDUSTRY 5.0 ENTERPRISE

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Purpose: The purpose of the article is presenting the conception of using CMMS class systems in supporting maintenance in Industry 5.0 concept.

Design/methodology/approach: The above-mentioned purpose was achieved as research was executed focusing on Industry 5.0 and Society 5.0 ideas and opportunities of their applications in maintenance activities in enterprise.

Findings: During the conducted research, it was found that there is a necessity to integrate CMMS class system with another co-operating computer systems in which it is required to implement model solutions guaranteeing existence of humanocentric character of computer tool, sustainable development in maintenance of technical means and also resilience in this area.

Research limitations/implications: The article shows the conception of application of CMMS class system when Industry 5.0 conception is development. Since the article only presents an outline of the concept, it is necessary to continue work in this area, in particular by developing qualitative and quantitative models, as well as measures for assessing processes and systems in the company, based on which it will be possible to determine whether the implementation of a CMMS class system meets the requirements are the criteria: human-centricity of technical systems, sustainable development and resilience.

Practical implications: The presented research resulting in the concept can be used in (long-term) planning of the development of an enterprise or in scientific and research activities focused on the future of societies and the technical means that they use.

Social implications: Conducting a research using the method proposed in the article it is possible to convince people interested in it that there are needs and possibilities - means and methods for environmental protection and ensuring human well-being.

Originality/value: The methodology presented in the article is original and is addressed to employees of maintenance departments interested in implementing new solutions - methods and tools, as well as creators of CMMS systems and people who implement them.

Keywords: exploitation, maintenance, management, CMMS, Industry 5.0, Society 5.0.

Category of the paper: Research paper.

1. Introduction

Modern civilization faces various challenges. Many of them are related to the functioning of the technosphere, the elements of which are technical means, and the occurrence of negative consequences of its impact on the ecosphere. For this reason, human life on Earth is at risk. This causes the company to take actions that will reduce or eliminate the impact of undesirable phenomena on the future of subsequent generations. As an antidote to these problems, technical and organizational solutions resulting from the Industry 4.0 concept, which is now increasingly widely implemented in enterprises, are increasingly used. Care for the environment goes hand in hand with reflection on the needs of the quality of life of society's representatives, an increasing number of whom will belong to the group of older people.

Therefore, the topic of Industry 5.0 becomes the subject of discussion in the scientific community and among practitioners, which, complementing the assumptions of Industry 4.0, pays special attention to the human-technical relationship. In the light of its goals, there is a need for a sustainable approach to operation and maintenance. By confronting the assumptions of the Industry 4.0 concept with the theses of Society 5.0 and Industry 5.0, it is possible to increase the quality of life in societies where the number of older people is increasing and will increase in the future. The adoption of the mentioned ideas for solving the problems discussed in the article will include, among others, the development and implementation in enterprises of means and methods supporting decision-making that meet technical, organizational, economic, environmental and social criteria. These include CMMS systems that support operation and maintenance management in the enterprise. The development of models describing phenomena in the human-technical means relationship and their implementation in systems of this class creates a chance to achieve the goals that are the subject of the author's interest in the publication.

Therefore, in the article, in addition to the characteristics of the discussed industry concepts, attention was paid to the challenges faced by Industry 5.0 enterprises. An outline of how to support maintenance management in such an enterprise is presented. The possibilities offered by their implementation and development for CMMS systems and their integration with other ones, carried out at the methodological and tool level, were shown.

2. The philosophy of Industry 5.0 and its possibilities – literature research

2.1. Industry 5.0 – introduction

Industry 5.0 is the result of the activities of the European Union, which in 2021 published the so-called policy briefs. In this document, Industry 5.0 is shown as a stage in the development

of enterprises, in which special attention is paid to social and environmental issues and combining advanced technologies (which are elements of the 4.0 philosophy with human needs). The technologies mentioned include (Fidali, 2021):

- machine learning,
- artificial intelligence,
- advanced data management systems,
- simulation models and digital twins.

The most important issues of interest to researchers of the Industry 5.0 concept include (Kaasinen et al., 2022; Leng et al., 2022; www.PrzemyslPrzyszlosci.gov.pl):

- human-centricity – the most important goal of the company is no longer to improve the effectiveness and efficiency of production, but the well-being, competences and development of employees. The question: how can employees use new technology? In the concept of Industry 4.0, the key question becomes: what can technology do for employee. By performing tasks (with humans), robots can achieve the goal of providing assistance to people and improving their quality of life;
- sustainability – circular resource management meets the need to reduce the impact of enterprises on the environment. Other changes resulting from the assumptions of the sustainable development policy and the objectives of implementing a circular economy include: reducing energy consumption and the use of green energy, reducing greenhouse gas emissions and waste, as well as avoiding the depletion and degradation of natural resources;
- resilience – this is a feature of industrial production that has a high degree of reliability. Such production is resistant to disruptions during a crisis resulting from the company's operation in the technological, economic and geopolitical environment.

The topic of Industry 5.0, although it is only a certain concept, has so far published a large number of literature on it. The goal related to the implementation of the Industry 5.0 philosophy focusing on people is the subject of interest, among others (Pizoń et al., 2023a, 2023b; Brunetti et al., 2022). Pizoń et al. (2023b) draws attention to the challenges that should be faced by organizations that intend to implement the considered concept. These include (Pizoń et al., 2023b):

- social challenges,
- technical challenges,
- security challenges,
- legal and ethical challenges.

The human-technical relationship should be a consequence of human needs and the type of available technology (Pizoń et al., 2023a). Hence, (Brunetti et al., 2022) was interested in various intelligent technical means, considered from the point of view of designing human – machine systems operating in an industrial environment. The work carried out in this area was

reviewed to highlight the advantages and disadvantages of each described technology and its application in the described area. Additionally, guidelines resulting from the human – centric approach were adopted for the integration of intelligent technologies in an Industry 5.0 enterprise.

The publication (Adel, 2022) draws attention to the need for proper communication between machines and their operators when the goal is to implement the 5.0 concept in companies. This can be guaranteed by implementing solutions developed in knowledge fields such as robotics and artificial intelligence (Adel, 2022). This allows for e.g. training using virtual or augmented reality techniques in employee training, which does not require stopping the production line, which contributes to reducing the company's operating costs.

In (Nahavandi, 2019) it is expressed that the fifth revolution will see the light of day when its three main elements – intelligent devices, intelligent systems and intelligent automation are fully connected with the physical world in cooperation with human intelligence.

Due to the challenge of Industry 5.0, there is a need to guarantee sustainable development. This is a concept that is increasingly being implemented as a management tool in enterprises. Its aim is to combine the economic needs of the company with the ecological needs of the natural environment, as well as the social needs of people living in a selected country or on a given continent (<https://www.kone.pl/informacje-referencje/wiadomosci/zrownowatyny-rozwoj-a-spoleczna-odpowiedzialnosc.aspx>). The definition of sustainable development speaks of a process of change in which the use of resources, the direction of investments, shaping technological development and institutional changes of the company and the state are compatible and mutually reinforcing in order to meet the needs of current and future generations. (<https://www.kone.pl/informacje-referencje/wiadomosci/zrownowatyny-rozwoj-a-spoleczna-odpowiedzialnosc.aspx>). Environmental sustainability is the ability to maintain ecological balance in our planet's natural environment and protect natural resources to support the well-being of current and future generations. The concept of economic sustainable development is related to economic development and is a process in which the exploitation of natural resources, the direction of investment, the direction of technological development and institutional changes or reforms are coordinated and harmonious and increase both the current and future potential to meet human needs (<https://www.elibrary.imf.org/display/book/9781557755421/ch010.xml>).

Social sustainable development, presented (Ciarko, Paluch-Dybek, 2014; Murphy, 2012; Morck, Yeung, 2009) focuses on concern for the social development potential accompanying economic growth.

Sustainable development covers the human population, the world of animals and plants, ecosystems, the Earth's natural resources, energy resources, and also treats in an integrated way the most important challenges facing the world, i.e.: fighting poverty, gender equality, human rights and his security, education, health, intercultural dialogue (Ciarko, Paluch-Dybek, 2014).

A quantitative approach to sustainable development is presented in (Strezov, 2017).

The issue of sustainable development as a key goal of the Industry 5.0 concept is addressed in (Baig, Yadegaridehkordi, 2024). These literature items discuss the current status in the area of Industry 5.0 technologies (which are the Internet of Things, artificial intelligence (intelligent stationary and portable devices) and collaborative robots/cyber-physical systems, but also big data, digital twins, machine learning) for needs to ensure sustainable development (Jafari et al., 2022; Maddikunta et al., 2022).

Resilience, the ability to respond to disruptive changes such as trade wars, pandemics and climate impacts, has become an essential element of running a business. Industry 5.0 technologies play an important role in developing industry agility and resilience through data collection, automated risk analysis and improved security. The issue of resilience as a problem of the Industry 5.0 economy is addressed by (Leng, 2023; Romero, Stahre, 2021; Kaasinen, 2022).

In parallel, with the concept of Industry 5.0, the idea of Society 5.0 appeared – a modern, future-oriented and human-centered society in which the integration of cyberspace and the real world will take place using the latest technologies such as artificial intelligence, the Internet of Things, robotics and big data. Society 5.0 is a super – intelligent society that aims to create a world where essential goods and services are delivered to everyone at any time, anywhere, regardless of region, age, gender, language or other restrictions. Its goal is to simultaneously achieve economic growth and prosperity and overcome social challenges, thereby contributing to the well-being of the global community (du Vall, 2019). Particular attention was paid to this philosophy in (Fukuyama; Shiroishi et al., 2018, Wlazło, 2021; Grudowska, Ziel, 2022; Kiepas, 2020).

The comparison, complementation and co-evolution of the Industry 5.0 concept with the Society 5.0 concept is proposed in (Huang et al., 2022), in order to address the relevant fundamental arguments regarding Industry 5.0 and Society 5.0, which can be a fundamental inspiration for future research and discussion and can accelerate the development of Industry 5.0 and Society 5.0. The results of the comparison of Industry 5.0, Society 5.0 and Smart Cities and Villages are presented in (Kasinathan, 2022).

2.2. Maintenance in Industry 5.0 enterprise – bibliography research

Implementation of the Industry 5.0 concept in enterprises requires consideration of the possibilities of its implementation in individual areas of its activity. One of them is the operation and maintenance of technical means involved in the production of a product or the provision of services. Its aim is to maintain and restore the operational suitability (of machines, devices, buildings). Contemporary problems requiring solutions in this area include (<https://utrzymanieruchu.pl/zrownowazone-utrzymanie-ruchu-jak-systemy-cmms-przyczyniaja-sie-do-osiagniecia-celow-zrownowazonego-rozwoju/>):

- increasing operating costs and increasing competition; they force enterprise management to look for effective strategies and operational policies that will ensure the stability of enterprise operations as well as minimizing the negative impact of the use of technical means on the natural environment,
- lack of awareness regarding the life cycle of devices; it may lead to excessive consumption of maintenance resources, generation of waste and frequent and expensive repairs,
- the need to reduce the negative impact of overloading employees with work on their motivation to work and to optimize the use of resources – media due to rising prices,
- occurrence of accidents and machine failures, which not only pose a threat to employees, but also generate costs related to downtime and loss of customer trust.

The answer to the above – mentioned problems may be activities in the field of maintenance management of technical means, which may include pro – environmental strategies. Their examples are Green Maintenance and Sustainable Development. Green Maintenance Strategy according to (Jasiulewicz-Kaczmarek, 2019) is a set of all technical, administrative and management tasks during the life cycle of a technical means, aimed at maintaining or restoring it to a state in which it can perform the required function in an environmentally friendly manner. The implementation of the Green Maintenance policy will be influenced, among others, by the strategy of using technical resources, the method of planning maintenance works, as well as the repair technologies and materials used (Jasiulewicz-Kaczmarek et al., 2023).

The purpose of implementing the sustainable development strategy in maintenance, according to (Jasiulewicz-Kaczmarek, 2023) is also achieving certain social benefits (ensuring a proper working environment, health and safety of employees and their satisfaction) in addition to achieving environmental benefits (technical means should be operated and maintained in a rational manner, taking into account the rational use of natural resources and reducing the impact on the natural environment (electricity consumption, emissions , waste)).

By (Marco Baur et al., 2020) an appropriate maintenance strategy/policy can extend the life of a technical asset and prevent unexpected failures that may affect losses in production activities, schedule irregularities and lower product quality, being key to reducing costs and improving productivity.

The topics of other aspects of the Industry 5.0 economy (human-centricity, resilience) in operation and maintenance management are represented by selected publications, including: (Siew et al., 2020, 2021; Almeida et al., 2023; Kohl et al., 2024; Sun et al., 2022; Bukowski, Werbińska-Wojciechowska, 2020).

3. The concept of computer maintenance management systems in an Industry 5.0 enterprise

The above – mentioned problems experienced by enterprises and the suggested ways to cure them require attention to the means that are necessary to achieve the maintenance goals consistent with the Industry 5.0 concept. The chosen mean is a CMMS system that supports tasks related to the operation and maintenance of technical objects. CMMS systems are successfully and increasingly used in many organizations. Currently, they are adopted for use in enterprises in accordance with the Industry 4.0 concept. In this case their usefulness was demonstrated in (Wieczorek, 2023). Since the Industry 5.0 concept complements the Industry 4.0 concept, it can be assumed that a CMMS system will also be used within it. The application of the Industry 5.0 concept and CMMS system in it must involve the analysis of basic aspects of maintenance management, i.e.:

- maintenance strategy,
- structures – organizational, information and decision – making,
- activities,
- culture.

Compliance with the assumptions of the Industry 5.0 economy will be possible if the CMMS system is treated as:

- eco – innovation,
- “provider” of well – being,
- guarantor of resistance.

3.1. CMMS class system as an eco-innovation

There are many definitions of eco-innovation. One of them, based on the definition proposed by René Kemp and Peater Pearson (Daktyw, Rybaczewska-Błażejowska, 2020) says that eco – innovation includes the production, exploitation (operation and maintenance) or application of a product, service, production process, organizational structure or management method that is new for the organization or users/operators, and at the same time ensuring, reducing the risk of negative impact on the environment, pollutant emissions and other effects related to the exploitation of natural resources from a life cycle perspective. However, according to (Daktyw, Rybaczewska-Błażejowska, 2020) eco-innovation means developing products and processes that contribute to sustainable development and using this knowledge to achieve direct or indirect environmental benefits in the enterprise and in its business environment .

Therefore, a CMMS system will be an eco – innovation if it supports the planning and implementation of tasks in accordance with the Green Maintenance and Sustainable Development policies. For this purpose, an analysis of the above-mentioned aspects of

maintenance management should be carried out, including procedures implemented in organizations, as well as information systems that will function as a result of their implementation. The procedure enabling such an analysis is presented in (Wieczorek, 1999). However, its use must be preceded by the development of a model that will be used at one of the stages of the above – mentioned method. This could be a DFD (Data Flow Diagram) model that could be developed to meet the needs discussed. An example of such a diagram, applicable in the case of ongoing repairs of a public transport bus, is shown in Fig. 1.

Analysis of the information system in accordance with the model presented above will allow for:

- indication of the optimal information system, taking into account the assumptions of sustainable development, in which a CMMS system is implemented,
- indication of the optimal form of the CMMS system itself, which will allow achieving the intended goals of the adopted operational strategy/policy,
- election of computer tools that will be integrated with the CMMS system.

Not all data and information are collected, transferred and processed in the CMMS system, in accordance with the Sustainable Development policy; this can be stated on the basis of (Loska, 2002). Therefore, they were not included in the proposed model, so it would be necessary to:

- supplement the activities in the process/system (included in the model) with those that are consistent with the sustainable development strategy (the completed activities and transitions with data are shown in Figure 1 using dashed lines),
- meet the need to integrate CMMS with other systems.

The complex nature of processes and systems, shown during the analysis of the information system of the maintenance organization and given to them by the need for sustainable development, may require the integration of CMMS systems with other systems that will enable:

- simulation using a digital twin to estimate the values of measures/indicators for assessing production and maintenance efficiency,
- decision making support – in this area, e.g. expert systems can be used to plan and implement maintenance and repair tasks.

As a component of an integrated IT system including these tools the task of the CMMS class system will be:

- provide data for analyzes conducted using the RCM (Reliability Centered Maintenance) method, FMEA (Failure Mode Effect Analysis, analysis of environmental effects), another ones and use the obtained data in making decisions about the selection of tasks (based on 6R),
- visualization (in the form of a report/system report) of decisions that need to be made in accordance with the concept of Sustainable Development.

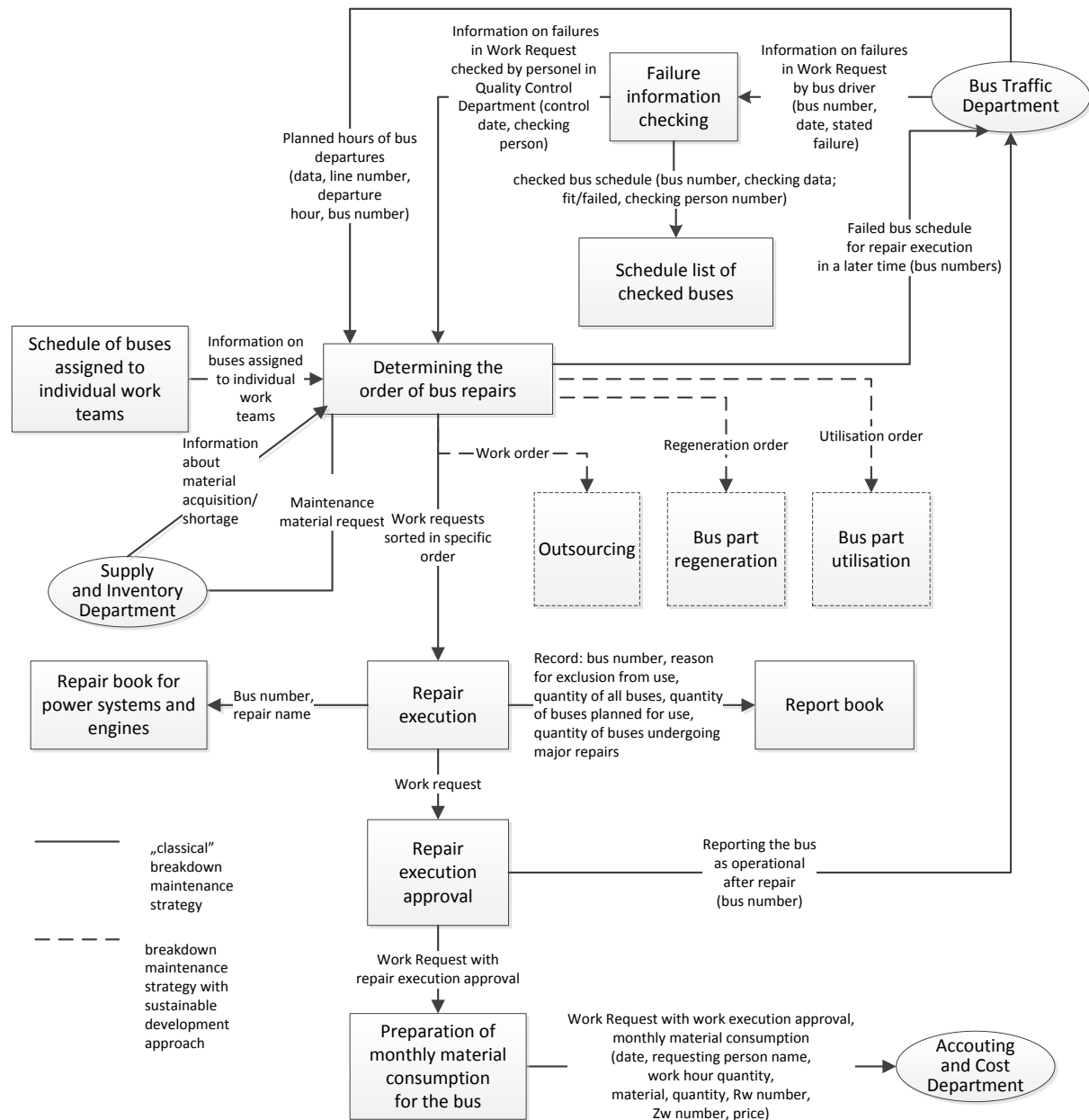


Figure 1. Data Flow Diagram (DFD) for the procedure of city – bus ongoing repairs.

3.2. CMMS class system as a "provider" of well-being

Implementing the sustainable development policy also means meeting social needs. The social dimension of sustainable maintenance concerns the following needs (Jasiulewicz-Kaczmarek et al., 2023):

- employee safety and health,
- working hours (compliance with legal requirements),
- financial resources allocated to employee training and investments in new hardware and software supporting employees in their work.

An important problem, the importance of which will become more and more meaningful in the future, is the aging of societies and the related increasing share of work carried out by such people in the enterprise. A CMMS system will be a "provider" of human well-being: an employee of an enterprise, if its management is proper, including taking into account the employee's age. This means that there is a need to properly plan, organize, motivate and control work for employees to be performed in appropriate locations, depending on working conditions. Tasks in this area include:

- reducing the frequency of employee work in locations where working conditions are the least favorable for them and/or redesigning the workplace,
- organization of work so that the routes used by employees are suitable for employees of different ages,
- organization of maintenance and repair works so that employees can complete their tasks on time, while ensuring high quality of their work,
- training that will enable the use of modern technologies, including those supporting the protection of the natural environment (so – called "green" competences).

Achieving the goal of reducing the frequency of employee work in selected locations will be possible thanks to the integration of methodological and tool solutions based on the model: human – technical means – environment. It is shown in Fig. 2. The environment in this case will have different impacts: positive and negative on humans. Its development is an example of a model solving the problem of work frequency, described in (Groja, 2014; Wieczorek, 2018). This model concerns the adaptation of the production line in an enterprise in the automotive industry; in the opinion of the author of the article, such a model can also be used for the organization of maintenance and repair works. The method developed based on this model involves assigning employees to tasks taking into account the ergonomics criterion. Its use will require the use of computer ergonomic analysis tools, an example of which is the 3DSSPP system.

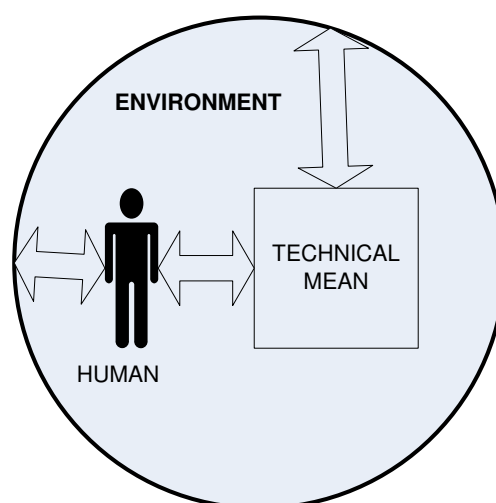


Figure 2. Man – technical mean – environment model system.

Achieving the above – 2nd and 3rd mentioned objectives will consist in the use of vision systems: monitoring cameras, which will be able to detect potential threats to the health and life of employees and respond to them in real time (Gacmęga, 2024). Moreover, vision systems should be used to monitor environmental conditions, such as temperature, humidity or the presence of harmful substances, which allows maintaining appropriate safety standards (Gacmęga, 2024). Data on the above-mentioned environmental conditions, including inconveniences and threats affecting the work of employees, should be processed and visualized using a GIS (Geographic Information System), and on their basis and using a CMMS system, employees can be assigned to work in appropriate locations.

The fourth goal, which is employee training, can be achieved using computer systems supporting knowledge management. In an aging society, the knowledge of older people differs from that of younger people in enterprises. Therefore, it is necessary to acquire and share knowledge, which is why systems of this class should have various knowledge repositories implemented, which should be supplemented with knowledge derived from the use of the mentoring method in order to acquire knowledge by employees (examples of such repositories are shown in (Wieczorek et al., 2012). In such cases, the CMMS system will provide data and information about:

- technical means,
- operational and maintenance events,
- operational and maintenance processes,
- systems for the operation and maintenance of technical means and systems that support them,
- employees – machine operators and maintenance staff.

The concept of well – being is increasingly associated with the concept of positive thinking, which is a consequence of the presence of the field of knowledge in scientific research, which is positive psychology or the psychology of emotions. It is expected that they will contribute to the development of man - technical means – environment, which will be implemented in solutions using CMMS systems.

3.3. CMMS class system as a guarantor of resilience

The concept of Industry 5.0 is related to the concept of resilience, including technological resilience. It can be guaranteed through an appropriate technical or technical – social assessment of the technical means and/or the system: man – technical means – environment, carried out using the spatial econometrics method or accelerated aging models, or by improving the reliability of technical means, in particular through the use of appropriate operational reserves, but also by implementing more perfect technical diagnostics and predictive maintenance methods, based on classic prognostic models, but also efficiency and ergonomics assessment models supporting diagnosticians and forecasters who are elderly people, which include:

- anthropometric methods, the use of which, together with the use of artificial intelligence (rule method) and a cobot compensating for human disabilities, will allow for the performance of diagnostic work, taking into account the physical dysfunctions of older people,
- cognitive methods, the use of which, together with the use of artificial intelligence (rule-based method), will allow for the assessment of the technical condition of the technical means, taking into account the dysfunctions that will appear in the thinking of the human diagnostician of the technical means.

In the discussed case, the CMMS class system, for the purposes of making decisions about the implementation of maintenance and repairs, should provide data on the technical means in use, including data on their technical condition.

4. Conclusions

The future is the Society 5.0 philosophy, which will be visible in all spheres of human life, including the work environment. It is closely related to the concept of Industry 5.0, the competitiveness of which in the conditions of a market economy will require new methodological and tool solutions that will be integrated with each other. These solutions include CMMS systems, which will guarantee the correct human – technical relationship, sustainable development, and ensure technical, economic and environmental resilience in the organization. Sustainable development is concern for human problems in the work environment. A social problem is the aging of the society, which will contribute to an increase in the number of older people in relation to all company employees. This will make it necessary to support the work of such people with complex technical systems in which models of the human-technical means-environment system will be implemented, taking into account not only the proper functioning of humans, but also their dysfunctions. CMMS systems should also be an element of such systems, which will enable the sharing of data and information not only about the machine, but also about people. This topic will be the subject of further research.

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THE USAGE OF PDCA CYCLE IN INDUSTRY 4.0 CONDITIONS

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Purpose: The purpose of this publication is to present the usage of PDCA Cycle 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: This paper explores the integration of the PDCA Cycle with Industry 4.0 and Quality 4.0 concepts, highlighting how the systematic approach of the PDCA Cycle can be significantly enhanced by the technological advancements associated with Industry 4.0. Industry 4.0, characterized by the use of IoT, big data analytics, AI, and automation, aligns with the iterative nature of the PDCA Cycle to facilitate more precise planning, efficient execution, and real-time evaluation of processes. The study details how this integration promotes continuous improvement by leveraging real-time data and advanced analytics to inform decision-making and enhance quality management. It also addresses the challenges of implementing these technologies, such as high costs and complexity in data management, proposing strategies to overcome these obstacles. Ultimately, the paper demonstrates that combining the PDCA Cycle with Industry 4.0 and Quality 4.0 not only drives operational excellence and innovation but also helps organizations adapt swiftly to dynamic market conditions.

Originality/Value: Detailed analysis of all subjects related to the problems connected with the usage of PDCA Cycle in Industry 4.0 conditions.

Keywords: Industry 4.0; Quality 4.0, quality management; quality methods, PDCA Cycle.

Category of the paper: literature review.

1. Introduction

The relationship between Industry 4.0 and the PDCA Cycle is one of mutual reinforcement, where the principles of continuous improvement inherent in the PDCA Cycle are significantly enhanced by the technological advancements of Industry 4.0. Industry 4.0, characterized by the integration of digital technologies such as the Internet of Things (IoT), big data analytics,

artificial intelligence (AI), and cyber-physical systems, revolutionizes how businesses operate, offering unprecedented levels of automation, real-time data collection, and analysis. These advancements align closely with the systematic approach of the PDCA Cycle, enabling more efficient and informed decision-making throughout the cycle's phases.

Industry 4.0 enhances the effectiveness of the PDCA Cycle by providing the tools and technologies necessary for more precise planning, efficient execution, thorough evaluation, and rapid adaptation. This integration allows organizations to achieve higher levels of quality and efficiency, driving continuous improvement in a highly competitive and fast-paced industrial environment (Barsalou, 2023; Maganga, Taifa, 2023).

The purpose of this publication is to present the usage of PDCA cycle approach in Industry 4.0 condition.

2. The basics of PDCA Cycle approach

The PDCA Cycle, also known as the Deming Cycle or Shewhart Cycle, is a systematic and iterative method used in business process management and continuous improvement. This approach is central to quality management and is designed to facilitate the identification and resolution of issues in a methodical manner, ensuring that processes are continuously refined and enhanced.

The PDCA Cycle consists of four distinct phases: Plan, Do, Check, and Act. Each phase has a specific purpose and set of activities that contribute to the overall goal of improving processes.

The first phase, Plan, involves identifying an opportunity for improvement or a problem that needs to be addressed. During this phase, teams conduct an analysis of the current situation to understand the underlying causes of the issue. This might include data collection, brainstorming, and root cause analysis. Once the problem is clearly defined, goals are established, and an action plan is developed. This plan includes detailed steps, timelines, resources required, and criteria for measuring success. Following the planning stage is the Do phase, where the action plan is implemented (Jokovic et al., 2023). This is the stage where the proposed changes or improvements are put into practice on a small scale or in a controlled environment. The focus here is on executing the plan while closely monitoring the process to gather data on its effectiveness. It is essential to document any deviations from the plan and the outcomes of the implementation. This phase is often experimental, allowing for learning and adjustments before a full-scale implementation.

Once the changes have been implemented, the process moves to the Check phase. In this stage, the outcomes of the implementation are assessed against the expected results. The data collected during the Do phase is analyzed to determine whether the changes have led to the desired improvements. If the results are positive and the objectives have been met,

this phase also serves as a validation of the changes made. However, if the results are not satisfactory, this phase helps in identifying what went wrong, providing insights for further adjustments.

Finally, the Act phase is where decisions are made based on the outcomes of the Check phase. If the changes have been successful, the process or solution is standardized and fully implemented across the organization. This phase also includes the documentation of best practices and lessons learned, ensuring that the organization can replicate success in future projects. If the desired results were not achieved, the cycle begins again, starting with a revised plan based on the insights gained. This cyclical nature of the PDCA approach ensures continuous improvement, as each cycle builds on the lessons of the previous one (Yanamandra et al., 2023).

The PDCA Cycle is a dynamic and flexible tool that promotes a culture of continuous improvement. By emphasizing planning, careful execution, rigorous evaluation, and thoughtful action, it enables organizations to refine their processes, reduce waste, improve quality, and enhance overall efficiency (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). The iterative nature of the cycle ensures that improvement is ongoing, with each iteration bringing the organization closer to its goals of optimal performance and quality excellence (Singh et al., 2023).

Table 1 contains description of PDCA Cycle key principles.

Table 1.
Key principles of PDCA Cycle

Key principle	Description
Continuous Improvement	The PDCA Cycle embodies the principle of continuous improvement, encouraging organizations to persistently seek ways to enhance their processes, products, or services. Each cycle allows for incremental refinements, fostering a culture where progress is ongoing rather than finite. This principle ensures that no process remains stagnant, as the cycle is designed to loop indefinitely, with each iteration building upon the lessons learned from the previous one. The ultimate goal is to achieve sustained excellence by continuously identifying and eliminating inefficiencies.
Systematic Approach	The PDCA Cycle provides a methodical framework for addressing problems and implementing improvements. It begins with a thorough analysis during the planning phase, where the problem or opportunity is clearly defined, followed by structured execution in the Do phase. The Check phase involves rigorous evaluation of results, ensuring that the implementation aligns with the expected outcomes. The final Act phase focuses on standardizing successful changes or revisiting the plan if goals were not met. This systematic approach ensures that improvements are not haphazard but are carefully planned and executed.
Data-Driven Decision Making	Central to the PDCA Cycle is the reliance on data and empirical evidence to guide decisions at every stage. During the planning phase, data is used to identify the root causes of issues, while in the Do phase, data is collected to monitor the effectiveness of changes. In the Check phase, this data is analyzed to assess the impact of the implemented actions. By basing decisions on solid evidence rather than assumptions, organizations can ensure that their actions lead to tangible improvements. This principle helps in minimizing risks and increasing the likelihood of success in the improvement process.

Cont. table 1.

Feedback and Learning	The PDCA Cycle emphasizes the importance of feedback and continuous learning. After implementing changes, the Check phase serves as a crucial feedback loop, where the outcomes are measured and analyzed. This feedback is essential for determining the success of the actions taken and identifying any areas that need further improvement. The learning derived from each cycle is then used to inform future planning and implementation. This principle ensures that organizations do not repeat mistakes and can continually refine their processes based on real-world results, leading to more effective and efficient operations over time.
Flexibility and Adaptability	The PDCA Cycle is designed to be highly adaptable to different types of processes, industries, and organizational structures. Its flexible nature allows it to be applied to a wide range of problems, from simple process improvements to complex, organization-wide initiatives. The cycle's iterative nature also means that it can be easily adjusted based on the outcomes of each phase. If a solution does not work as expected, the organization can quickly return to the planning stage, revise the approach, and begin the cycle anew. This adaptability makes the PDCA Cycle a powerful tool for continuous improvement in diverse environments.
Employee Involvement	A key principle of the PDCA Cycle is the active involvement of employees at all levels of the organization. Successful implementation of the cycle requires input and collaboration from those who are directly involved in the processes being improved. Employee involvement ensures that a diverse range of perspectives is considered, leading to more innovative solutions and a greater sense of ownership over the improvements. Additionally, involving employees in the PDCA process fosters a culture of quality and continuous improvement, as they become more engaged in the pursuit of organizational excellence and more committed to the success of implemented changes.

3. How PDCA Cycle method can be integrated with Industry 4.0 and Quality 4.0 concept

The integration of the PDCA Cycle with Industry 4.0 and the Quality 4.0 concept creates a powerful framework for achieving continuous improvement and maintaining high standards of quality in modern industrial environments. This integration leverages the technological advancements of Industry 4.0—such as IoT, big data analytics, AI, and automation—while aligning with the principles of Quality 4.0, which focuses on using these technologies to enhance quality management practices (Arabadi et al., 2023).

Incorporating the PDCA Cycle within this context begins with the Plan phase, where Industry 4.0 technologies play a crucial role in data collection and analysis. IoT devices and sensors embedded in machines and processes generate real-time data, providing a comprehensive view of the operational landscape (Bousdekis et al., 2023). This data can be analyzed using AI and advanced analytics to identify patterns, predict potential issues, and uncover opportunities for improvement. Quality 4.0 emphasizes the use of this data to inform decision-making, ensuring that the planning process is grounded in accurate and timely information. By integrating these insights, organizations can develop more effective action plans that are tailored to the specific needs of their operations, leading to more targeted and impactful improvements.

In the Do phase, Industry 4.0 technologies enable the efficient implementation of the planned changes. Automation, robotics, and AI-driven systems ensure that tasks are executed with precision and consistency, reducing the risk of human error and enhancing overall process reliability. The interconnected nature of Industry 4.0 systems facilitates seamless communication and coordination across different departments and stages of production, ensuring that the entire organization works cohesively towards the implementation goals. Quality 4.0 further enhances this phase by incorporating advanced quality control mechanisms, such as real-time monitoring and AI-based defect detection, ensuring that quality is maintained throughout the execution process (Maganga, Taifa, 2023).

The Check phase benefits significantly from the real-time data and advanced analytics capabilities provided by Industry 4.0. Continuous monitoring and data collection allow organizations to evaluate the outcomes of their actions promptly and accurately. AI and machine learning algorithms can analyze this data to provide deeper insights into the effectiveness of the implemented changes, identifying any discrepancies or areas that require further attention. Quality 4.0 aligns with this by emphasizing a data-driven approach to quality assurance, where real-time analytics and predictive models are used to assess quality performance and detect issues before they escalate. This phase ensures that feedback is immediate and that learning is integrated into the cycle quickly, allowing for rapid adjustments and refinements (Antony et al., 2023; Escobar et al., 2023; Salimbeni, Redchuk, 2023).

In the Act phase, the insights gained from the previous stages are used to standardize successful practices or initiate further cycles of improvement. Industry 4.0 technologies provide the flexibility and adaptability needed to make these changes swiftly and effectively. For instance, digital twin technology allows for the simulation of process adjustments before they are implemented in the physical world, reducing risks and ensuring optimal outcomes. Quality 4.0 supports this phase by emphasizing the continuous evolution of quality standards and practices, encouraging organizations to leverage technological advancements to sustain high levels of quality and operational excellence.

By integrating the PDCA Cycle with Industry 4.0 and Quality 4.0, organizations can create a synergistic approach that enhances both operational efficiency and quality management. This integration ensures that continuous improvement is driven by real-time data, advanced analytics, and automation, leading to more informed decision-making, faster implementation of changes, and more effective quality assurance processes. As a result, organizations can achieve greater agility, resilience, and competitiveness in the face of rapidly changing market conditions and technological advancements.

Table 2 is listing examples of integration of PDCA Cycle with Industry 4.0.

Table 2.
PDCA Cycle integration with industry 4.0

Aspect	Description
Data Collection and Analysis	Industry 4.0 technologies, such as IoT sensors and big data analytics, enable continuous, real-time data collection from all aspects of the production process. This data is crucial for the Plan phase, as it allows for precise problem identification and predictive insights.
Implementation Efficiency	The Do phase benefits from Industry 4.0 through automation, robotics, and AI, which enable the precise and consistent execution of planned actions. These technologies reduce human error, increase speed, and ensure uniform implementation across the organization.
Real-Time Monitoring and Feedback	During the Check phase, Industry 4.0 facilitates real-time monitoring of outcomes through advanced analytics and AI. Continuous feedback loops allow for immediate assessment of changes, ensuring that any deviations from expected results are quickly identified and corrected.
Predictive Maintenance	Industry 4.0 supports the Plan and Do phases by integrating predictive maintenance strategies. IoT sensors monitor equipment health, predicting failures before they occur, which informs better planning and reduces downtime during implementation.
Digital Twin Technology	In the Act phase, digital twin technology allows organizations to simulate and test changes in a virtual environment before full-scale implementation. This aspect reduces risks and ensures that only the most effective solutions are rolled out.
Flexibility and Agility	Industry 4.0 enhances the overall agility of the PDCA Cycle. Rapid data analysis and automation allow organizations to quickly adapt to new information and changing conditions, ensuring that the cycle can be repeated with greater speed and responsiveness.
Advanced Quality Control	The Do and Check phases are strengthened by Industry 4.0's advanced quality control mechanisms, such as AI-based defect detection and real-time quality monitoring, ensuring that quality is maintained consistently throughout the process.
Scalability of Improvements	Industry 4.0 enables scalable improvements by connecting various systems across the organization. Successful changes can be rapidly deployed across multiple locations or processes, ensuring consistent application of best practices as identified in the Act phase.
Enhanced Collaboration	The interconnected nature of Industry 4.0 promotes better collaboration across departments during all phases of the PDCA Cycle. Shared data platforms and communication tools ensure that all stakeholders are aligned and can contribute effectively to the improvement process.
Resource Optimization	In the Plan and Do phases, Industry 4.0's data-driven insights enable more efficient use of resources by optimizing production schedules, material usage, and energy consumption, which leads to cost savings and sustainability improvements.
Continuous Learning and Adaptation	The iterative nature of the PDCA Cycle, combined with Industry 4.0 technologies, supports continuous learning. AI and machine learning algorithms analyze past cycles to provide insights that refine future cycles, driving continuous adaptation and improvement.

Table 3 is describe the advantages PDCA cycle approach usage in industry 4.0.

Table 3.
The advantages of PDCA Cycle integration with industry 4.0

Advantage	Description
Enhanced Decision-Making	Industry 4.0 provides real-time data and advanced analytics, enabling more informed and precise decision-making throughout the PDCA Cycle. This leads to better planning and execution of improvements.
Increased Efficiency	Automation and AI-driven processes reduce the time and effort required to implement changes, making the PDCA Cycle faster and more efficient, with fewer manual interventions and reduced risk of errors.
Real-Time Feedback	Continuous monitoring and real-time data analysis allow for immediate feedback during the Check phase, enabling rapid identification and correction of deviations from expected outcomes.
Predictive Capabilities	Industry 4.0 technologies enable predictive maintenance and forecasting, allowing organizations to anticipate and prevent issues before they occur, enhancing the effectiveness of the Plan phase.

Cont. table 3.

Improved Quality Control	Advanced quality control tools, such as AI-based defect detection, ensure consistent quality throughout the process, reducing defects and enhancing overall product quality during the Do and Check phases.
Scalability	Successful improvements can be quickly scaled across the organization due to the interconnected nature of Industry 4.0 systems, ensuring uniform application of best practices identified in the Act phase.
Greater Flexibility	The integration with Industry 4.0 allows the PDCA Cycle to be more adaptable to changes, enabling organizations to quickly adjust plans and processes in response to new data or market conditions.
Cost Reduction	Optimized resource usage, reduced downtime, and more efficient processes contribute to significant cost savings, making the overall improvement process more economical and sustainable.
Continuous Learning	Machine learning and AI continuously analyze outcomes and past cycles, providing insights that enhance future iterations of the PDCA Cycle, fostering a culture of ongoing improvement and innovation.

Table 4 is describe the problems of PDCA cycle approach usage in Industry 4.0 and methods to overcome them.

Table 4.

The problems of PDCA Cycle integration with industry 4.0

Problems	Description of Problem	Overcoming Strategies
High Implementation Costs	Integrating Industry 4.0 technologies into the PDCA Cycle can require significant financial investment in new hardware, software, and training, which may strain budgets.	Start with a phased implementation approach, focusing on the most critical areas first. Seek government grants, incentives, or partnerships to offset initial costs.
Complexity of Data Management	The vast amount of data generated by Industry 4.0 systems can be overwhelming, making it difficult to manage, analyze, and derive actionable insights efficiently.	Implement advanced data management systems and employ data scientists or analysts. Use AI and machine learning tools to automate data processing and extract relevant insights.
Resistance to Change	Employees may resist the adoption of new technologies and processes, particularly if they are not familiar with Industry 4.0 concepts or fear job displacement.	Provide comprehensive training programs and involve employees in the integration process. Communicate the long-term benefits and create a culture of continuous improvement.
Integration with Legacy Systems	Existing legacy systems may not be compatible with Industry 4.0 technologies, leading to challenges in data integration and process synchronization.	Gradually upgrade legacy systems or use middleware solutions to bridge the gap. Develop a clear integration roadmap that prioritizes critical areas for immediate attention.
Cybersecurity Risks	The increased connectivity and data exchange in Industry 4.0 can expose organizations to higher cybersecurity threats, including data breaches and unauthorized access.	Invest in robust cybersecurity measures, including encryption, firewalls, and regular security audits. Provide continuous training on cybersecurity best practices for employees.
Skill Gaps in Workforce	Employees may lack the necessary skills to operate and manage Industry 4.0 technologies, hindering the effective integration of these technologies into the PDCA Cycle.	Offer continuous education and training programs tailored to Industry 4.0 skills. Partner with educational institutions to develop specialized courses or certifications.

Cont. table 4.

Over-reliance on Technology	Excessive dependence on technology can lead to neglecting human insights and creativity, which are essential for successful PDCA Cycle implementation.	Encourage a balanced approach that integrates human judgment with technological tools. Foster a culture of innovation where technology supports, rather than replaces, human input.
Data Privacy Concerns	The collection and use of large amounts of data can raise privacy concerns, especially if personal or sensitive information is involved.	Implement strict data privacy policies and ensure compliance with relevant regulations (e.g., GDPR). Regularly review and update privacy practices to protect sensitive data.
Short-Term Disruption	The initial integration of Industry 4.0 technologies can cause temporary disruptions to existing processes, affecting productivity and operational flow.	Plan for a gradual rollout with pilot projects to minimize disruptions. Communicate clearly with all stakeholders about expected changes and provide support during the transition.

4. Conclusion

The integration of the PDCA Cycle with Industry 4.0 and the Quality 4.0 concept represents a significant advancement in continuous improvement practices, aligning traditional quality management principles with modern technological innovations. This synergy between the systematic approach of the PDCA Cycle and the real-time data capabilities, automation, and advanced analytics of Industry 4.0 enhances organizations' ability to achieve higher levels of efficiency, quality, and adaptability in a rapidly evolving industrial landscape.

The PDCA Cycle, with its iterative phases of Plan, Do, Check, and Act, provides a robust framework for identifying problems, implementing solutions, evaluating outcomes, and standardizing improvements. When augmented by Industry 4.0 technologies, this cycle becomes more dynamic and responsive, allowing for more precise planning based on comprehensive data analysis, more efficient execution through automation, real-time monitoring for immediate feedback, and rapid adaptation through advanced simulation tools like digital twins.

However, the integration of these advanced technologies is not without its challenges. High implementation costs, complexity in data management, resistance to change, and cybersecurity risks are significant barriers that organizations must address to fully capitalize on the benefits of Industry 4.0. Overcoming these challenges requires strategic planning, phased implementation, robust data management systems, comprehensive employee training, and a balanced approach that combines human insights with technological capabilities.

The fusion of the PDCA Cycle with Industry 4.0 and Quality 4.0 concepts creates a powerful engine for continuous improvement in the modern industrial environment. This integration not only enhances decision-making and efficiency but also supports a culture of continuous learning and adaptation, ensuring that organizations remain competitive and resilient in the face of ongoing technological advancements and market dynamics. The successful application of this

integrated approach will depend on careful management of the associated challenges, with a focus on maximizing the synergistic potential of traditional quality management practices and cutting-edge Industry 4.0 technologies.

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EVOLUTION OF SOLID AND GAS FUEL REACTORS IN THE MUNICIPAL ECONOMY

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Purpose: The aim of this article is to show the evolution of reaction chambers for solid and gaseous fuels and to propose a new design solution that intensifies the heat exchange process and increases the efficiency of the heating device.

Design/methodology/approach: Previous designs of reaction chambers in boiler devices are mainly based on convective heat exchange. New solutions proposed in this work make the heat exchange process mainly through radiation more effective. These solutions have been patented in the Polish Patent Office.

Findings: New designs of combustion chambers, in which mainly radiative heat flow is realized, allow for increased power of the boiler device and low emission of pollutants. They eliminate the disadvantages of conventional solutions, which are often burdensome in operation.

Research limitations/implications: The new type of reaction chambers based on radiative heat flow will certainly be the subject of energy and emission research, as a result of which it will be possible to carry out a possible correction of the design parameters to optimize the energy conversion process, taking into account different types of fuel burned.

Practical implications: The article presents a practical solution for the construction of reaction chambers realizing radiative heat flow between the combustion zone and the heat exchanger walls. The increase in the power of heating devices with their relatively small dimensions and friendly use will stimulate their common use in the municipal economy.

Social implications: Correct implementation of the projects included in the article may contribute to the satisfaction of users with improved living conditions, generated savings and contact with modern construction solutions.

Originality/value: This paper presents new and patented designs of reaction chambers of boiler devices in which mainly radiative heat exchange is carried out.

Keywords: reaction chambers, combustion, gas boilers, coal boilers, heat exchange.

Category of the paper: Research paper.

1. Introduction

Coal is the basic energy carrier on the basis of which the Polish energy system, municipal economy and scattered individual users operate. Figure 1 shows the balance of hard coal in the last decade. There is a decrease in coal consumption and extraction in Poland, while its import remains almost unchanged. This action has resulted in the occurrence of small reserves, which is a positive phenomenon compared to the large shortages in 2021.

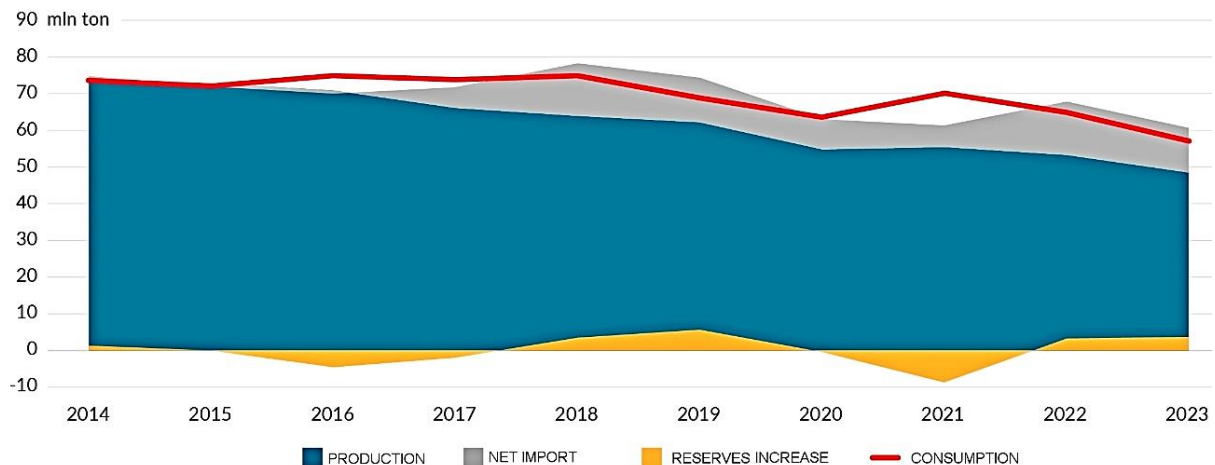


Figure 1. Hard coal balance in Poland.

Source: Dusilo, 2024.

Figure 2 shows the structure of coal consumption in the past decade. The largest amount of coal is consumed by professional power industry for the production of electricity (55.7%) and heating (20.4%). In third place are households (12.6%) using coal for heating and social and living needs. The high demand for coal among individual users results from its relatively low price, tradition of its use and ease of use of power equipment for converting chemical energy into useful energy.

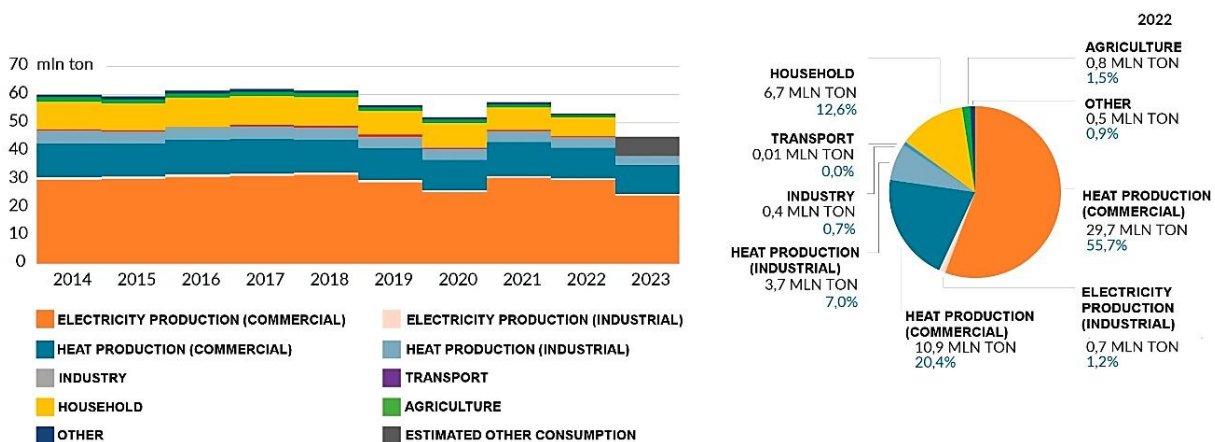


Figure 2. Structure of consumption of hard coal for energy purposes in Poland.

Source: Dusilo, 2024.

The natural gas balance is shown in Figure 3. The extraction of this raw material in Poland in 2023 decreased by 29% compared to 2014 (Dusiło, 2023). Unfortunately, the downward trend continues. Gas imports follow its consumption, which has increased by 13% over the last decade. A slight upward trend in gas consumption is observed.

The structure of natural gas consumption in the last decade is shown in Figure 4. The main recipient of gas is industry (33%), which, taking into account the production of electricity, heat and other branches of the economy, uses 67% of this raw material. In second place, right after industry, are households – about 29%.

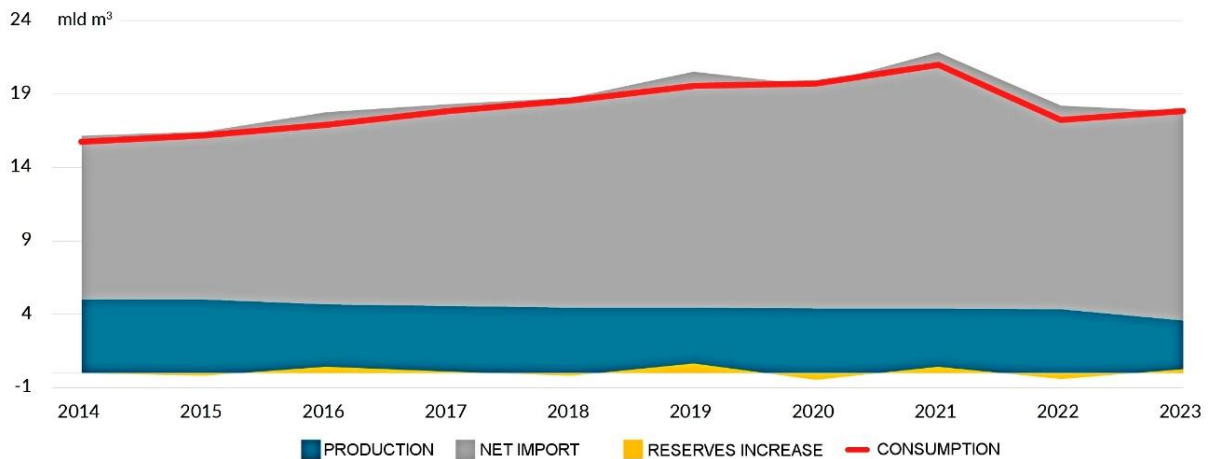


Figure 3. Natural gas balance in Poland.

Source: Dusilo, 2024.

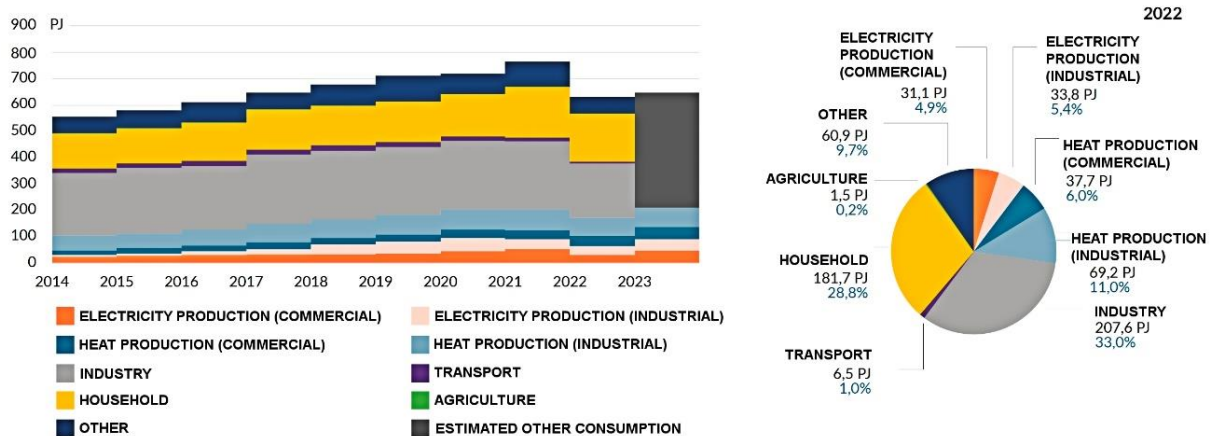


Figure 4. Structure of natural gas consumption in Poland.

Source: Dusilo, 2024.

The above data show that the municipal economy sector is a significant recipient of energy carriers, therefore their increasingly efficient use will reduce maintenance costs and contribute to anti-inflationary measures.

Figure 5 presents various heating techniques used in municipal economy. Although the data concerns 2018, it can still be considered reliable, because the period of operation of heating devices is relatively long and amounts to at least a dozen or so years. The share of energy from

the heating network (40%) is comparable to the share of solid fuels (43%) used by individual users. The main component of solid fuels is hard coal. In small towns and rural areas, biomass (logs, round logs, wood chips, briquettes) is used for heating purposes in addition to coal.

The spectrum of design solutions for reaction chambers is wide for both gas and solid fuel reactors. This is due to the fact that these energy carriers have a long history of operation. Most of the older design solutions are widely known, so their detailed analysis of the design will be omitted in this work.

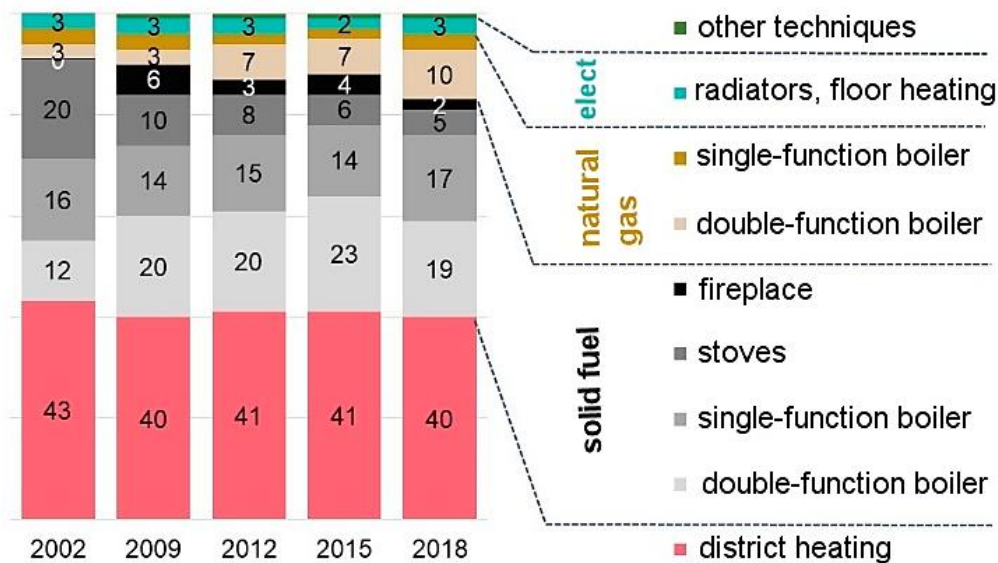


Figure 5. Structure of heating techniques used in domestic households.

Source: Dusiło, 2023.

2. Solid fuel reactors

Combustion of solid fuels will be referred to hard coal, because it has a dominant share in the energy economy. Due to the processes occurring in coal, the energy conversion process is complex. Pyrolysis reactions occur in the heated coal mass, the speed of which increases with temperature. The products of these reactions are, in addition to inert gases, flammable gases (hydrocarbons, carbon monoxide). The share of gaseous pyrolysis products in the coal mass is large and often amounts to about 30%. The dominant share in them is hydrocarbons with high calorific value, therefore, effective combustion of these gases, in addition to coke residue, affects the efficiency of conversion of chemical energy into thermal energy. This problem is easily illustrated on the example of stoker boilers. Figure 6 shows the principle of operation of a boiler with a solid stoker with bottom-up and top-down combustion (Wójcik, 2011a, pp. 105-110).

In the topsoil of a bottom-up combustion boiler (Figure 6a), four zones can be distinguished in the initial period of the combustion process:

1. Oxygen zone – located above the grate, under which the so-called primary air is supplied. All the heat energy in the boiler is generated in this zone.
2. Reduction zone – located directly above the oxygen zone. The oxygen content in this zone drops to zero, but due to the thermal effect of the oxygen zone, the temperature here is quite high. The CO_2 flowing here from the oxygen zone is reduced to CO in contact with the hot surface of the char.
3. Degassing zone – located above the reduction zone. The temperature here is still relatively high, allowing for the degassing of the coal. The degassing products and the carbon monoxide flowing here move further, to the zone located higher.
4. Drying zone – located above the degassing zone. In this zone, surface moisture is removed from the coal and that which is in the pores near the surface. Through this zone flow: carbon monoxide – from the reduction zone and degassing products – from the degassing zone, which together with water vapour rise to the space above the bed.

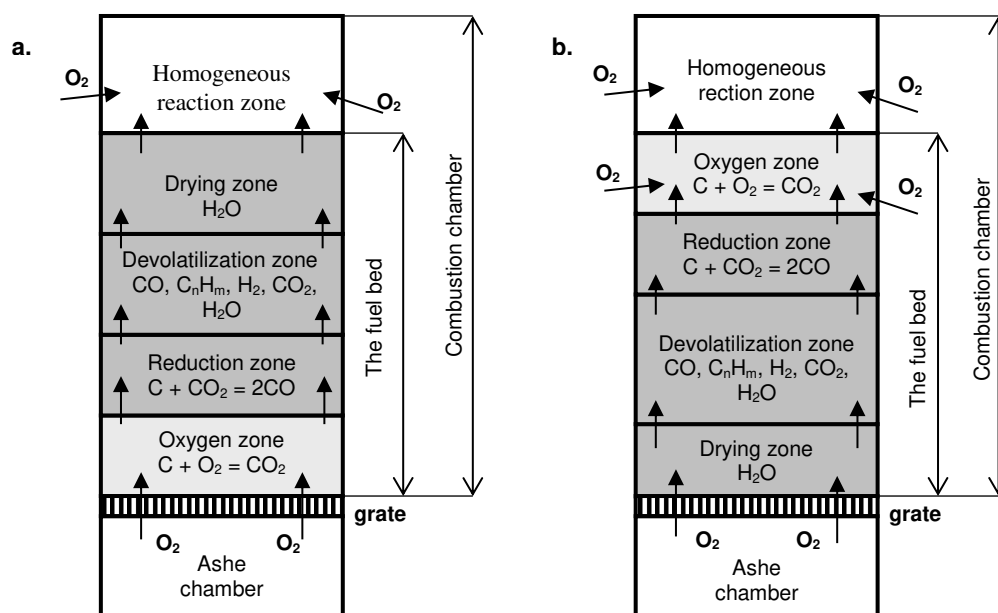


Figure 6. Burning stratum (fuel-bed) in the grate boiler: a.) with bottom-up burning; b.) with top-down burning.

Source: Wójcik, 2011a, pp. 105-110.

The area above the bed, the homogeneous reaction zone, is supplied with so-called secondary air in order to enable combustion of degassing products and CO . However, the temperature above the bed is too low to ensure proper combustion. In this type of grate furnaces, in the initial combustion period, significant emission of hydrocarbons into the atmosphere is observed. There are large energy losses.

In the top-down combustion boiler hopper (Figure 6b), the same zones are distinguished in the initial period of the combustion process as in bottom-up combustion, but they are located under the oxygen zone - the heterogeneous reaction zone.

The oxygen zone is located in the upper part of the combustion chamber, where the primary air is supplied. The amount of supplied air is greater than the demand of this zone by heterogeneous reactions, so its surplus is used to burn carbon monoxide and hydrocarbons in the homogeneous reaction zone.

The reduction zone is located below the oxygen zone. The carbon monoxide generated in the reduction zone flows through the hot heterogeneous reaction zone, where it has the greatest chance of burning. If this does not happen in the oxygen zone, the oxidation of CO will occur in the homogeneous combustion zone.

The degassing zone is located under the reduction zone, so the volatile parts rich in hydrocarbons will go through the reduction zone to the oxygen zone, where they will be burned. The part of the hydrocarbons that does not have time to burn in the oxygen zone will be burned in the homogeneous reaction zone. It must be remembered that the combustion of a certain amount of fuel does not occur immediately but lasts for a certain period of time.

The drying zone is located below the degassing zone. The steam passes through the subsequent zones to the homogeneous reaction area. It improves the CO combustion rate.

Below the drying zone there is a fixed grate through which secondary air is supplied to the boiler combustion chamber. This air forces the flow of gaseous components towards the oxygen zone, preventing them from flowing back and getting through the ash chamber door to the environment. Figure 7 shows a practical solution of a boiler with top-down combustion.

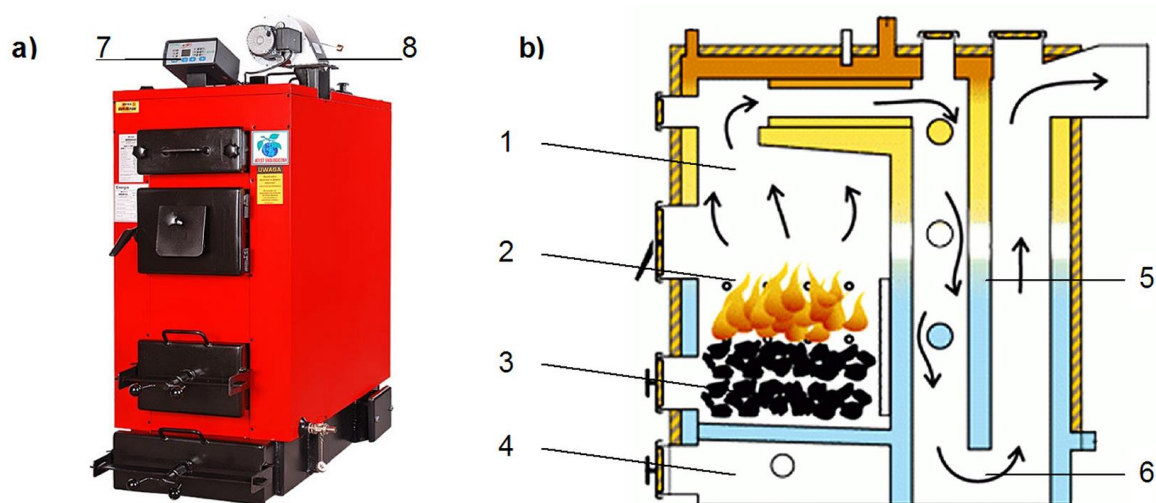


Figure 7. KWM-S 50 kW top-combustion grate boiler: a) general view; b) operation diagram. Explanations: 1 - fire chamber; 2 - secondary air nozzles; 3 - filling layer; 4 - ash chamber; 5 - heat exchanger, 6 - exhaust gases, 7 - control system; 8 - air supply system to the combustion zone.

Source: Wójcik, 2011a, pp. 105-110.

During the operation of a boiler with top-down combustion, the heterogeneous reaction zone moves towards the grate and above it there are combustion wastes, which hinder the course of homogeneous reactions due to the inaccurate mixing of the gas fuel with the oxidizer. This zone tends to channel, i.e. it does not move towards the grate evenly over the entire surface.

The boiler operates cyclically. After the end of one cycle, the chamber is refilled with fuel, it is ignited on the surface and another cycle begins. Such a furnace is relatively troublesome to operate. These disadvantages are not present in furnaces with a sliding mechanical grate, in which top-down combustion is also carried out. The sliding grate and a relatively thin layer of fuel cause good burning of the char and flammable gases above the grate surface. Furnaces with a mechanical grate are used in professional heating plants and their thermal power exceeds several dozen megawatts, so they are not suitable for individual users.

The modernization of the top-down combustion method is a reaction chamber with a retort – the so-called retort furnace. The principle of operation of such a furnace is shown in Figure 8.

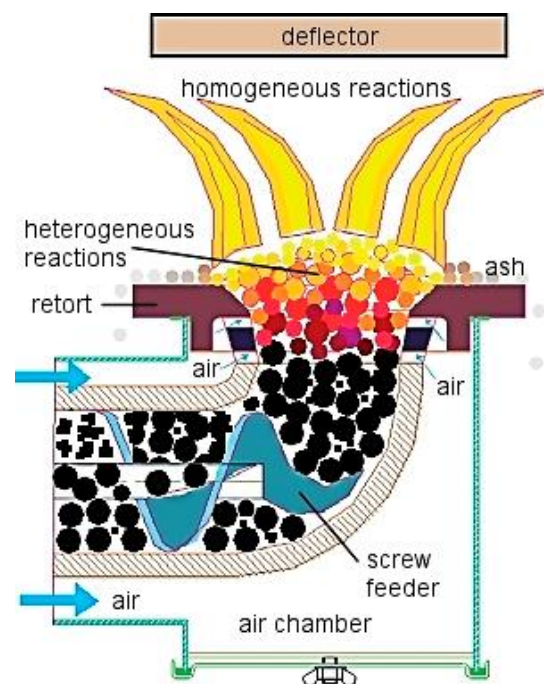


Figure 8. Construction of a typical retort furnace.

In the upper part of the retort there is a heterogeneous reaction zone and below it the next zones shown in Fig. 6b. Here all the zones are stationary due to the movement of the fuel, which is supplied by a screw feeder. Air is forced into the air box and from there to the nozzles located on the circumference of the retort in the heterogeneous reaction zone. Excess air flows into the homogeneous reaction zone, where the coal degassing products are burned. In the upper part of the homogeneous reactions there is a deflector - a steel plate on which the ash particles lose their kinetic energy and fall to the edge of the retort. From there they fall into the ash chamber located under the air box.

Figure 9 shows the operation of a reaction chamber with a retort furnace. This solution eliminates all the disadvantages of a furnace with a fixed grate, both with bottom-up and top-down combustion. Reaction chambers with retort furnaces are currently among the most modern, suitable for burning both coal and biomass. However, the fuel must be previously

properly prepared, mainly in terms of granulation and sinterability. A detailed description of these furnaces can be found in (Wójcik, 2011b, pp. 515-525).

The heat exchange process in the retort reactor comes down to generating high-temperature exhaust gases that transfer heat energy to the circulating medium in the heat exchanger as a result of transferring heat from the exhaust gases to the exchanger wall in accordance with the equation

$$\dot{q} = \alpha (T_g - T_w), \quad (1)$$

where:

\dot{q} is the unit heat flux [J/m²s],

α – heat transfer coefficient from the gas to the exchanger walls [J/m²sK],

T_g – gas (exhaust gas) temperature [K],

T_w – temperature of the heat exchanger walls [K].



Figure 9. Operation of the retort furnace.

Source: Wójcik, 2011b, pp. 515-525.

The value of the unit heat flow is influenced by the temperature difference and the value of the heat transfer coefficient, which strongly depends on the local velocity of the exhaust gases relative to the heat exchanger walls. The higher the velocity, the higher α . By using appropriate exhaust gas swirlers, a turbulent flow is obtained in the exchanger and the value of the heat transfer coefficient increases significantly. The efficiency of the process increases.

The heat exchange process can be further intensified by generating a large flux of thermal radiation energy in the reaction chamber from the heterogeneous reaction area to the exchanger wall. Heat exchange by radiation between the surface of the embers and the exchanger wall proceeds according to the equation:

$$\dot{q}_r = \sigma \varepsilon (T_c^4 - T_w^4) \quad (2)$$

where:

$\sigma = 5.67 \cdot 10^{-8} \text{ J/sm}^2\text{K}^4$ is the Stefan-Boltzmann constant,

T_c – the temperature of the glow,

ε is the emission capacity of the body ($0 \leq \varepsilon \leq 1$).

The value of the unit heat radiation flux is significant due to the temperature difference in the fourth powers.

Figure 10 shows a diagram of a boiler with a radiation combustion chamber for solid fuel. The solution is original and has been granted a patent in the Patent Office of the Republic of Poland (Wójcik, *Radiacyjna komora paleniskowa na paliwo stałe...*).

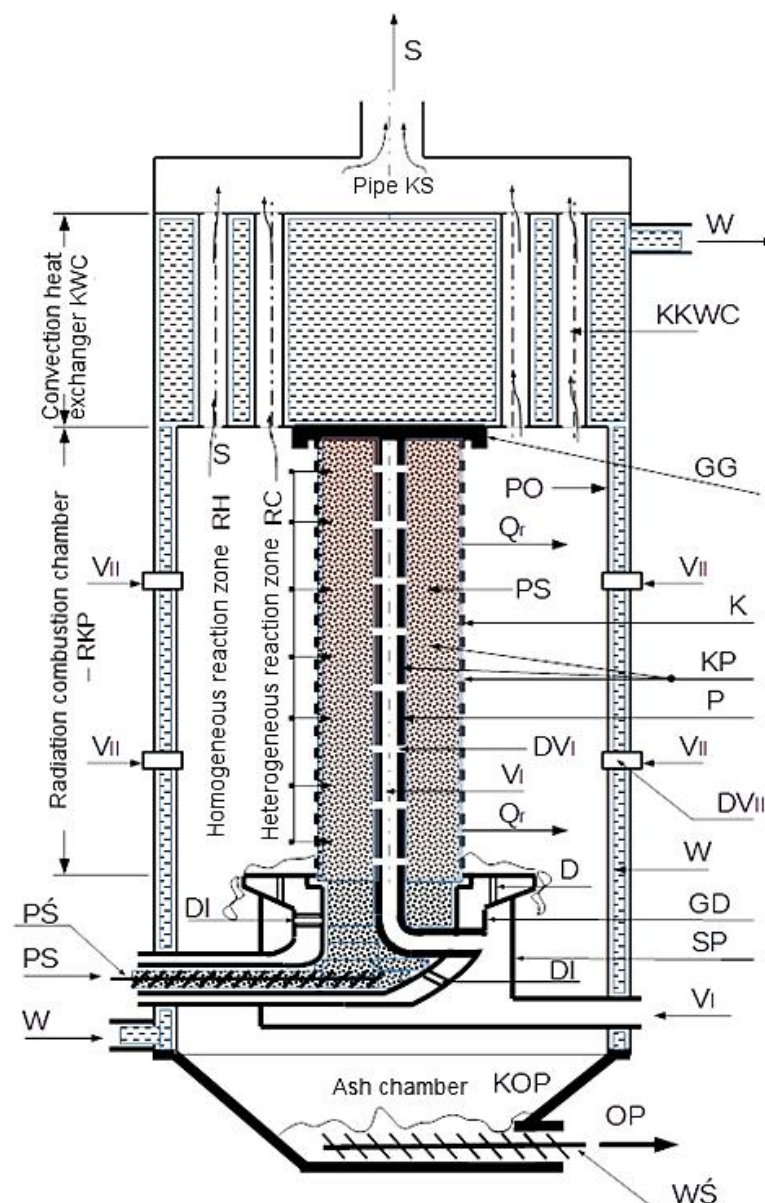


Figure 10. Boiler with a radiation combustion chamber (description in the text).

Source: Wójcik, *Radiacyjna komora paleniskowa na paliwo stałe...*

The solid fuel radiation reaction chamber is composed of a **KP** radiant column made of a heat-resistant basket **K**, inside which there is a combusted fuel **PS** and a centrally located air duct **P** with **DVI** nozzles supplying primary air **V_I** to the heterogeneous reaction zone **RC**. The design of the **KP** radiant basket depends on the type of combusted solid fuel, the size of the fraction and its sintering ability. The **KP** radiant column is thermally insulated from the top of the **KWC** convection heat exchanger by the upper socket **GG**, and in the lower part it is mounted in the lower socket **GD**, which is placed in the **SP** air box, to which the primary air **V_I** is supplied.

On the perimeter of the lower socket **GD** there are nozzles **D** supplying primary air **V_I** supporting the combustion of char, small amounts of which may be present in the combustion waste leaving the radiant column **KP**. In the lower part of the lower socket **GD** there are nozzles **DI** supplying air **V_I** to the fuel **PS** feeding the radiant column **KP**, in order to pneumatically isolate the combustion chamber from the environment. The solid fuel **PS** is supplied by the screw feeder **PS'** to the lower socket **GD** from where it moves to the heat-resistant basket **K** of the radiant column **KP**, where it is dried, degassed and burned. In order to prevent the gases generated during coal pyrolysis from flowing back, primary air **V_I** is supplied through nozzles **DI**, which here acts as a pneumatic barrier isolating the radiant combustion chamber **RKP** from the environment. The **OP** combustion waste is automatically discharged from the **KP** radiant column and through the offset located on the circumference of the lower **GD** socket falls into the **KOP** ash chamber from where it is discharged outside by means of the **WS'** screw selector. The unburned char contained in the **OP** combustion waste is post-burned on the offset of the lower **GD** socket, where primary air **V_I** necessary for burning the coke residue is supplied through nozzles **D**. High-energy heterogeneous reactions of combustion of solid fuel **PS** take place in the **KP** radiant column, the intensity of which depends on the amount of primary air **V_I** supplied through nozzles **DVI** located on the circumference of the air duct **P**. The amount of fuel **PS** burned must be synchronized with the speed of its supply by the **PS'** screw feeder. The released thermal energy **Q_r** in the heterogeneous reaction zone **RC** of the combustion of char formed from solid fuel **PS** is radiated towards the wall **PO**, behind which there is a circulating medium **W**. Combustible products of degassing of solid fuel **PS** containing hydrocarbons and unburned carbon monoxide from heterogeneous reactions are combusted in the homogeneous reaction zone **RH**, in the vicinity of the radiant column **KP**, and the products of these reactions leave the radiant combustion chamber **RKP** in the form of exhaust gases **S**. Secondary air **V_{II}** is fed to the homogeneous reaction zone **RH** through **DV_{II}** nozzles in order to efficiently conduct these reactions and obtain high energy of exhaust gases **S**. Hot exhaust gases **S** leave the radiant combustion chamber **RKP** and move through the **KKWC** channels in the **KWC** convective heat exchanger, releasing thermal energy to the circulating medium **W**, which was previously preheated by the heat **Q_r** radiated from the radiant column **KP**. The exhaust gases **S** cooled in the convection heat exchanger **KWC** move to the exhaust gas chamber **KS** and are then removed outside.

The aim of the new solution is to increase the total heat energy flux generated in the reaction chamber as a result of radiation energy from the heterogeneous reaction zone and the energy contained in hot exhaust gases moving to the heat exchanger.

3. Gas fueled reactors

Like solid fuel reactors, gas fuel reactors have a long tradition of use, hence the large variety of technical solutions. Leaving aside the historical outline, the paper will present solutions that are currently commonly used. These are structures that operate classically, but they use new materials and manufacturing technologies. The basic element in a gas fuel reaction chamber is a gas burner. Basically, gas burners are divided into atmospheric and fan burners. Figure 11 shows an atmospheric injector burner.

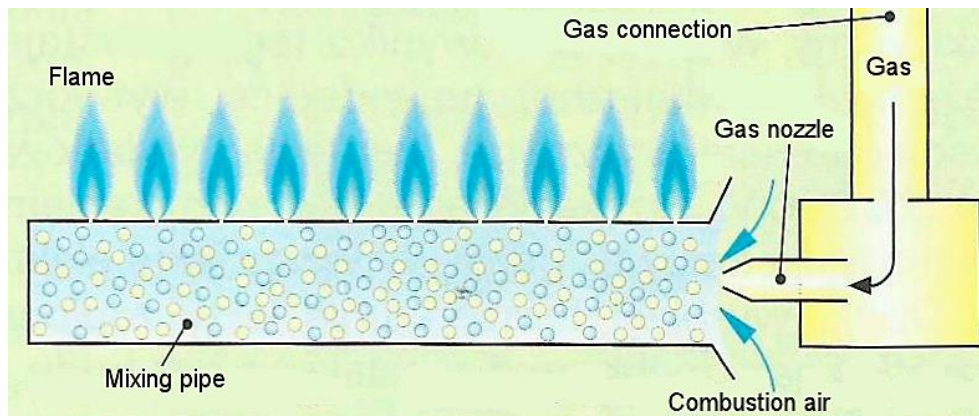


Figure 11. Principle of operation of an atmospheric injector burner.

Source: Vissmann sp. z o.o.

The gas flowing out of the nozzle creates a static vacuum due to the suction action of the jet. As a result, atmospheric air is sucked into the pipe, where it mixes with the gas fuel to create a combustible mixture. These burners are characterized by simple construction and quiet operation. Their efficiency is lower than that of blower (fan) burners. Figure 12 shows an example of the use of an injector burner in gas boilers with a power of up to several kW.

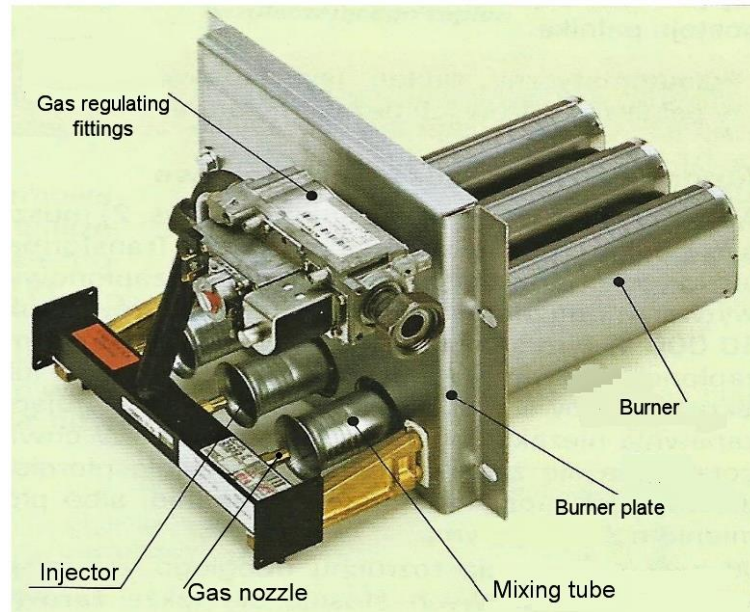


Figure 12. Atmospheric (injector) Gas Burner.

Source: Vissmann sp. z o.o.

Currently, the most modern gas burners include structures that generate a swirl flame. Figure 13 shows the principle of operation of such a burner. The oxidizer and fuel streams flowing out of the burner are introduced into a swirling motion, thanks to which the fuel and oxidizer are well mixed. This is a necessary condition for rapid combustion. Gas particles have two velocity components - axial v_x and radial v_r . Circumferential velocity v causes the particle to move in a spiral. As a result of the radial velocity, the flame thickness increases and a negative pressure is created inside it. Hot exhaust gases from the flame front are sucked into its interior and heat the fuel-air mixture - as a result, the combustion rate increases.

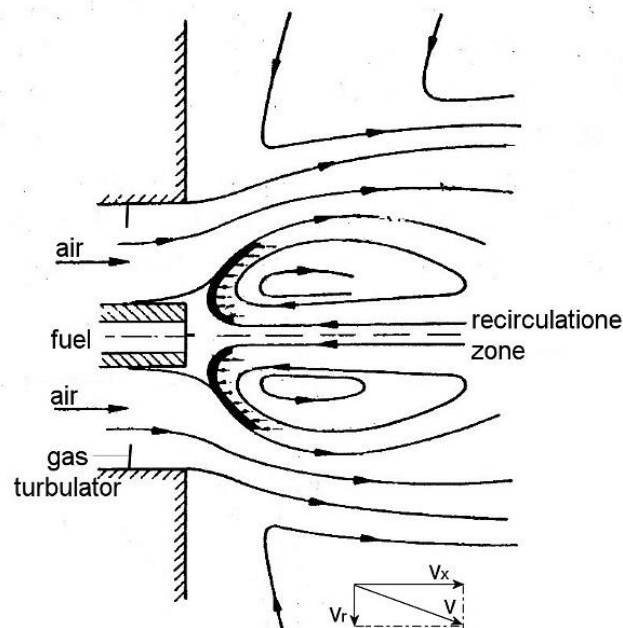


Figure 13. Swirled flame with exhaust gas recirculation.

Depending on the degree of swirling, the shape of the flame can be formed by adapting it to the size of the reaction chamber. The issues related to this are described in (Wójcik, 2011b, pp. 515-525; Wójcik, 2021, pp. 103-122). Figure 14 and Figure 15 show reaction chambers for gas fuel with burners generating a swirled flame. The degree of swirling is different, so in Figure 14 the flame is elongated, in Figure 15 - circular.

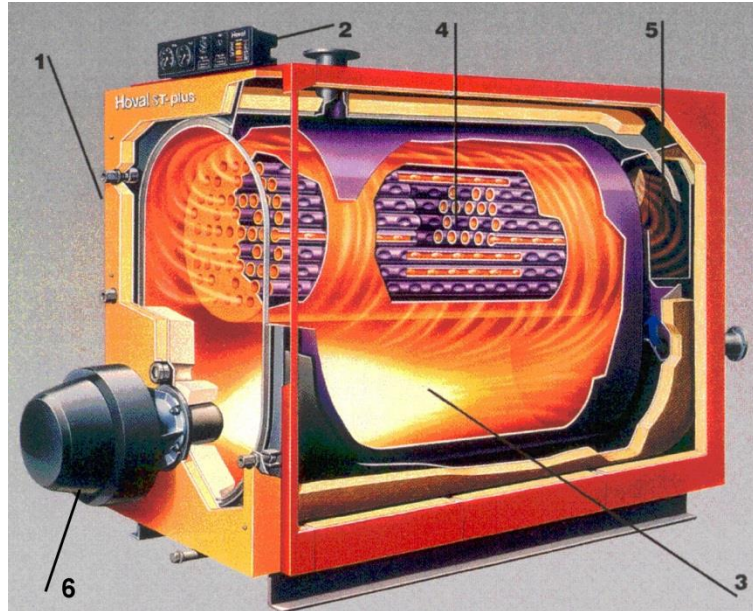


Figure 14. Gas boiler: 1 - body, 2 - control panel, 3 - swirl flame, 4 - flame heat exchanger, 5 - exhaust gas outlet, 6 - gas burner.

Source: Hoval sp. z o.o., 2012.

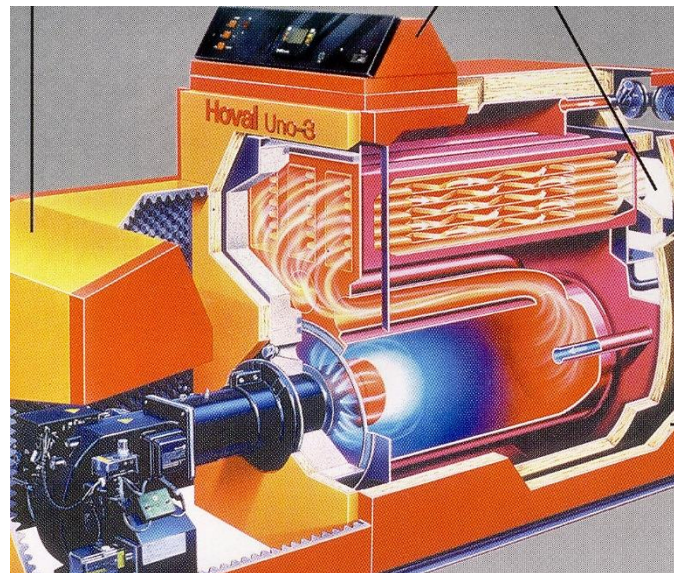


Figure 15. Gas boiler: 1 - body, 2 - control panel, 3 - swirl flame, 4 - heat exchanger.

Source: Hoval sp. z o.o., 2012.

As in solid fuel reactors, these reactors also have a problem with heat exchange efficiency. Gas radiation is negligible and practically negligible. Therefore, the entire energy flow is transferred through hot exhaust gases to the heat exchanger according to equation (1).

Generating an additional stream of energy emitted by radiation can significantly increase the efficiency of heat exchange in the reaction chamber of the boiler. Design changes are necessary, consisting in introducing a radiator into the reaction chamber, which can be a porous ceramic mass. Figure 16 shows a diagram of a boiler with a radiation combustion chamber for gas fuel. The solution is original and has been granted a patent in the Patent Office of the Republic of Poland (Wójcik, *Radiacyjna komora paleniskowa na paliwo gazowe...*).

The gas fuel radiation combustion chamber consists of a **KP** radiant column located in a reaction chamber limited by the internal walls of the boiler. Gas fuel **G** is supplied to the **KM** mixing chamber via the **PG** pipe. At the end of the **PG** pipe there is a swirler **Z**, the task of which is to create turbulence in the gas fuel. At the same time, air flows through the **PP** pipe to the **KM** mixing chamber, previously also introduced into a swirling motion by the **Z** swirlers. The combustible gas **G** and air **P** mix in the **KM** mixing chamber and a fuel-air mixture **PG** is created, which moves to the channel **K**, located centrally in the **KP** radiant column built of a ceramic porous mass **MP** and then moves through the pores in the ceramic porous mass towards its external surface **MPA**, where the homogeneous combustion zone **SH** is located. The surface layer of the ceramic porous mass is heated by the heat generated in the homogeneous combustion zone and, as a result, its temperature increases. The heated external surface **MPA** of the ceramic porous mass **MP** sends thermal radiation energy Q_r towards the internal surface **PO** of the radiant combustion chamber **RKP**, heating the circulating medium **W**. The hot exhaust gases **S** generated in the homogeneous combustion zone **SH** move towards the channels **KKWC** of the convective heat exchanger **KWC** where they transfer thermal energy to the circulating medium. The cooled exhaust gases accumulate in the combustion chamber **KS** from where they are discharged outside. On the external surface **MPA** of the ceramic porous mass **MP** of the radiant column **KP** there is a heat-resistant steel mesh **SS**, the task of which is to protect the radiant column **KP** against damage in the event of high thermal stresses in the ceramic porous mass **MP**. Such a situation can occur when the radiation atmosphere of the combustion chamber suddenly cools down, e.g. when it is opened and cold air is let into its interior. The **KP** radiant column is fixed in the radiation combustion chamber by means of the lower socket **GD** and the upper socket **GG** thermally insulating it from the convection heat exchanger **KWC**. The holes in the porous mass on its external surface act as miniaturized burners, to which the combustible gas mixture flows through channels inside the ceramic porous mass. The porous mass heated by the miniature flames emits thermal radiation Q_r causing heating of the circulating medium **W**. Due to the lack of a long flame of combustion of the gas fuel, the volume of the combustion chamber decreases, which increases the amount of energy generated in the unit of the radiation volume of the combustion chamber.

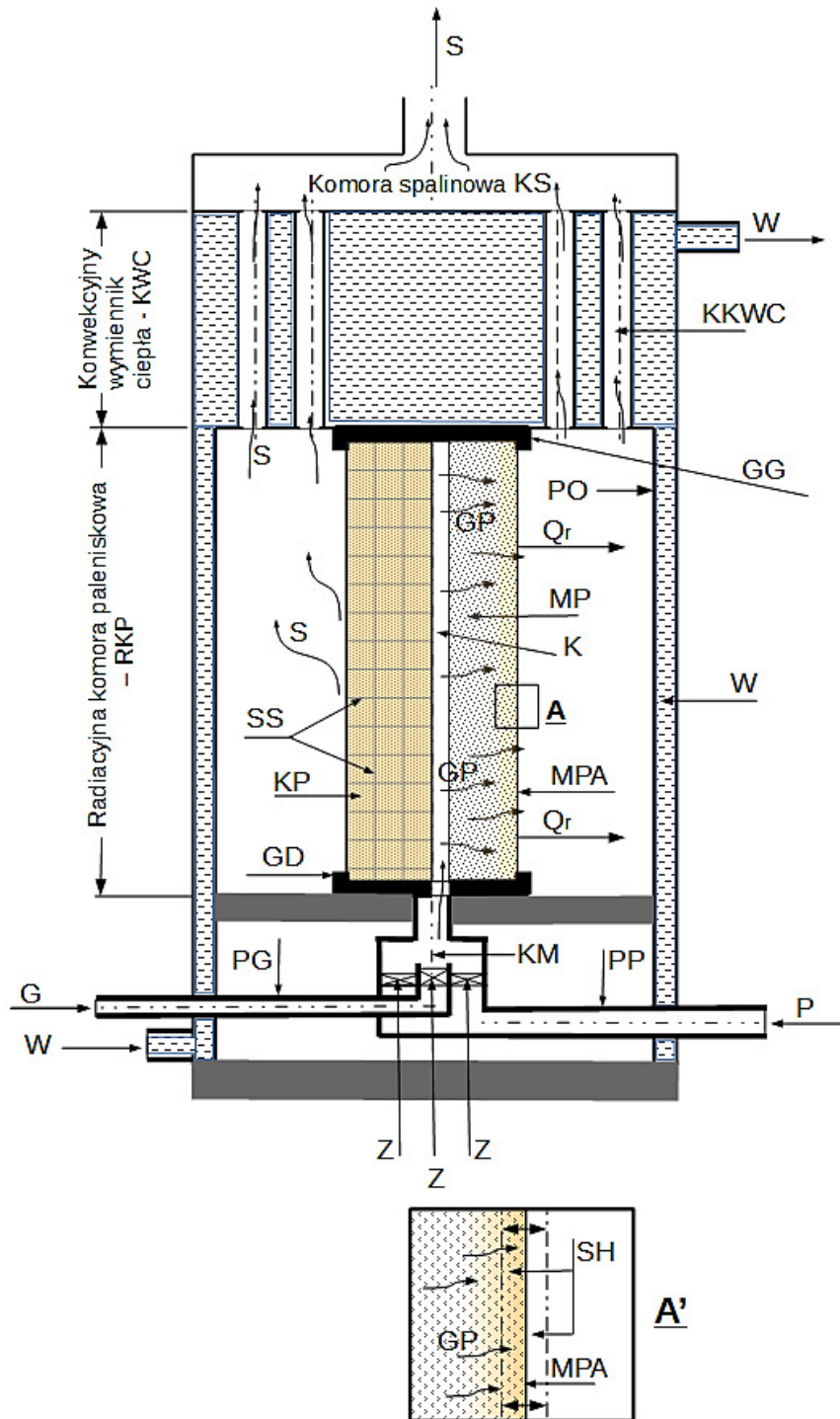


Figure 16. Gas boiler with radiation reaction chamber (description in the text).

Source: Wójcik, *Radiacyjna komora paleniskowa na paliwo gazowe...*

The quality of combustion of the gas fuel increases and the noise that occurs during the operation of the gas burner is eliminated. These improvements are unheard of in conventional solutions. The boiler is designed to operate in automatic mode, maintaining all the rigors regarding the combustion of gas fuels. Flame control and the reliability of the ignition system are particularly important.

The advantage of the proposed solution is the large amount of energy generated in the unit of the radiation volume of the reaction chamber. Kinetic combustion of gas ensures high temperature and purity of exhaust gases. The operation of the device is environmentally friendly - there is no noise, as is the case with gas burners with strong turbulence. The described design is unheard of in previous solutions. The method of operation of the boiler predisposes it to work with advanced automation taking into account the current demand for thermal energy, control of the combustion process in order to determine the composition of the fuel-air mixture, switching the device on and off, controlling and safety elements. Controlling the operation of energy devices is a broad topic and goes beyond the scope of the work.

4. Summary

Solid and gas fuels are the main source of meeting the energy needs of municipalities and individual users. Although fuel prices are constantly rising, the share of these carriers is still dominant. This results not only from the tradition of energy economy based on coal and gas, but mainly from operating costs, which consist of relatively low prices of energy devices. Requirements for fuel combustion efficiency require the use of modern structures with high energy efficiency. It seemed that the previous design solutions of solid and gas fuel reactors are such that it is not possible to significantly improve them. Yes, the control of these devices is constantly being improved, which is the result of the use on an increasingly large scale of industrial processors and detectors with high sensitivity and resistance to temperature, dust, etc.; The new proposed solutions are the next step in the evolution of the design of solid and gas fuel boilers for municipal economy. The emphasis here is on heat exchange by radiation to the surfaces absorbing heat in the reactor. The higher the emitter temperature, the greater the flow of energy radiated to the surfaces radiated in the reactor. This is due to the temperature difference in the fourth powers between the emitter and the exchanger walls. The increase in the prices of energy carriers forces their rational management.

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CREATOR AND VIEWER ACTIVITY ON YOUTUBE IN POLISH CONTENT ABOUT ELECTRIC VEHICLES

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Purpose: This study aims to examine the activity of content creators and viewers on YouTube in the context of Polish-language videos related to electric vehicles (EVs). The study aims to explore trends in video publication, user engagement through comments, and the relationships between video characteristics (such as duration and views) and user interaction.

Design/methodology/approach: The research uses a dataset of 1152 videos and 125,680 comments collected from YouTube using Python and R tools. The videos were identified through specific search phrases related to EVs. The methodology includes descriptive analysis of video publication trends and linear regression models to investigate the relationships between video duration, views, and comment count. Data were cleaned and pre-processed to remove non-Polish comments, duplicate entries, and outliers.

Findings: The analysis revealed a growing trend in user engagement with EV-related content on YouTube over the years. A small group of highly active users contributed the majority of videos, while a significant portion of user interaction consisted of replies, indicating a high level of viewer-to-viewer engagement. Regression models showed a statistically significant but weak correlation between video duration and comments, as well as between video views and comments, but found no significant relationship between video length and views.

Research limitations/implications: This study is limited to videos and comments in the Polish language, which restricts the generalizability of the findings to other linguistic or cultural contexts. Furthermore, data were collected up until May 2024, making the analysis of trends in that year incomplete. Future research could include a broader range of content and explore additional factors that influence user engagement, such as video content quality or audience demographics.

Practical implications: The findings suggest that content creators in the EV sector on YouTube may benefit from building more engaging discussions among viewers. Understanding that longer videos or videos with more views may attract slightly more comments can help creators tailor their content strategies. For platform managers and marketers, fostering user interaction through replies and discussions may be a key way to increase engagement with content.

Originality/value: This study is among the first to analyse the dynamics of creator and viewer activity on YouTube specifically within the Polish-language content about electric vehicles. It contributes to a better understanding of how creators and viewers engage with this topic, providing insights into content trends and user interaction that may guide future content development strategies.

Keywords: YouTube, Electric vehicles, User engagement, Viewer comments, Creator activity, Regression analysis.

Category of the paper: research paper.

1. Introduction

The European Union has implemented various initiatives aimed at fostering the adoption of electric vehicles (EVs), including financial incentives, infrastructure development, and strategic plans designed to encourage consumers to transition to EVs (Hawkins et al., 2013; Pasaoglu et al., 2012; Sierzchula et al., 2014). Research shows that widespread adoption of EVs is difficult to achieve without government subsidies (Rahmani, Loureiro, 2018). Incentives, particularly in the early stages of new technology introduction, play a crucial role in increasing consumer adoption (Davies et al., 2016), (Figenbaum et al., 2015), and (Trip et al., 2012).

Electric vehicles (EVs) have emerged as a critical technology in reducing greenhouse gas emissions. Alongside government incentives and infrastructure developments, social media platforms like YouTube have played an increasingly influential role in shaping public opinion and consumer behaviour towards EVs. This paper explores the activity of creators and viewers within Polish-language content on YouTube, providing insights into the patterns of engagement and interaction surrounding electric vehicles (EVs).

EVs are considered a key component in reducing greenhouse gas emissions and improving urban air quality, benefiting public health by reducing pollutants such as nitrogen oxides and particulate matter (Hannan et al., 2014; Ma et al., 2012; Van Mierlo et al., 2006). Despite these benefits, many consumers prioritize personal convenience and cost over environmental concerns when making purchasing decisions (Buenstorf, Cordes, 2008).

Given the rapid growth of the electric vehicle market, which is projected to make up over 30% of the light-duty vehicle market in the United States by 2030 (Wolinetz, Axsen, 2017) understanding public perception and sentiment towards EVs is increasingly important for both policymakers and manufacturers. One avenue for understanding these perceptions is through online platforms, particularly YouTube, where creators and viewers discuss and engage with content related to electric vehicles.

2. YouTube as a Platform for EV Discussion

YouTube has become a vital platform for disseminating information and shaping opinions about new technologies, including electric vehicles. The platform not only allows creators to upload videos about the latest EV models, charging infrastructure, and technological advancements but also provides a space for viewers to engage in discussions through comments. This interaction offers valuable insights into the public's perception of electric vehicles, as well as trends in viewership and content creation.

Research on user interactions and content creation on YouTube regarding EVs is still in its infancy, but the platform provides a rich source of data for understanding how people discuss and react to EV-related topics. Previous studies have shown that online platforms such as Twitter and discussion forums play a significant role in shaping consumer attitudes toward EVs. For example, (Suresha, Tiwari, 2021) used topic modelling to analyze tweets about EVs, finding that "Tesla" was one of the most frequently used hashtags. Similarly, sentiment analysis conducted by (Bhatnagar, Choubey, 2021) indicated that Tesla was viewed more positively compared to other EV manufacturers.

While studies like those (Ha et al., 2021), (Jiang, Everts, 2021), and (Asensio et al., 2008) have analyzed user sentiments and opinions about EVs using natural language processing (NLP) tools, YouTube remains an underexplored platform for understanding consumer engagement with EV-related content. This study aims to fill this gap by examining creator and viewer activity on YouTube, specifically focusing on Polish-language content about electric vehicles. The research explores trends in video publication, user engagement through comments, and the relationships between video characteristics (such as duration and view count) and user interaction. By analyzing the interactions between creators and viewers, this study contributes to a better understanding of how electric vehicles are perceived and discussed in Polish-speaking online communities.

3. Research Methodology

This section outlines the methods and tools used to gather, preprocess, and analyse data from YouTube related to electric vehicles (EVs) in Polish-language content. The methodology covers two main groups of data: videos and comments associated with the selected videos.

3.1. Data Collection

The dataset was collected in two stages, focusing on video data and user comments:

- YouTube video data: A total of 37,317 YouTube video links related to electric vehicles were gathered using Python's scrapetube package (Twersky, n.d.). The search was conducted using 74 phrases associated with electric vehicles, which included both car brand names and model names. These phrases were compiled based on information from an online platform dedicated to EVs (*No Title*, n.d.). Videos that did not contain the search phrase in the title or were not produced by Polish channels were excluded, resulting in a refined list of 1152 videos.
- YouTube comment data: On May 24, 2024, comments for each of these 1152 videos were collected using the Python package youtube-comment-downloader (*Youtube-Comment-Downloader*, n.d.). This tool allowed the retrieval of 128,851 comments without the need for the official YouTube API which allowed for the retrieval of 128,851 comments without the need for the official YouTube API.

3.2. Data Preprocessing

The data was preprocessed to ensure accuracy and relevance for analysis:

- Language filtering: Non-Polish comments were removed from the dataset to focus on Polish-language content.
- Duplicate removal: Repeated comments from the same user, such as advertisements or promotions, were treated as text strings and compared using the '==' operator to identify and remove duplicates.
- Comment filtering: Comments of zero length or those that contained fewer than one word after preprocessing were excluded.
- Content cleaning: Several steps were applied to clean the comment text:
 - Removal of URLs, hashtags, emojis, usernames, and non-letter characters to retain only textual content.
 - Verification of word count for each cleaned comment, and exclusion of comments with fewer than one word.

The final dataset consisted of 125,680 comments associated with 992 videos. Videos that did not have any comments or whose comments became empty after cleaning were excluded.

3.3. Data Transformation

Once the data was preprocessed, several transformations were applied to prepare the dataset for analysis:

- Video data:
 - Video duration, initially formatted as "HH:MM" was transformed into a numerical value representing the total duration in minutes to enable consistent analysis.

- The publication dates were used to calculate the number of months and weeks since each video's release, which facilitated the calculation of average monthly and weekly views.
- **Outlier removal:** Extreme outliers in view counts and comment counts, such as videos with unusually high numbers of views or comments, were excluded. For instance, four videos with exceptionally high average monthly views (ranging from 231,894 to 1,682,899 views per month) were removed from specific analyses.
- **Statistical transformations:** Square root transformations were applied to certain variables (e.g., views, comments) to address skewness and ensure a more linear relationship in the regression models.

3.4. Data Analysis

The analysis consisted of two key approaches:

- **Visual Descriptive Analysis:** Descriptive visual analysis was used to explore trends in video publication and user engagement, utilizing box plots and bar charts to visually represent the distribution of comments, videos, and user activity over time.
- **Regression Analysis:** Three linear regression models were applied to examine the relationships between video characteristics and user engagement:
 - **Model 1:** Relationship between the number of comments and the duration of the video.
 - **Model 2:** Relationship between the number of comments and the number of views.
 - **Model 3:** Relationship between the number of views and the duration of the video.

Each model's statistical significance and R-squared values were assessed to determine the proportion of variance explained by the independent variables. Outliers were filtered to improve the models' accuracy.

3.5. Tools Used

- **Python:** Used for scraping video and comment data from YouTube, specifically with the scrapetube and youtube-comment-downloader packages.
- **R programming language:** Used for data manipulation, visualisation, and statistical analysis, employing packages like dplyr (Wickham et al., 2023), ggplot2 (Wickham, 2016) and tidyverse (Wickham et al., 2024).
- **Microsoft Excel:** Used during the data cleaning and preprocessing stages to manually inspect the dataset in a tabular format.

4. Results

Figure 1 presents the number of videos published each month from 2015 to May 24, 2024. The data reveals a steady increase in video publications over the years, with a noticeable peak in 2022, where 295 videos were published. The colours represent different months, showing the distribution of video publications throughout the year. The year 2024, although incomplete, shows a significant decline in the number of videos published compared to the peak years.

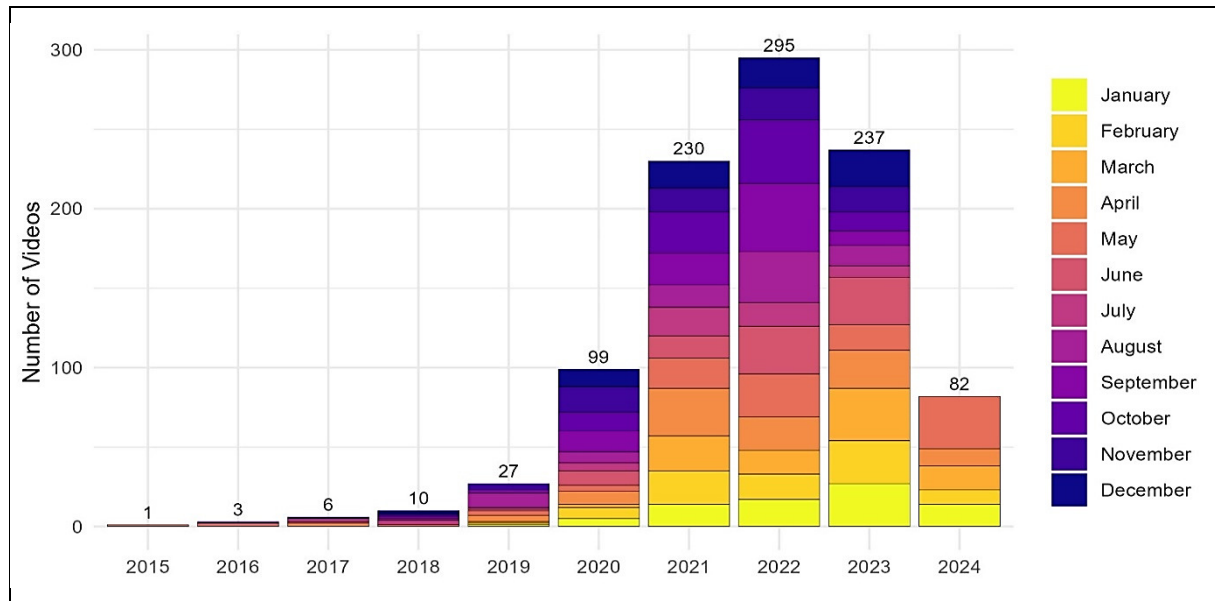


Figure 1. Number of Videos Published per Month in Each Year (data as of May 24, 2024).

Sources: original research.

Figure 2 illustrates the distribution of YouTube videos published by users each year. The box plot displays the median, interquartile range, and outliers for the number of videos published annually. A noticeable increase in publication activity is evident starting around 2019, with a significant rise in 2021 and 2022. The plot also emphasizes the variability in video publication, with 2021 and 2022 showing a wider distribution, suggesting more diverse activity among users during these years.

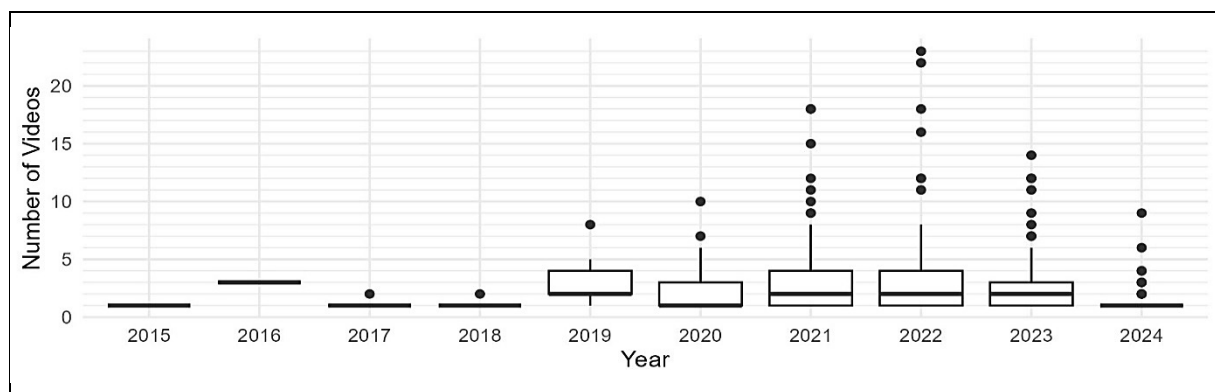


Figure 2. Distribution of YouTube Videos Published by Users per Year (data as of May 24, 2024).

Sources: original research.

Figure 3 shows the number of videos published by users each year, grouped by quantile. Each quantile group represents a different segment of users, categorized based on the number of videos they published in a given year. The chart displays how many videos were published by users in each quantile, with the groups arranged from those who published the fewest videos (quantile 1) to those who published the most (quantile 4). In the chart for the year 2021, it is clear that the largest segment of the bar (representing the 4th quantile) is significantly bigger than the others. This suggests that more than 50% of the videos were published by the top 25% of the most active users (those who published the most videos). Quantile 4, representing these highly active users, dominates the number of videos published that year.

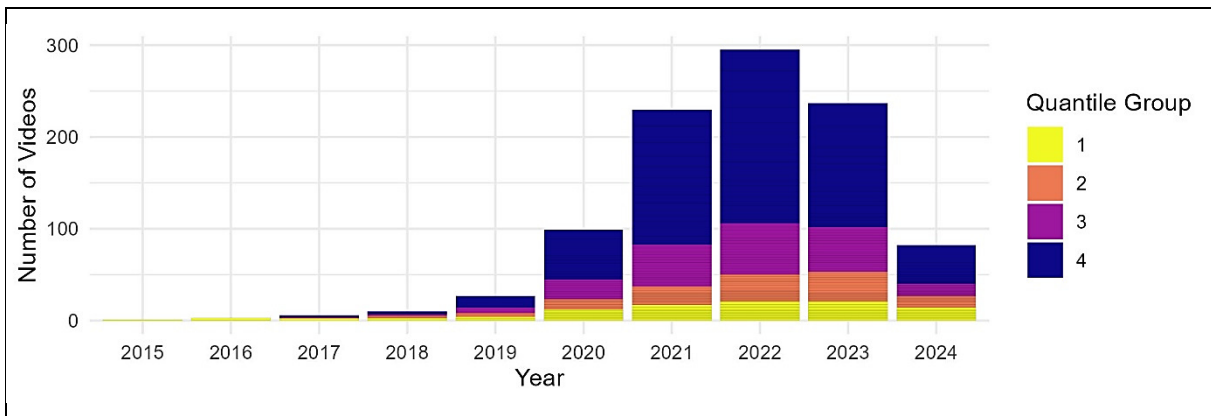


Figure 3. Quantile Distribution of YouTube Videos by Users per Year (data as of May 24, 2024).

Sources: original research.

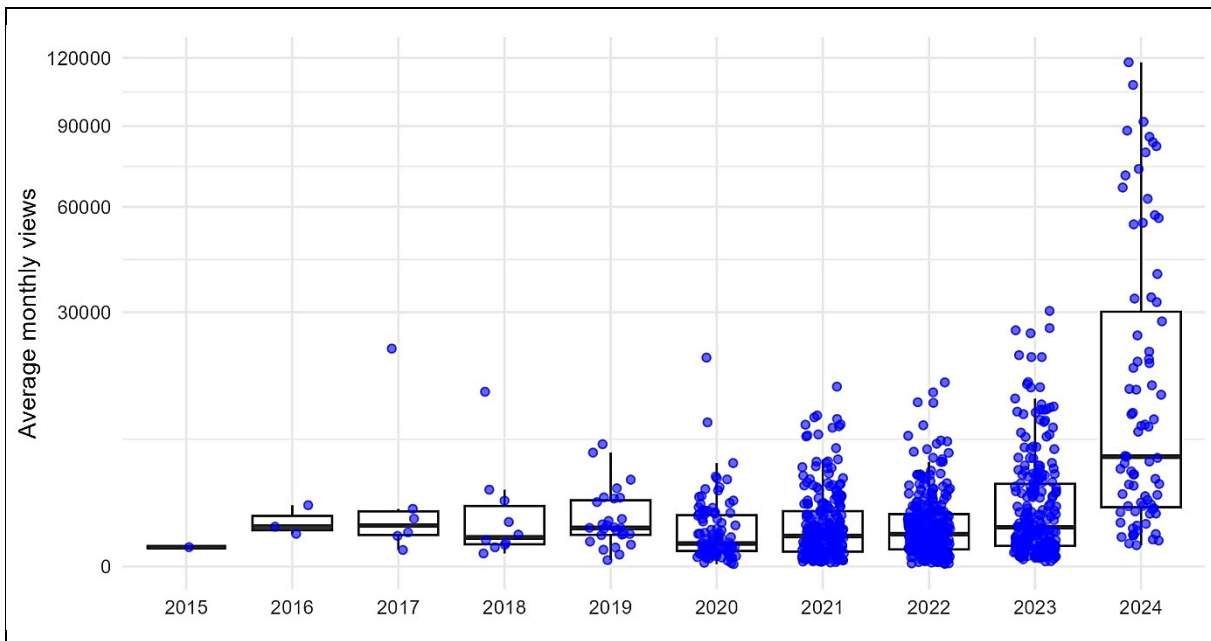


Figure 4. Distribution of average monthly views of videos by year (data as of May 24, 2024).

Sources: original research.

Figure 4 shows the distribution of average monthly views of videos over the years. Each point represents a video and indicates its average monthly views, which were calculated by dividing the total number of views by the number of months from its publication date up to May 24, 2024. This metric reflects the average audience interest per month, providing a more precise assessment of viewing trends over time. The increasing spread and higher median values in recent years suggest growing interest and viewership for the content, particularly in 2024, where a significant rise in average monthly views is evident. This trend highlights increased engagement with these videos in recent years. To ensure a more accurate representation of the overall data, four extreme outliers were excluded from this chart. These excluded videos had exceptionally high average monthly views, with one video from 2023 reaching 231,894 views per month, and three videos from 2024 reaching 346,415.2, 556,472.8, and 1,682,899.1 views per month, respectively. Additionally, the data shows a growing trend in video viewership, with an increase in engagement from 2021 to 2023. This highlights that recent content attracts more attention from viewers.

Figure 5 illustrates the total number of comments made on videos over the years, broken down by month. The vertical bars represent each year from 2015 to 2024, with colours corresponding to the different months of the year. The height of each bar reflects the cumulative number of comments made in that year, revealing an increasing trend in user engagement over time. This trend is especially notable in 2021, 2022, and 2023, which show a significant increase in the number of comments compared to previous years. In 2024, while there is a visible decline, the number of comments still indicates considerable activity despite being a partial year, as data collection stops on May 24, 2024. This chart highlights the increase in user interaction with the video content, showing a peak in activity starting in 2021.

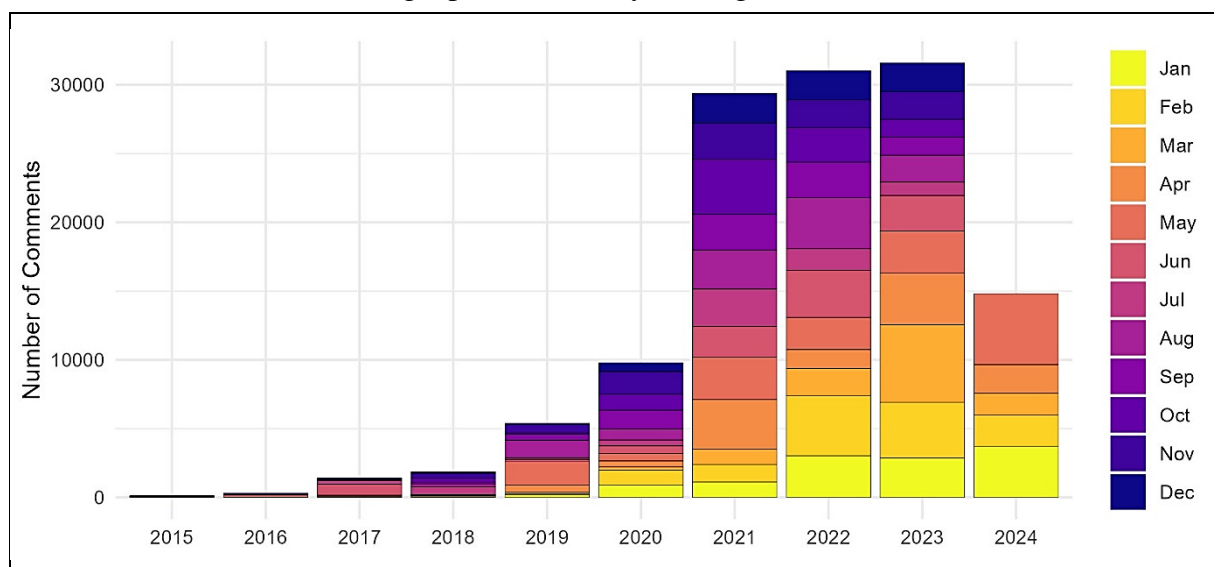


Figure 5. The number of comments.

Sources: original research.

Figure 6 shows the proportion of replies to original comments by year and overall. The high percentage of replies suggests that users are not only posting original comments but are also actively engaging in discussions with one another. This indicates a higher level of interaction and community engagement, as users respond to others' comments and debate among themselves, rather than just reacting to the video content itself. A reply rate of 48% for all comments highlights a strong tendency towards dialogue among users, reflecting a vibrant and interactive community.

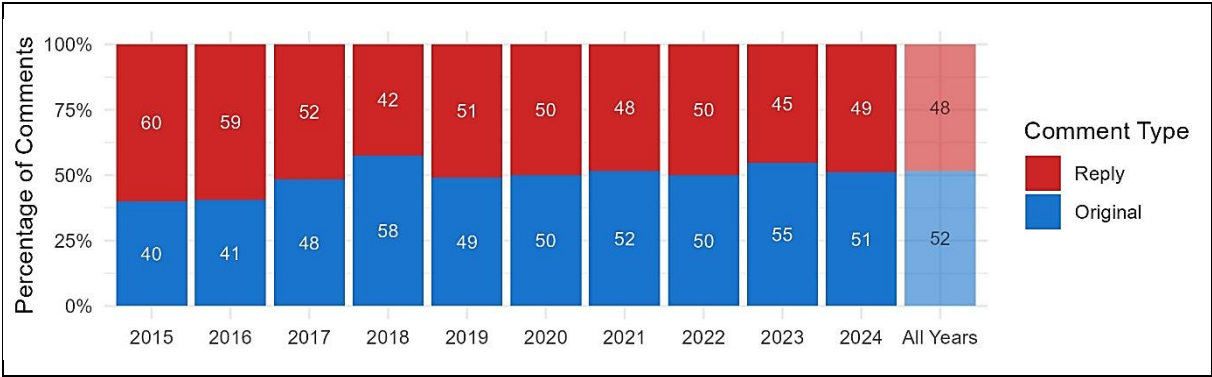


Figure 6. The proportion of Replies to Original Comments (data as of May 24, 2024).

Sources: original research.

Figure 7 depicts the distribution of original comments by the number of replies they have received, grouped into categories. The x-axis represents the number of replies, categorized into groups (1, 2-5, 6-10, 11-20, and 21+), while the y-axis indicates the count of original comments within each group. The chart reveals that a significant portion of original comments (11,240) receive only one reply, followed by 8748 comments that receive between two to five replies. The number of comments significantly decreases as the number of replies increases, with only 1553 comments receiving between six to ten replies, 553 comments receiving between eleven to twenty replies, and just 173 comments receiving more than twenty-one replies. This distribution highlights the pattern of engagement with original comments, showing that while most comments receive some level of interaction, only a few become the centre of more extensive conversations.

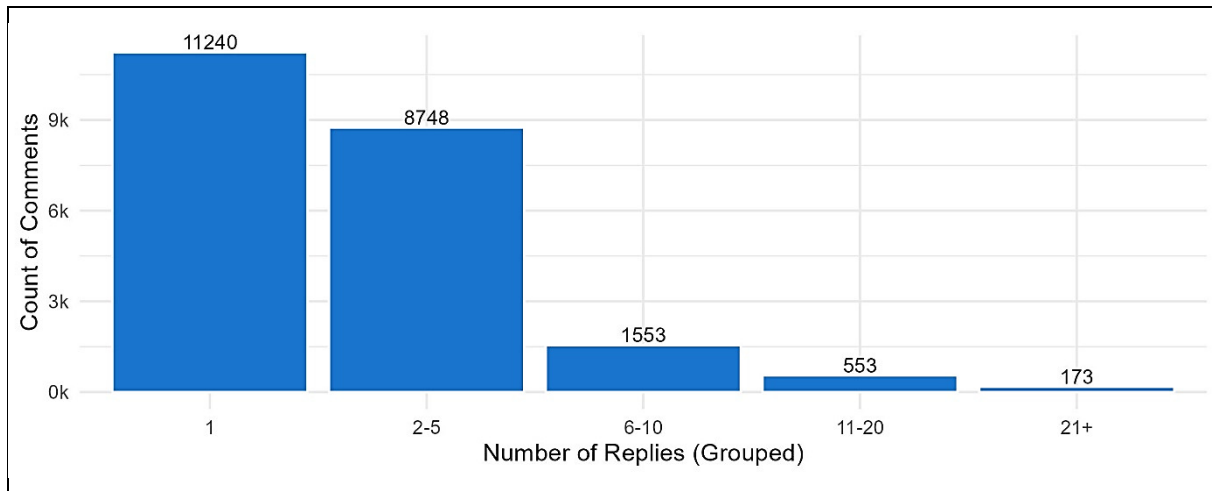


Figure 7. Distribution of Original Comments by Number of Replies (data as of May 24, 2024).

Sources: original research.

Figure 8 illustrates the distribution of the number of comments per video by year, using a boxplot to display the spread of data. The y-axis represents the number of comments and employs a square root scale to better visualize the distribution, especially given the presence of outliers. Each boxplot shows the interquartile range of comments, highlighting the median and spread of data within each year. The use of a square root scale on the y-axis helps to compress the range of data, allowing for clearer observation of the central tendency and spread of comments, particularly in years with high variability. This chart indicates that while most videos have a relatively low number of comments, a few videos each year receive a significantly higher number, demonstrating substantial engagement on select content.

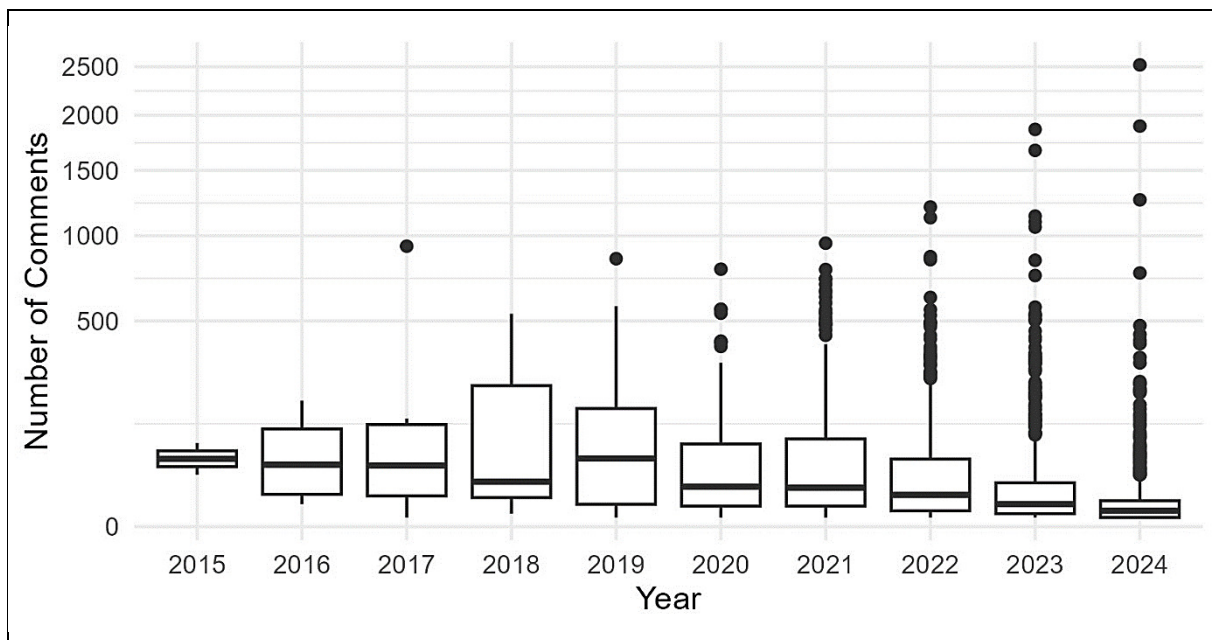


Figure 8. Comments per Video by Year (Data as of May 24, 2024).

Sources: original research.

Figure 9 presents three scatter plots illustrating the relationships between video duration, views, and comments. To better visualise the data, a square root scale has been applied to both the x and y axes. The top left plot shows the relationship between video duration and the number of comments, indicating that longer videos tend to receive more comments, which might suggest that longer content generates higher viewer engagement. The top right plot depicts the relationship between the number of views and the number of comments, showing that videos with a higher number of views generally have more comments. The bottom left plot illustrates the relationship between video duration and the number of views, where no strong correlation is evident, suggesting a weak or negligible relationship between the length of a video and its view count. The points on the scatter plots are colour-coded according to the year of video publication, allowing for an analysis of trends and changes over time. These colours highlight potential differences in user behaviour across different periods.

Table 1 provides a summary of the regression model results based on a dataset containing 990 videos and 125,680 comments. The table includes information on whether each model is statistically significant and the proportion of variance explained by each model.

- Model No. 1: This model investigates the relationship between the number of comments and the duration of the video. The model is statistically significant, with a p-value of $2.91e-08$. It explains approximately 3.07% of the variance in the number of comments, as indicated by an R^2 value of 0.0307. This suggests that while the model is significant, video duration only accounts for a small portion of the variability in comment counts.
- Model No. 2: This model examines the relationship between the number of comments and the number of views. The model is highly statistically significant, with a p-value of $1.18e-55$. It explains about 22.13% of the variance in the number of comments, as indicated by an R^2 value of 0.2213. This indicates a moderate level of explanatory power for the number of comments based on the number of views.
- Model No. 3: This model explores the relationship between the number of views and the duration of the video. The model is not statistically significant, as reflected by a p-value of 0.365. It explains only 0.08% of the variance in the number of views, as indicated by an R^2 value of 0.0008, demonstrating that video duration has almost no explanatory power for predicting view counts.

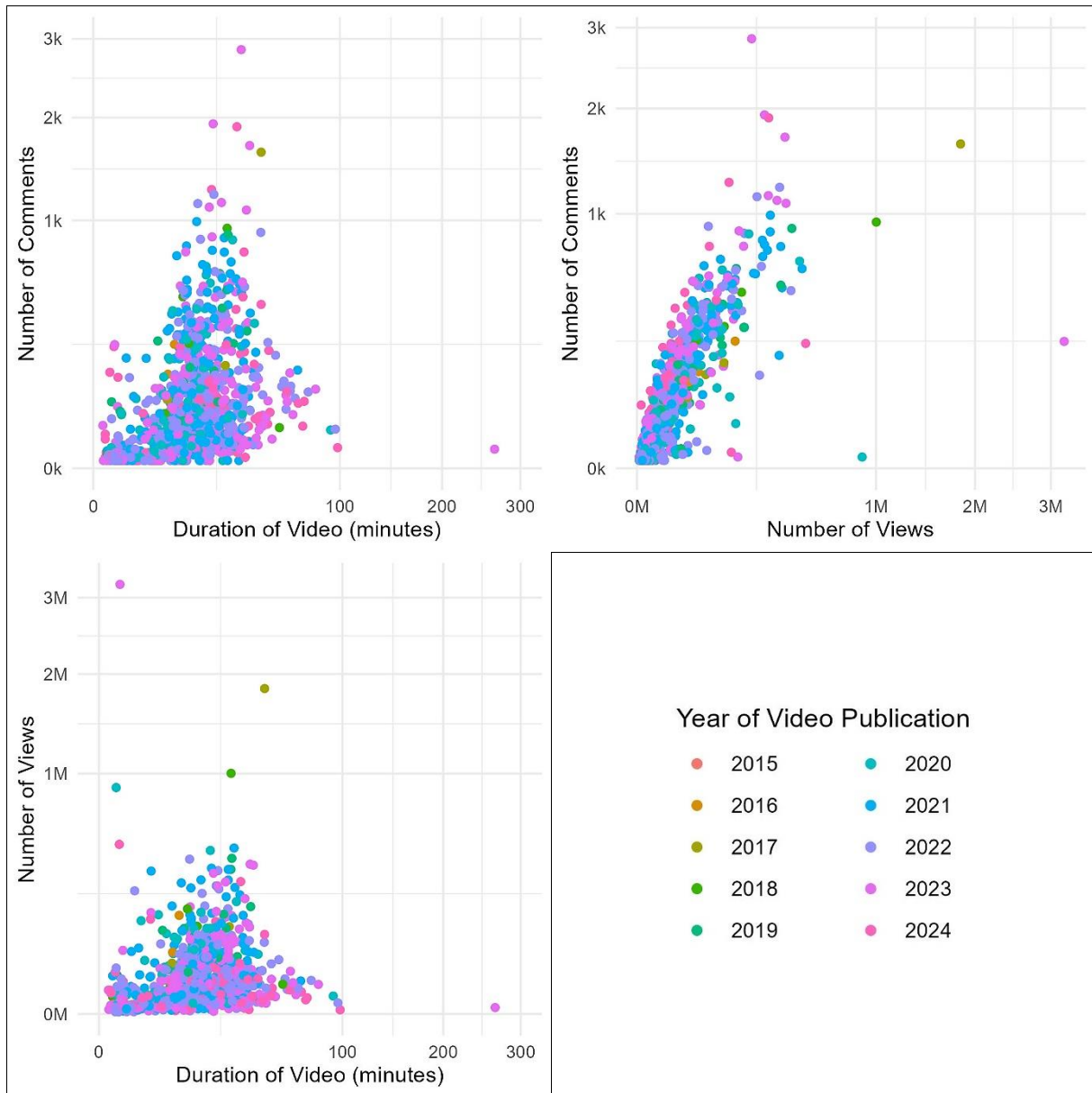


Figure 9. Relationships Between Video Duration, Views, and Comments (Data as of May 24, 2024).

Table 1. Summary of Regression Model Results

	Model		
	No. 1: Number of Comments ~ Duration of Video	No. 2: Number of Comments ~ Number of Views	No. 3: Number of Views ~ Duration of Video
Intercept	78,51	94,46	37384,43
Slope	2,5622	0,0008	257,9255
Residual SE	222,94	199,82	138476,36
R squared	0,0307	0,2213	0,0008
p-value	2,91e-08	1,18e-55	3,65e-01
Comments	Low R squared, moderate positive relationship between video duration and comments, statistically significant	Moderate R squared, strong positive relationship between views and comments, highly significant	Very low R squared, no statistically significant relationship between video duration and views

5. Conclusion

This study investigated the activity of content creators and viewers on YouTube, focusing on Polish-language videos related to electric vehicles (EVs). The analysis spanned multiple aspects of user engagement, including video publication trends, comment activity, and the relationship between video characteristics and user interaction.

Several key findings emerged from the analysis:

- **Increasing Engagement Over Time:** The data revealed a clear upward trend in both the number of videos published and the level of user interaction (measured through comments and views) over the years. Particularly, the years 2021, 2022, and 2023 showed a significant increase in engagement, as reflected by the growing number of comments and views. However, early data from 2024 suggests a decline in activity.
- **Dominance of Active Users:** The distribution of videos published across quantile groups showed that a small portion of highly active creators (quantile 4) were responsible for the majority of the content. This trend was most evident in recent years, where the top 25% of users contributed more than 50% of the published videos, indicating that a concentrated group of creators is driving most of the content production.
- **High User Interaction:** The comment analysis demonstrated that a significant portion of user engagement comes from responses to other comments rather than original comments. This trend, particularly evident in recent years, highlights a high level of interaction and discussion among viewers, pointing to the creation of a more engaged community around EV content. Replies accounted for 48% of the total comments, indicating a vibrant environment where users not only react to the videos but also actively engage in discussions.
- **Relationships Between Video Characteristics and Engagement:** Regression models were used to assess the relationships between video duration, views, and comments. The analysis found statistically significant but relatively weak relationships between video length and comment count, as well as between video views and comments. This suggests that while longer videos and those with higher view counts tend to attract more comments, these factors only explain a small portion of the variability in user engagement. The relationship between video length and views, however, was found to be statistically insignificant, indicating that video duration does not have a significant impact on the number of views.

The findings confirm that while video duration and the number of views are weak predictors of comment activity, they do show that viewer engagement has increased over time. The large proportion of replies to original comments points to a dynamic community, indicating that discussions about electric vehicles are growing in depth and interaction.

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UNCOVERING TOPICS IN YOUTUBE COMMENTS ON ELECTRIC VEHICLES USING LATENT DIRICHLET ALLOCATION

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Purpose: The purpose of this study is to analyse YouTube comments related to electric vehicles (EVs) to uncover the underlying topics discussed by users. By applying Latent Dirichlet Allocation (LDA), the study aims to gain a deeper understanding of public opinion and the key themes driving conversations about EVs online.

Design/methodology/approach: This research utilized the “scrapetube” package to gather YouTube video links related to EVs. Comments were then downloaded using the “youtube-comment-downloader” package. After preprocessing the comments, including removing duplicates and irrelevant content, Latent Dirichlet Allocation (LDA) was applied to identify and analyze the topics discussed in these comments. The analysis focused on comments in Polish to ensure contextual accuracy and relevance.

Findings: The study identified a diverse range of topics, including technical aspects, consumer concerns, environmental impacts, market dynamics, and charging infrastructure. These topics provide insights into the public's perception towards EVs.

Research limitations/implications: The analysis was confined to comments in Polish, which may not capture the full spectrum of global perspectives. Future research could expand the scope to include comments in other languages and from different platforms to provide a more holistic view. Additionally, while LDA effectively identified key topics, some nuances may be lost in the process of topic modeling. Further qualitative analysis could complement the findings.

Practical implications: The insights gained from this study can help shape policies that address consumer concerns about EV affordability and infrastructure. Manufacturers can focus on areas that need improvement, such as enhancing battery capacity and increasing the efficiency and range of EVs. Marketing strategies can be refined to highlight the benefits of EVs in everyday use.

Originality/value: This study demonstrates the utility of LDA in uncovering the underlying topics in YouTube comments about electric vehicles. It provides a comprehensive overview of consumer interests and concerns, highlighting areas that require attention from policymakers, manufacturers, and researchers. The methodology used in this study can serve as a blueprint for further research into public opinion on other emerging technologies.

Keywords: Electric Vehicles (EVs), Latent Dirichlet Allocation (LDA), Topic Modeling, YouTube Comments.

Category of the paper: research paper.

1. Introduction

The European Union has implemented a variety of initiatives aimed at fostering the adoption of electric vehicles (EVs). These initiatives include providing financial incentives, developing infrastructure, and crafting strategic plans designed to encourage consumers to transition to EVs (Hawkins et al., 2013; Pasaoglu et al., 2012; Sierzchula et al., 2014). Studies indicate that the widespread adoption of EVs is challenging to accomplish without government subsidies. Rahmani & Loureiro highlight the necessity of such financial support (Rahmani, Loureiro, 2018). Additionally, incentives are critical during the initial phase of introducing new innovations, as evidenced by the work of (Davies et al., 2016; Figenbaum et al., 2015; Trip et al., 2012).

EVs have the potential to significantly lower greenhouse gas (GHG) emissions and enhance urban air quality. This improvement in air quality directly benefits public health, as EVs produce only natural by-products instead of harmful exhaust fumes. By reducing pollutants such as nitrogen oxides and particulate matter, EVs contribute to cleaner, healthier environments in cities (Hannan et al., 2014; Ma et al., 2012; Van Mierlo et al., 2006). However, from the perspective of potential buyers, environmental benefits may hold less significance, as society inherently tends to be driven by individual and hedonistic motivations (Buenstorf, Cordes, 2008). As a result, purchasing decisions are often based more on personal benefits and convenience rather than environmental impact.

EVs are becoming a significant part of the automotive industry, with projections indicating they will make up over 30% of the light-duty vehicle market in the United States by 2030 (Wolinetz, Axsen, 2017). Given this growth, understanding public perception and sentiment towards EVs is crucial for both policymakers and manufacturers. YouTube as a social media platform is one of the main places where users share their opinions and experiences about various products, including electric vehicles. Its global reach and diversity of content make it a valuable source of data for analysing public opinion (Aydın, Yılmaz, 2021; Muhammad et al., 2019; Radescu, Muraru, 2019).

The field of NLP-based research on electric vehicles (EVs) is relatively new, but there have been efforts to leverage topic analysis, topic modeling, and sentiment analysis for classifying user reviews. For instance, Ha et al. conducted an analysis focusing on user experiences with electric vehicles, employing language transformer models and supervised topic classification. Their research primarily concentrated on consumer reviews of EV charging stations, aiming to extract insights into user sentiments and recurring themes within these reviews (Ha et al., 2021). Jiang et al. provided a broader comparison between consumer and media sentiment towards electric vehicles, aiming to identify differences and similarities in perceptions and discussions surrounding EV technology (Jiang, Everts, 2021). Asensio et al. utilized a CNN classifier based

on the word2vec model to classify sentiment. Their research revealed that positive and negative sentiments in user reviews are distributed roughly equally (Asensio et al., 2008).

Suresha and Tawari using topic modeling and Valence Aware Dictionary tools to analyse 45,000 tweets, discovered that “Tesla” was one of the most frequently used hashtags associated with EVs (Suresha, Tiwari, 2021). Bhatnagar and Choubey conducted a sentiment analysis of tweets using TF-IDF scores and a Naive Bayes classifier, finding that the hashtag “Tesla” exhibited a more positive sentiment compared to other manufacturers (Bhatnagar, Choubey, 2021). Carpenter used data collected from user discussion forums related to EVs to identify key sentiments and topics of interest, finding that “range anxiety” and “price” were two of the most common barriers to EV adoption (Carpenter, 2015).

This article analyses YouTube comments on EV videos using Latent Dirichlet Allocation (LDA) to uncover the underlying topics discussed by users. By examining these comments, the goal is to gain a deeper understanding of public opinion and the key themes that drive conversations about EVs online. This paper is organized as follows: section 2 describes the research methodology, section 3 presents the results, followed by a discussion in section 4, and the conclusion in section 5.

2. Research methodology

Using the “scrapetube” package (Twersky, n.d.), a list of 37,317 YouTube video links related to electric vehicles (EVs) was obtained. To conduct video searches, the author employed 74 phrases associated with EVs. The phrases included the brand name and the model name of the car. These phrases were established based on information obtained from one of the online platforms dedicated to EVs (<https://motorvolt.pl/>). Subsequently, videos that did not contain the search phrase in the title and were not created by a “Polish” channel were excluded. This process yielded a list of 1152 videos.

In the next step, comments posted by users under each of these 1152 videos were downloaded on May 24, 2024, using the “youtube-comment-downloader” package. This package provides a straightforward script for downloading YouTube comments without the need to utilise the YouTube API (*Youtube-Comment-Downloader*, n.d.). A total of 128,851 comments were downloaded.

The next phase involved removing:

- comments written in languages other than Polish,
- comments that were identical to others posted by the same user (often advertising services, products, or job opportunities from a company); the content was treated as a character string and compared using the “==” operator,
- comments of zero length.

The content of the comments was then pre-processed. This process followed standard steps for text mining (Gładysz, 2012; Turban Efraim et al., 2014). Uppercase letters were replaced with lowercase letters. URLs, hashtags, emojis, user names, words not considered useful (such as stop words, conjunctions, or prepositions), and all characters except letters were removed from the content. The word count of each cleaned comment was then verified, and comments containing fewer than one word were excluded. After this process, it was found that some videos had no comments or the comments became empty after cleaning. Ultimately, 125,680 comments remained. These comments were associated with one of 992 videos.

The next step was to reduce words to their base forms (e.g., verbs to infinitives, nouns to nominative forms, etc.). This is particularly important for the Polish language, which is characterized by extensive inflection. For this purpose, the services developed by CLARIN-PL were used (Branco et al., 2023; Fišer et al., 2018; Fišer, Witt, 2022; Janz et al., n.d.). The processing pipeline included the following services:

- Any2txt: It converts text files (e.g., doc, docx, xlsx) into plain text.
- Speller2: It checks the spelling of the text, utilizing a tool known as Autocorrect (<https://languagetool.org/pl/>) for this purpose.
- Wcrft2: A basic morpho-syntactic tagger for the Polish language.
- WSD: A service designed for word sense disambiguation, specifically tailored for Polish texts. It employs plWordNet as a source of potential meanings, which organizes lexical units into synsets connected through lexico-semantic relationships. Each lexical unit encapsulates a lexical meaning and is defined by three elements: a lemma, a part of speech, and a sense identifier (Janz et al., 2017).

In the final part of the analysis, Latent Dirichlet Allocation (LDA) was employed. LDA is described as a generative probabilistic model for collections of discrete data, such as text corpora (Blei et al., 2003). It is a widely used algorithm for Topic Modeling. More on topic modeling can be found in (Abd-Alrazaq et al., 2020; Garcia, Berton, 2021; Mottaghinia et al., 2020). This algorithm assumes that each document is represented by a mixture of topics, and each topic is represented by a mixture of words. The authors used the 'topicmodels' package for R (Hornik, Grün, 2011) to generate abstract, hidden topics describing comments related EVs. The probability of each word corresponding to topic was estimated using the Gibbs Sampling method (Anupriya, Karpagavalli, 2015).

One of the challenges when using the LDA algorithm is the need to choose the number of topics (k) before running the algorithm. There are several metrics for estimating k for a series of fitted LDA models. All of these methods require fitting the LDA model multiple times to the same dataset with various candidate values of k . Four metrics were used to determine k :

- Arun2010: This metric measures the divergence between the distribution of topics in documents and the distribution of words in topics. A lower value of this metric indicates a more optimal model with a better fit (Arun et al., 2010).

- CaoJuan2009: This metric calculates the density of word co-occurrences within topics. Lower values of this metric indicate higher quality and more distinct topics (Cao et al., 2009).
- Deveaud2014: This metric is based on the normalized pointwise mutual information (NPMI) of word pairs within topics. Higher values suggest more coherent topics that are easier to interpret (Deveaud et al., 2014).
- Griffiths2004: This metric evaluates the likelihood of the data under the model, with higher values indicating that the model better explains the observed data (Griffiths, Steyvers, 2004; Ponweiser, 2012).

3. Results

To determine the optimal number of topics for the Latent Dirichlet Allocation (LDA) models, the extrema were analyzed: maximum values in the case of Deveaud2014 and Griffiths2004, and minimum values in the case of Arun2010 and CaoJuan2009. From Figure 1, it can be observed that the optimal number of topics according to the applied metrics is 22 (Deveaud, 2014), 98 (Griffiths, 2004), 100 (Arun, 2010), and 90 (CaoJuan, 2009). Therefore, it can be assumed that the optimal number of k lies within the range of 22 to 100.

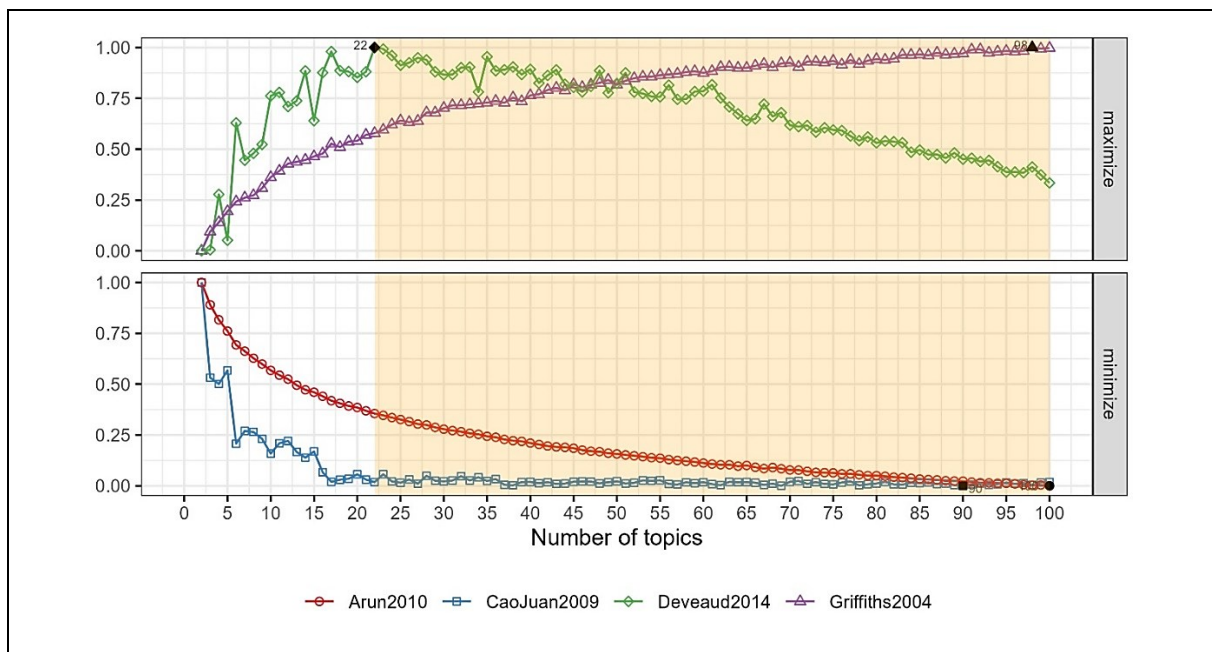


Figure 1. Metrics of LDA model quality for different numbers of topics.

Sources: original research.

Based on these values, LDA models were trained with the number of topics (k) set sequentially from 22 to 100. In the following step, the author conducted a manual evaluation of each generated model. The evaluation involved attempting to interpret the generated topics.

The identified topics were presented as word clouds. Each cloud contained the 15 most probable words assigned to the topic. Each cloud was generated with the same settings, and their images were not cropped. The larger the word, the higher the probability of the word occurring in the given topic. If the author was unable to interpret a given topic and assign a label (e.g., "Car model comparison"), the model was rejected. The model with the number of topics set to 22 was positively evaluated. Only in this case was the author able to interpret all identified topics and assign a single label to each topic, allowing for clear interpretation and presentation of the results.

 <p>Car model comparison</p>	 <p>Car quality</p>	 <p>Trim levels</p>
 <p>Car appearance</p>	 <p>EV as a daily driver</p>	 <p>Powertrain specifications</p>
 <p>Fuel types</p>	 <p>Car usability</p>	 <p>Car maintenance</p>
 <p>EV viability and future of internal combustion engine</p>	 <p>Eco and non-eco energy sources</p>	 <p>Energy consumption at high speed</p>

Figure 2. LDA topics displayed as word clouds with labels – part 1.

Source: original research.

The topics identified by LDA are presented as word clouds in Figures 2 and 3. The assigned labels for these topics, which were created by the author, are placed below the word clouds. The clouds consist of words with the highest probabilities, representing the most significant terms for each topic according to the LDA model. These words are in their original form, i.e., in Polish, reduced to their base forms. It was decided not to translate them into English due to the fact that some words might have different meanings depending on the context.











 <p>EV purchase, cost, and subsidies</p>	 <p>Market in Poland and other regions</p>	 <p>New car purchase considerations</p>
 <p>Weather impact on EV range</p>	 <p>General EV charging</p>	 <p>Home EV charging</p>
 <p>Battery capacity</p>	 <p>User competence</p>	 <p>Route report</p>
 <p>Thanks for cool and interesting tests</p>		

Figure 3. LDA topics displayed as word clouds with labels – part 2.

Source: original research.

The labels of the identified topics, along with short descriptions and interpretations are as follows:

- Car model comparison:
 - Description: Discussions comparing different car models.
 - Interpretation: Users frequently compare different electric car models to evaluate their advantages and disadvantages. Such comparisons help potential buyers make informed purchasing decisions.
- Car quality:
 - Description: Conversations about the build and quality of cars, especially premium brands.
 - Interpretation: The quality of build, especially for premium brands, is a significant topic of discussion. Users pay attention to the materials used in production and the overall durability of the vehicles.
- Trim levels:
 - Description: Dialogues about different equipment versions and specifications.
 - Interpretation: Equipment versions and technical specifications are often discussed, indicating that buyers are attentive to the various options available in each model.
- Car appearance:
 - Description: Opinions on the design and aesthetic appeal of cars.
 - Interpretation: The appearance of cars, including their design and aesthetics, is an important factor for consumers. Discussions on this topic can influence brand perception and attractiveness.
- EV as a daily driver:
 - Description: Considerations about using EVs for everyday commuting.
 - Interpretation: Users analyze whether electric vehicles are practical for everyday use, including range, charging convenience, and overall functionality in daily life.
- Powertrain specifications:
 - Description: Technical details about engines, gearboxes, and drivetrains.
 - Interpretation: Technical specifications of powertrains, including engines and gearboxes, are crucial for understanding the performance and reliability of vehicles.
- Fuel types:
 - Description: Discussions on various fuel types including LPG, gasoline, diesel, electric, and hybrid.
 - Interpretation: Consumers compare different fuel types, analyzing the benefits and drawbacks of each, which can influence their decisions about transitioning to electric vehicles.

- Car usability:
 - Description: Debates on the ease of use and practicality of cars.
 - Interpretation: The ease of use and practicality of cars are key topics that can affect user satisfaction and purchasing decisions.
- Car maintenance:
 - Description: Issues related to the maintenance and repair of cars.
 - Interpretation: Maintenance and repair issues are important for owners, affecting operating costs and overall vehicle satisfaction.
- EV viability and future of internal combustion engine:
 - Description: Debates on the practicality of EVs and the future of traditional internal combustion engines.
 - Interpretation: Discussions about the practicality of electric vehicles and the future of internal combustion engines reflect changing trends in the automotive industry and consumer expectations.
- Eco and non-eco energy sources:
 - Description: Comparisons between environmentally friendly and non-environmentally friendly energy sources.
 - Interpretation: Comparisons of environmentally friendly and non-environmentally friendly energy sources highlight the importance of sustainable development and the impact of energy choices on the environment.
- Energy consumption at high speed:
 - Description: Concerns about energy efficiency and consumption at high speeds.
 - Interpretation: The energy efficiency of vehicles at high speeds is a significant topic, influencing the range and performance of electric vehicles.
- EV purchase, cost, and subsidies:
 - Description: Discussions on the financial aspects of buying EVs, including costs and available subsidies.
 - Interpretation: Purchase costs and available subsidies are key factors affecting consumers' decisions to buy electric vehicles.
- Market in Poland and other regions:
 - Description: Insights into the EV market dynamics in Poland and other regions.
 - Interpretation: Analysis of the electric vehicle market in Poland and other regions helps understand the differences in technology adoption and the impact of local policies on the market.
- New car purchase considerations:
 - Description: Factors influencing the decision to buy a new car.
 - Interpretation: Factors influencing the decision to buy a new car include both financial and practical aspects, helping consumers make informed choices.

- Weather impact on EV range:
 - Description: The effect of weather conditions on the driving range of EVs.
 - Interpretation: The impact of weather conditions on the range of electric vehicles is a crucial issue that can affect practicality and user satisfaction. This is particularly significant in extreme weather conditions where energy consumption increases due to the need for heating in cold weather or cooling in hot weather. Such factors can significantly influence the driving range and overall efficiency of electric vehicles, making it a key concern for potential buyers and current users.
- General EV charging:
 - Description: General issues and experiences related to EV charging.
 - General issues related to electric vehicle charging, such as the availability of charging stations and charging time, are critical for EV users.
- Home EV charging:
 - Description: Specific discussions about the practicality and setup of home charging for EVs.
 - Charging electric vehicles at home is an important aspect, influencing convenience and operating costs. Homeowners have the advantage of access to their own power source, making it easier to charge their vehicles overnight. In contrast, individuals living in apartments or multi-unit dwellings may face challenges finding accessible and reliable charging stations, which can affect their ability to conveniently charge their vehicles.
- Battery capacity:
 - Description: Concerns and discussions about the battery capacity of EVs.
 - Interpretation: Battery capacity is a key factor affecting the range and performance of electric vehicles, which is frequently discussed by users.
- User competence:
 - Description: Competence and experience of users in discussing and handling EV-related topics.
 - Interpretation: The competence and experience of users in discussing and handling electric vehicle-related topics can affect the quality and value of these discussions. Often, YouTube viewers accuse others of lacking competence on the subject, leading to unnecessary conflicts and disputes. This dynamic can detract from constructive conversations and diminish the overall value of the discourse.
- Route report:
 - Description: Reports from journeys undertaken using EVs.
 - Interpretation: Reports from specific journeys undertaken with electric vehicles provide practical information on the real-world use of EVs. They cover topics such as charging the vehicle on the road, the time needed for charging, and using chargers

from specific companies. These firsthand accounts offer valuable insights into the challenges and benefits of using EVs for long-distance travel, enhancing the overall understanding of the practicality and convenience of electric vehicles.

- Thanks for cool and interesting tests:
 - Description: Appreciation for informative and engaging test videos on EVs.
 - Interpretation: Appreciation for interesting and valuable vehicle tests shows the important role of content creators in educating and informing consumers.

Each of these topics reflects different aspects of consumer interest and concern, providing a comprehensive overview of the public discourse on electric vehicles. By examining these discussions, we can better understand the key issues that matter to consumers, from technical specifications and practical usability to environmental impact and economic considerations.

4. Discussion

The analysis of YouTube comments on electric vehicles (EVs) using Latent Dirichlet Allocation (LDA) has yielded significant insights into the public discourse surrounding EVs. This study identified a range of topics discussed by users, offering a comprehensive overview of consumer interests and concerns. These findings can inform policymakers, manufacturers, and researchers about the key themes that drive conversations about EVs online.

Key findings are as follows:

- Diverse range of topics: The identified topics cover a broad spectrum, including technical aspects, consumer concerns, environmental impacts, market dynamics, and charging infrastructure. This diversity reflects the multifaceted nature of public discussions on EVs. Previous studies have also highlighted the wide range of consumer interests in EVs, such as user experiences and technical specifications (Ha et al., 2021; Jiang, Everts, 2021).
- Consumer concerns: The analysis revealed common concerns among consumers, such as the viability of EVs, the future of internal combustion engines, and financial aspects related to purchasing EVs. These findings are consistent with other research showing that range anxiety and cost are significant barriers to EV adoption (Bhatnagar, Choubey, 2021; Carpenter, 2015).
- Environmental impact: The prominence of topics related to eco and non-eco energy sources indicates significant interest in the environmental implications of different energy types. This highlights the importance of sustainability in consumer decision-making, aligning with research that emphasizes the environmental benefits of EVs (Hannan et al., 2014; Ma et al., 2012; Van Mierlo et al., 2006).

- **Market dynamics:** Discussions about the EV market in Poland and other regions, as well as considerations for purchasing new cars, point to the economic and regional factors influencing EV adoption. Studies have shown that regional policies and market conditions significantly impact EV adoption rates (Sierzchula et al., 2014; Wolinetz, Axsen, 2017).
- **Charging Infrastructure:** The focus on EV charging, both general and home-specific, suggests that charging infrastructure remains a critical area of concern for potential EV buyers. This finding is supported by research indicating that the availability and convenience of charging stations are crucial for EV adoption (Ha et al., 2021; Suresha, Tiwari, 2021).

It should be noted that the topics identified by LDA did not solely pertain to electric vehicles but also encompassed other aspects of YouTube activity and the broader automotive industry. For example, some comments referred to the activities of content creators on YouTube, expressing gratitude for interesting and valuable vehicle tests (label: Thanks for cool and interesting tests). Other topics included discussions about various energy sources, ranging from fossil fuels to renewable energy sources. Additionally, there were conversations comparing different car models and deliberating the pros and cons of traditional combustion engines versus electric engines. These findings highlight the broader context in which discussions about EVs occur, reflecting a wide range of interests and concerns among users.

5. Conclusion

The study demonstrates the utility of LDA in uncovering the underlying topics in YouTube comments about electric vehicles. The identified topics offer a snapshot of consumer interests and concerns, highlighting areas that require attention from policymakers, manufacturers, and researchers. Addressing these concerns can contribute to broader adoption and acceptance of electric vehicles, ultimately supporting the transition to a more sustainable transportation system.

By leveraging the insights gained from this analysis, stakeholders can make informed decisions that better align with public sentiment and address the practical challenges associated with EV adoption. This approach not only enhances the understanding of consumer perspectives but also fosters a more consumer-centric development of EV technologies and policies.

The findings underscore the importance of addressing issues such as EV viability, cost, and charging infrastructure. Policymakers can utilize this information to design targeted incentives and infrastructure projects that more effectively address these consumer concerns. Manufacturers can focus on enhancing battery capacity, efficiency, and range to better meet consumer expectations and improve the overall appeal of EVs.

Future research should consider expanding the linguistic scope to include comments in other languages and from various platforms to provide a more comprehensive view of global perspectives on EVs. Additionally, further qualitative analysis could complement the quantitative findings, capturing nuances that may be lost in the process of topic modeling.

In summary, this research highlights the effectiveness of LDA in analysing large datasets of user-generated content to uncover key topics in discussions about EVs. The insights gained can inform future policies, manufacturing strategies, and research directions, contributing to the broader discourse on sustainable transportation and helping to accelerate the adoption of electric vehicles.

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