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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 39 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: the climate change, logistics, labor market, finances, knowledge management, energy transition, consumer expectations, the impact of COVID-19 pandemic on management, agile organization, risk management, strategic management, innovation management, project management, services management, economics, logistics, sustainable development, the impact of AI on management, sport management, organizational culture, Industry 5.0 and human resource management.

Radosław Wolniak

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ADAPTING TO CLIMATE CHANGE – LOCAL CHALLENGES AND CONSTRAINTS

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Purpose: The research presented in this article was carried out in order to identify the potentials, challenges and limitations of the local government units (JST) included in the Szczecin Metropolitan Area Association (SSOM) in the area of climate change adaptation
Design/methodology/approach: The realization of the objective of the study was possible thanks to the use of the method of analysis of literature, legal acts and documents of the European Union, as well as information from representatives of JST obtained by the method of in-depth interviews.
Findings: The survey found that the constraints to climate change adaptation processes are the financial limitations of JST, legal and procedural difficulties, as well as the reluctance of local communities, the low level of environmental awareness of residents and insufficient digital competence. High availability of funds for adaptation activities, growing interest of residents in environmental topics, and above all strong EU support were identified as opportunities.
Research limitations/implications: The most significant limitation of the conducted research was the limited time for conducting the interviews, due to the fact that the interviews were conducted during the work of the officials.
Practical implications: The research presented here can be used by representatives of JST to assess their climate change adaptation activities and to raise awareness of the opportunities and risks associated with this process. The results of the survey can provide a voice in the discussion on the creation of good practices in JST cooperation on adaptation concepts.
Social implications: The results of the study provide an overview of JST's climate change adaptation efforts.
Originality/value: This study is an independent analysis of JST's activities in the field of climate change adaptation. The conducted study fills the research gap and complements the body of work on the analyzed topic mainly through the applied research method, thanks to which information was obtained from representatives of JSTs affiliated with SSOM, which can

provide a basis for developing good practices at the local level related to the studied phenomenon.
Keywords: climate change, adaptation, local government units (JST).
Category of the paper: Research paper.

Introduction

As climate change continues, adaptation to new environmental conditions is becoming one of the key challenges for public policy at the local and regional levels. The European Green Deal (European Commission, 2019a) and related initiatives, such as the European Climate Law (European Commission, 2020a), the Fit for 55 Package (European Commission, 2021) and the Biodiversity Strategy 2030 (European Commission, 2020b), set ambitious targets for EU member states. Support in this regard is also provided by the European Funds for Western Pomerania for 2021-2027.

The article hypothesizes that local government units that are members of metropolitan structures show a higher level of adaptation readiness than units that function independently. The purpose of this article was to identify the potentials, challenges and constraints of the local government units (JSTs) included in the Szczecin Metropolitan Area Association (SSOM) in the area of climate change adaptation. The research was conducted using the in-depth interview method, taking into account a broad spectrum of political, economic, social, technological, environmental and legal factors affecting the implementation of adaptation projects.

Literature review

The European Climate Law (European Commission, 2020a) was adopted in 2021 as a key piece of legislation in achieving the goals of the European Green Deal (European Commission, 2019a). It introduces a legally binding goal of achieving climate neutrality in the European Union by 2050 and an intermediate target of reducing greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. The law requires member states to develop national action plans and to periodically monitor their progress toward meeting climate targets (European Commission, 2020a).

In order to implement these ambitious goals, the “Fit for 55” Package was developed, which includes a set of legislative acts that align the EU's climate and energy policy with the new targets. The package includes, among other things, reform of the emissions trading system (EU ETS), new emission standards for the transport sector, support for the development of

renewable energy sources and measures to improve energy efficiency (European Commission, 2021). It forms the foundation of the EU's energy and economic transition.

Also integral to the European Green Deal is the EU's Biodiversity Strategy 2030, which calls for restoring degraded ecosystems, expanding the network of protected areas and reducing pressure on the environment. The strategy emphasizes that biodiversity protection is integral to successful climate change adaptation and improved quality of life (European Commission, 2020b).

The transformation of the economy toward low-carbon is also indicated in the New European Industrial Strategy, which promotes the decarbonization of industry and accelerates the transition to a closed-loop economy (European Commission, 2020c). Supporting these goals, the Closed Economy Roadmap (European Commission, 2020d) focuses on efficient use of resources, minimizing waste and promoting recycling as a basis for sustainable development.

To ensure social equity in the transition process, the Just Transition Mechanism was introduced to support regions and sectors most affected by the economic changes resulting from decarbonization. The mechanism offers investment funds and financial instruments to create new jobs and retrain workers (European Commission, 2020e).

At the same time, a key element of the EU's energy transition is ensuring access to clean, affordable and secure energy. The 2019 Clean Energy for All Europeans strategy emphasizes the importance of developing renewable energy sources, modernizing energy grids and improving energy efficiency as a basis for achieving climate neutrality (European Commission, 2019b).

In support of these efforts, the European Commission has launched the Renovation Wave, aimed at increasing the number of building renovations in Europe. The initiative aims to improve the energy efficiency of buildings, which will reduce emissions, reduce energy costs for citizens and create new jobs in the construction sector (European Commission, 2020f).

In Poland, activities under the new financial perspective 2021-2027 have been aligned with the goals of the European Green Deal. European funds for Western Pomerania have been allocated to, among other things:

- energy transition,
- investments in green infrastructure,
- environmental protection and climate change adaptation,
- supporting the equitable transformation of regions (Urząd Marszałkowski Województwa Zachodniopomorskiego, 2022).

Regional strategies are closely linked to the environmental and economic transformation goals set at the EU level, particularly under the Fair Transformation Fund.

Climate change adaptation is the process of adjusting natural or human systems to actual or projected climate change in order to reduce damage or take advantage of beneficial opportunities (IPCC, 2014). The UNFCCC (2011) defines adaptation as initiatives and measures to reduce exposure and increase resilience to the impacts of climate change.

In the literature, adaptation is also understood in a broader context as a person's ability to transmit information non-genetically, enabling him to adapt to changing environmental conditions (Strzałko, Ostoja-Zagórski, 1995; Kozłowski, 1986). Smit and Wandel (2006) indicate that adaptation is a process, action or outcome that increases the preparedness of a system (e.g., a household) for new conditions. Adger et al. (2005), on the other hand, emphasize that adaptation includes both building adaptive capacity and implementing specific activities. According to Albin (2023), climate change adaptation activities have not been singled out as a separate and independent public task. However, climate change adaptation includes a set of conscious and purposeful activities that are closely related to the implementation of the municipality's tasks as a basic unit of local government. In doing so, it is important to determine the specific forms of public administration activity in the analyzed area and the most effective way to carry out this task, in accordance with the principle of subsidiarity. Dumieński, Lisowska, Tiukało (2019) assessed the adaptive capacity of Polish flood-prone municipalities, treating them as social-ecological systems. They identified four key categories influencing adaptation: human and social capital, financial potential, ecological potential and organizational potential, distinguishing a total of 15 characteristics describing the current adaptive capacity of municipalities. Cities are particularly intensely affected by climate change due to their population density, infrastructure accumulation and social problems (Siekierska-Rosiak, 2016). Cities face such threats as urban heat island, air pollution, hurricanes, and floods (Wietewska-Rosiak, 2017).

Adaptation at the local level should include spatial planning, integrated development approaches and climate policies in urban development strategies (Carter et al., 2015; Urwin, Jordan, 2008). Legutko-Kobus (2017) points out that local adaptation policies should serve not only to protect the environment, but also to ensure a high quality of life for residents, with full awareness of the risks and uncertainties associated with future changes. The anthropocentric development model based on technocratism and the free market is criticized (Legutko-Kobus et al., 2020). The need to change to a more biocentric approach, in which environmental protection is a value in itself, is pointed out (Piątek, 2008).

Sustainable development should combine economic rationality with social and environmental goals, which can improve the quality of life of the population. International organizations such as the IPCC, UNEP and UNFCCC have played a key role in shaping global adaptation policies.

- The IPCC (2014) defines adaptation as the process of reducing vulnerability to the effects of climate change by adapting natural and social systems.
- UNEP (2009) promotes the development of national adaptation programs and climate education, emphasizing the importance of technology transfer and resilience building.
- The UNFCCC (2011) supports adaptation efforts at the global level, requiring countries to prepare strategies that reduce climate risks and increase the resilience of societies.

The European Union has developed its own adaptation framework: 2009 White Paper. (European Commission, 2009) introduced the European Framework for Action on Adaptation, pointing out the need to integrate adaptation actions with sectoral policies and emphasizing the role of cooperation among member states. The EU Adaptation Strategy, which in Poland is promoted by the Strategic Adaptation Plan for Sectors and Areas Vulnerable to Climate Change to 2020 with an Outlook to 2030, the so-called SPA2020 (Ministerstwo Środowiska, 2013), develops these assumptions, promoting, among other things, increased public awareness of adaptation, integration of adaptation into infrastructure investments, and support for the regions most vulnerable to climate change. It aims to improve the resilience of member states to current and expected climate change, paying particular attention to better preparing for extreme climate and weather events and reducing the socioeconomic costs associated with them.

Methodology

The article uses a qualitative research technique, i.e. an in-depth interview consisting of conducting intensive individual interviews with representatives of local government units included in the SSOM, namely: Kobylanka Municipality, Stare Czarnowo Municipality, Police Municipality, Dobra Szczecin Municipality, Goleniow Municipality, Kolbaskowo Municipality, Gryfino Municipality, City of Szczecin, City of Stargard, Stargard Municipality, Nowe Warpno Municipality, Police District, Stepnica Municipality, City of Świnoujscie. The respondents were mostly coordinators of cooperation of a given JST within the SSOM, specialists for many years involved in obtaining funds from the European Union Funds. During the interview, the respondents consulted on an ongoing basis on issues related to the area of adaptation to climate change with their colleagues, superiors (mayor, president) and, if necessary, with representatives of municipal organizational entities or subordinate JSTs that are responsible for policies on environmental protection, water management, energy supply and adaptation to climate change. The respondents were deliberately recruited on the basis of their involvement in activities within the Szczecin Metropolitan Area (SSOM). They were representatives of local self-government units, mainly people who acted as coordinators of cooperation of a given territorial unit within the SSOM, as well as specialists who dealt with obtaining funds from the European Union on a daily basis. The contact with the interviewees was made directly through the official communication channels of the municipality and with the support of the Association. A total of 14 individual in-depth interviews were conducted in the first half of 2024. The interviews were conducted remotely (online or by telephone), which allowed for efficient data collection despite time and geographical constraints. Each interview lasted between 45 and 90 minutes, depending on the engagement of the interviewee and the complexity of the issues raised.

The survey was conducted in accordance with ethical standards. Participants were informed of the purpose of the study, how the data would be processed and their rights, including the ability to withdraw at any stage of the study. All interviews were anonymous - no identifying information about respondents will be published. Verbal consent to participate in the study was also obtained.

The study used an individual in-depth interview technique. A proprietary interview script with open and semi-open questions was used. The scenario was divided into thematic blocks, including the following issues: general experiences of TSU in adapting to climate change, sources of funding used (with particular emphasis on EU funds), inter-municipal cooperation and the role of SSOM, institutional and technical barriers and needs, future prospects in the context of climate change. The interviews were conducted in a flexible manner - the interviewees were able to consult with other SSOM staff, which made it possible to obtain in-depth information. The data collected was analysed using the method of thematic analysis. The analysis process involved open coding the content of the interviews, identifying recurring categories and patterns and grouping them into overarching themes. The analysis was done manually. Conclusions were drawn on the basis of the identified themes.

The purpose of the survey was to identify the potentials, constraints, challenges and needs of JST representatives related to climate change adaptation. For this purpose, factors affecting the implementation of projects in the area of climate change adaptation were identified. The survey allowed the authors to formulate a list of key adaptation measures, the undertaking of which can contribute to long-term and comprehensive planning for the development of JST, taking into account all climate risks.

Results

Interviews conducted with representatives of local government units included in the SSOM made it possible to create a list of key political, economic, social, technological, environmental, legal factors affecting the implementation of projects in the area of climate change adaptation. The factors listed below were indicated by all respondents:

1. Political:
    - the war in Ukraine,
    - centralization of support procedures and processes,
    - lack of sustained government policy on climate change, including actions taken in parallel at different levels,
2. Economic:
    - increase in inflation,
    - budgetary constraints of local government units,

- large costs associated with the implementation of environmental investments, including the high cost of local governments' own participation and subsequent maintenance of investments,
- accumulation of public procurement in one period resulting from the launch of external funds, generating problems in finding service contractors,
- increase in prices of services or goods due to high demand in the market during a given period,

3. Social:
   - reluctance of local communities to selected environmental investments concerning, for example, waste treatment plants in their immediate vicinity,
   - low level, both of local community knowledge and awareness of climate change and the need for action to minimize the adverse effects of climate change,
   - lack of a sense of identity with the environment,
   - low level of confidence in the sharing economy, low propensity to use a common good/product,
4. Technological:
   - impediments in the form of low level of development of digital infrastructure in rural areas - problem with the provision of digital services to certain social groups, e.g. seniors, low-income individuals and families,
   - incompatibility between modern technological solutions - the need for additional coordination in the introduction of various smart technologies,
   - fear of technological risks,
   - barrier to the use of modern technologies especially ICT, low digital competence of residents,
5. Environmental:
   - negative effects of climate change - occurring e.g. heat wave periods, heat islands pose new challenges for local governments, against which good practices have not yet been developed,
   - extreme weather events,
   - restrictions on the implementation of selected investments due to the presence of protected areas,
6. Legal:
   - instability of the law, constant changes in standards, environmental obligations,
   - bureaucracy,
   - complicated and excessive system of supervision and multi-level control at each stage of project implementation.

Based on the analysis of conditions affecting the possibility of investing in the area of climate change adaptation, it is possible to identify those that have the most significant impact on project implementation, which have the nature of opportunities and threats. Opportunities include the growing interest among the population in climate change issues; the strong emphasis of European policies on caring for the environment and climate; the large allocation of funds for climate change adaptation activities; a taxonomy of terms that provides clarity and a common understanding of what activities can be considered sustainable; increasing access to knowledge, good practices, platforms dedicated to climate change adaptation, and environmental/climate risk assessment data and tools.

On the other hand, among the threats, the state of JST budgets - the lack of sufficient financial resources for financial contributions for climate change adaptation projects and the high cost of green/energy transition - should be mentioned first and foremost.

Based on the interviews, it can also be concluded that:

- the state of knowledge of climate change adaptation issues among respondents varies;
- respondents have no experience in implementing adaptation projects. So far, they have successfully implemented mitigation projects, although not all of them;
- development strategy updates are underway in local governments. Territorial strategies are being developed. The area of climate/adaptation to climate change is not breaking through as one of the strategic areas. Strategies are prepared based on past experience and habits, do not respond to crises (pandemic, war), are not prepared based on scenario modeling. Therefore, it is worth deepening the analysis of climate change phenomena;
- strategies developed for functional areas still do not correspond to the objectives for which they should be developed. The territorial approach, including the understanding of the role of areas of strategic intervention, is not the strongest point of JSTs developing strategies. In most cases, the strategies are developed as a reaction to the provisions of EU regulations to focus interventions on the development of functional areas, particularly urban areas;
- due to financial factors such as the state of JSTs finances, inflation and the high cost of investment implementation, calls for actions that fit into the climate and environmental limits should be launched first. Otherwise, investments related to basic infrastructure will exhaust the capacity of co-financing and for tasks related to adaptation to climate change there will be not only the will, but also financial resources in the budgets of JSTs;
- calls for projects in mitigation and adaptation activities should be synchronized;
- despite the lack of mandatory climate change adaptation plans for all beneficiaries of the measures in question, having such a plan demonstrates an evidence-based approach to adaptation investment planning. Requiring an adaptation plan as an eligibility criterion for support under the FEPZ would be overly burdensome. However, a clear

point bonus should be implemented for beneficiaries with a climate change adaptation plan or document;

- respondents pointed to the legitimacy of educational projects, the implementation of which promotes raising awareness of residents in the area of climate change adaptation. It is worth considering the preparation of model educational projects, in the form of standardized descriptions, completed application forms, which each potential beneficiary could download from the institution managing the FEPZ and adapt to their needs;
- a group of representatives of JSTs specializing in climate change adaptation could in the future constitute a group for exchanging experiences in the field of adaptation. Cooperation among JSTs, exchange of ideas, communication and knowledge sharing, engaging in joint activities, initiatives should reduce the risk of lack of interest in adaptation measures;
- as a good practice in the context of strengthening knowledge and building a team of experts, the use and improvement of remote forms of communication between JSTs, increasing the use of cloud solutions both at the stage of project preparation and implementation should be indicated.

Based on a long list of problems, the authors of the study proposed key investments that are reasonable to implement in individual JSTs in connection with climate change and the need to build greater resilience of JSTs to the effects of climate change:

- inventorying greenery in the municipality and assessing its condition and potential for retention;
- restoration/development of green areas in municipalities;
- an extensive system of small retention - in cooperation with private entities and housing cooperatives, implementation of the city-sponge idea and promotion of rainwater retention at the site of precipitation (instead of discharge into the rainwater or combined sewer system);
- completion of the stormwater drainage system with missing sections in cities/communities;
- renaturalization of river valleys and floodplains with emphasis on maintaining/ rebuilding biodiversity;
- environmental education of residents;
- development of a rapid response system for violent weather events;
- improvement of water resources management through modernization of water treatment plants.

The research revealed that climate change adaptation in local government units affiliated with the Szczecin Metropolitan Area Association (SSOM) is highly differentiated and depends not only on financial resources, but also on the competence of staff and the degree of

cooperation between units. Another new finding is the significant role of so-called "cooperation coordinators" as informal leaders of the adaptation process - their involvement has proved crucial in initiating strategic actions.

Previous studies (e.g., Carter et al., 2015; Legutko-Kobus et al., 2020) have pointed to the general difficulties of local governments in implementing adaptation strategies, highlighting mainly financial and institutional shortcomings. Our research supplements this picture with the perspective of local practitioners and shows that while these shortcomings are important, internal decision-making processes, the possibility of ongoing consultation between departments, and access to informal networks are equally important. In addition, the importance of inter-municipal coordination within structures such as SSOMs is shown as a potential factor in increasing the effectiveness of adaptation efforts. The results of our study coincide with the findings of Siekierska-Rosiak (2016), who emphasized the role of local leadership in climate governance, and the research of Dumenski et al. (2019), showing problems with implementing adaptation strategies in small municipalities. However, unlike previous studies, our analysis shows that some local governments are able to successfully initiate action even with limited resources - as long as there is a clear structure for cooperation and access to expertise, including through participation in cross-border programs or EU projects.

In further stages, comparative studies are planned with other functional areas in Poland - particularly in the context of the implementation of Municipal Adaptation Plans. It is also planned to analyze strategic documents and assess the implementation of EU-funded projects in the context of their actual impact on the climate resilience of local governments. The results of the study partially confirmed the hypothesis that local government units that are members of metropolitan structures show a higher level of adaptation readiness than units operating independently. Nevertheless, it turned out that the decisive influence on the effectiveness of adaptation has human and institutional factors, and not only membership in a cooperation network.

Conclusions

Climate change is a growing challenge for local and regional development, requiring local government units to implement effective adaptation strategies. The results of in-depth interviews conducted with representatives of JSTs included in the SSOM indicate a growing awareness of the need for adaptation, although the level of knowledge and institutional preparedness in this regard still varies.

The survey showed that the main barriers to the implementation of adaptation projects are financial constraints related to the cost of investment and the need to provide a high own contribution, as well as procedural difficulties arising from ambiguous laws and complicated

administrative processes. Additional challenges are the reluctance of local communities to make selected environmental investments, the low level of environmental awareness, and insufficient digital competence of local residents and local government employees.

At the same time, a number of opportunities have been identified that could foster greater regional resilience to the effects of climate change. These include the strong support of EU policies under the European Green Deal, the large availability of funds for adaptation measures, the growing interest of residents in environmental issues, and the development of expert knowledge and platforms for the exchange of good practices.

An important conclusion from the study is the need for better integration of the topic of adaptation to climate change with strategic documents of local government units. Development strategies, currently updated in many units, often do not take into account climate risks or the need for scenario modeling in territorial development planning to a sufficient extent. There is also a lack of an appropriate territorial approach, understanding the role of strategic intervention areas and broad cooperation between neighboring local government units.

Recommended activities include:

- preparation of climate change adaptation plans at the local or regional level,
- development and implementation of investments such as small-scale retention, development of urban greenery, modernization of water and sewage infrastructure, and restoration of natural areas,
- organization of educational projects on climate change and adaptation measures,
- creation of a network for cooperation and exchange of experience among local governments to strengthen competencies and share good practices.

It also stressed the need to synchronize calls for mitigation and adaptation projects and to provide adequate support to JSTs in preparing high-quality project applications. Implementation of these measures would allow the region to adapt more effectively to the effects of climate change, increase social, environmental and economic resilience, and improve the quality of life of West Pomerania's residents.

However, it is worth noting some limitations of the survey conducted. First of all, it was mainly based on in-depth interviews, which may lead to subjectivity in the interpretation of the results and limited representativeness of the research sample. It would be advisable in the future to extend the analysis with additional quantitative methods that would allow a more precise estimation of the scale of problems and challenges.

In spite of these limitations, the study provided valuable information on the actual barriers and opportunities for adaptation of local government units, which can form the basis for further, more comprehensive research. The results obtained can also support the development of local climate strategies and improve the effectiveness of adaptation measures taken.

Furthermore, based on the data obtained, adaptation measures can be more clearly prioritised. For example, investments in retention systems can bring rapid benefits in terms of water resource management, while educational measures, while crucial, require a long-term

commitment. It is therefore advisable to focus efforts on those areas that can produce the most immediate and measurable results.

The results of the study may have significant practical relevance, influencing regional policy-making and supporting TSUs to better prepare for climate challenges. Appropriate incorporation of the findings into strategic documents can significantly increase the resilience of regions to climate change and improve the quality of life for residents.

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A MODEL FOR SHAPING REVERSE LOGISTICS IN MANUFACTURING COMPANIES USING INDICATOR ANALYSIS

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Purpose: The aim of the study was to modify the classic SCOR model to include a key area for manufacturing companies (quality control) and to propose a herarhical set of key performance indicators designed to measure the implementation of selected processes in line with reverse logistics and the idea of sustainable development.
Design/methodology/approach: The study addresses the topics of indicator analysis and sustainability in the context of quality control implementation. The developed set of metrics was based on a modified SCOR supply chain model taking into account quality control and reverse logistics.
Findings: Using the assumptions of the SCOR model in constructing a set of metrics allows it to be extended in the context of key supply chain links as well as defining hierarchical performance measurement.
Research limitations/implications: A limitation of the proposed model was the lack of consideration of important business processes (sales, marketing, product development). The SCOR model lacks a link to the strategy and objectives of the supply chains considered. Further research will look at extending the model with missing elements and detailing the quality control process as envisaged by the SCOR model at level two adequately to the types of quality control occurring in the manufacturing space (input, inter-operational and final quality control).
Practical implications: The proposed universal set of indicators and yardsticks is intended to enable its implication in manufacturing enterprises in the form of a traditional model (no recycling) or under conditions of reverse logistics application. The model makes it possible to compare the two options and choose the more efficient one.
Social implications: The developed model for analysing the efficiency of one link in the supply chain allows the efficiency of reverse logistics to be monitored, which is closely related to the implication of the concept of sustainability in manufacturing enterprises.

Originality/value: Modification of the SCOR supply chain model to include quality control and the return aspect in the production context. Based on which, a proprietary set of indicators was developed.
Keywords: Mechanical engineering, manufacturing enterprise, SCOR model, quality control, circular economy, logistics security.
Category of the paper: Research paper, Viewpoint.

1. Introduction

Increasing globalisation and the dynamic development of new industrial and information technologies are a source of radical changes in manufacturing, planning and control systems (Stawiarska et al., 2021). Growing in global markets, manufacturing companies have the latest production and automation technologies at their disposal, as well as extensive communication networks and sophisticated computer software to integrate resources, which significantly assists in making appropriate business decisions (Czerwińska et al., 2024a). Nowadays, with similar technology and comparable quality of products, goods and services provided by business entities, both IT systems, ways of controlling production processes and the need to coordinate decisions made by all members involved in the supply chain are gaining importance (Ulewicz, Blaska, 2018; Pacana, Czerwińska, 2023a). The synchronisation of activities and the fulfilment of quality characteristics contribute to increasing the quality of manufactured products, increasing productivity, reducing inventory levels while maintaining high standards of customer service (Wolniak, 2021; Czerwińska et al., 2024b).

The increase in the intensity of competition is, among other things, resulting in an increase in customer demands for environmental care. When considering the formation of the concept of sustainability in the production space, the terms sustainable consumption and sustainable production emerge (Gajdzik, Wolniak, 2022; Diaconeasa et al., 2022). Sustainable consumption and sustainable production are two areas of activity with a significant impact on the economy of any country, especially a developed one. Sustainable consumption does not necessarily mean reducing the level of consumption intensity - it should be closely linked to efficiency. Both sustainable production and consumption require economic actors, public administration, households to intervene to increase the quality of the natural environment through the realisation of efficient production, minimisation of the consumption of natural resources, minimisation of waste generation and optimisation of production processes (Papamichael et al., 2024; Glavic, 2021). One specific definition of sustainable production defines it as the search for value-adding technologies that meet the needs of buyers while minimising material use and maximising process efficiency. The need to use raw materials efficiently is a result of their limited quantity. Sustainable production represents the next stage of change and development in the global organisation of production after the period of craftsmanship, mass production and

flexible production systems (Kumawat et al., 2021; Greenland et al., 2023). Loss reduction and recycling, which are the pillars of sustainable production, are also important in terms of sustainability (Lim et al., 2025; Kar, Harichandan, 2022). Loss reduction refers to reducing the generation of production waste, post-production waste and packaging materials, while recycling recovers already used natural raw materials (Czerwińska et al., 2024). Efficient sourcing of waste materials and raw materials for reuse belongs to the area of reverse logistics. Material flow management ends when non-hazardous product residues are returned to nature or raw materials are reused - we are talking about a closed product life cycle (Rossi et al., 2025; Uniyal et al., 2021; Pacana et al., 2020).

The success of the implications of the sustainability concept depends on top-down and bottom-up actions. A first step to improving products, services and controlling the quality of processes according to the sustainability concept can be the use of reference modelling (Wolniak, Grebski, 2023; Dabees et al., 2023). The task of reference models is to create structural and methodological framework representing a complex prodfucation reality. Reference models define the information structures of a company, represent organisational knowledge, set the standards for modelling and clearly define the space dedicated to controlling the correctness of actions taken (Klimecka-Tatar et al., 2021; Gajdzik, 2016). One example of reference models is the Supply Chain Operations Reference (SCOR) model. The overarching goal of developing the model, was to create a tool that would allow the execution of a supply chain analysis to identify the activities and processes occurring within it and to improve physical and information flows (Zhou et al., 2011).

The standardisation of the description of the relations occurring between individual processes and links in the supply chain enables the development of a system of metrics that allows not only the assessment of efficiency, but also supports adequate decision-making leading to its improvement (Ulewicz et al., 2014; Czerwińska et al., 2025). Measurement and evaluation of individual links and process execution in the SCOR model is possible through the use of appropriately selected key performance indicators (KPIs) (Li et al., 2011; Kottala, Herbert, 2020). The aim of this study was to modify the classical SCOR model to include a key area for manufacturing companies (quality control) and to propose a hierarchical set of key performance indicators designed to measure the implementation of selected processes in line with sustainability. The aim of extending the SCOR model was also to imply the premises of the concept of sustainability by considering its application to the idea of the circular economy on the ground of manufacturing enterprises. The implication of an adequate set of KPIs will contribute to the implementation of a management system based on the monitoring of performance measures, which will significantly facilitate the flexible alignment of short-term objectives of manufacturing enterprises with market requirements in line with the rationale of sustainable development.

2. Application of KPIs in the SCOR reference model

The SCOR model (Supply Chain Operations Reference Model) is an international reference model developed by the Supply Chain Council. The main objective of creating the model was to create a tool that would allow for a comprehensive analysis of the supply chain in terms of detailing the activities and processes involved, as well as improving information and physical flows (Rotaru et al., 2014; Li et al., 2011). The model was based on key supply chain processes which included (Ayyildiz, Gumu, 2021; Saen, Izadikhan, 2024):

- plan, which refers to supply and demand as determined by overall plans that take into account the management of resources and the building of the companies' operational capacities in the long term;
- source, which is the purchase of materials according to a procurement system that includes the verification of suppliers and negotiation;
- make, concerning the realisation of production activities within the framework of the production system and activities which increase the value of the product (creation of added value);
- delivery, concerning all stages from the receipt of customer orders through the definition of the delivery route to the selection of means of transport, as well as the activities currently carried out within the framework of demand management, storage space, order fulfilment;
- returns, concerning the activities related to the return of defective products (starting with raw materials), as well as the acceptance of products that do not meet customer requirements for repair or replacement, as well as activities related to the disposal of materials not needed by the purchasers;
- enable, covering advice on how to support other processes.

The dependencies and relationships between the processes described are shown in Figure 1.

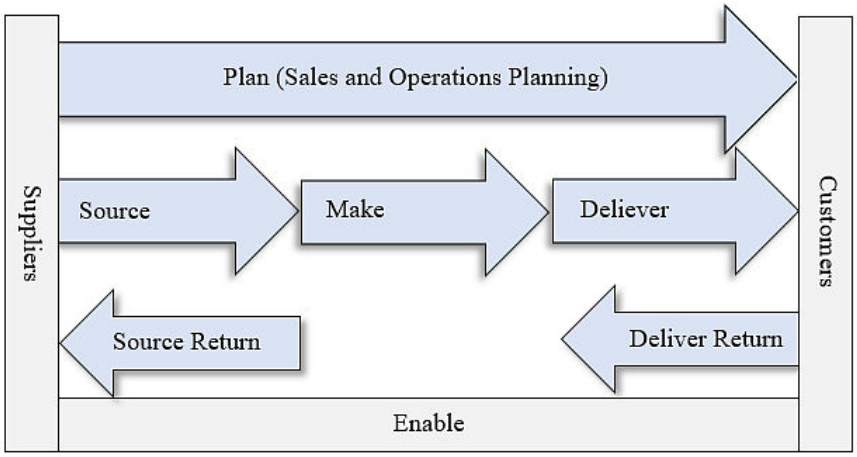

Figure 1. General overview of the SCOR model processes.

Source: Own elaboration based on: (Li et al., 2011; Kottala, Herbert, 2020).

The SCOR model defines dependencies and frameworks that link processes, technologies, metrics and best business practices into a unified structure - a hierarchical, interactive arrangement that is interconnected. The hierarchical structure includes the performance indicator model and process creation (Huang et al., 2005; Webb et al., 2014). One of the key components of the model is the measurement of the results and performance of the various links in the supply chain. The concept of using indicator analysis implies the need for the implication of a balanced approach, indicating that single indicators (including, for example: time, cost) are not adequate to illustrate the achievements of the components of the supply chain. They should be measured and monitored at multiple levels (Georgise et al., 2017; Mazo et al., 2014).

The hierarchical structure of the SCOR model is manifested in the system of measures. The first level takes into account the fundamental evaluation criteria, while subsequent levels can use measures and indicators with greater detail that will fall under the criteria of the first level and at the same time address individual processes in the supply chain (Palma-Mendoza, 2014; Lima, Carpinetti, 2020). Grouped into categories, the indicators from the first level of decomposition include: flexibility, reliability, agility, asset management and cost. Subjecting the indicated characteristics to analysis ensures the comparability of companies, which in a strategic context is defined as a provider of low-cost products to a company that chooses to compete on the basis of ensuring efficiency and reliability (Kocaoglu et al., 2013). Ensuring the hierarchical structure of indicators leads to linking them into meticulously defined sets that relate to different levels of management in a manufacturing enterprise (Aem-on et al., 2024; Khan et al., 2023).

The indicators used within the SCOR model should highlight areas for improvement. The criterion for the selection of an indicator should be the usefulness of the information it provides in relation to the achievement of the stated objectives (Akkawuttiwanich, Yenradee, 2018; Czerwinska et al., 2020). Important within the structure and interpretation of the results is the shift away from local to global optima. Findings based on local metrics can, in the long term, have an adverse impact not only on individual processes but also, on the entire supply chain (Pacana, Czerwinska, 2023; Ahmed et al., 2023).

3. Method

The modified SCOR model solves the problems and limitations of the classic SCOR model. The developed model takes into account the management of the quality control process, capturing it as an integral part of the manufacturing (make) system. The model was extended to include the quality control process. Post-operational inspection is included in the model. This process was included in the model because it is an important area for manufacturing companies. Effective quality control, by ensuring that the final product complies with technical

requirements and customer expectations, contributes to minimising the risk of complaints, returns and financial losses. Consequently, an efficient quality control system contributes to a company's competitiveness, increased customer satisfaction and long-term market success. The inclusion of quality control within the analyses carried out using the SCOR model is important because this process is a system without an information feedback loop. Which means that information about irregularities, errors and their causes does not directly reach the employees on the production line. Therefore, such a system cannot self-improve. A diagram of the modified SCOR model is shown in Figure 2.

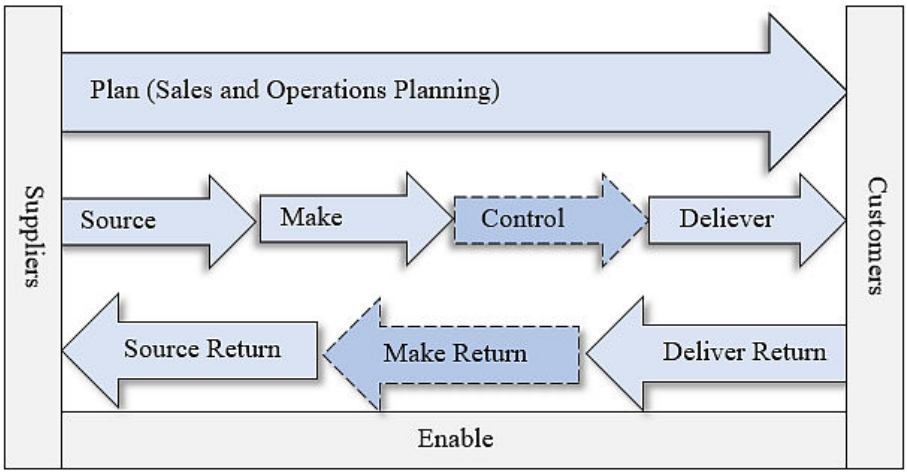

Figure 2. Process approach of the modified SCOR model.

Source: Own elaboration.

The return element of the SCOR model (source return, deliver return) can be seen as a way of performing and fulfilling the demands of the sustainability concept in the execution of environmentally friendly production processes (in line with green manufacturing). The addition of the return make element (Figure 2) makes the SCOR model complete in the context of meeting the sustainability requirements of manufacturing companies. Return make is the implication of the circular economy in manufacturing enterprises, which minimises the use of raw materials and the generation of waste by creating closed loops of processes in which the waste generated is used as a raw material in subsequent production phases.

Implications of the proposed extended SCOR model include:

- creating a model of the current state (‘as is’),
- the use of defined (proposed in the study) performance measures to assess the degree of efficiency of own processes, to compare them with the best ones, to identify priority areas (needing most improvement) and to specify target, expected values of indicators (including desirable, acceptable, warning and unacceptable values),
- implication of SCOR's proposed business practices,
- creation of a target (‘to be’) model.

The integrated processes by in the modified SCOR model should be considered as a whole chain. A comprehensive and unified system translates into a strategy to help companies achieve their goals. There are flows of input materials, labour and information within the production enterprise ensuring the right quantity of products of the right quality and at the right time.

4. Verification of the model

Based on the modified SCOR model, a set of metrics was developed to assess the performance of one of the links in the supply chain - manufacturing enterprises. The metrics were hierarchised based on the structural assumptions of the elements of the SCOR model and developed adequately to one of the main objectives, enterprises in the supply chain - increasing their efficiency. The different levels identified in the schematic illustration of the set of indicators (Figure 3 and Figure 4) correspond to the layers of the SCOR model. The indicators within the first level relate to an element of the model (quality control). Within the second level are metrics that can be adapted to a specific type of process (input, inter-operational, final control). The third level takes into account the metrics corresponding to the main elements of the processes. The links between the metrics indicate dependencies and aggregation in terms of individual process activities.

The developed set of integral indicators allows a detailed analysis of supply chain efficiency in the traditional variant (not including recycling, re-manufacturing and waste use (Figure 3).

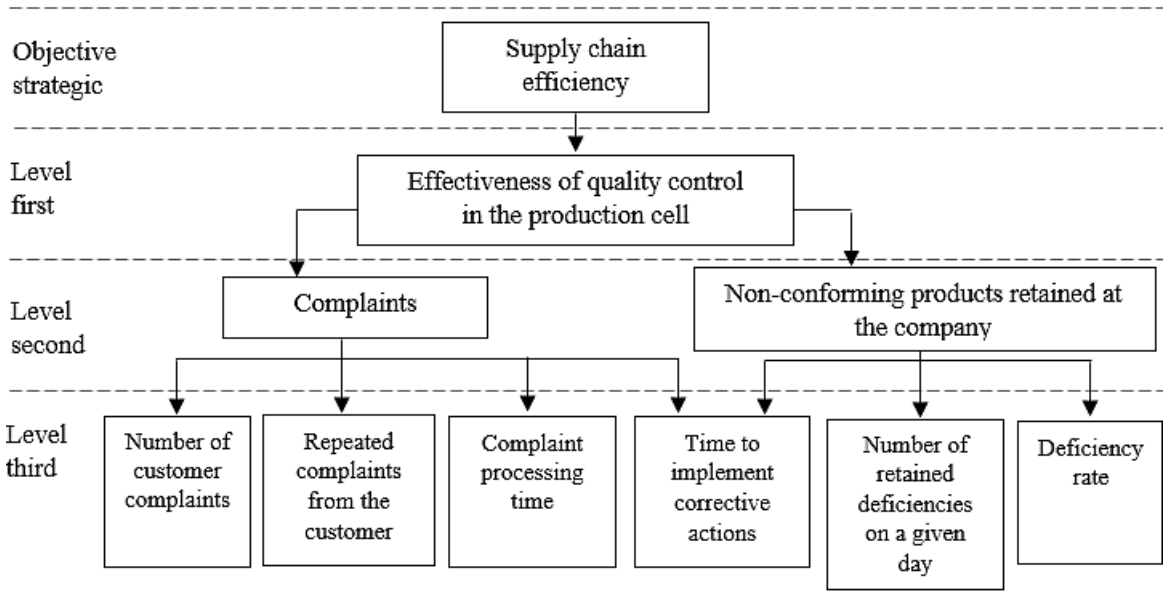

Figure 3. Set of indicators for quality control process (traditional approach - no recycling).
Source: Own elaboration.

A set of indicators aimed at monitoring the level of effectiveness of quality control in production companies that are not oriented towards reverse logistics was developed taking into account the level of external and internal complaints (Figure 3). Within the complaints from customers, the number of complaints, processing time, and recurring complaints were considered, while within the products identified by internal quality control, the number of defects retained on a given day and the defect rate were considered as key metrics. A complementary measure for both levels was the time taken to implement corrective actions.

With reference to the return element of the SCOR model (source return, deliver return), a set of hierarchical indicators was also proposed in a variant including aspects of reverse logistics (Figure 4). The set of indicators is aimed at manufacturing companies capable of implementing and fulfilling the postulates of the sustainability concept in the execution of environmentally friendly production processes (green manufacturing assumptions).

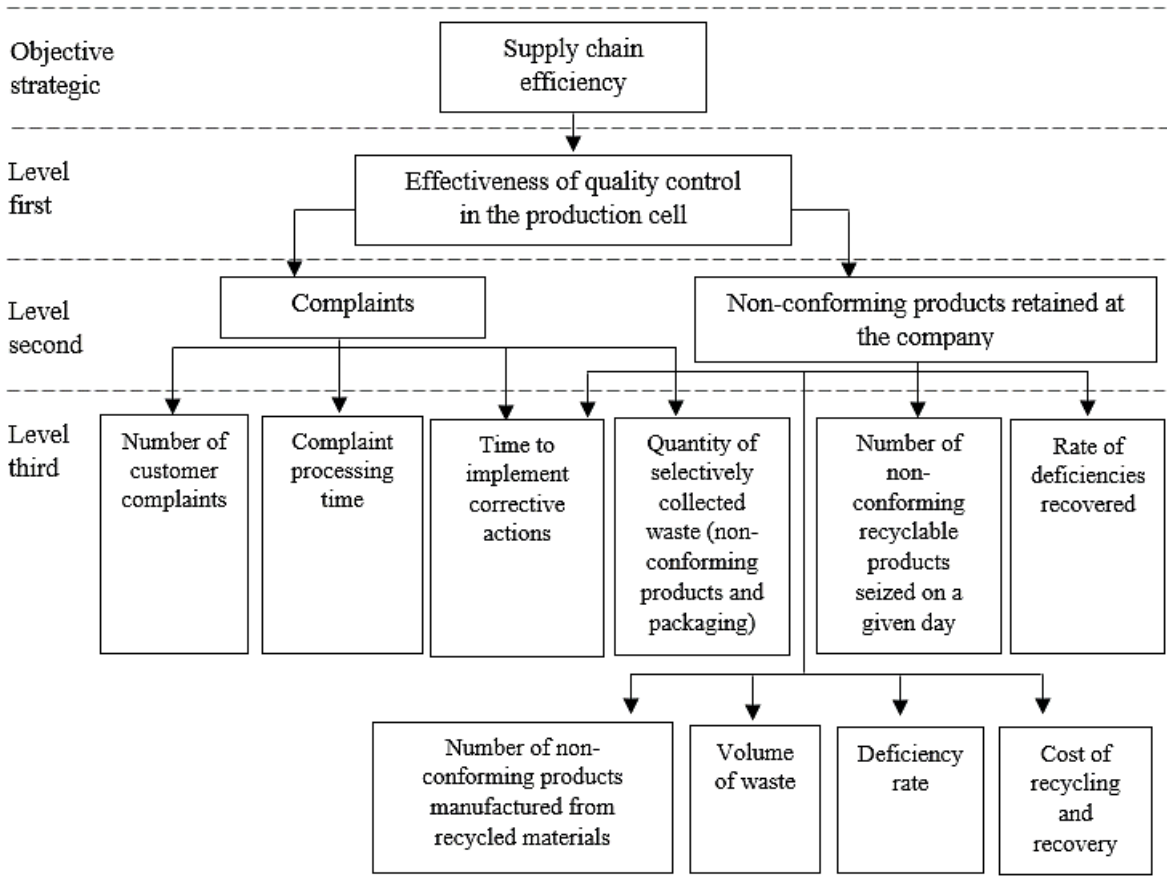

Figure 4. Set of indicators for the quality control process (variancia with feed-back logistics aspects). Source: Own elaboration.

When monitoring the level of effectiveness of the quality control process within a specific supply chain where recycled or remanufactured raw materials are used, a multi-faceted approach should be taken. Relevant levels include external complaints and non-conforming products identified within the company. The third tier within complaints takes into account the number of complaints, the time taken to process them, while in terms of essential products identified in the quality control process: the rate of deficiencies and the rate of recovered

deficiencies, the number of recycled products retained, the volume of waste, the number of non-conforming products produced from recovered materials. The time taken to implement corrective actions and the amount of selectively collected waste were also included in both levels presented. The holistic approach presented for assessing the effectiveness of quality control within the supply chain is important in the context of sustainable development, the foundation of which is a reasonable balance between a variety of factors.

The implementation of the modified SCOR model, together with the proposed set of KPIs, brings tangible benefits within the four main business sectors of manufacturing companies. The first area is control, the next is management in the broad sense, the next is cost savings, which cover the entire product development cycle, and the last segment is quality, which should be a continuous process. Other advantages of the model include:

- integration and provides a cross-industry, universal view of individual supply chain processes,
- ensuring process and functional orientation,
- consistent approach to supply chain improvement,
- the ability to make cross-industry comparisons,
- proposing a coherent set of metrics and indicators with their priorities,
- consideration of multiple areas and dimensions of management.

A limitation of the proposed model is the lack of consideration of important business processes (sales, marketing, product development). The SCOR model lacks a link to the strategy and objectives of the supply chains considered.

5. Summary and conclusion

Providing a comprehensive system of metrics makes it possible to assess the planning processes taking place within the supply chain. This is a basic element that allows further search for savings and efficiency improvements in the flow of products and information. The purpose of the study was to modify the classic SCOR model to include a key area for manufacturing companies (quality control) and to propose a herarchical set of key performance indicators designed to measure the performance of selected processes. The purpose of expanding the SCOR model was also to imply the premises of the concept of sustainable development by considering its application to the idea of circular economy on the ground of manufacturing enterprises.

The developed set of hierarchical indicators and metrics developed with regard to process types (production and quality control in a non-recycling approach and using reverse logistics) allows a detailed analysis of efficiency. The development of two variants of indicator sets allows manufacturing companies to identify the more favorable variant. Implication of a set of

indicators aimed at enterprises running processes with reverse logistics in mind will support segmentation of waste materials and their rational reuse. Implication of both models into the production-control environment will help make managers aware of the benefits of applying the concept of sustainability. The idea of implementing indicator analysis based on the expanded SCOR model is based on the elements of a win-win strategy, where the parties are the participants in the supply chain (especially manufacturing companies) and society. Striving to find a solution that takes into account the interests of each link in the supply chain fosters positive relationships based on trust and cooperation.

Further research will be related to the expanded model (detailing the quality control process in accordance with the assumptions of the SCOR model at level two) adequately to the types of quality control occurring in the manufacturing space (input, inter-operational and final quality control). Future work will also be related to the digitalization of indicator analyses in the manufacturing space conducted based on the proposed model

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STRESS FACTORS AMONG GEOSCIENCE STUDENTS AND ACADEMIC COMMUNITY RESPONSES

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Purpose: The purpose of this paper is to investigate stress levels among students in the geoscience academic environment and to formulate practical recommendations for the academic community. The study aims to identify key stressors, symptoms, and coping strategies among students.
Design/methodology/approach: A quantitative research approach was adopted, utilizing a survey conducted in 2024 with students from the Faculty of Geoengineering, Mining, and Geology at Wrocław University of Science and Technology. The research was preceded by a literature review, and the data were analyzed to identify trends and propose interventions.
Findings: The research identified academic demands-exams, presentations, and project deadlines-as the primary sources of stress. Students reported symptoms such as decreased motivation and health disturbances. Awareness of psychological support services was noted as increasing, yet their utilization remains limited. The findings support the need for systemic changes to reduce student stress.
Research limitations/implications: The study is limited to one faculty within a single institution, which may affect the generalizability of results. Further research could involve broader student populations and longitudinal analysis.
Practical implications: The results highlight the need for improved access to and promotion of psychological support services, as well as the development of stress-reducing academic practices. Institutions should implement regular monitoring and tailored interventions to support students' mental well-being.
Social implications: Reducing academic stress contributes to better student quality of life and may positively influence the university's social responsibility by fostering a healthier educational environment.
Originality/value: This study provides updated data on student stress in a technical university setting and proposes targeted strategies to address it. It is valuable for academic administrators, student advisors, and policymakers.
Keywords: student stress, higher education, psychological support, academic environment, geoscience education.
Category of the paper: Research paper.

1. Introduction

Stress is the body's response to external stimuli that exceed an individual's ability to cope effectively (Selye, 1976). Hans Selye, the creator of the stress concept, defined it as "the non-specific neuroendocrine response of the body" (Rochette, Vergely, 2017). Meanwhile, Lazarus and Folkman (1984) described stress as a transactional process between a person and the environment, occurring when an individual perceives environmental demands as threatening to their resources or well-being.

Student well-being is understood as encompassing positive emotions, the absence of negative emotions, relationships, engagement, accomplishment, purpose at school, intrapersonal or internal factors, and contextual or external factors (Hossain, O'Neill, Strnadová, 2023). Khatri et al. (2024) define student well-being as the physical, psychological, and social wellness of students – elements increasingly at risk in the high-pressure environment of higher education.

Stress is one of the most prevalent factors in the academic environment, significantly affecting students' mental, physical, and social health (Barbayannis et al., 2022; Córdova Olivera et al., 2023; Di Mario et al., 2024; Lee, Park, Kim, 2024). In the academic context, stress should be understood as high levels of anxiety, sadness, burnout, and psychological discomfort (Di Mario et al., 2024) or a physiological, emotional, cognitive, and behavioral activation response to stimuli and academic events (Barbayannis et al., 2022). According to Córdova Olivera et al. (2023), stress can also be defined as a ubiquitous phenomenon in daily life that results from a natural physiological and psychological response of the body to situations perceived as challenging or threatening, acting as a catalyst to confront and resolve problems. Increasing educational demands, performance pressure, and the need to balance studying with other responsibilities make stress a growing concern among students. Numerous studies, including those by Buwalda et al. (2005), Schneider et al. (2005), Dhabhar (2014), Lee et al. (2024), Nevado et al. (2024), and Wang et al. (2025), indicate the negative effects of chronic stress, such as emotional disorders, declining academic performance, and an increased risk of health problems (Buwalda et al., 2005; Schneider et al., 2005; Dhabhar, 2014; Lee et al., 2024; Nevado et al., 2024; Wang et al., 2025).

According to the guidelines of the European Agency for Safety and Health at Work (EU-OSHA, 2024), psychosocial hazards, such as excessive workload, conflicting demands, or a lack of role clarity, can lead to health problems and a reduced quality of life. In the academic context, students often experience similar challenges (Zięba, Król, Nowak-Starz, 2018; Matteau et al., 2022; Pilch et al., 2023), highlighting the need to analyze these factors within the educational environment.

Moreover, the Regulation of the Polish Minister of Science and Higher Education of October 30, 2018, on ensuring safe and hygienic working and learning conditions at universities imposes an obligation on rectors to analyze and identify health and life hazards and to take preventive measures to mitigate these risks. Therefore, understanding the sources of stress among students is crucial for implementing effective preventive measures. A similar situation exists, for example, in Norway, where universities are subject to the Act on Health and Environment in Schools, Kindergartens, and Further Education Programs (Lov Om Arbeidsmiljø, Arbeidstid Og Stillingsvern Mv., 2005) or in Germany, where workplace safety is regulated by the Occupational Safety Act (ArbSchG, 2024).

The aim of this study was to conduct a detailed analysis of stress levels among students of the Faculty of Geoengineering, Mining, and Geology at Wrocław University of Science and Technology (WUST), one of the 14 faculties at the university. This faculty was selected due to the thesis writing requirement for one of the programs offered there. The study focused on identifying the main stress-inducing factors, the most common symptoms, and the strategies used to cope with emotional tension. Furthermore, the collected data allowed for identifying areas requiring intervention to improve student well-being.

The conducted study not only provides insight into the specifics of stress in the academic context but also indicates potential directions for the university's efforts to support students' psychological and organizational well-being. Additionally, an analysis of the current mental support available for students and university staff was carried out, and recommendations were proposed that could be implemented to improve the comfort and well-being of the academic community. To clarify the scope of the study, the following research questions were formulated:

- What are the main stressors affecting students of Geoscience?
- What stress-coping strategies are most commonly used by students?
- To what extent do students make use of the psychological support services available at the university?

These questions guided the development of the survey and the analysis of the collected data.

2. Methods

The research methodology was based on the following methods: literature analysis, definition of the research problem, survey (selection of the survey format and sample group), data analysis (qualitative data), and formulation of recommendations. The study was conducted using an original survey directed at students of the Faculty of Geoengineering, Mining, and Geology at Wrocław University of Science and Technology (WUST) (see Attachment 1). As a student of this department for several years, the author was closely familiar with the academic environment, challenges, and expectations experienced by the student community.

This direct experience provided valuable insight into the context of the study and allowed for more effective design and implementation of the research. The survey was anonymous and consisted of 38 closed- and open-ended questions, designed to assess the main sources of stress, its symptoms, its impact on students' lives, and strategies for coping with emotional tension. The questions also addressed specific aspects of studying, such as the type of courses, forms of assessment, and relationships with lecturers.

The questions in the survey were divided into several categories:

- Frequency of stress occurrence, e.g., "How often do you find yourself in a stressful situation?".
- Sources of stress, including studies, family life, finances, or work.
- The most stressful aspects of studying, such as subject groups, forms of assessments, and relationships with course leaders.
- The impact of stress on behavior and health, with questions about somatic and psychological symptoms, such as headaches, insomnia, decreased concentration, or general discomfort.
- Coping strategies for stress, including support from others, use of stimulants, or seeking psychological help.
- Awareness of available support options at the university, asking about knowledge and use of free psychological assistance offered by the university.

To obtain reliable data, the survey was distributed online through the Dean's Office to all students of the faculty using the university's domain accounts “@student.pwr.edu.pl”. A total of 166 respondents participated in the study, accounting for almost 25% of all students in the faculty. However, two surveys were rejected due to technical issues. The responses to the open-ended questions indicated a lack of seriousness regarding the topic and a dismissive approach to the effort put into conducting the research. The respondents included both women and men from different study programs and years of study within the faculty. Responses were collected anonymously. The data collection process took place from May 16 to May 23, 2024, including weekends. The study was designed to address three core research questions: (1) identification of the main causes of stress among Geoscience students, (2) recognition of the most commonly used coping strategies, and (3) evaluation of the extent to which students utilize available psychological support services. These questions structured both the formulation of survey items and the organization of the subsequent data analysis.

3. Results

A total of 164 students from the Mining and Geoscience programs at our Faculty at Wrocław University of Science and Technology (WUST) completed the questionnaires properly, allowing them to participate in the survey. The number of respondents was similar to the number of graduates from the faculty in recent years (Yikealo, Gebregergis, Karvinen, 2018). A larger proportion of the respondents were women (99 individuals) compared to men (65 individuals), with 47% of them living in cities with populations over 100,000, and 25% residing in rural areas. The largest group in the study consisted of students from the "Geodesy and Cartography" program (37.8%), followed by Geoinformatics (22%) and Mining and Geology (21.3%). The smallest number of surveys were completed by students from the "Geoenergy Engineering" and "Raw Materials Engineering" programs – 4.3% and 3.7%, respectively.

The survey revealed that studying at our Faculty is a source of stress for over 90% of the students. For 76% of the respondents, studies were the most important stress factor. Other choices are shown on the crosstabulation (Table 1).

Tabela 1.
A cross-tabulation showing the distribution of responses to the question about the most common stress-causing factor among women and men

	studies	financial situation	relationship	family members	separation from family	work	other
woman	77 (47%)	4 (2,4%)	2 (1,2%)	2 (1,2%)	0	6 (3,7%)	8 (4,9%)
man	47 (28,7%)	5 (3%)	4 (2,4%)	1 (0,6%)	0	4 (2,4%)	4 (2,4%)

Regular stressful situations were experienced by 43% of the respondents, who reported these situations occurring several times a week. A the crosstabulation shows the distribution of responses among men and women (Table 2). The greatest stress among the respondents was caused by exams, colloquia, assessments, and presentations in front of a group. Among the subject groups, the most stressful were mathematics courses, such as mathematical analysis or statistics, which 46% of respondents reported having difficulties with. Furthermore, stress led to neglecting academic duties, with 45% of students admitting to skipping classes due to stress.

Table 2.
A cross-tabulation showing the distribution of responses to the question about the frequency of stress among men and women

	few times a day	every day	few times a week	every week	less than once a week
woman	28 (17,1%)	18 (11%)	41 (25%)	7 (4,3%)	5 (3%)
man	15 (9,1%)	7 (4,3%)	29 (17,7%)	6 (3,7%)	8 (4,9%)

The forms of assessments also influenced the level of stress. The most stressful form was the oral exam, which was indicated by 72% of respondents. Participants admitted that stress often led to a decrease in motivation, with 62% of students reporting this experience.

Stress also affected interpersonal relationships. As many as 85% of respondents acknowledged that stress caused conflicts with other students. At the same time, 65% of students noted that stress positively affected their relationships, for example, by strengthening bonds in difficult moments. Regarding student-teacher relationships, most respondents rated them as positive, although 54% of respondents expected more support from the Faculty Administration in coping with stress-related issues.

Stress symptoms were varied, but the most common one was a bad mood, reported by 65% of the respondents. The remaining symptoms were presented in Figure 1 (Fig. 1). In stressful situations, students sought support from friends (65%), family members (61%), and partners (49%). Only 7% of respondents used professional psychological help, despite 65% of respondents being aware of the availability of free psychological support offered by WUST (https://ddo.pwr.edu.pl/en/, 2025).

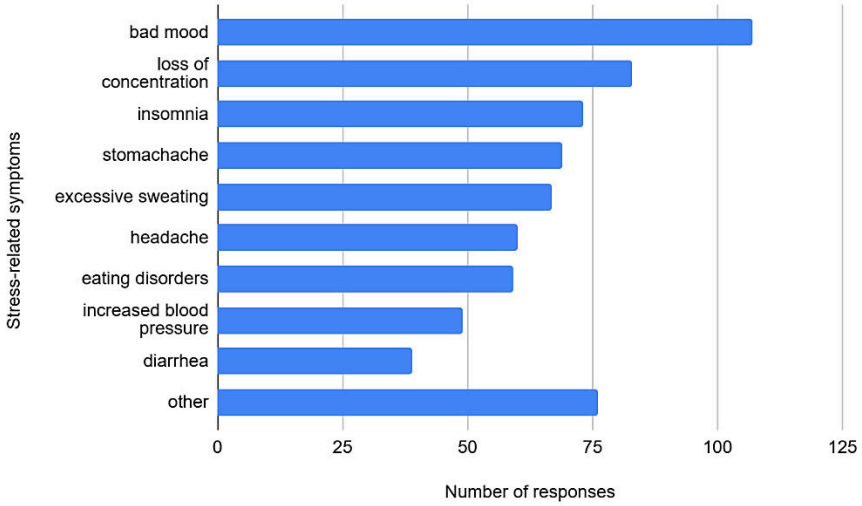

Figure 1. Reported stress-related symptoms and number of responses.

The actions taken by students to cope with stress included entertainment (58%), physical activity (36%), and conversations with loved ones. Among substances, the most commonly used were cigarettes (31%), tranquilizers (26%), and alcohol (25%). Awareness of the negative impact of stress on health was relatively high, with around 80% of respondents agreeing that stress can lead to serious health issues such as depression, heart disease, or hypertension. Despite this, 73% of students consider stress an inseparable part of studying, and 52% believe it can be motivating.

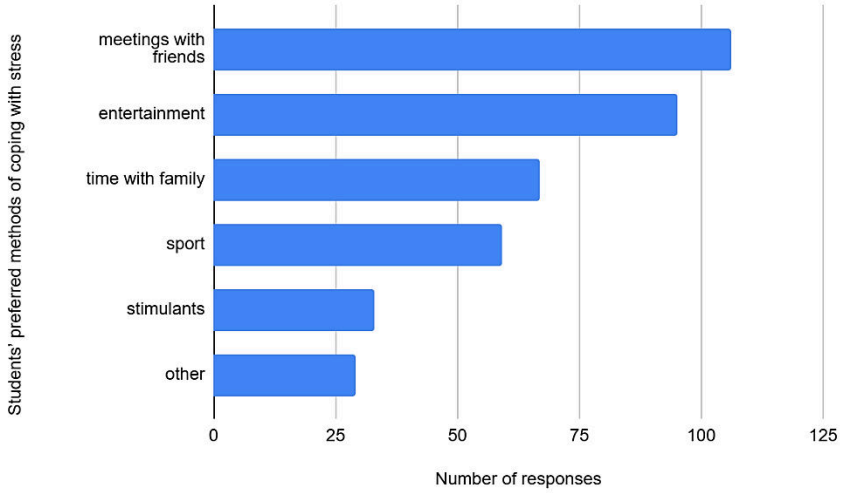

Figure 2. Students' preferred methods of coping with stress.

When it comes to coping strategies, the majority of respondents (65%) prefer meetings with friends, with many also choosing entertainment or time spent with family. This is shown in Figure 2 (Figure 2). Confirmation of these results can also be found in the answers to the question of whom students most often receive support from in stressful situations. More than half of the participants receive support from friends, while slightly fewer receive support from family members (Figure 3).

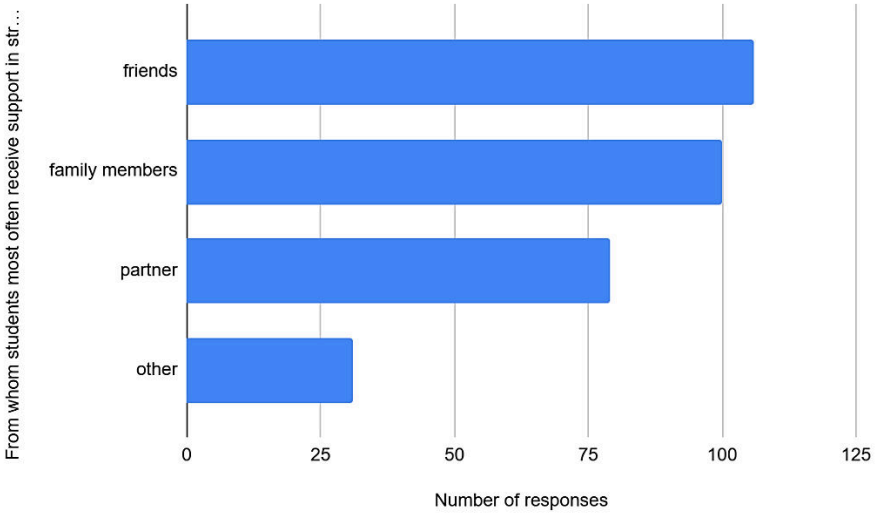

Figure 3. Sources of support for students in stressful situations.

After conducting the survey, several conclusions can be drawn regarding stress-related situations among students. It is important to consider some methodological limitations, such as the selection of the surveyed group from only one department (out of the entire university). Based on these findings, recommendations were made for the academic community to improve conditions and openness toward students, as well as for students to enhance their well-being and mental health. Analyzing the results of the survey, it can be concluded that the availability of psychological support at the university remains underutilized. Although students have access

to free support, very few take advantage of this opportunity. Despite the presence of departments offering support for students from dysfunctional families, minorities, and in various other aspects of life, not all members of the academic community are aware of their existence. A student seeking help will surely find it, but it is important for them to know that it is available.

More efforts should be made to promote the Accessibility Department and the university's "barrier-free" concept at WUST, which is open and friendly to students with disabilities. The Accessibility Department sends recommendations to all academic teachers at the beginning of each semester, asking them to inform students about the university's open-door policy toward those with special needs. This collective information includes messages about free and anonymous psychological support, including in English. Unfortunately, it is unclear how well these recommendations are being implemented by staff and whether they reach students.

Many students are reluctant to seek psychological help, despite 65% being aware of university support, with only 7% using it. This may be due to high demand and limited appointments, suggesting the need for more psychologists and expanded availability. Online sessions, though not ideal, could improve access. Promotional efforts, such as social media campaigns and awareness events, could also encourage more students to seek support.

Students highlighted issues in their interactions with instructors. Expanding student government initiatives, such as field trips and team-building activities, could strengthen these relationships. Verifying faculty compliance with accessibility recommendations would also help. Additionally, fostering student connections through integrative events like academic trips and workshops is crucial, as most respondents rely on friends and family for support.

Another idea would be to create additional workshops focusing on stress management techniques or relaxation practices. These workshops could be held online so that individuals who want to participate do not feel uncomfortable or worried about others discovering their problems or need for support.

Such actions could not only reduce stress but also positively impact academic results and involvement in university life. Ultimately, taking actions aimed at improving students' well-being could significantly reduce stress levels and increase students' satisfaction with their academic life.

4. Discussions

Based on the results of the survey, it is evident that stress remains a significant and widespread issue in the lives of students at the Faculty of Geoengineering, Mining, and Geology at Wrocław University of Science and Technology (WUST). The data indicate that the primary sources of stress are academic factors, such as exams, colloquia, and assessments.

These findings are consistent with those presented by Rana et al. (2019), who identified academic pressure as one of the most prominent stressors in the student population.

This conclusion is further supported by Campbell et al. (2022), whose systematic review of student mental health in the UK highlighted similar stressors – academic workload, performance expectations, and financial pressure – as key contributors to declining student well-being. The alignment between those findings and the results of this study suggests that the academic dimension of stress is a cross-cultural and persistent challenge in higher education.

When comparing the emotional and physical symptoms reported by students, similarities also emerge. In the current study, the most frequently indicated symptoms included poor mood, headaches, and sleep disturbances. These reflect findings from the study by Pilch et al. (2023), where physiological complaints such as fatigue and palpitations were also predominant. Furthermore, both studies observed a strong connection between stress and decreased motivation, which often limits students' ability to meet academic demands effectively.

Zięba et al. (2018) also emphasized the role of exam sessions as the most stressful element of university life, a view supported by the current findings. However, some differences arise when analyzing the academic content areas that generate the most stress. In this study, mathematical subjects (e.g., calculus, statistics) were most frequently identified as the most mentally taxing, whereas Waghachavare et al. (2013) found the greatest levels of stress among students of medicine and dentistry, where academic intensity and competitive expectations were much higher. These differences may be attributed to the nature of the academic programs and their cognitive demands, as well as to cultural or institutional differences in assessment and teaching styles.

An additional perspective is offered by Yikealo et al. (2018), who noted that moderate stress can sometimes be a motivating factor, enhancing academic performance. This nuance is echoed in the current research, where although the majority of respondents associated stress with negative outcomes, over half also acknowledged that it can serve as a motivating factor in certain situations.

Taken together, the results of this study are largely consistent with existing literature, reinforcing the notion that academic pressure is a dominant and transdisciplinary source of student stress. However, the specific nature of stressors and symptoms may vary depending on the institutional context and curriculum. These findings highlight the importance of tailoring support strategies to students' academic profiles and cultural settings. Further studies exploring the influence of organizational factors, course structure, and faculty-student relationships could offer deeper insight into how stress develops and manifests within specific educational environments.

5. Summary

The conducted study confirmed that stress remains a significant challenge among students of the Faculty of Geoengineering, Mining, and Geology at WUST. The most frequently reported sources of stress included academic pressure, exams, and organizational issues, underscoring the need for ongoing monitoring of students' well-being.

From a theoretical perspective, the study adds to the growing body of research on stress in academic environments by confirming previously identified stressors and highlighting the role of student awareness and support systems in managing mental health. Importantly, the study shows that while stress remains prevalent, student awareness of psychological support services has increased compared to earlier findings.

In practical terms, the results underscore the importance of continuing to develop support mechanisms, including expanding access to psychological counseling, organizing stress management workshops, and strengthening relationships between students and academic staff. Regularly repeated surveys could support long-term monitoring of student well-being and inform the refinement of intervention strategies. Implementing these measures can contribute to improved well-being, increased academic engagement, and a healthier university environment – aligned with broader efforts to meet health, accessibility, and inclusion standards on campus.

The results provide clear answers to the study's guiding questions. Academic factors such as exams and project deadlines were identified as the primary sources of stress. Students most frequently coped with stress through informal methods such as talking to friends or engaging in physical activity. While awareness of psychological support services has grown, actual usage remains limited, highlighting the need for further outreach and normalization of mental health support on campus.

Future research in this area could focus on the influence of specific institutional or organizational factors – such as scheduling, assessment types, or faculty-student communication – on student stress. Longitudinal studies would also be valuable in tracking how stress levels and coping strategies evolve over the course of academic programs. Moreover, comparative research across faculties or institutions could help identify effective, scalable practices for reducing stress in diverse academic environments.

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Appendix

1. Gender
   * Female
   * Male
2. Place of residence
   * Village
   * <10 thousand residents
   * 10-50 thousand residents
   * 50-100 thousand residents
   * >100 thousand residents
3. Department position
   * Student
   * Graduate
4. Course of study
   * Mining and Geology
   * Geodesy and Cartography
   * Occupational Health and Safety
   * Geoinformatics
   * Geoenergy
   * Engineering of Mineral Resources
   * Applied Geology
5. Year of study
   * 1st BSc
   * 2nd BSc
   * 3rd BSc
   * 4th BSc
   * 1st MSc
   * 2nd MSc
   * Graduate
   * PhD student
6. Have you studied at another faculty other than W6?
   * Yes
   * No
7. Where did you live during your studies?
   * Rented/own apartment in Wrocław
   * Dormitory
   * Commuted from another city
8. Did starting your studies involve separation from your family (moving to another city/changing residence for the duration of your studies)?
   * Yes
   * No
9. How often do you find yourself in a stressful situation?
   * Several times a day
   * Once a day
   * Several times a week
   * Once a week
   * Less frequently

10. What is the most frequent cause of stress for you?
    * Studies
    * Financial situation
    * Relationship
    * Family members
    * Separation from family
    * Work
    * Other
11. Are your studies a source of stress for you?
    * Yes
    * No
12. What situation at your studies is most stressful for you? (Select up to 3)
    * Exams
    * Tests
    * Credits
    * Laboratory classes
    * Project classes
    * Seminars
    * Lectures
    * Giving presentations in front of the group
    * Other students
    * Contact with professors
    * Too high level of classes
    * Too low level of classes
    * Too many requirements
    * Too few requirements
    * Too many classes
    * Poorly scheduled class timetable
    * Writing a thesis
    * Other
13. Which group of subjects causes you the most stress? (Select up to 3)
    * Mathematical (mathematical analysis, algebra, statistics, economics, etc.)
    * Mechanical (rock mechanics, technical mechanics, material strength, etc.)
    * Geological (basic geology, mineralogy, deposit geology, hydrogeology, etc.)
    * Humanities (psychology, ethics, project management, occupational health and safety, etc.)
    * Surveying (surveying, geodesy, cartography, etc.)
    * IT (informatics, information technologies, databases, GIS, etc.)
    * Drawing (engineering graphics, descriptive geometry, technical drawing, etc.)
    * Natural sciences (physics, chemistry, geophysics, mineral processing, etc.)
    * Mining (mining basics, surface mining, blasting techniques, etc.)
    * Other
14. Has stress ever caused (You can select more than one answer)
    * Absence from classes
    * Absence from exams
    * Absence from tests
    * Failure to submit a project on time
    * Withdrawal from studies
    * None of the above

15. What form of crediting is most stressful for you?
    * Oral
    * Written - multiple choice test
    * Written - open-ended questions
16. Does stress cause you to?
    * Increase motivation
    * Decrease motivation
17. How much stress do you feel during an exam you are prepared for?
    * I am not stressed at all
    * 1
    * 2
    * 3
    * 4
    * 5
    * 6
    * 7 - I am very stressed
18. How much stress do you feel during an exam you are NOT prepared for?
    * I am not stressed at all
    * 1
    * 2
    * 3
    * 4
    * 5
    * 6
    * 7 - I am very stressed
19. How much does your efficiency in completing a task change in a stressful situation?
    * Fear paralyzes me
    * 1
    * 2
    * 3
    * 4
    * 5
    * 6
    * 7 - Stress improves the quality of task performance
20. How negatively do you react to stressful situations?
    * I shout, cry, become aggressive
    * 1
    * 2
    * 3
    * 4
    * 5
    * 6
    * 7 - Stress does not affect my behavior
21. How often do you quit performing a task because of stress?
    * Never
    * 1
    * 2
    * 3
    * 4
    * 5
    * Always

22. Have you considered quitting your studies because of stress related to studying?
    * Yes
    * No
23. Has stress ever caused you to reach for (You can select more than one answer)
    * Alcohol
    * Cigarettes
    * Psychoactive substances
    * Sedatives
    * None of the above
    * Other
24. Has stress caused arguments with other students?
    * Yes
    * No
25. Has stress ever had a positive effect on your relationships with other students?
    * Yes
    * No
26. What symptoms of stress do you most often experience? (You can select more than one answer)
    * Shortness of breath
    * Excessive sweating
    * Lack of concentration
    * Increased blood pressure
    * Diarrhea
    * Vomiting
    * Headache
    * Stomach pain
    * Insomnia
    * Eating disorders
    * Decreased libido
    * Bad mood
    * No symptoms
    * Other
27. In stressful situations, can you count on support?
    * Yes
    * No
28. From whom do you receive support in stressful situations? (You can select more than one answer)
    * Family members
    * Partner
    * Friends and acquaintances
    * Psychologist
    * None of the above
    * Other
29. How do you cope with stress? (You can select more than one answer)
    * Use of substances
    * Sports
    * Gambling
    * Entertainment
    * Spending time with friends
    * Time with family
    * Talking to a psychologist

30. How often do you seek help from loved ones in stressful situations?
    * Always
    * 1
    * 2
    * 3
    * 4
    * 5
    * Never
31. Are you aware that as a student at WUST you can access free psychological help?
    * Yes
    * No
32. Do you use the free psychological help offered by WUST?
    * Yes
    * No
33. Do you think that prolonged stress can lead to depression?
    * Yes
    * No
    * Not sure
34. Do you think that prolonged stress can cause heart disease and hypertension?
    * Yes
    * No
    * Not sure
35. Do you think stress can be motivating for learning?
    * Yes
    * No
    * Not sure
36. Do you think stress is an inseparable element of studying?
    * Yes
    * No
    * Not sure
37. Do you know of any methods of dealing with stress undertaken at the Faculty of Geoengineering, Mining and Geology? (You can select more than one answer)
    * Support from mentors or psychologists
    * Proper relationships between students and professors
    * Adherence to student rights
    * Well-planned work schedule
    * Sense of security
    * None of the above
38. Do you expect other forms of support for stress from the Faculty authorities?
    * Yes
    * No

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THE PERCEPTION OF GENDER EQUALITY ON THE LABOUR MARKET IN POLAND

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Purpose: The article aims to analyse the society's perception of gender equality, with particular emphasis on opinions on women's and men's access to equal professional, educational and career development opportunities in the context of management. It also addresses the impact of gender stereotypes on career choices and the perception of the roles of women and men in organisations, particularly in relation to personnel decisions, promotion and management structure. The study aims to identify potential barriers and challenges in the field of gender equality in organisations and to suggest actions that may contribute to their elimination.
Design/methodology/approach: The first part of the article included a literature review, which introduced the concept of stereotype and the aspect of unequal gender perception in professional and private life. At a further stage, the answers obtained from respondents, related to the perception of roles and equality between women and men, were analysed. For this purpose, the results of a survey carried out at the end of 2024 were used.
Findings: The conducted study revealed that the Polish society still notices gender inequalities on the labour market, especially in the context of access to high-level positions and remuneration. The respondents note persisting gender stereotypes that affect the perception of women's role in professional and family spheres, especially in the context of maternal responsibilities. Despite these challenges, the study also shows a growing awareness of the need for gender equality, including expectations for a more balanced division of work and parenting responsibilities.
Research limitations/implications: The analysis of the study results indicates that gender inequalities and stereotypes regarding the roles of women and men still pose a challenge in human resources management. The respondents notice inequalities in the access to positions, remuneration and promotions, which affects management efficiency. Therefore, it is necessary to implement diversity management strategies that promote the equality of opportunities. The study should be extended to include analyses of management policies and should also take into account the perspective of employers and managers. The study was a pilot one, therefore no limitations were identified during its implementation.
Social implications: The results of the conducted research indicate that the phenomenon of gender inequality is a common problem that causes negative emotions in society. This situation demonstrates the need to develop a strategy that could prevent such practices and at the same time reduce prejudice.

Originality/value: The considerations contained in the paper emphasise the problem of gender inequality on the labour market, including discrimination of women and men in various professional aspects. This work is addressed to employees, employers and people involved in management, who have a key role in eliminating stereotypes and implementing gender equality policies in the workplace.
Keywords: Gender stereotypes, professional roles, family roles, equal opportunities for women and men.
Category of the paper: Research paper**.**

1. Introduction

Stereotypes can be defined as thought patterns common in a given social group, which result from a simplified perception of reality - both in relation to social and cultural phenomena, as well as specific groups of people. They are often associated with value judgments based on prejudices and incomplete knowledge (Warszewska-Makuch, Mockałło, 2019, pp. 15-19). Among all stereotypes, we can distinguish those that are beliefs and prejudices about the characteristics, roles and behaviours that society assigns to women and men. These opinions shape the way we perceive and evaluate people depending on their gender, and they also influence expectations regarding their social, professional and family roles (Wolak-Libuszowska, 2024, pp. 263-271). In the context of gender equality and stereotypical perceptions of women and men in the labour market, the literature on the subject widely discusses phenomena such as discrimination, differences in pay and limited opportunities for promotion (Dudak, 2019, pp. 33-38).

An important issue related to the stereotypical role assignment is the division of professions into "typically female" and "typically male" (Andraszczyk, Szymczak, 2017, pp. 433-437). This phenomenon is manifested by occupational segregation, i.e. the tendency to overrepresent or underrepresent women or men in specific industries or occupational groups. This also frequently applies to specific positions in organisational structures (Coron, Clotilde, 2025). As noted by Coron and Clitilde (2025), women are more likely to choose professions that are less prestigious, less well-paid, do not require high qualifications, and offer limited opportunities for advancement and low requirements in terms of time availability and further education. The research conducted by Heilman and Okimoto (2007, pp. 81-92) shows that women who achieve success in fields perceived as masculine, such as technology or engineering, often encounter scepticism and their achievements are less appreciated than men's successes in the same fields. On the other hand, in professions considered "feminine" (e.g. teachers or nurses), men encounter similar difficulties in gaining recognition and professional respect. Women in managerial positions often face higher requirements and a more stringent evaluation of their competences compared to men (Flood et al., 2021, pp. 593-608). Many organisations still prefer a "masculine" leadership style based on authority, dominance

and competition, while female managers more often use a transformational style based on cooperation, empathy and relationship building (Gurung, 2025, pp. 147-159). Although the transformational style is increasingly recognised as more effective in managing modern organisations, women often encounter the so-called double standard effect – they are criticised for both being too decisive (when they behave like a stereotypical male leader) and for being indecisive (when they display traits stereotypically attributed to women) (Grunow et al., 2018, pp. 42-60).

Gender stereotypes also influence educational choices. Boys and girls are often guided into different areas of study based on stereotypical beliefs about their “natural” abilities. Studies show that girls are less likely to choose technical and scientific fields, which are seen as the domain of men, and men are less likely to choose fields related to care and education, which are seen as "feminine" (Sax, 2008).

Despite strong stereotypes, a gradual change in the perception of gender roles has been visible in recent years. Women and men are increasingly questioning traditional roles (Yu, 2025, pp. 165-171). More and more men are involved in raising children and sharing household responsibilities, which contributes to a change in the perception of a man's role in the family (Hochschild, Machung, 2012). Similarly, the influence of gender stereotypes in the workplace is decreasing, especially in the context of recruitment and performance appraisals. A research on gender equality policies in organisations shows that greater awareness of stereotypes and their impact on staffing decisions leads to more equitable treatment of employees (Koch et al., 2015, pp. 989-1014).

Modern organisations are increasingly taking steps to eliminate barriers resulting from gender stereotypes by implementing diversity management strategies (Sukiennik, Dziadkiewicz, 2024, pp. 527-541). One of the key solutions is the introduction of transparent promotion and remuneration procedures, which allows to minimise the impact of subjective assessments and biases, and thus increase fairness in making personnel decisions (Kabus et al., 2024, pp. 307-309). Mentoring and development programmes also play an important role, supporting women in acquiring leadership skills and helping them overcome barriers to advancement. Thanks to them, the number of women in managerial positions increases, which has a positive impact on the gender balance in management structures (Koch et al., 2015, pp. 989-1014). Another important aspect is the work-life balance policy, which enables both women and men to combine their professional and private lives in a more flexible way. Conveniences such as flexible working hours, the possibility of remote work or parental leave mean that professional and family responsibilities can be shared more fairly, which helps to equalise opportunities on the labour market (Pfeffer et al., 2016, pp. 652-672). An important element of activities for gender equality are also trainings in the field of unconscious biases, which increase managers' awareness of stereotypes and their impact on decisions regarding recruitment, promotion and remuneration of employees. Thanks to this type of initiatives,

organisations can more effectively eliminate barriers that hinder the professional development of both women and men (Koch et al., 2015, pp. 989-1014).

These activities show that contemporary companies increasingly recognise the need to implement strategies that support gender equality and minimise the impact of stereotypes on the functioning of an organisation (Sukiennik, Dziadkiewicz, 2024, pp. 489-503). As a result, they contribute not only to greater fairness in the workplace, but also to improving the efficiency and innovation of the entire company. Promoting equality and informing about the harmfulness of stereotypes also translates into the awareness of the entire society (Stewart et al., 2021).

2. Methods

In order to analyse the perception of gender equality in the labour market in Poland, with particular emphasis on social opinions regarding education, discrimination and professional roles, a survey was conducted in 2024. The survey questionnaire consisted of a main part, including 6 questions, and a personal data part. The answers to the questions were constructed according to a Likert scale, to which appropriate values were assigned, namely:

- I strongly disagree – 1.
- I tend to disagree – 2.
- I have no opinion – 3.
- I tend to agree – 4.
- I strongly agree – 5.

The research group consisted of both women (52.22%) and men (47.22%). The subjects of the study (i.e. the respondents) represented various levels of education – most people had secondary education (43.89%), followed by primary education (31.39%). 28.33% of the respondents had higher education, and 20.83% had vocational education.

In terms of age, the majority of participants were at the age of 36-45 (30.56%) and 46-55 (25.83%). The group also included younger people – 18.33% were aged 26 to 35, and 6.11% were aged 18-25. People over 56 years of age constituted a smaller percentage, and the least numerous group were people under 18 years of age (1.11%).

Taking into account the place of residence, 58.33% of respondents indicated an urban commune, 23.33% an urban-rural commune, and 14.17% a rural commune.

The subjects of the study were selected randomly. 370 people took part in the research. The research group was diverse in terms of gender, age and level of education, which allowed for a broad perspective on the analysed issues.

3. Results and discussion

The issue of gender equality in the labour market represents a significant area of research in the context of contemporary challenges in human resource management and the implementation of diversity and inclusion strategies within organizations. This study aimed to assess public opinions on equal professional opportunities for women and men. The collected data provide valuable insights into how this phenomenon is perceived by respondents. The analysis and interpretation of the findings are presented in the following sections of the article.

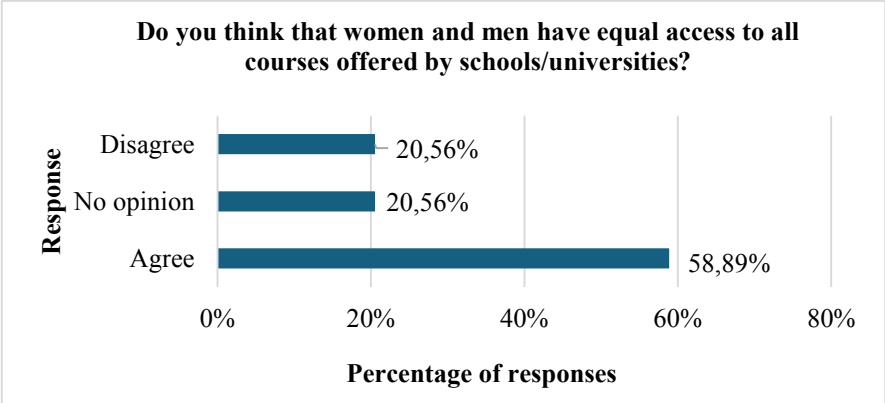

Figure 1. Assessment of equal access to courses offered by universities.

Source: Own study.

The analysis of the perception of the issue of equal access for women and men to all courses or fields of study offered by schools and universities presents an interesting picture of the perceived state of educational reality. The majority of respondents (58.89% in total) expressed the opinion that women and men have equal opportunities to pursue studies in any field. 42.50% of the respondents answered "I tend to agree" and 16.39% "I strongly agree", which indicates faith in an education system that does not place barriers for any gender, regardless of whether it is in fields traditionally considered to be male, such as science of technology, or professions within uniformed schools.

However, the survey results also show that 20.55% of respondents (14.44% “I tend to disagree” and 6.11% “I strongly disagree”) perceive some gender-related restrictions in access to education. This indicates that there are still stereotypes in society, which can affect the educational choices of women and men.

It is worth noting that 20.56% of the respondents had no clear opinion on this issue. Part of society may not perceive this problem as significant or does not notice it in their everyday lives. There may also be an insufficient level of awareness regarding the impact of gender stereotypes on educational choices, especially in the context of less visible barriers. Additionally, some respondents may perceive the education system as already balanced, which leads them to overlook the existing challenges related to gender equality.

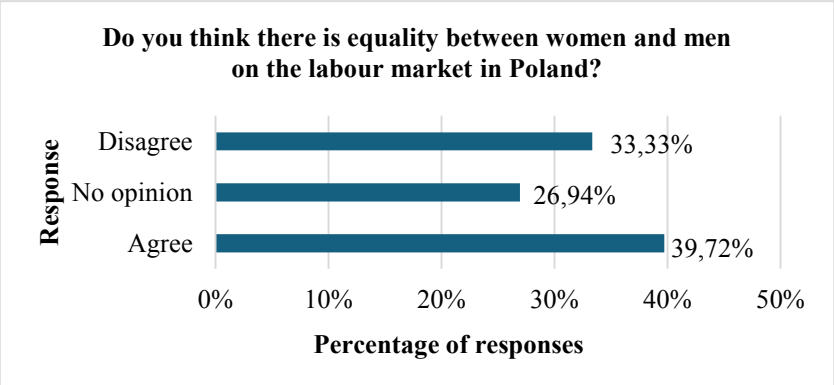

Figure 2. Perception of equality between women and men on the labour market.
Source: Own study.

The subjects' responses to question 2 indicate that despite ongoing social changes and growing awareness of gender equality issues, a significant part of society still perceives inequalities on the labour market. Only 39.73% of the respondents believe that women and men have equal opportunities in their professional lives.

More than 33% of the respondents indicate that equality has not yet been achieved. These results confirm that many people notice persistent barriers for women in the professional sphere.

It is worth emphasising that these inequalities may result not only from structural factors, such as a lack of transparency in promotions and remuneration systems, but also from deeply rooted gender stereotypes. Heilman and Okimoto's research (2007, pp. 81–92) shows that women who achieve success in professions traditionally perceived as "masculine" often face more scepticism and harsher judgment than their male counterparts. Moreover, the mechanisms related to the so-called "glass ceiling" (Flood et al., 2021, p. 593-608) make it difficult for women to achieve the highest career levels, which contributes to the maintenance of the gender-based professional hierarchy. At the same time, studies show that women are more likely to work in sectors with lower prestige and lower salaries, which additionally affects the perception of their position in the labour market (Otterbach et al., 2021).

In the context of gender equality policies, more and more organisations are implementing diversity management strategies such as mentoring programmes, transparent promotion systems or trainings in the field of unconscious bias (Koch et al., 2015, pp. 989-1014). Their purpose is not only to eliminate the existing inequalities, but also to change the social perception of gender roles. Nevertheless, as the study results show, these actions have not yet led to full equality, and beliefs still play a significant role in shaping women's situation in the labour market.

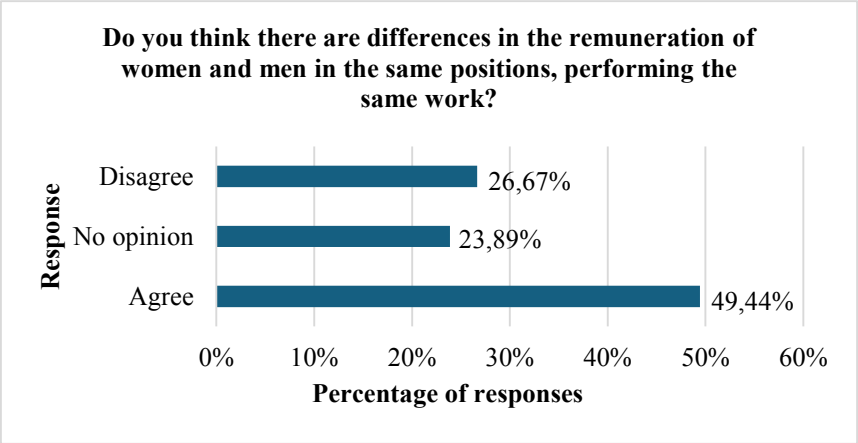

Figure 3. Perception of the gender pay gap.

Source: Own study.

The analysis of the study results shows that 49.44% of the respondents see differences in the remuneration of women and men holding the same positions (i.e. pay gap), which is an important signal about the continuing problem of pay inequality in Poland. However, only 29.17% of the subjects believe that salaries are equal, which suggests that the belief in actual pay equalisation is still not widespread.

The phenomenon of gender pay gap is well documented in the literature on the subject. Studies show that women still earn less than men, even after taking into account the level of education, professional experience and the nature of the job performed (Priyashantha et al., 2021). In Poland, according to the data from the Central Statistical Office (GUS, 2023), the pay gap is approximately 10-20%, depending on the industry and the position level.

An important aspect of the problem is also pay discrimination, which may be a result of both unconscious biases and structural barriers in remuneration systems. As the research by Koch et al. (2015, pp. 989-1014) shows, decisions regarding pay and promotions are often based on subjective evaluations by superiors, which may lead to the perpetuation of inequality. Solving the problem of pay gap requires both legislative action and social change. Introducing transparent remuneration systems, such as the obligation for companies to report pay differences, can help identify and eliminate disparities (Kabus et al., 2024, pp. 307-309).

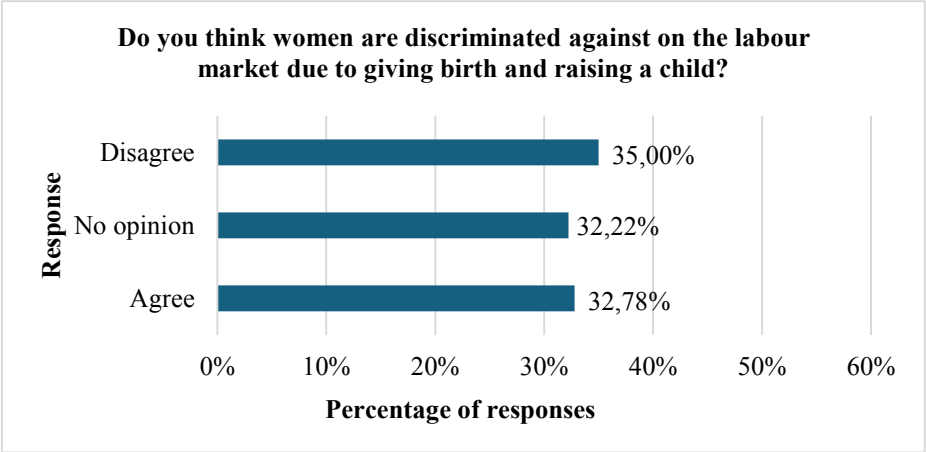

Figure 4. Perception of discrimination against women on the labour market due to having a child. Source: Own study.

The results associated with the fourth question indicate varied attitudes towards the problem of discrimination against women on the labour market related to birth and raising a child. 32.78% of the respondents notice this problem, which indicates a significant number of people aware of the difficulties that women may encounter after giving birth. On the other hand, 35% of the respondents feel that they tend to disagree or strongly disagree with this statement, which suggests that for many people this topic is not an important issue in the context of gender equality in the labour market. A group that constitutes 32.22% has no opinion on this subject, which may result from a lack of personal experience in this matter, insufficient awareness of discrimination related to motherhood, as well as a lack of an educated view of the mechanisms of the labour market functioning from a gender perspective. Additionally, insufficient awareness of the problem may result from a lack of knowledge about the mechanisms of the labor market from a gender perspective and the impact of motherhood on women's career advancement. Some individuals may also not perceive this issue as significant, believing that legislative changes, such as maternity leave or flexible working hours, have resolved the problem of discrimination against mothers in the labor market.

Women who have become mothers often face negative professional consequences, both in terms of promotions and salaries (Steckermeier, Delhey, 2019, p. 143). Employers fear that women who have children may require more flexibility in their working hours or will be less available professionally, which affects their perceived value as employees (Salter, 2016, p. 73). The prejudice about women's limited availability after childbirth often leads to lower chances of promotion and fewer opportunities for professional development (Sax, 2008).

Despite the introduction of legal regulations granting flexible working hours or parental leave, many companies still do not offer sufficient support to employees who are raising children, which may lead to the perception that a woman, especially after maternity leave, is less effective at work (Pfeffer et al., 2016, pp. 652-672). Employers' concerns about reduced productivity due to caring responsibilities continue to be present in many industries and influence decisions about women's hiring, promotion and pay (Sng et al., 2024, pp. 477-507).

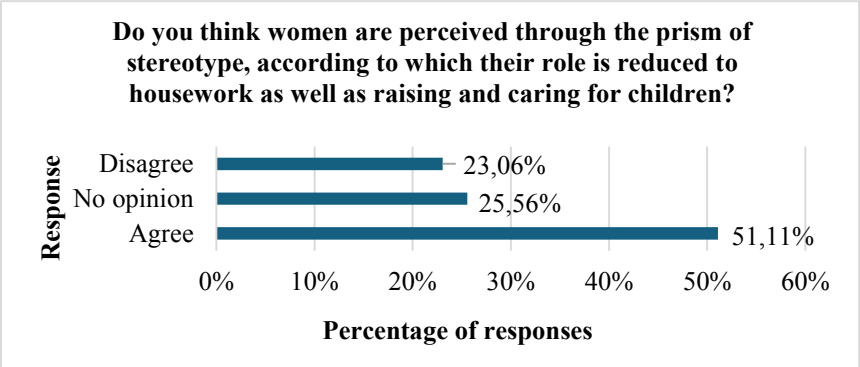

Figure 5. Perception of women through the prism of stereotype, according to which their role is reduced to housework as well as raising and caring for children.

Source: Own study.

The analysis of data regarding the perception of women through the prism of stereotypes related to housework and childcare indicates a significant impact of this phenomenon on the social perception of gender roles.

A total of 51.11% of the respondents (17.78% – "I strongly agree" and 33.33% – "I tend to agree") think that women are perceived stereotypically, which suggests that the belief in traditional roles assigned to women still persists in Polish society. On the other hand, 23.06% of the respondents do not agree with this statement (20.28% – "I tend to disagree" and 2.78% – "I strongly disagree"). The percentage of people who have no opinion on the subject is also significant (25.56%). This may indicate a lack of a clear position in society or insufficient awareness of the problem. In some cases, this may result from a lack of direct experience with such stereotypes or from the belief that changes in society, particularly regarding gender roles, have already progressed sufficiently, making this issue less relevant. Additionally, some respondents may not notice this phenomenon in their daily lives or may feel that they do not have enough knowledge to express an opinion on the matter.

The results indicate that the stereotypical perception of women as being mainly responsible for housework and childcare is still prevalent, although there are groups which notice some changes in this regard.

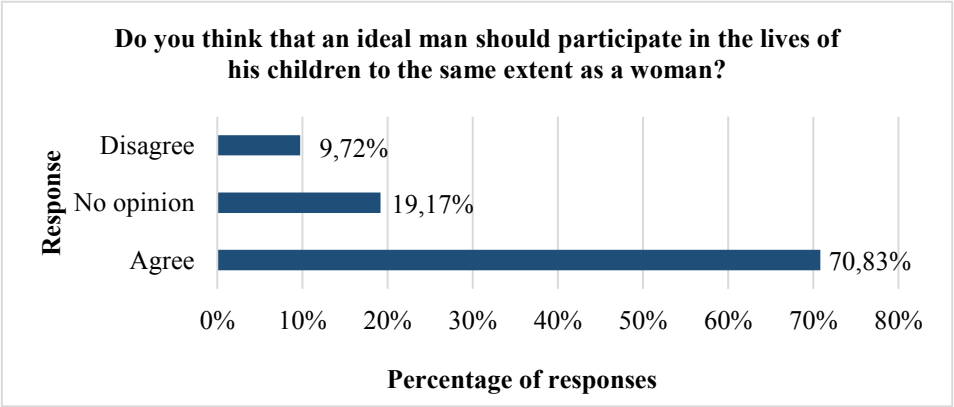

Figure 6. Perception of a man's participation in family life.

Source: Own study.

According to the survey results, 70.83% of the respondents believe that men should participate in the lives of their children to the same extent as women, both at the upbringing stage and in everyday duties related to paternity leave, parental leave and sick leave. The society is becoming more and more aware of the need for an equal division of responsibility between parents. Modern families are increasingly forced to share professional and family responsibilities, and therefore the expectations towards fathers are becoming more diverse and are extending to educational aspects.

However, the change in parental roles in the context of raising children does not only concern fathers' participation in everyday duties, but also a change in the perceived family model in a broader social context (Smirthwaite, 2009). In the traditional division of roles, the woman was responsible for taking care of the children, while the man focused mainly on providing the means to support the family. However, from a modern perspective, both parents are responsible for raising a child, which results not only from social needs, but also from economic realities in which both must participate on the labour market to ensure the financial stability of the family.

4. Summary

Summarising the study results, it can be noted that the society in Poland sees progress in the field of gender equality, but there are still serious barriers and stereotypes that affect women and men's access to equal professional, educational and labour market opportunities. On the one hand, the majority of respondents believe that women and men have equal opportunities to undertake studies in various fields, which suggests ongoing changes in the perception of equality in higher education. On the other hand, the findings indicate existing inequalities in access to work, differences in wages and persistent stereotypes related to gender role in the labour market. It was also noted that despite the wide acceptance of the idea of gender equality in education, there is still a belief that women have limited professional opportunities. The findings indicate the society's belief in pay inequality, where women, despite doing the same work, still earn less than men. These problems are often related to deeply rooted gender stereotypes and the so-called "glass ceiling" that hinders the advancement of women to top positions.

Despite these difficulties, the study results indicate a clear trend of changing social attitudes. Modern society is becoming more and more open to gender equality, both in the sphere of education and in the labour market. An important signal is also the acceptance of the idea of equal division of parental responsibilities, where men are increasingly perceived as active participants in their children's lives. These social changes have a huge impact on management in organisations, which are increasingly implementing diversity strategies and programmes

supporting gender equality. Although progress has been made in gender equality, there are still many barriers and inequalities which require further action by educational institutions, employers and society itself. Further education, changing stereotypical attitudes and introducing systemic solutions supporting equality in organisations will be crucial for the full implementation of gender equality in Poland.

The situation of women and men on the labour market, especially in the context of persistent gender stereotypes, should become the subject not only of scientific research, but also of considerations by employers and management organisations. It is an undeniable fact that the success of an organisation largely depends on the ability to use the potential of individuals with diverse intellectual, physical and mental characteristics, as well as a rich reservoir of knowledge and experience.

Employers who wish to support equality and build an inclusive work environment should take concrete actions. A key step is the implementation of transparent rules for remuneration and promotion, which help eliminate pay disparities and subjective evaluations. It is also recommended to organize training sessions on gender stereotypes and unconscious bias, particularly for managerial staff.

It is equally important to create parent-friendly workplace policies—such as flexible work arrangements, equal treatment of women returning from maternity leave, and the promotion of fathers' involvement in childcare. Employers should support women's professional development through mentoring programs and regularly analyze internal data for gender-based disparities. Equality should not only be a value but also an integral part of management strategy, shaping organizational culture, company reputation, and long-term effectiveness.

In subsequent stages, the research should be expanded to include a more nuanced analysis of demographic variables, particularly the age and cultural background of participants, which may significantly influence the perception and interpretation of gender stereotypes within the context of corporate environments. Incorporating these dimensions will allow for a more comprehensive understanding of the phenomenon, taking into account its complex socio-cultural underpinnings. Furthermore, it is recommended that the perspective of individuals in managerial positions be included in future analyses. This will enable the identification of potential discrepancies in the perception of gender stereotypes between management and non-managerial staff, thereby contributing to a deeper understanding of gender role dynamics within organizational structures.

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POLITICAL BUDGET CYCLE AND FINANCIAL PERFORMANCE OF LOCAL GOVERNMENT: AN INTERNATIONAL PERSPECTIVE

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Purpose: The purpose of this article is to identify an influence of the political budget cycle (PBC) on the financial performance of local government sector in OECD countries against the background of socio-economic and institutional conditions.
Design/methodology/approach: The literature on the subject was studied to present the specific effect of the election cycle on the financial condition of local government. Then, longitudinal data models were estimated, i.e. fixed effects models, random effects models, panel quantile regressions with fixed effects using the method of moments, based on data on the local government sector in 28 OECD countries for the period 2007-2022.
Findings: The study shows that local government elections affect the financial performance of the local government sector in OECD countries, i.e. both the revenue and expenditure side of the budget, as well as the deterioration of the fiscal balance. However, in the post-election year this balance improves. This is an expression of opportunistically motivated fiscal policies at the sub-national level.
Research limitations/implications: Theoretically, the paper advances understanding of an impact of the socio-economic and institutional circumstances, as well as the potential interactions of certain factors, on the fiscal sustainability. Although the study did not find a statistically significant effect of the level of democracy on fiscal balance, its higher level mitigates the negative impact of local elections on the fiscal sustainability of the local government sector.
Practical implications: The PBC phenomenon in the local government sector intensified in economies with less sustainable local public finances. Practically, the study identifies areas of policymakers' activities that can be supervised in order to maintain sound public budgets.
Social implications: It is crucial to strengthen the principles of democracy, especially the aspects of free and fair elections, the greater scope of which does not restrain the authorities to raise local taxes during elections.
Originality/value: There is a dearth of surveys studying an impact of the election cycle on the financial performance of the local government sectors from the international perspective due to the scholars concentrate on the national context.
Keywords: political budget cycle, local government, fiscal balance, elections, democracy.
Category of the paper: Research paper.

1. Introduction

The notion on an influence of politicians on the voting behavior through the economic instruments was proposed by Nordhaus (1975, pp. 169-189). According to his concept, incumbent politicians seeking re-election would behave opportunistically by promoting expansionary economic policies prior to elections (Klein, Sakurai, 2015, p. 21). Therefore, their decisions are biased against future generation. This mechanism is studied within the political budget cycle (PBC) theory, which emphasizes sphere of fiscal instruments (Filipiak, Kluza, 2022, p. 1058). This concept assumes that before the elections there is a greater probability of a decrease in the tax burden (lower budget revenues) and an increase in public spending, which results in a deterioration of fiscal balance (e.g. larger budget deficit) and greater debt (Swianiewicz et al., 2019, p. 464). Therefore, the policy of the incumbent, who might have an incentive to use fiscal instruments during election years to increase chances for reelection, adversely affects fiscal sustainability. Simultaneously, this sustainability should be restored after the elections (Ebeke, Ölçer, 2017, pp. 63-72). Nevertheless, it has been empirically proven that the appearance of the PBC may depend on numerous factors, i.e.: economic development, level of democracy, government transparency (Kang, 2025, p. 141), political system (Köppl-Turyna et al., 2015, p. 790), government's ideology (the partisan cycle model) (Klein, Sakurai, 2015, p. 22) or the case of single-party in comparison to coalition governments (Benito et al., 2013, pp. 6-29). Thus, democracy, seen in Schumpeter's approach as an institutional arrangement determining political decision-making (Schumpeter, 2003, p. 269; Elliott, 1994, p. 290), together with the features of the electoral system, may affect the PBC phenomenon. Therefore, the scholars indicate that the PBC does not vanish in countries with more mature democracies and more experienced behavior of voters (Furdas et al., 2015, pp. 2-26), although democracy may lead to an increase of the public spending (Ferraz et al., 2015, pp. 750). Guo (2009, p. 630) adds that in China local leaders also have an incentive and capacities to manipulate public expenditures during their tenure to improve the chances for political advancement. Furthermore, the level of transparency moderates the magnitude of PBC over time and across economies, and this relationship is stronger for advanced than for developing countries (Herzog, 2017, p. 683). This phenomenon may appear in every institutional and political system and is a part of the research on fiscal federalism (Köppl-Turyna, 2016, p. 177; Trzeciakowski et al., pp. 1-3). Besides, there is a strict relationship between democracy and fiscal rules (Beyala, Owoundi, 2025), the relaxation of which affects the financial performance of local governments in the election cycle (Giacobbe, Ordine, Rose, 2024). As a result, democracy and fiscal rules are substitutes to achieve fiscal discipline (Beyala, Owoundi, 2025).

However, the scholars indicate that the number of findings on the political cycle related to local public finances is still very modest compared to studies referring to the national level (Swianiewicz et al., 2019, p. 465). There is also a dearth of surveys examining the impact of

the election cycle on the performance of the local government sectors from an international perspective. This could reveal the similarity of the PBC mechanism for individual countries to the trend in the entire local government sector and help introduce policies aimed at increasing the rationality of fiscal decisions. It results from the fact that the PBC determines instability in the sphere of public finance, which leads to inefficiencies in the allocation of resources. This, in turn, may require imposing additional fiscal rules on the management of municipal finances (Veiga, Veiga, 2007, p. 63) to decrease the impact of the PBC (Bonfatti, Forni, 2019, p. 1). Therefore, the purpose of this article is to identify the influence of the political budget cycle on the financial performance of local government sector in OECD countries against the background of socio-economic and institutional conditions. The research hypothesis assumes that the election cycle determines tax revenues and capital expenditures and then the fiscal balance of the local government sector. Thus, the novelty of the article is the examination of the PBC in an international perspective and the consideration of the impact of socio-economic and institutional aspects on the financial outcomes of the local government and potential interactions within certain explanatory variables, using longitudinal models. The originality of the study also lies in revealing the mechanism of the impact of the level of democracy or certain features of the election system on the fiscal sustainability of the local government sector in context of the existence of the PBC. In turn, the application of the panel quantile regressions allowed the estimation of the PBC across the distribution of the fiscal sustainability of the local government sector.

2. The importance of the political budget cycle for local government budgets

In the subject literature, there is a view about the impact of the election cycle on the fiscal situation of the public sector. Therefore, in the miscellaneous studies the scholars develop the concept of political budget cycle (PBC), within which majority of the findings concerns the national perspective (Budzeń, Wiśniewski, 2024, p. 181). These research studies reveal that politicians might influence the voting behaviours at the local level through the financial policy in the sphere of revenues and expenditures and by means of shaping the fiscal balance or debt.

As far as the revenue side of the local budgets is concerned there are certain findings of the PBC in this field. Analysing Brazilian municipalities Sakurai & Menezes-Filho (2011, p. 242-245) found a decline of local tax revenues in election years, whereas in German and Canadian local governments the authorities are reluctant to increase tax rates before elections (Furdas et al., 2015, p. 26; Kneebone, Mckenzie, 2001, p. 771). Similarly, Alesina, Paradisi (2017, pp. 157-174) proved that in the Italian local governments, the closer to a new election, the lower the tax rates were chosen in these units. In the other study on Italian local governments, it was

verified that revenues from the property tax and user fees and charges significantly decreased just before elections (Ferraresi, 2021, p. 1150). Moreover, Bracco et al. (2024, p. 339) also revealed a decrease of municipal solid waste fee revenues and property tax revenues in pre-election years in Italian municipalities. In turn, Swianiewicz & Kurniewicz (2015, pp. 70-75) confirmed the existence of this cycle in service charges in Poland, mainly in the case of public transport ticket prices, and less in municipal housing rents.

The phenomenon of PBC also appears in the expenditures side of local public budgets. Rosenberg (1992, p. 79) found that in pre-election periods, expenditure on the development of local governments deviates significantly from normal levels. Simultaneously, incumbents who did not run for re-election were found to deviate significantly more from their pre-election discretionary spending than incumbents who ran for re-election. The findings of Nazir et al. (2022, p. 364) show that at the sub-national level in Pakistan expenditures are systematically reduced in post-election years and then increase gradually. This mainly stems from increased capital expenditures (Olejnik, 2022, p. 496), especially on construction (Furdas et al., 2015, p. 26) and infrastructure investments (Veiga, Veiga, 2007, pp. 60-63), which are very visible to the electorate and signal greater competences in pre-election periods. Since investments tend to materialize in election years, this is evidence of political rent-seeking and a general argument for term limits in local governments (Filipiak, Kluza, 2022, p. 1076). Moreover, researchers also examine the PBC in some spending categories, including education, culture and transport, waste management, public safety (Swianiewicz et al., 2019, p. 465) or wages (Olejnik, 2019, p. 198). Incumbents also tend to increase discretionary spending ahead of elections, which include grant spending, social assistance, financial assistance expenditures. Hence, the opportunistic motive to win the election is underlined (Darmastuti, Setyaningrum, 2021, pp. 378-388). In consequence local authorities may change their budget composition by reducing current expenditures and increasing capital investments (Klein, Sakurai, 2015, p. 34).

As a result of modifications in revenue and expenditure policy, the size of the budget balance and debt is also affected by the election cycle. Działo et al. (2019, p. 1050) displayed that in Poland the municipal authorities strategically use the deficit and the debt to influence voting behaviours. Moreover, Budzeń & Wiśniewski (2024, p. 190) estimated that, in Poland at the local level, both in the election year and in pre-election year, the value of financial liabilities to total assets increased. Similarly, Mourão et al. (2023, p. 30) display the presence of PBC in Croatian local government debt, arguing that in pre-election and election years, this debt is higher and enables politicians to increase the quantity and quality of local services. Hence, the factor affecting the growth of debt is the desire to complete the investment before the elections in the context of impressing the voters, as indicated by Brusca et al. (2015, pp. 475-481) in connection with the research on Valencia's local governments in Spain. This increase of indebtedness may change the level and composition of local revenues. In Spain, municipalities with greater debt level collect less revenue from fines (Benito et al., 2021, p. 8). The study of Setiawan & Rizkiah (2017, p. 543) on Indonesian local government also shows

an increase in local budget deficit in election years, resulted from an increase of total expenditures. Similarly, Rakhman & Saudagaran (2023, p. 518) found that at the local level in Indonesia both lower budget surplus and cash holdings occurred due to higher spending in the run-up to the elections. In addition, a negative impact of the election year on the budget balance in the local government sector in Poland was presented by Galiński (2021, p. 3962). Sakurai & Menezes-Filho (2011, p. 234) also revealed a growth of Brazilian municipal deficits resulted from an increase of total and current expenditures and a fall of local tax revenues. Referring to the impact of fiscal rules on debt and deficit, Vicente et al. (2013, p. 52) show that after the introduction of these instruments in Spain in Budgetary Stability Law, local governments ceased manipulating debt as a mechanism to increase their chances of staying in power. However, this did not reduce the size of the deficit cycle due to the lack of penalization. So, politically more polarized and fiscally less transparent countries record cycles in budget balance in the election years (Mačkić, 2014, p. 11). On the other hand, legal requirements regarding the use of budget funds in election campaigns may be violated (Crispim et al., 2021, p. 137).

Summarizing the above findings, it is clear that researchers focus on identifying the relationships between PBC and specific budget indicators. However, the election cycle influences other qualitative circumstances of the functioning of local government, which may lead to modifications in the budget structure. Moreover, the budgetary impact of PBC may also result from the institutional status in the area of democracy. Therefore, there is a research gap to consider other institutional factors along with PBC to verify the actual relationship between these factors.

3. Methodology and Data

The aim of the empirical study is to determine the impact of the local election cycle, and a set of certain economic, financial, and institutional ratios, on specific indicators characterizing the financial performance of the local government sector in the OECD countries (table 1, figure 1). Taking into account the availability of data for the period 2007-2022 and the specificity of the institutional system, the variables were extracted from the databases of: the OECD, the World Bank as well as the V-Dem and Economist Intelligence Unit, processed by Our World in Data, and other resources concerning the local election cycle in the countries.

Because of the purpose of empirical study and data, panel models were applied. The simplest estimator for this kind of data is the pooled OLS (Ordinary Least Square) model, which assumes that all coefficients in the model are the same across all units and periods. However, relaxing this restriction leads to a fixed effects model (FEM) (1) (Brooks, 2019, pp. 491-493):

$$Y_{it} = \alpha + X'_{it}\beta + u_i + v_{it}, \quad (1)$$

where:

Y_{it} is the dependent variable for the country i in the period t,

α represents the intercept term,

X_{it} is a $k \times 1$ vector of explanatory variables observed for the studied OECD country i in the period t,

β is a $k \times 1$ vector of the parameters to be estimated on the explanatory variables (table 1),

u_i is an individual specific effect,

v_{it}, is the 'remainder disturbance'.

In turn, the random effects model (REM) (2) takes a form (Brooks, 2019, p. 500):

$$Y_{it} = \alpha + X'_{it}\beta + \varepsilon_i + v_{it}, \quad (2)$$

in which the new cross-sectional error term, ε_i, has zero mean, is independent of the individual observation error term (v_{it}), has constant variance φ_ε^2 and is independent of the explanatory variables (X_{it}) (table 1).

The application of the certain type of the longitudinal model resulted from the Wald test, the Breusch-Pagan Lagrange Multiplier test and the Hausman test (the choice between FEM and REM). In the model estimation the problems of the heteroscedasticity (Breusch-Pagan test) and the serial correlation (Breusch-Godfrey test) were also verified. Therefore, clustered standard errors were applied (Croissant, Millo, 2018, pp. 94-101; Gehrke, 2019, pp. 101-118; Verbeek, 2022, pp. 19-51; Cottrell, Lucchetti, 2024, pp. 219-224; Galiński, 2023c, p. 119).

Due to the aim of the study and the verification of the stability of the results, a panel quantile regression with fixed effects using the method of moments, i.e., method of moments-quantile regression, (MM-QR) (Machado, Santos Silva, 2019, pp. 145-173; Rios-Avila, 2020), was applied. In this type of the longitudinal model, it is estimated the conditional τ-th quantiles $Q_Y(\tau|X)$ for location-scale model, which takes a formula (Machado, Santos Silva, 2019, pp. 146-148):

$$Y_{it} = \alpha_i + X'_{it}\beta + (\delta_i + Z'_{it}\zeta)U_{it}, \quad (3)$$

with $P\{\delta_i + Z'_{it}\zeta > 0\} = 1$. In the model (3) the parameters (α_i, δ_i), $i = 1, \ldots, n$, capture the individual i fixed effects; U is an unobserved random variable; in turn Z is a $k \times 1$ vector of known differentiable (with probability 1) transformations of the components of X with element l given by $Z_l = Z_l(X)$, $l = 1, \ldots, k$; ζ *is a* $k \times 1$ vector of additional parameters. Simultaneously, the Wald test was estimated to check the significance of the MM-QR (Koengkan et al., 2023, pp. 263-265; Galinski, 2024, pp. 88-89).

To identify the factors (a local election cycle and other socio-economic and institutional characteristics) influencing the financial performance of the local government sector in the analysed countries (figure 1), a set of variables was used (table 1). There were applied three dependent variables (table 1), i.e.: 1) local government tax revenues as percentage of GDP (*TAXES*), 2) local government investment spending as percentage of local government total

expenditures (*INVEST*), 3) net lending/net borrowing of local government as percentage of GDP (*BALANCE*), which represent the revenue and expenditure side of the local budget and the fiscal balance. In turn, a set of independent variables (table 1) includes:

- election year (*ELECT*), pre-election year (*PRE-ELECT*), post-election year (*POST-ELECT*) to identify the phenomenon of the political budget cycle;
- control variables: (a) GDP growth, % (*GDPGR*); (b) inflation, % (*INFL*); (c) unemployment rate, % (*UNEMPL*); (d) demographic situation: population ages 0-14 as % of total population (*PRE-WORK*), or population ages 65 and above as % of total population *(POST-WORK*) to take into account the impact of socio-economic conditions on the financial performance of the local government sector;
- decentralization, which is decomposed as: (a) fiscal decentralization in the sphere of the revenues (*REVDEC*), (b) institutional (political) decentralization through the use of strong elected local governments index (*SLG*) as a measure of the strength of local government. In addition, an interaction (*REVDEC×SLG*) between the revenue decentralization and the strength of local government is examined;
- free and fair elections index (*FAIRELECT*);
- democracy index (*DEM*) and an interaction between the local election year and the democracy index (*ELECT×DEM*).

Table 1.
Characteristics of variables used in the regressions and codes for the OECD countries studied

Variable (definition)	Label	Argumentation for application and specificity	Source
Dependent variables			
Local government tax revenues as % of GDP	*TAXES*	It shows the tax inflows in relation to the size of the economy and reveals the general direction of local government tax policy (Dahal, 2020, p. 81).	OECD (2024a, 2024b)
Local government investment spending as % of local government total expenditures	*INVEST*	The principal measure of the local government investment activity (Siwińska-Gorzelak et al., 2020, p. 663).	OECD (2024c)
Net lending/net borrowing of local government as % of GDP	*BALANCE*	This ratio is used as a dependent variable to identify factors influencing the fiscal balance of local government. Moreover, a fiscal balance is perceived as a measure of fiscal sustainability (Galiński, 2023b, pp. 40-46).	OECD (2024)
Independent variables			
Election year/ pre-election year/ post-election year	*ELECT/ PRE-ELECT/ POST-ELECT*	These variables represent the typical way to identify an impact of the election cycle on the explanatory variable. In each regression only one dummy variable was applied, which took the value 1 if election/pre-election/post-election year at the local government level appears, or the value 0 if not. These variables are included in the research studies on investment spending (Ryu et al., 2022, p. 352; Vicente et al., 2013, p. 50; Filipiak, Kluza, 2022, p. 1069), fiscal balance (Galiński, 2023b, p. 50) and the PBC is considered within the tax revenues (Swianiewicz et al., 2019, pp. 464-465).	Other
GDP growth, %	*GDPGR*	The economic growth in the country determines the fiscal categories in the field of tax revenues in general (Đurović Todorović et al., 2024, p. 6.), local investment spending (Ryu et al., 2022, p. 352; Siwińska-Gorzelak et al., 2020, p. 651), and then the fiscal balance of the local government (Galiński, 2023b, p. 48).	World Bank (2024)

Cont. table 1.

Inflation, %	*INFL*	An inflation has an impact on the financial situation of local government (Martell, 2024, p. 235; Galiński, 2023b, pp. 49-55).	World Bank (2024)
Unemployment rate, %	*UNEMPL*	Due to the specific nature of local budgetary inflows and tasks, the unemployment rate may affect both tax revenues (Benabdellah, Fahim, 2024, pp. 1036-1037), and investment expenditures (Vicente et al., 2013, pp. 49-50) at the subnational level.	World Bank (2024)
Population ages 0-14 as % of total population/population ages 65 and above as % of total population	*PRE-WORK/ POST-WORK*	The demographic structure and its changes may affect the tax revenues in general due to an impact on the economic activity and tax bases (Dougherty at al., 2022, p. 27), as well as the local government investment spending (Ryu et al., 2022, p. 352, Siwińska-Gorzelak et al., 2020, p. 651).	World Bank (2024)
Local government revenues as % of total general government revenues	*REVDEC*	This ratio shows the extent of the fiscal decentralization (Schneider, 2003, p. 41) in the country, which might affect the fiscal position of the local government in the field revenues (Benabdellah, Fahim, 2024, pp. 1036-1037), expenditures, and fiscal balance (Sow, Razafimahefa, 2017).	OECD (2024)
Strong elected local governments index	*SLG*	This index displays information on the extent to which citizens elect local governments which are free from the influence of unelected local actors except for courts. This ranges from 0 to 1 (strongest extent). This shows the institutional scope of decentralization.	V-Dem. (2024)
Local government revenues as % of total general government revenues × Strong elected local governments index	*REVDEC× SLG*	This represents an interaction between the revenue decentralization and the strength of local government. Kyriacou & Roca-Sagalés (2011, p. 210) considered an interaction between fiscal and political decentralization.	OECD (2024) V-Dem. (2024)
Free and fair elections index	*FAIRELECT*	Good governance mechanisms, such as accountability instruments that include free and fair elections, are essential to counteract corruption (Chen, Ganapati, 2023, p. 260) determining the fiscal balance at the local government level (Galiński, 2023b, p. 61). This index, from 0 to 1 (most free and fair), informs about the extent to which election violence, government intimidation, fraud, large irregularities, and vote buying are absent.	V-Dem. (2024)
Democracy index	*DEM*	There is an ongoing debate on the relationship between democracy and PBC (Furdas et al., 2015, pp. 1-26) or democracy and fiscal sustainability (Ferraz et al., 2015, p. 750). Beyala & Owoundi (2025) found that democracy and the fiscal rules are substitutes in the process of attaining fiscal discipline. In this way, democracy creates institutional principles that allow for the adjustment of some legal solutions to protect fiscal sustainability. This measure of the level of democracy, which ranges from 0 to 10 (most democratic), combines information on the extent to which citizens can choose their political leaders resulted from free and fair elections, enjoy civil liberties, prefer democracy over other political systems, can and do participate in politics, and have a functioning government that acts on their behalf. The index for 2007 and 2009 was not published, so the method of the mean of nearby points was applied to fill the missing values (George, Mallery, 2020, p. 64).	EIU (2025)
Election year × Democracy index	*ELECT×DEM*	This represents the interaction between the local government election year and the democracy indicator to estimate the potential moderating effect of democracy in an election year on the financial situation of local government.	EIU (2025) Other
Codes for the 28 OECD countries			
BEL, CHL, CRI, CZE, DNK, EST, FIN, FRA, GRC, HUN, ISL, IRL, ISR, JPN, KOR, LTU, LVA, LUX, NLD, NZL, NOR, POL, PRT, SVK, SVN, ESP, SWE, TUR			

Source: own elaboration.

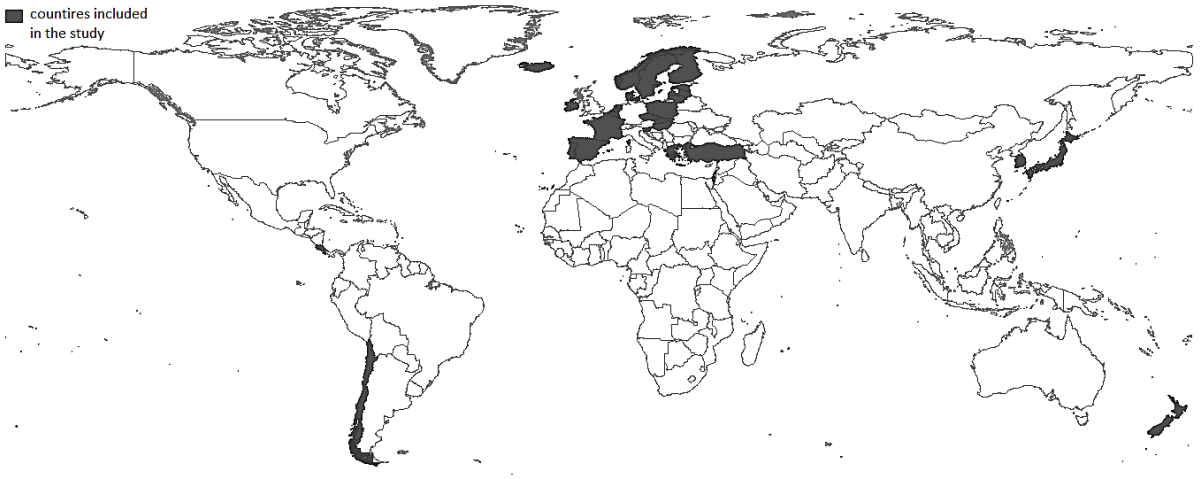

Figure 1. Map showing OECD countries included in the empirical study.
Source: own elaboration based on the map retrieved from (Opendatasoft, 2024).

During the estimation process, only statistically significant coefficients were included in the final models. Therefore, the pre-election year was not presented in the regressions, and the models consist of a different set of variables.

The empirical study was conducted on a sample of 28 OECD countries (figure 1, table 1). The application of these states was based on the availability of comparable data and the specifics of the local government elections (local election cycle) that can be coded using a dummy variable in the longitudinal regressions. Therefore, the use of these 28 OECD countries (figure 1, table 1) allows for the identification of the occurrence of the political budget cycle in the local government sector and its impact on the financial results of the public sector under study.

4. Results and Discussion

The descriptive statistics show that the 28 OECD countries studied differ in the field of local government budget performance, economic and demographic condition, and the scope of fiscal decentralization between 2007 and 2022 (table 2). There are significant differences in the fiscal balance, as a principal measure of fiscal sustainability (Galiński, 2023b, p. 39), and disparities in the extent to which citizens elect local authorities which are independent in policy decisions.

Table 2.
Summary statistics for the analysed OECD countries for the period 2007-2022

No.	Variable	Obs	Mean	SD	Min	Max
1	*TAXES*	448	3.8717	3.7510	0.1953	15.7063
2	*INVEST*	438	18.7498	8.3002	3.5694	51.0511
3	*BALANCE*	441	-0.0181	0.6058	-1.7972	3.2228
4	*GDPGR*	448	2.1242	3.9212	-14.8386	24.4753
5	*INFL*	448	2.9638	4.7046	-4.4781	72.3088
6	*UNEMPL*	448	7.8594	4.4053	2.0150	27.6860
7	*PRE-WORK*	448	17.3518	3.5890	11.5716	28.2973
8	*POST-WORK*	448	16.4454	4.3144	6.0421	29.9246
9	*REVDEC*	414	12.7298	8.2128	2.4900	33.9400
10	*SLG*	448	0.9574	0.0474	0.6730	0.9970
11	*REVDEC×SLG*	414	12.2714	8.0938	2.2996	33.6673
12	*FAIRELECT*	448	0.9291	0.0880	0.3480	0.9760
13	*DEM*	448	8.1086	1.0165	4.0900	9.9300
14	*ELECT×DEM*	448	1.8579	3.4599	0	9.9300

Source: own elaboration in STATA 17.0 based on OECD (2024a, 2024b, 2024c) – No. 1-3, 9; World Bank (2024) – No. 4-8; V-Dem. (2024) – No. 10-12; EIU (2025) – No. 13-14.

Table 3.
Diagnostic tests for the regressions

Test/Model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Wald test	2 448.99 [<0.01]	2 534.34 [<0.01]	61.71 [<0.01]	32.48 [<0.01]	30.58 [<0.01]	26.81 [<0.01]
Breusch-Pagan Lagrange Multiplier test	3 185.54 [<0.01]	3 292.89 [<0.01]	1 924.61 [<0.01]	920.28 [<0.01]	857.73 [<0.01]	936.55 [<0.01]
Hausman test	2.61 [0.63]	1.74 [0.78]	2.41 [0.49]	31.44 [<0.01]	35.91 [<0.01]	20.05 [<0.01]
Breusch-Pagan test for Heteroskedasticity	305.77 [<0.01]	298.23 [<0.01]	340.28 [<0.01]	206.53 [<0.01]	210.64 [<0.01]	283.39 [<0.01]
Breusch-Godfrey test for serial correlation	148.02 [<0.01]	147.07 [<0.01]	142.07 [<0.01]	72.43 [<0.01]	76.20 [<0.01]	83.08 [<0.01]

Note: 1) under the level of the statistics there are p-values in brackets […].

Source: own elaboration in STATA 17.0 and RStudio.

According to the characterized methodology, based on the diagnostic tests (table 3), firstly six models with different sets of variables were estimated (table 4), i.e. three random-effects models (model 1, model 2, model 3) and three fixed-effects models (model 4, model 5, model 6), which include only statistically significant predictors. In turn, tests for heteroskedasticity (Breusch-Pagan test) and autocorrelation (Breusch-Godfrey test) (table 3) resulted in the use of clustered standard errors in the final estimations (table 4).

Table 4.
Estimation results for the longitudinal data models

Independent variable	Model 1 (REM)	Model 2 (REM)	Model 3 (REM)	Model 4 (FEM)	Model 5 (FEM)	Model 6 (FEM)
	Dependent variable					
	TAXES	***TAXES***	***INVEST***	***BALANCE***	***BALANCE***	***BALANCE***
ELECT	-0.0283* (0.0142)	-0.0282** (0.0140)	0.7612** (0.2970)	-0.1630*** (0.0334)	-0.7401** (0.3223)	-
POST-ELECT	-	-	-	-	-	0.0591* (0.0331)

Cont. table 4.

GDPGR	-	-	-	0.0195*** (0.0040)	0.0190*** (0.0038)	0.0140** (0.0057)
INFL	-0.0125*** (0.0044)	-0.0118** (0.0050)	-	-0.0190** (0.0077)	-0.0191** (0.0078)	-0.0222*** (0.0067)
UNEMPL	0.0146* (0.0087)	-	-0.3486*** (0.1164)	-	-	-
POST-WORK	-		-0.7461 (0.2495)***	0.0934*** (0.0238)	0.0957*** (0.0241)	0.0786*** (0.0230)
PRE-WORK	-0.1278* (0.0453)	-0.1413*** (0.0450)	-	-	-	-
REVDEC	-	-	-	0.6495** (0.3152)	0.6597* (0.3353)	-
SLG	-	-	-	4.1507* (2.1115)	3.9059* (2.0984)	-
REVDEC×SLG	-	-	-	-0.5983* (0.3212)	-0.6090* (0.3454)	-
FAIRELECT	-	0.9457* (0.5166)	-	-	-	-
DEM	-	-	-	-	0.0408 (0.1284)	-
ELECT×DEM	-	-	-	-	0.0710* (0.0396)	-
Intercept	6.0186*** (1.2925)	5.4854*** (1.2595)	33.7284*** (5.1158)	-6.3863*** (2.1661)	-6.5189** (2.8451)	-1.2988*** (0.3736)
Obs	448	448	438	410	410	441
Within R^2	0.1595	0.1593	0.1294	0.2509	0.2580	0.1450
F/Wald test	[<0.01]	[<0.01]	[<0.01]	[<0.01]	[<0.01]	[<0.01]

Note: 1) ***, ** and * denotes statistical significance at 1%, 5% and 10% levels respectively; 2) cluster standard errors in parentheses (…); 3) p-value in brackets […].

Source: own elaboration in STATA 17.0.

The outcomes of the empirical models (table 4) show that the election year (*ELECT*) determines the financial performance of the local government sector in the OECD countries. Firstly, it influences a decrease in the share of local government tax revenues in GDP (*TAXES*, model 1). During the elections, the public authorities are not willing to increase the tax burden. Secondly, it affects an increase in the local government investment spending in total expenditures (*INVEST*, model 3). Since the local governments have high control over capital expenditures, they are opportunistically managed. Thus, this extends the studies of Filipiak & Kluza (2022, p. 1076), Olejnik (2022, p. 508) or Andonoska (2022, pp. 381-386) who found this relationship in the specific countries. Simultaneously, these findings are consistent with the view that voters prefer candidates who incur higher spending or provide tax reductions prior to elections because this indicates their high managerial competencies (Działo et al., 2019, p. 1036). Finally, in the election year the fiscal balance deteriorates (*BALANCE*, model 4, model 5), whilst in the post-election year this category improves (model 6). In the second case, the expiry of the fiscal relaxation occurs after elections in order to restore fiscal sustainability, which was also empirically proven by Ebeke & D. Ölçer (2017, p. 72) at the central level. The election year therefore affects the loosening of fiscal policy, whereas fiscal tightening is resumed in the next budgetary year. In this way, the fiscal balance is used in opportunistically motivated local fiscal policies aimed at promoting expansionary policies during the period of

the local voting. As a consequence, this may encourage the use of off-budget instruments (Kluza et al., 2024).

As far as the economic and institutional issues are concerned, they also determine the financial performance of the local government sector. An increase of inflation influences a decrease of local government tax revenues in GDP (model 1), and deteriorates a fiscal balance (model 4, model 5, model 6). In addition, the higher the unemployment rate (*UNEMPL*) and the share of post-working age population (*POST-WORK*) the lower the share of the capital spendings in the total expenditures. Therefore, an increase in the share of the population ages 65 and above affects the fiscal balance improvement (model 4, model 5, model 6). Regarding the share of the pre-working age population, its growth affects a decrease of the share of local tax revenues in GDP.

The empirical study (table 4) also shows that an increase in revenue decentralization (*REVDEC*) and strong elected local governments index (*SLG*) affect an improvement in the fiscal balance. The model 4 and the model 5 also reveal a statistically significant impact of the interaction between revenue decentralization and strong elected local governments index (*REVDEC*×*SLG*) on the level of the fiscal balance. In consequence, an increase in fiscal decentralization improves the fiscal balance, but this impact is smaller the greater the *SLG* in the country. This indicates that the positive impact of fiscal decentralization on the fiscal balance is larger at the beginning of the decentralization process. Therefore, it is crucial to prepare the appropriate foundations for the devolution of financial competences. This applies to the principle of adequacy of financial resources in the process of delegating tasks. It results from the fact that without adequate funds local authorities cannot exercise their right to local self-governing (Boggero, 2018, p. 298). Hence, the lack of sufficient revenues to meet the expectations of local communities contributes to the growth of deficit and risk of loss of fiscal sustainability. In addition an improvement of the 'free and fair elections' (*FAIRELECT*) contributed to an increase of the local government tax revenues as % of GDP (model 2), maintaining fiscal sustainability. As far as the level of the democracy is concerned, it affected the fiscal balance by mitigating the negative impact of local elections (*ELECT*×*DEM*, model 5). The study did not find that democracy (*DEM,* model 5) itself had a statistically significant impact on the balance. However, in countries with a higher democracy index, the negative impact of the election year on the fiscal balance was therefore smaller. Therefore, strengthening democracy, which has a direct relationship with fiscal rules (Beyala, Owoundi, 2025), leads to a reduction in actions easing fiscal discipline in the election cycle.

Table 5.
Estimation results for MM-QR models

Variable/ Test	Quantiles			Quantiles			Quantiles		
	25th	50th	75th	25th	50th	75th	25th	50th	75th
	Model 7MM-QR Independent variable: *BALANCE*			Model 8MM-QR Independent variable: *BALANCE*			Model 9MM-QR Independent variable: *BALANCE*		
ELECT	-0.1816*** (0.0367)	-0.1615*** (0.0324)	-0.1442*** (0.0409)	-0.8103*** (0.2708)	-0.7331** (0.3206)	-0.6719 (0.4111)	-	-	-
POST-ELECT	-	-	-	-	-	-	0.0882** (0.0382)	0.0558* (0.0315)	0.0294 (0.0346)
GDPGR	0.0168*** (0.0059)	0.0197*** (0.0037)	0.0222*** (0.0036)	0.0162*** (0.0058)	0.0193*** (0.0035)	0.0216*** (0.0036)	0.0135* (0.0072)	0.0141** (0.0055)	0.0145** (0.0060)
INFL	-0.0257*** (0.0073)	-0.0184** (0.0076)	-0.0121 (0.0087)	-0.0263*** (0.0073)	-0.0184** (0.0079)	-0.0122 (0.0090)	-0.0267*** (0.0058)	-0.0217*** (0.0069)	-0.0175** (0.0081)
POST-WORK	0.1028*** (0.0266)	0.0926*** (0.0227)	0.0838*** (0.0206)	0.1073*** (0.0255)	0.0945*** (0.0230)	0.0844*** (0.0227)	0.0882*** (0.0255)	0.0775*** (0.0220)	0.0688*** (0.0203)
REVDEC	0.5765 (0.3796)	0.6554** (0.3028)	0.7236*** (0.2554)	0.5960 (0.3905)	0.6660* (0.3208)	0.7215** (0.2859)	-	-	-
SLG	3.4430 (2.6352)	4.2079** (2.0260)	4.8694*** (1.6027)	3.3448 (2.5325)	3.9615** (2.0032)	4.4511*** (1.6850)	-	-	-
REVDEC ×SLG	-0.5255 (0.3919)	-0.6042** (0.3080)	-0.6722*** (0.2545)	-0.5460 (0.4059)	-0.6153* (0.3299)	-0.6703** (0.2900)	-	-	-
DEM	-	-	-	0.0719 (0.1396)	0.0377 (0.1238)	0.0105 (0.1290)	-	-	-
ELECT× DEM	-	-	-	0.0777** (0.0324)	0.0704* (0.0394)	0.0645 (0.0512)	-	-	-
Wald test	[<0.01]	[<0.01]	[<0.01]	[<0.01]	[<0.01]	[<0.01]	[<0.01]	[<0.01]	[<0.01]

Note: 1) ***, ** and * denotes statistical significance at 1%, 5% and 10% levels respectively; 2) clustered standard errors in parentheses (…); 3) *p*-value in brackets […].

Source: own elaboration in STATA 17.0.

On the other hand, public spending discipline and continued budget deficit reduction are justified as necessary to return the government to a better implementation of its policy priorities, considering the principle of intergenerational fairness (Dyson, 2004, p. 191). Deficits and rising public debt can transfer the tax burden to future generations and threaten the sustainability of public finances (Catrina, 2013, p. 171). Simultaneously, incumbents tend to increase capital expenditure, especially through additional debt, which is consistent with findings of Crispim et al. (2021, pp. 136-137). This relationship also determines the risk of lack of the financial liquidity and then the fiscal distress (Galiński, 2023a, p. 70), which undermine sustainable development.

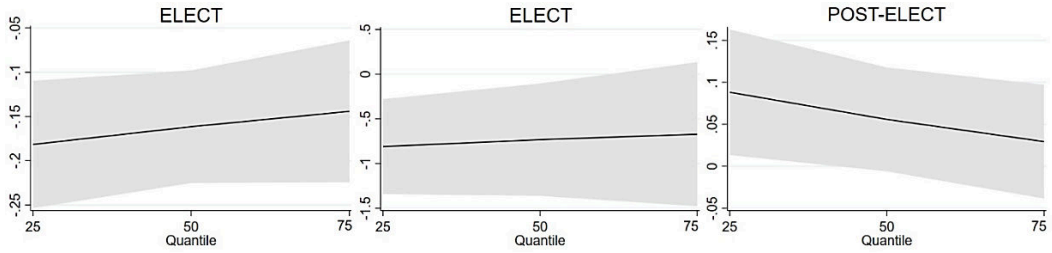

Figure 2. PBC coefficients (black lines) at the background of 95% confidence intervals (grey areas) in the Models: 7MM-QR (ELECT), 8MM-QR (ELECT), 9MM-QR (POST-ELECT) across quantiles.

Source: own elaboration.

The panel quantile regressions with fixed effects (MM-QR models: model 7MM-QR, model 8MM-QR and model 9MM-QR; table 5), estimated for the set of variables of FEM (i.e. model 4, 5 and 6; table 4), also show an impact of the PBC on the fiscal balance against the background of socio-economic and institutional conditions. Simultaneously, the results on 25th, 50th and 75th quantile regressions (table 5) represent the distribution of OECD countries with low, median and high fiscal sustainability path respectively. In consequence, the PBC phenomenon in the local government sector intensified in economies with less sustainable local public finances. The higher the fiscal balance the lower implication of the election (negative impact; model 7MM-QR and model 8MM-QR) and post-election (positive impact; model 9MM-QR) years on the fiscal balance (table 5; fig 2). Furthermore, the sound fiscal situation of the local government sector protects these units from the deterioration of the socio-economic and institutional conditions. Thus, rising inflation poses greater risks to local government sector with larger deficits, while more unbalanced local government finances benefit less from improved economic growth in the process of enhancing the fiscal sustainability (table 5).

5. Conclusions

The financial performance of the local government sector is determined by various factors in terms of socio-economic, institutional and political conditions. In the latter case, the phenomenon of the political budget cycle (PBC) is indicated. This study also reveals that the local elections affect the financial performance of the local government sector in the OECD countries. It concerns both the revenue and expenditure side of the budget. Therefore, there is both the election-motivated decrease of the local tax revenues and increase of the capital spendings, which result in the deterioration of the fiscal balance. This balance is then improved in the post-election year. Hence, the research hypothesis was positively verified.

The findings are consistent with the classical PBC view that elections see a decline in tax revenues and an increase in capital expenditure, leading to a deterioration in the fiscal balance (Klein, Sakurai, 2015, p. 26). This is an expression of opportunistically motivated local fiscal policies, which are aimed at increasing the chances for the re-election. Simultaneously, the study research confirms the notion that office-oriented politicians may use their local budgeting competences to pursue their own agenda (Köppl-Turyna, 2016, p. 177) to enhance the appearance in the eyes of voters. This creates a pressure to ease fiscal policy in the upcoming election campaign. On the one hand, it is justified to introduce specific fiscal rules or institutional arrangements, including number of terms in office, to protect fiscal sustainability of the local government sector and the intergenerational fairness. On the other hand, politically motivated actions are consistent with assumptions of the sustainable development. Nevertheless, the introduced fiscal rules ought to be in practice accompanied by regulations

concerning their non-compliance due to the growing likelihood of resistance to specific norms in election years.

However, the level of tax burden and capital spending of the local government sector is also determined by the economic and demographic condition in the country. This also applies to the fiscal balance, which is additionally influenced by the degree of decentralization. The study proved that an increase of fiscal decentralization and institutional strength of local government affected an improvement of the fiscal balance. In this context, it is important to maintain the principle of financial adequacy in the division of public tasks between central and local governments. Incumbents tend to increase capital spending during election periods, despite the growing risk of the reduced fiscal sustainability. Politically motivated financial decisions (especially capital spendings) may result in an unfavourable expenditure structure, e.g. through a strong increase in current expenditures because of the use of a newly created investment. This in turn may disrupt financial liquidity of the local government and increase an exposure on the fiscal distress. It is therefore important to develop investments that support revenue generation to reduce this risk, not undermine intergenerational equity, or excessive use of off-balance instruments that may reduce the transparency of the local public finance. In addition, some fiscal anchors on the expenditure side of the budget could prevent the build-up of imbalances. Researchers may seek to establish ceilings on expenditure increase that do not threaten stability.

The study also extends the remarks of Furdas et al. (2015) in the sphere of the impact of the level of the democracy and the fairness of the elections on the fiscal sustainability. Mechanisms that increase transparency of elections contribute to improving the fiscal balance, while higher level of the democracy mitigates the negative effect of the PBC on the local finances. Hence, the increase in voter awareness results from access to information about budget decisions made during local government elections and, together with the improvement of democracy institutions, may influence the better financial performance of local government sector even in more mature democracies. As a result, strengthening civil society institutions in practice may limit the PBC. It is therefore justified to support watchdog institutions in the field of financial audit. Hence, there is space to study the impact of these issues on the budget and to formulate new theoretical conclusions. To sum up, the sound fiscal situation of the local government results from economic, political and institutional issues and an improvement of the fiscal sustainability strengthens resistance to the effects of the PBC.

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KNOWLEDGE-SHARING NETWORKS OF HIGHER EDUCATION INSTITUTIONS FOR INNOVATION AND ENTREPRENEURSHIP: EVIDENCE FROM THE "DISCO" PROJECT CASE STUDY

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Purpose: The aim of this article is to assess the impact of the inter-organisational collaboration and knowledge-sharing networks among the higher education ecosystems on higher education institutions' (HEIs') innovation potential, based on the DISCO project case study.
Design/methodology/approach: The study is based on the self-assessment tool named HEInnovate which was used by higher education institutions (HEIs) engaged in the project to compare the 'before' and 'after' results. Its eight dimensions were integrated with theoretical dimension from the heuristic framework providing a structured way to measure the impact of inter-organisational collaboration on the innovation potential of HEIs.
Findings: This study affirms that higher education innovation is best understood as a networked, collaborative, and evolving process. The presented case study of the DISCO project shows the benefits of cooperation among HEIs from different countries, with different levels of development, innovation and entrepreneurship support.
Research limitations/implications: The model offers a valuable structure for further comparative analysis across HEI collaboration projects in different regional or disciplinary settings. It also provides a foundation for developing longitudinal impact tracking tools that combine self-assessment data with network analytics and case-based learning.
Practical implications: Based on the DISCO project's positive impact on the participating HEIs' innovation potential, the authors provide practical recommendations regarding e.g. focus on digital development, joining the leading entrepreneurial ecosystems, investing in further entrepreneurial support successes and continuing the innovation labs.
Social implications: The heuristic framework helps to interpret institutional change more holistically and serves as a guide for both practitioners and policymakers aiming to foster sustainable and scalable innovation in higher education across Europe.
Originality/value: Within this heuristic framework, we draw upon a selection of complementary theories and concepts—such as stakeholder theory, co-production and co-creation, knowledge transfer and management, innovation ecosystems, platform theory and

living labs - to understand the mechanisms and impact of HEI collaboration in the field of innovation and entrepreneurship education based on the specific case study.
Keywords: Higher Education Institutions, international cooperation, management in higher education, innovation, innovation ecosystems.
Category of the paper: case study.

1. Introduction

In a time of rapid societal transformation, digital disruption, and urgent sustainability challenges, collaboration among European higher education institutions (HEIs) has become essential for advancing innovative and entrepreneurial education that prepares students to navigate and shape an uncertain future (Guererro et al., 2024; Syed et al., 2023). This paper attempts to answer the research question of how international collaboration in networks of higher education institutions (HEIs) and the development of joint activities along clearly defined entrepreneurial HEI development and reflection categoriesfields can influence can influence the innovativeness and entrepreneurship support capabilities of these organisations. Specifically, the article examines the impact that international collaboration within the framework of a European project can have on the entrepreneurial and innovative potential of on the innovation potential of HEIs,higher education institutions (HEIs). ISpecifically, it summarises by analysing the results of the HEInnovate self-assessments conducted by the HEIs participating in the DISCO (Developing Innovative Sustainable Cooperation Opportunities) project, which was co-financed by the EIT-HEI Initiative.

The EIT HEI Initiative – *Innovation Capacity Building for Higher Education* (EIT HEI Initiative, 2025; Volkert, Bunescu, 2024) – is designed to enhance innovation and entrepreneurial capacity in higher education by fostering integration across HEIs, industry, and societal actors in pan-European innovation ecosystems. A central guiding model is the EIT Knowledge Triangle (EIT Knowledge Triangle, 2025), which stresses the integration of education, research, and innovation to create systemic institutional transformation. Participating HEIs are expected to leverage this model alongside Smart Specialisation Strategies (S3), the Regional Innovation Impact Assessment (RIIA) Framework (Jonkers et al., 2018), and the goals of the EIT Regional Innovation Scheme (EIT RIS). Through this integrated and place-based innovation logic, projects are designed to embed higher education institutions more deeply into their regional and transnational innovation ecosystems, to leverage synergies, and to mobilise resources beyond the funding period.

Accordingly, the DISCO project aimed to strengthen the innovation capacity of European HEIs by fostering structured knowledge sharing, joint coaching formats, and entrepreneurial capacity-building through collaboration between HEIs, SMEs, and civil society actors. Through DISCO, participating HEIs not only shared best practices in entrepreneurship education and

startup coaching but also acted as knowledge hubs within a broader European co-innovation network. Each partner institution contributed unique approaches to teaching innovation and coaching student startups, and these were exchanged and adapted across borders through the DISCO platform. In doing so, the project exemplified the role of inter-HEI collaboration as an innovation ecosystem in its own right—where participating institutions co-evolved, co-created, and scaled new methods for entrepreneurship education.

This paper frames DISCO as a *higher education innovation ecosystem* (Smorodinskaya et al., 2017) - a form of co-innovation platform in which multiple HEIs, and their respective HEI-industry networks, collectively amplify their impact. As such, we understand HEI networks not just as cooperative arrangements, but as meta-structures that multiply innovation potential by interlinking university-industry ties across national boundaries, creating shared value and fostering systemic change. This framing builds on recent literature emphasising value co-creation (Cai et al., 2019), knowledge platform models (Doering et al., 2022), and the transition of universities toward entrepreneurially oriented multi-actor, open innovation institutions.

HEInnovate provided the framework to assess each HEI's institutional readiness and development in eight key areas related to innovation. As an open self-reflection tool, HEInnovate (HEInnovate, 2025) enabled HEIs to identify strengths, define priorities, and develop action plans. Completion of the HEInnovate self-assessment was a prerequisite for proposal submission, and the same tool was used post-project to assess institutional change.

This paper presents a comparative analysis of HEInnovate self-assessments conducted at the beginning and end of the DISCO project. Through this 'before-and-after' approach (Leiber et al., 2015), we aim to understand how participation in the DISCO collaboration affected each institution's perceived innovation potential. The paper also outlines the theoretical framework underpinning the project design and assumptions—including organizational network theories like stakeholder theory, co-production, co-creation, knowledge transfer, innovation ecosystems, platforms and the living lab approach. The paper concludes with an analysis of the survey results, followed by implications for future transnational collaboration among HEIs seeking to build long-term innovation capacity.

2. Methods

The central methodological idea of this research was to compare the 'before' and 'after' HEInnovate self-assessment scores of the HEIs participating in the DISCO project. While the 'before' self-assessment was predominantly completed at the proposal or project initiation stage, the 'after' self-assessment took place in May 2024, during the final phase of the project.

The HEInnovate platform offers the possibility to form groups for comparative analysis among peers. However, a key limitation in the platform's functionality is that it does not allow for multiple entries per HEI over time. This constraint limited the possibility of using the group function for longitudinal within-HEI comparisons. Additionally, the late entry of a partner institution, Sumy State University, further complicated direct comparisons.

To address these challenges, each HEI partner submitted individual self-assessments, which were then manually transferred into a shared Excel database. This facilitated data visualisation, enabled direct comparison across time points, and allowed for a more nuanced post-hoc analysis of category-level changes.

It is important to note that the HEInnovate tool has evolved over time, and changes in sub-question formulations across its eight categories prevent a reliable question-level comparison between the initial and final assessments. As such, the 'before-after' design used in this study must be interpreted at the aggregated category level for time-series analysis, with a more detailed item-level analysis only possible for the final assessment round.

Integration of a QA Impact Evaluation Perspective

To further strengthen the methodological rigour and align with broader European discussions on quality in higher education, the study also draws on the conceptual and methodological framework of impact evaluation of quality assurance (QA) as articulated by Leiber et al. (2015). This framework introduces a more comprehensive view of causality, complexity, and longitudinal change in institutional quality development.

From a QA impact evaluation perspective, the DISCO project's design aligns with a before–after comparison model, a common and pragmatic approach in higher education settings where experimental or control-group designs are typically unfeasible due to institutional and ethical constraints. According to Leiber et al., such longitudinal designs allow researchers to observe change over time, provided that a baseline (pre-intervention) and end-line (post-intervention) are clearly defined, which was achieved here using HEInnovate at two distinct project phases.

In addition, this methodology can be further understood through the lens of causal social mechanisms, as discussed in the QA impact literature. These mechanisms can be divided into:

- Situational mechanisms, such as the influence of the project's external funding and collaboration context on institutional priorities.
- Action-formation mechanisms, including internal decision-making processes triggered by the project (e.g. changes in entrepreneurial support structures, changes in HEI leadership practices).
- Transformational mechanisms, which reflect how individual or departmental-level changes scaled into broader institutional shifts, as reflected in higher HEInnovate scores.

This layered perspective acknowledges that improvements in HEInnovate scores are not simply 'outputs' but may also be indicators of mid-term outcomes and *emerging institutional impacts*, contributing to the transformation of entrepreneurial culture and practices (Wright et al., 2017).

Furthermore, embedding this QA lens enriches the interpretation of self-assessment results by stressing that impact is not linear and must consider the multi-level nature of change in higher education (from individual staff to institutional policy), as well as the contextual factors (e.g. national policies, resource availability, stakeholder engagement) which condition how QA-related interventions play out.

The use of HEInnovate itself, as a self-reflection tool, can be interpreted as part of a broader quality enhancement process. When assessed through the QA impact evaluation framework, such tools serve both a diagnostic function (revealing institutional capacities) and a developmental function (stimulating strategic reflection and change). The process of repeated engagement with HEInnovate over time can thus be seen as an example of participatory evaluation, a key feature of embedded QA cultures.

It should be noted that HEInnovate, as an institutional self-assessment platform, is designed primarily for structured reflection and strategic dialogue rather than for statistical analysis; consequently, inferential statistics (e.g., significance testing) could not be applied to the 'before and after' comparisons due to the nature of the available data.

3. Inter-Organisational Collaboration and Networked Innovation in Higher Education – Theoretical Considerations

This study frames the DISCO project and its outcomes through the lens of inter-organisational collaboration between HEIs, interpreted as a dynamic form of organisational networking. Within this heuristic framework, we draw upon a selection of complementary theories and concepts—such as stakeholder theory, co-production and co-creation, knowledge transfer and management, innovation ecosystems, platform theory and living labs - to understand the mechanisms and impact of HEI collaboration in the field of innovation and entrepreneurship education (Wright et al., 2017). HEI faculties with entrepreneurial experience play a significant role in supporting other HEI faculties who are new to the student start-up support or spin-off processes (Mosey, Wright, 2007).

Collaboration among HEIs has evolved into more than bilateral cooperation or project-based partnerships. It increasingly represents purpose-driven, networked ecosystems where universities act as co-creators of shared value within a broader innovation infrastructure (Cai et al., 2020; Doering et al., 2022). These ecosystems are essential to support both

institutional transformation and student-centred innovation formats, including startup coaching, spin-off development, and the integration of entrepreneurship into curricula.

Stakeholder Orientation as a Foundation for HEI Collaboration

Considerations regarding the types of entities with which HEIs cooperate, and the motivations for such cooperation, are widely discussed in the literature and serve as an important entry point for understanding inter-organisational collaboration. Stakeholder theory provides a foundational perspective by framing organisations as systems embedded in networks of relationships (Freeman, 1984). Freeman defines stakeholders as "any group or individual who can affect or is affected by the achievement of the organisation's objectives" (Freeman, 1984, p. 46). HEIs, in this view, must respond to the expectations and needs of diverse stakeholders—including students, academic staff, local communities, industry partners, public agencies, and policymakers (Crane, 2004; Gamble, 2001; Gianiodis, Meek, 2020).

Stakeholder-theory related research emphasizes the importance of collaboration within the broader entrepreneurial ecosystem in which the university is embedded (Bischoff et al., 2018; Gianiodis, Meek, 2020; Kuratko, 2005). Stakeholder theory in the HEI context intersects with the broader discussion on corporate social responsibility (CSR) and Environmental, Social and Governance (ESG) frameworks, which are increasingly being adopted in higher education as guiding paradigms (Guerro, Lira, 2023; Rasche, Moon, 2017). These perspectives underpin the strategic imperative for HEIs to engage in inclusive, responsive, and impact-oriented forms of innovation, particularly considering pressing societal challenges and sustainability agendas.

Co-Production and Co-Creation in the HEI Environment

In line with stakeholder-oriented thinking, the concepts of co-production and co-creation offer additional theoretical scaffolding for understanding collaborative innovation processes. Co-production, as defined by (Chathoth, 2013), refers to the firm-centric involvement of customers in the production of services, emphasizing simultaneity in production and consumption. In contrast, co-creation highlights reciprocity, interdependence, and blurred boundaries between producers, users, and stakeholders (Galvagno, 2014). This conceptual shift is especially relevant in education, where students, faculty, entrepreneurs, and external actors engage in collaborative design and delivery of innovative learning experiences.

In the context of the DISCO project, co-creation was a core operational logic: HEIs shared responsibility for designing and delivering entrepreneurial education and startup support activities, co-developing tools, coaching frameworks, and best practices. These interactions created mutually reinforcing knowledge flows and supported institutional transformation through peer learning and iterative experimentation.

Organisational Network Theory and Knowledge Transfer

The framing of HEIs as nodes in knowledge-intensive, inter-organisational networks is central to our interpretation of the DISCO collaboration. Organisational network theory (Popp et al., 2014; Provan et al., 2007) views innovation as a product of networked interdependence, where actors exchange resources, generate trust, and co-produce novel solutions. Knowledge, in this view, is not only transferred but co-developed through embedded relationships, structured interactions, and shared learning.

Recent research emphasises the multi-level nature of knowledge transfer between HEIs (Cerver Romero et al., 2021; Sjöö, Hellström, 2019) —occurring at micro (intra-institutional), meso (peer institution), and macro (societal/industry) levels (Doering et al., 2022). The DISCO project activated all three levels by enabling internal self-reflection (*via* HEInnovate), peer-to-peer exchange, and the creation of transnational coaching formats. Furthermore, the use of digital tools and shared platforms helped to institutionalise this knowledge, increasing visibility, reusability, and scalability of innovations.

HEI Innovation Ecosystems and Co-Innovation Platforms

The concept of innovation ecosystems, adapted to higher education by Cai et al. (2020) and Cai et al. (2019) provides a powerful meta-theoretical framework for understanding the structural and dynamic features of the DISCO network. Innovation ecosystems differ from traditional innovation systems in that they are based on ecological interdependence and co-evolution, rather than hierarchical coordination. HEIs, in this context, are no longer passive knowledge providers but active orchestrators of value co-creation within complex, transdisciplinary constellations of actors.

A transnational innovation ecosystem refers to the integration of two or more innovation ecosystems across national borders, each with varying degrees of transnational cooperation and coordination. To grasp the nature of such systems, it is first essential to understand the concept of an innovation ecosystem. As commonly defined, innovation ecosystems consist of "complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation" (Jackson, 2011, p. 2).

Sotarauta et al. (2016) identify several defining characteristics of innovation ecosystems, including their interconnectedness—the idea that all elements within the system are linked; their organic nature, referring to the system's capacity to evolve through continuous adaptation of its components to changing conditions; and their multi-locational structure, whereby knowledge flows and innovation processes occur across multiple geographical contexts.

DISCO can be seen as a *HEI innovation ecosystem* (Figure 1) that brought together universities, student entrepreneurs, SMEs, and non-profits to generate shared innovation outcomes. Each HEI acted as a local node with unique regional and institutional assets, but through the DISCO collaboration, these assets were mutually amplified, resulting in a

richer, more diverse and scalable innovation landscape. The project thus exemplifies how co-innovation networks can emerge from HEI collaboration, where knowledge, methods, and tools are continuously exchanged and adapted across institutional and national boundaries (Cai et al., 2019).

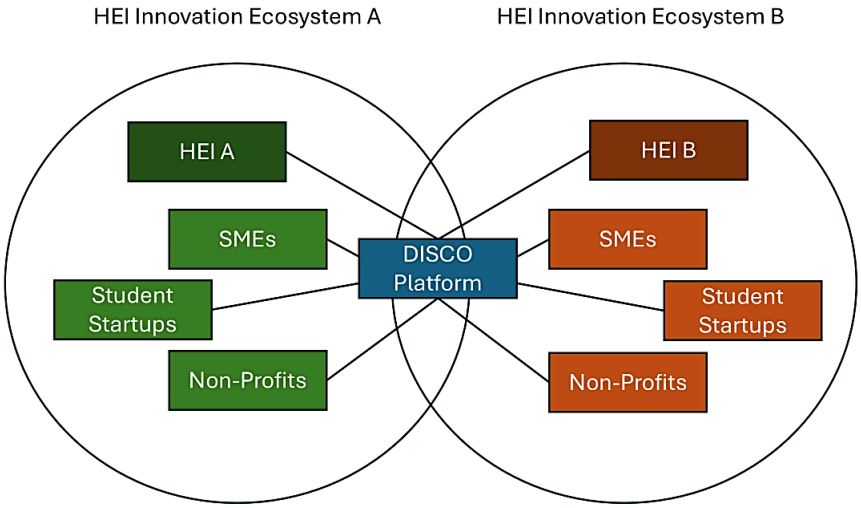

Figure 1. DISCO as a transnational HEI co-innovation ecosystem amplifying institutional assets through shared platforms and knowledge exchange.

Source: own study, based on the HEInnovate surveys conducted by analysed HEIs.

The (living) lab concept as basis for HEI cooperation

Before discussing the concept of a living lab, it is worth emphasizing that it belongs to a larger family of 'labs', which includes, among others, innovation labs, social innovation labs, community labs, gov labs or enterprise labs, to name a few. A living lab is understood as a way of actively involving the city dwellers in planning the development of the city (Mitchell, 2005) is widely discussed in the literature on the subject (Almirall, 2009; Ballon, 2005; Nyström, 2014; Paskaleva, 2015). Westerlund is indicating that living labs "... are physical regions or virtual realities where stakeholders form public-private-people partnerships (4Ps) of firms, public agencies, universities, institutes, and users all collaborating for creation, prototyping, validating, and testing of new technologies, services, products and systems in real-life contexts" (Westerlund, 2011, p. 20).

The living lab concept can be understood more broadly, not only in terms of city management but also with regards to innovative processes within organisations. Living labs can be understood as a platform for implementing the open innovation concept (Paskaleva, 2015), p. 119). In this sense (Nyström, 2014, p. 483) claim that living lab is a network of open innovation characterized by openness and user involvement. In this way, ideas for the development and implementation of innovative enterprise solutions are derived from the external environment. These processes occur in real-life environments, not in closed research laboratories (Almirall, 2009). Nyström justifies the network nature of a living lab by the

voluntary cooperation of entities having similar roles (Nyström, 2014, p. 484). The users are particularly important, being both the subject and the object in innovative processes, acting as co-creators, testers and co-producers (Ballon, 2005).

Considering the above, we can say that living lab is a voluntary network of cooperation among various entities - higher education institutions, enterprises, public entities and users (such as students, in the HEI context), with particular importance of the latter. They participate in the design, development and implementation of innovative solutions based on the experiences of everyday life. Such activities can be classified as open innovation (Chesbrough, 2003).

Platform Theory and Digital Transformation of HEI Collaboration

An important enabler of such inter-organisational collaboration is the emergence of platform-based collaboration models (Doering et al., 2022). Platforms—whether digital or hybrid—serve as intermediary spaces where knowledge, practices, and resources are exchanged among previously disconnected actors. In the context of the DISCO project, the creation of shared knowledge repositories, coaching frameworks, and joint events functioned as platform elements that facilitated cross-institutional knowledge flows. Simultaneously, the digital transformation of HEIs is reshaping how knowledge is produced, shared, and transferred. Digital platforms lower the threshold for collaboration and increase the visibility of institutional practices. They also allow HEIs to extend their third mission activities—entrepreneurship education, startup incubation, and social innovation—beyond their physical and national boundaries (Doering et al., 2021; Klofsten et al., 2019). DISCO exemplifies how digitally enabled HEI networks can drive systemic change in innovation teaching and entrepreneurial capacity-building.

Framing HEI Collaboration and Innovation: A Heuristic Model for HEInnovate Impact Analysis

Taken together, these perspectives form a heuristic framework for interpreting the results of the HEInnovate self-assessments and the transformation dynamics of the participating HEIs in the DISCO project. The theories and concepts—stakeholder orientation, co-creation, network theory, knowledge transfer, innovation ecosystems, platform collaboration and living labs—provide complementary lenses through which the institutional, educational, and strategic impact of the DISCO project can be understood.

This layered framework allows us to interpret the observed changes not only as isolated outcomes but as emergent properties of a collaborative HEI innovation network. In doing so, we aim to contribute to a deeper understanding of how European HEIs can collectively mobilize their innovation capacity through structured, networked cooperation.

4. Dimensions of the HEInnovate Framework as a Reflection Tool for HEI collaboration effectivity

To operationalize the heuristic framework developed in this chapter, we integrate the eight dimensions of the HEInnovate self-reflection tool (https://www.heinnovate.eu/en), which served as the baseline and post-assessment methodology for all DISCO project participants. These dimensions provide a structured way to measure the impact of inter-organisational collaboration on the innovation potential of HEIs. Each HEInnovate dimension can be aligned with specific components of our heuristic framework in Table 1.

Table 1.
HEInnovate dimensions

HEInnovate Dimension	Theoretical Dimension from the Heuristic Framework
1. Leadership and Governance	Stakeholder theory; innovation ecosystems require adaptive leadership to manage interdependence and external alignment.
2. Organizational Capacity	Organizational network theory; capacity is distributed across institutions and enhanced through collaboration and shared resources.
3. Entrepreneurship in Teaching and Learning	Co-creation and co-production; active student and staff participation in creating new pedagogies.
4. Preparing and Supporting Entrepreneurs	Knowledge transfer and co-innovation networks; collaborative coaching and incubation practices as transfer mechanisms.
5. Digital Transformation and Capability	Platform theory and digital transformation literature; digitally mediated collaboration enables scale, visibility, and innovation.
6. Entrepreneurial Ecosystems and Networks	Central pillar of the network perspective; peer-learning, mutual trust, and shared learning objects.
7. The Internationalized Institution	Globalised innovation ecosystems and transnational collaboration; leveraging cross-border complementarities.
8. Impact of the Entrepreneurial HEI	Governance and accountability in ecosystems; platform analytics and stakeholder-centric metrics (e.g., entrepreneurial outcomes, startup formation).

Source: own study.

Through this alignment, the HEInnovate dimensions not only serve as assessment categories but also act as analytical filters through which we can observe how theoretical principles manifest in practice. This integration allows us to use the HEInnovate results not just descriptively (as 'before and after' scores), but as evidence of how inter-organisational collaboration contributes to systemic institutional change.

In the following empirical section, we revisit the results of the HEInnovate self-assessments of the DISCO HEIs through this lens, offering a theoretically grounded interpretation of the observed shifts.

5. HEInnovate Results Summary

In this part of the article, we want to focus on a less common perspective on the effects of living lab, but not from the perspective of enterprises, but HEIs. Specifically, it is about evaluating the impact of the cooperation on the consortium members, identifying the crucial areas of improvement and the ones that need more focus in the future.

At the outset of the DISCO project, participating HEIs engaged in a structured self-assessment of their institutional innovation capacity using the HEInnovate tool. Anchored in a stakeholder- and network-oriented understanding of institutional development, this process served not only as a diagnostic instrument but also as a platform for strategic reflection and capacity mapping. By identifying both institutional strengths - seen as potential assets for knowledge sharing and peer learning - and areas requiring development, the self-assessment laid the groundwork for targeted interventions, collaborative experimentation, and the co-creation of improvement strategies across the network. In this way, the HEInnovate tool functioned as an *activation point* within a broader co-innovation ecosystem, aligning with the project's aim of fostering institutional transformation through inter-organisational learning and distributed knowledge flows.

The DISCO project baseline began with a self-assessment in which HEIs evaluated their innovative potential, using the HEInnovate tool. The process has identified both the strong points (to share and leverage) and the weak ones (to target for training and development). The initial HEInnovate self-assessments of participating HEIs are presented in Table 2.

Table 2.
HEInnovate self-assessments at a glance, before project implementation

Score	Krakow University of Economics (KUE)	Lviv Polytechnic National University (LPNU)	Lucerne University of Applied Sciences and Arts (HSLU)
Highest	Knowledge Exchange and Collaboration 4.8 Preparing and Supporting 4.7	Organisational capacity: funding, people and incentives 4.2 Preparing and Supporting entrepreneurs 4.2	Organisational capacity: funding, people and incentives 5.0 Preparing and Supporting entrepreneurs 5.0
Lowest	Organisational Capacity: Funding, People and Incentives 3.2 The Internationalised Institution 3.4	Measuring Impact 3.3 Leadership and Governance 3.4	Digital transformation and capability 4.4 The Internationalised Institution 4.0

Source: own study, based on the HEInnovate surveys conducted by analysed HEIs.

This summary underlines the differences among the engaged HEIs from Poland, Ukraine and Switzerland. Lucerne University of Applied Sciences and Arts (HSLU), as the most developed university, played a key role in sharing the good practices. However, thanks to the different experiences and national specificity of other HEIs, also HSLU was also able to improve its results.

In the following section, we present the 'before' and 'after' results of the whole HEI-part of the DISCO consortium, across eight HEInnovate categories. These are presented in Figure 2.

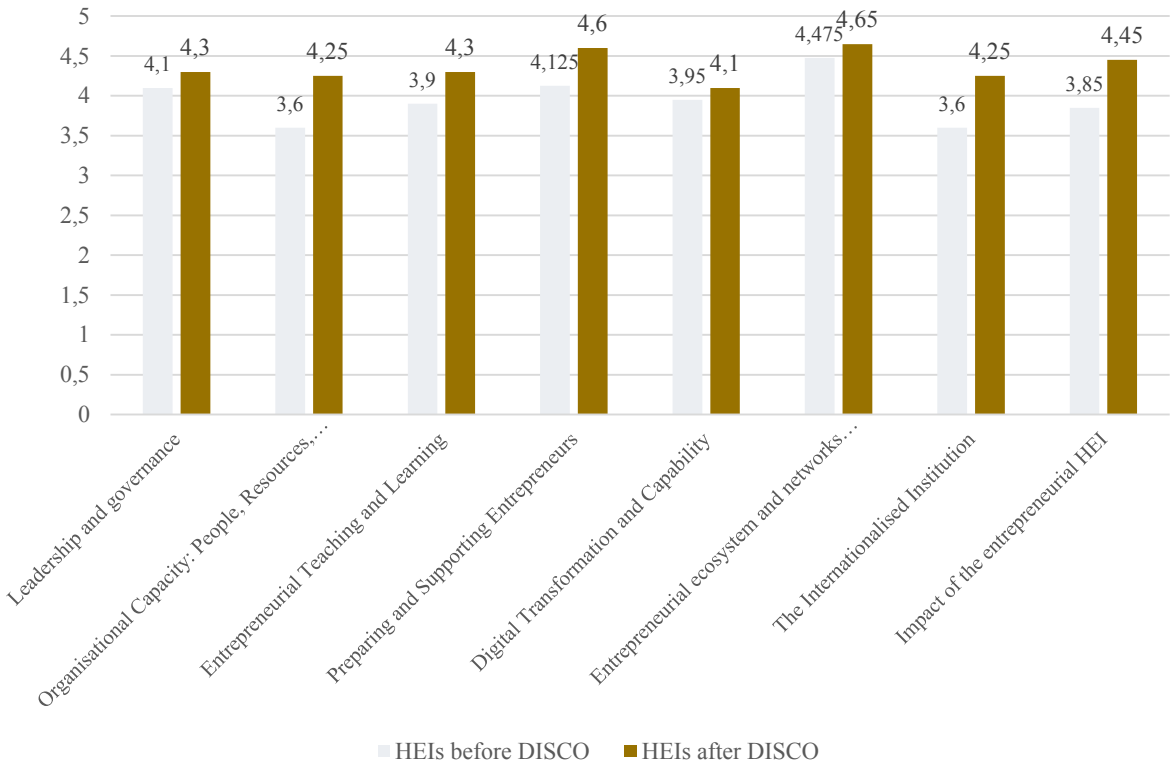

Figure 2. HEInnovate scores progress of all HEIs in the DISCO consortium: before and after the project. Source: own study, based on the HEInnovate surveys conducted by analysed HEIs.

The highest overall score both 'before' and 'after' the project was **'Entrepreneurial Ecosystem and Networks'**. This category is defined by HEInnovate as follows:

An entrepreneurial and innovative HEI proactively connects with its ecosystem (intended as an array of interlinked actors pooling skills and resources to pursue a common goal) to deliver social, cultural and economic benefits. The capacity to connect with entrepreneurial ecosystems and networks represents an important catalyst for organisational innovation in the HEI. It also helps the advancement of teaching and research, and transforms the HEI into an important actor in regional development and issues related to territorial cohesion (HEInnovate, 2025).

The 'before' result is understandable. The HEIs participating in DISCO were inherently interested in developing entrepreneurial ecosystems and networks, or else they would not have joined the consortium. What is interesting is that DISCO seems to have allowed the partners to push this capability even higher, as a result making it the most developed consortium capability, on average.

Indeed, DISCO in itself has organised various activities that have allowed for this to happen - predominantly thanks to the international exchange meetings and labs allowing for broadening of their entrepreneurial networks. As mentioned in a separate deliverable, several innovation labs have been implemented.

They brought together representatives from business, academia, and government. Each of the three-day conferences co-organised by all HEIs generated new relationships and improved the nature, content, and forms of collaborations with external partners such as corporations, research organisations, governmental agencies, non-governmental organisations (NGOs), and other societal partners. During these events, problems such as start-up support and the organisation of training in the fields of innovation and entrepreneurship for a diverse group of participants have also been addressed.

When it comes to the increase in scores on **'Internationalised Institution'**, the different project meetings, labs, workshops, and trainings have all offered the partners the opportunity to engage in discussions sharing their own HEIs' experiences, differences and similarities.

Second highest increase can be noted for the 'Impact of Entrepreneurial HEI' category. Here, too, part of the credit can be attributed to the Limitless Innovation Bootcamp and 'Developing Service Innovation Capabilities at HEIs' trainings that presented different international trends and practices in terms of the role HEIs play in social innovation and in terms of the environmental and social impact of HEI activities. After the former training, partners were asked to work on their good practices to be shared with the consortium - majority of these have indeed concerned the impact aspects.

Finally, the lowest final score, and also the lowest increase in absolute terms (3.95 to 4.1), has been recorded for the **'Digital Transformation and Capability' category**, which is defined by HEInnovate as follows:

HEIs are already deploying digital technologies, however the uptake and integration varies among and within institutions. HEIs should make the most out of the opportunities presented by digital transformation and consider digital technologies as a key enabler of innovation and entrepreneurship. An HEI's digital capability is defined as the ability to integrate, optimise and transform digital technologies to support innovation and entrepreneurship (HEInnovate, 2025).

This category is in general a complex issue that cannot be resolved by the activities of a European project alone, as it typically requires larger organisational decisions and significant infrastructure investments that were not part of the DISCO scope. Possibly, barriers to digital innovation in HEIs could include gaps in digital strategy and governance, competencies of the academic and support staff, limitations in terms of digital infrastructure, resistance to change and institutional inertia, or cybersecurity constraints, to name a few, all of which could have been easily exacerbated by the speed of recent technological developments, such as progress in artificial intelligence solutions. We theorise that most of these barriers, as predominantly internal issues, would not have been significantly overcome by increased collaboration in a European project, at least not in the short-term.

However, during the collaborative design and implementation of a MOOC for students at the participating universities, significant differences emerged with regard to the use of digital teaching tools and the respective national infrastructure for implementing MOOCs. On the Polish platform Navoica, the MOOC was implemented quickly and professionally,

while Ukrainian universities can easily integrate MOOCs into their curricula and test them. In contrast, the Swiss HEI lacks both the appropriate infrastructure and the openness of lecturers to integrate MOOCs into innovation and entrepreneurship modules on a test basis. At the Swiss HEI, the development of a MOOC is estimated to take 1.5 years, while in the project, the combination of digital skills and infrastructure in Poland required 3 months.

These different implementation speeds and digital learning cultures have clearly led the Swiss project partner to question the digital maturity in that area.

At the same time, the enormous opportunities for increase in digital innovation, driven by the recent progress in generative artificial intelligence technologies, immersive learning technologies, or virtual mobility solutions, to name a few, have not been fully explored in scope of the DISCO project. This is partially due to the fact that these trends were still emerging at the time the project took place, and the participating HEIs were still struggling to fully make sense of them internally. Our understanding is that the time was not 'ripe' enough yet for the knowledge sharing stage to bear significant fruit in this respect.

The most significant improvement—rising from 3.6 to 4.25—was observed in the categories of '**Organisational Capacity**' and **'Internationalised Institution**', reflecting the tangible impact of DISCO's targeted interventions in enhancing structural capabilities and fostering cross-border collaboration among HEIs.

In terms of **'Organisational Capacity'**, several activities took place explicitly dedicated to the topic of capacity development. One of them was the Limitless Innovation Bootcamp™ organised 14-15 July 2022 at the start of the project, with the following objectives:

- to increase the innovation and entrepreneurship capacities of the professional and support staff of the European higher education institutions and other project partners,
- to exchange good practices in innovation and entrepreneurship support among project partners,
- to exchange first ideas for further collaboration in the project within the proposed Innovation Vision Action Plan (IVAP).

On day one, in an informal setting inspired by the examples from and beyond Luxembourg, participants learned about collaborative innovation as a framework for innovating with and for public administration and society. Specifically, the methodologies of innovation labs as well as social impact measurement were discussed as effective approaches to mobilize public administrations, citizens and other stakeholders in collaborative innovation processes. On day two, focused on the specific ambitions of the DISCO project as reflected in its IVAP, participants learned about the ways in which HEIs innovate themselves as well as act as innovation and entrepreneurship enablers for other actors, from students, through public, private and third sectors, to community and society at large.

In 2024, a two-session training was organised again (this time jointly by HSLU and Limitless), on the topic of 'Developing Service Innovation Capabilities at HEIs – Trends, opportunities, challenges and requirements for an innovation-encouraging leadership culture at

HEI'. The learning objectives were that after completed training, the participants would be able to:

- understand what an organisational capability is,
- understand what a service innovation capability is and provide examples for knowledge intensive organisations such as HEIs,
- name megatrends in various service areas of HEIs,
- provide inspirational examples to promote the entrepreneurial and innovative skills in HEIs, both internally and of their students,
- present their service innovations and related organisational capabilities,
- understand the importance of service innovation institutions (such as labs, hubs, start-up centres etc.) at HEI and their importance for the development of organisational innovation capabilities and the development of service leaders,
- exchange ideas about possible future collaboration potential (leadership communities, mentoring, further research projects) to consolidate the exchange of knowledge.

6. Discussion

The DISCO project affirms that higher education innovation is a networked, collaborative, and evolving process. The findings show that international HEI collaboration can bridge capability gaps, particularly benefitting emerging institutions. In theoretical terms, this reflects knowledge transfer dynamics: multilateral exchanges allowed all HEIs to enhance their innovation capacities, consistent with the view that cross-border partnerships strengthen entrepreneurial ecosystems (Cerver Romero et al., 2021; Sjöö, Hellström, 2019).

Viewed through stakeholder theory, the project highlighted the strategic role of engaging diverse actors—students, staff, industry, and civil society - in co-creating innovation. DISCO's participatory model aligned institutional goals with broader societal expectations, confirming that stakeholder-driven collaboration can advance both entrepreneurship education and societal impact. This further illustrates the growing intersection of higher education with Corporate Social Responsibility (CSR) and Sustainability Development Goals (SDG)ESG frameworks (Guerrero, Lira, 2023; Gianiodis, Meek, 2020).

The project's strong emphasis on co-creation and co-production allowed participating HEIs not just to exchange knowledge, but to jointly develop new entrepreneurial education models, mentoring frameworks, and innovation labs. This resonates with recent research showing that co-creation accelerates organizational learning and deepens stakeholder engagement. Even the most advanced HEI partner in selected categories benefited from exposure to new cultural and operational contexts, highlighting the reciprocal nature of international learning (Doering et al., 2023).

From an innovation ecosystems perspective, DISCO functioned as a transnational network linking local startup and innovation hubs (like e.g. Smart-up from HSLU) into a broader system. Each HEI contributed and amplified unique strengths, resulting in richer ecosystem dynamics. The findings validate the idea that HEIs are not isolated knowledge producers but active orchestrators in multi-actor systems. The improvements in "Internationalized Institution" and "Entrepreneurial Ecosystems and Networks" dimensions of HEInnovate further underscore the transformative power of cross-border collaboration (Cai et al., 2020).

The living lab approach embedded in DISCO activities - —such as innovation labs and hackathons—involved students and external stakeholders directly in real-world experimentation. This reflects the theoretical model of living labs as spaces for open, user-centered innovation. By co-creating solutions with end-users, HEIs accelerated feedback loops and enhanced their entrepreneurial teaching capabilities. The project also demonstrates that universities can serve as living labs for their own institutional innovation processes (Nnyström, 2014).

A crucial enabler of DISCO's success was the use of digital platforms. Shared digital spaces allowed for frequent knowledge exchanges, document sharing, and co-development across borders. In line with platform theory, the digital infrastructure reduced transaction costs and increased collaboration efficiency. However, the relatively weaker progress in the "Digital Transformation and Capability" HEInnovate category shows that many HEIs still need to invest in digital skills and infrastructure to fully leverage these platforms (Doering et al., 2023).

For HEI managers, these findings underline the value of participating in international networks not just for benchmarking, but for co-creating new capacities. Embedding collaborative digital platforms, encouraging stakeholder-centered innovation, and maintaining living-lab formats can enhance institutional agility.

From a policy perspective, supporting cross-border HEI collaboration is a critical tool for reducing regional innovation divides. Funding bodies like the EIT and Erasmus+ should continue incentivizing projects that combine structured knowledge transfer with open innovation approaches (Volkert, Bunescu, 2024). Additionally, policymakers should promote the integration of platform technologies and encourage the use of longitudinal tools like HEInnovate to measure and sustain institutional transformation.

Overall, the DISCO project provides empirical support for theories of stakeholder-driven, ecosystem-based innovation in higher education. It shows that structured international collaboration can trigger sustainable change in entrepreneurial capacity, and highlights strategies for amplifying these effects in the European Higher Education Area.

7. Conclusions

The following practical recommendations for European HEIs can be concluded from our research:

1. **Focus on digital development**

'Digital Transformation and Capability' remains the least developed aspect of innovation at participating HEIs. Five action cards have been developed by HEInnovate to help further the development of this capability, namely: 5/01 General E-Learning Capabilities, 5/02 Educator E-Learning Capabilities, 5/03 Advanced E-Learning Capabilities, 5/04 IT Infrastructure and 5/05 Community Platform (cards can be found: https://www.heinnovate.eu/sites/default/files/2023-06/HEInnovate-Action-Cards_0.pdf). It is recommended that all DISCO HEIs use these in their own development.

2. **Join leading entrepreneurial ecosystems**

'Entrepreneurial Ecosystem and Networks' seem to be very well developed by the DISCO partners and it is recommended that the HEIs and consortium as a team builds upon this strength and learn from even more advanced startup ecosystems in Europe. These, in Europe, are according to the Global Startup Ecosystem Index 2023: London, Paris, Berlin, Stockholm, Amsterdam, Moscow, Munich, Barcelona, Helsinki, Madrid, Dublin, Istanbul, Copenhagen, Tallin, Zurich, Lisbon, Cambridge, Oslo, Milan and Vienna. Only HSLU is based in the country covered by the index, and none of the partners are located in any of these top 20 hubs in Europe. A recommendation would be to link to these ecosystems through new European or other international projects.

3. **Invest in further entrepreneurial support successes**

Besides collaboration with the established ecosystems, it is recommended to further invest in entrepreneurship support activities: entrepreneurship tracks and courses, startup coaching systems, incubation and acceleration methodologies, prototyping facilities and equipment, embedding entrepreneurship education across disciplines, early-stage investment opportunities. In addition, it is recommended to consider more advanced forms of support such as HEI-owned investment instruments to foster spin-offs.

4. **Launch or continue the innovation labs**

The innovation labs have proven effective in experience sharing. It would be recommended that these types of activities continue after the DISCO project, albeit in a limited (hybrid/virtual) form if needed. Participation in such initiatives is important not only for enterprises, but also for making changes in the functioning of HEIs - adapting the research carried out there and educating students to the needs and realities of enterprises.

5. **Keep the good practice sharing**

Continued investigation of more international good practices could prove helpful as further inspiration for the DISCO partners. Sharing within the consortium seemed to be even more

effective and could be upheld even in an informal format. In general, good practice sharing with peer HEIs can be recommended to any European higher education institution willing to progress more quickly on its innovation potential.

6. Consider dedicated funding options for structural cooperation

Besides the EIT-HEI programme, the main source of financial support for European HEIs is probably offered by Erasmus+. In addition, HEIs can access national or regional funding schemes, including bi-lateral or multilateral competitive research calls.

7. Establish or keep up the HEInnovate self-assessment habit

The self-assessment is an invaluable part of the progress monitoring and thus paying continuous attention to the service innovation capability development. It is recommended that HEIs exercise the good habit developed in DISCO and upkeep the HEInnovate self-assessment as a yearly practice. It would be beneficial if they continue to track their progress against themselves and their peers, for instance in the context of the DISCO project, by using the established 'benchmarking' community. The process could become a great opportunity for organising a shared session to discuss and share. These developments suggest that HEInnovate is not only a useful assessment tool but also a strategic enabler when integrated into regular planning and ecosystem alignment.

Recommendations for future research

The theoretical integration proposed in this article points to some future research avenues. First, the model offers a valuable structure for comparative analysis across HEI collaboration projects in different regional or disciplinary settings. Second, it provides a foundation for developing longitudinal impact tracking tools that combine self-assessment data with network analytics and case-based learning. Third, it encourages the refinement of self-assessment instruments like HEInnovate to better capture relational and systemic dimensions of institutional innovation.

In conclusion, this study affirms that higher education innovation is best understood as a networked, collaborative, and evolving process. The heuristic framework developed here helps to interpret institutional change more holistically and serves as a guide for both practitioners and policymakers aiming to foster sustainable and scalable innovation in higher education across Europe.

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MANAGING ENERGY TRANSITIONS THROUGH PLACE-BASED GOVERNANCE FRAMEWORKS. A CASE STUDY OF THE SILESIA REGION

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Purpose: This article examines the place-based governance as a tool for the energy transformation management.
Design/methodology/approach: This research adopts a qualitative, case study methodology, grounded in the principles of place-based governance analysis. The study integrates two main research methods: desk-based literature and policy review and focus group research.
Findings: The paper highlights that the energy transition is a complex, multidimensional process involving not only technological innovation but also deep social, economic, and political change. Central to this process is the energy trilemma—balancing energy security, affordability, and environmental sustainability. Successful transformation requires territorially-sensitive and adaptive governance. Top-down strategies, while useful for setting goals, often fail in practice. In response, place-based governance is emerging as a key approach. A focus group conducted in the Silesia region provided insights into local perceptions and stakeholder engagement. The paper concludes with recommendations for more effective and inclusive management of the energy transition.
Originality/value: This paper offers a novel perspective on the energy trilemma by foregrounding the importance of territorially-sensitive, place-based governance mechanisms in managing the inherent tensions between energy security, affordability, and environmental sustainability. Drawing on empirical findings from a focus group study conducted in the Silesia region, the paper provides original insights into stakeholder engagement and governance practices, thereby enriching the discourse on just transition. The study's context-specific recommendations enhance its practical relevance and offer valuable guidance for the design and implementation of inclusive energy transition policies.
Keywords: Energy Transition, Management, Governance, Transition Governance Models, Place-Based Governance.
Category of the paper: research paper.

1. Introduction

Energy system transformation constitutes a fundamental challenge for the years ahead, carrying profound implications for environmental sustainability, technological innovation, and policy development. With the EU's commitment to reducing carbon emissions and increasing the use of renewable energy, the transformation of energy systems has become central to achieving climate neutrality and energy security. By its very nature, the energy transformation is a complex, structural, and long-term process. It entails far more than a shift in technologies—it requires a fundamental rethinking of how energy is produced, distributed, and consumed (McGovern, 2021). This transition affects not only infrastructure and markets but also social behaviour, institutional frameworks, and political decision-making. Implementing such a transformation demands sustained effort and coordination at all levels—local, national, and international.

The shift to renewables—such as wind, solar, and bioenergy—requires not only new technologies but also new governance models and public engagement strategies. Energy transformation touches on multiple interconnected domains: energy infrastructure, climate and environmental policy, macroeconomic planning, public administration, and societal values. It requires strong intersectoral collaboration and coherent policy-making, as well as a long-term strategic vision that is both adaptive and inclusive. A transition to a low-carbon economy cannot be accomplished without public support and social acceptance (EC, 2023). Citizens must be given the opportunity to adjust—whether by adopting more sustainable lifestyles, acquiring new job skills in green industries, or adapting to regulatory and financial changes. According to the International Energy Agency (IEA), the transition could create over 13 million new jobs globally by 2030, but it could also displace millions of workers in high-emission sectors, highlighting the need for just transition strategies. Innovation is a cornerstone of the energy transition—not only in terms of technology (e.g., renewable energy systems, smart grids, hydrogen storage), but also in social organization and institutional resilience. Governments must create enabling environments for innovation and ensure that institutions remain flexible enough to respond to dynamic global developments, including supply chain disruptions and geopolitical tensions. Moreover, the ecological integrity of the transition must be carefully managed. Not all “green” technologies are environmentally neutral—for example, the production of batteries and photovoltaic panels often involves the extraction of rare earth elements and other strategic raw materials. This raises important concerns regarding resource dependency, geopolitical risks, and environmental justice, particularly in regions where mining conditions are exploitative or environmentally damaging.

In this context, effective governance of the energy transformation becomes not only a technical or economic imperative, but a strategic responsibility. Successful energy transitions require clear targets, measurable progress indicators, robust implementation tools, and support

mechanisms for vulnerable communities and industries. Transparency, public participation, and science-based decision-making must be central to this process. Only through a coherent, inclusive, and forward-looking approach can countries navigate the energy transformation in a way that ensures long-term sustainability, security, and social equity. The aim of this paper is to explore how place-based governance frameworks can effectively support energy transitions. The paper emphasizes the importance of integrating innovation, public participation, and institutional coordination in managing complex energy transformations at the regional level, aligning local efforts with broader EU climate and energy objectives.

2. Materials and methods

This research adopts a qualitative, case study methodology, grounded in the principles of place-based governance analysis. The chosen unit of analysis is the Silesia region of Poland—one of the most emblematic territories undergoing just energy transition in Central and Eastern Europe. The methodological framework is rooted in interpretive policy analysis, emphasizing the socio-institutional context of energy transition, stakeholder engagement, and regional governance dynamics. The study integrates two main research methods:

2.1. Desk-Based Literature and Policy Review

An extensive review of scholarly literature, policy documents, and EU strategic frameworks (e.g., the European Green Deal, Just Transition Mechanism, Territorial Just Transition Plans) was conducted. The purpose was to situate the energy transition within the broader context of European governance, and to identify conceptual foundations—such as the energy trilemma and polycentric governance—that inform place-sensitive policymaking.

2.2. Focus Group Research

To capture local perspectives and contextualized insights, a focus group was conducted in the Silesia region. The session was designed to assess stakeholder experiences and perceptions regarding the inclusiveness, transparency, and effectiveness of just transition governance. The method was particularly useful for uncovering power dynamics, institutional barriers, and local innovations. Participants were selected using purposive sampling, ensuring representation from key sectors: local government, academia, business, trade unions, and civil society organizations. The focus group was guided by four core questions designed to explore:

- Key elements of just transition governance.
- Challenges in engaging quadruple helix actors (policy, business, academia, and society).
- Measures to enhance local participation, and
- Strategies for embedding the place-based approach.

A case study approach was selected to enable in-depth, context-sensitive exploration of energy transition governance in a specific high-impact region. Silesia, due to its coal-dependent economy, social vulnerability, and strategic relevance in EU funding mechanisms, provides a critical lens through which to analyse the operationalization of place-based frameworks. The methodological triangulation—combining document analysis and stakeholder engagement—strengthens the validity of findings by capturing both normative frameworks and lived experiences.

3. Balancing the Energy Trilemma: Rethinking Governance for a Sustainable Transition

The energy transition represents a complex and multidimensional transformation that extends far beyond technological innovation, encompassing profound social, economic, and political change (Żuk 2023). At the core of this transformation lies the concept of the energy trilemma—a framework that articulates the inherent tensions between three fundamental and interdependent goals: energy security, economic affordability, and environmental sustainability (Tol, 2023). These pillars are central to the design and governance of contemporary energy systems, and achieving a balance among them remains one of the most critical challenges facing both national governments and international institutions. Environmental sustainability, as a guiding principle of the energy transition, involves systematic efforts to mitigate climate change by reducing greenhouse gas emissions, promoting energy efficiency, increasing the share of renewables in the energy mix, and protecting ecological systems (WEC, 2019). Within the European Union, these goals are reflected in the commitment to achieve climate neutrality by 2050, with interim targets such as a 55% reduction in emissions by 2030 relative to 1990 levels. In 2022, renewables accounted for approximately 23% of the EU's gross final energy consumption, with solar and wind energy growing at record rates (Eurostat, 2023). However, further decarbonization requires significant investment and long-term structural reforms. Energy security, the second dimension of the trilemma, refers to the availability of reliable and uninterrupted energy supply, resilience to disruptions—whether geopolitical, technological, or environmental—and strategic autonomy in energy sourcing (Kolde, Wagner 2021). The war in Ukraine has underscored the vulnerabilities of energy dependence on fossil fuel imports, particularly natural gas. In response, the European Commission's REPowerEU plan aims to reduce EU demand for Russian gas by two-thirds and accelerate the deployment of clean energy technologies (Schmieder et al., 2024). Moreover, ensuring energy security in the long term necessitates investments in grid infrastructure, energy storage, and supply chain diversification, particularly for critical raw materials. Affordability, the third pillar, concerns equitable access to energy at prices that are economically sustainable for households and businesses.

This dimension is especially important in light of growing energy poverty, which affects an estimated 35 million Europeans unable to keep their homes adequately warm (European Commission, 2022). The transition toward cleaner energy systems entails significant capital costs, which may lead to increased retail energy prices, particularly in the short to medium term. Without appropriate social policy instruments, these costs risk exacerbating inequality and undermining public support for decarbonization measures. What makes the energy trilemma particularly challenging is the tension and trade-offs between its constituent goals. For instance, advancing environmental objectives through investment in renewable energy technologies—such as photovoltaics, offshore wind farms, battery storage, and electric mobility—often requires substantial upfront expenditure (Daniel, Radu, 2024). These costs are frequently passed on to consumers, raising concerns about affordability and social equity. Likewise, strategies to enhance energy security, including domestic resource development and infrastructure expansion, may involve environmental degradation, particularly where the extraction of critical raw materials (e.g., lithium, cobalt, rare earth elements) leads to deforestation, water contamination, or biodiversity loss. Furthermore, ensuring the resilience and modernization of energy systems requires substantial capital investment in grid upgrades, digital infrastructure, and strategic reserves, which can strain public budgets and result in higher end-user costs, potentially triggering public resistance and political backlash (Kolde, Wagner, 2021). Navigating these competing priorities demands a coherent and integrative policy approach. Rather than privileging one objective at the expense of the others, policymakers must seek dynamic synergies and co-benefits (Barnes et al., 2024). This includes designing regulatory frameworks that incentivize low-carbon technologies while maintaining affordability; implementing progressive social policies that protect vulnerable populations from energy shocks; and fostering international cooperation to ensure stable access to sustainable energy and raw materials. At the same time, public engagement and participatory governance are essential to ensuring that the energy transition is both socially just and politically legitimate.

Energy trilemma underscores the need for a systems-based, long-term vision of energy policy that reconciles environmental imperatives with the practical realities of economic and geopolitical constraints. The success of the global energy transition will depend not only on technological progress, but also on institutional innovation, social inclusiveness, and multilateral coordination. Addressing the energy trilemma—the simultaneous pursuit of energy security, economic affordability, and environmental sustainability—has emerged as one of the most critical challenges in contemporary energy governance (Topaloglou et al., 2024). This complex and multidimensional issue requires a holistic and interdisciplinary approach that integrates technological advancement, socially equitable policy frameworks, and robust international cooperation. At the core of the energy transition lies the imperative for technological innovation. The rapid development and deployment of advanced energy storage solutions, including high-capacity battery systems and hydrogen-based technologies, are essential for managing the intermittency of renewable energy sources. These technologies

enable greater grid flexibility and reliability, supporting the integration of solar, wind, and other renewables into national energy systems. Equally important are smart grid infrastructures, which facilitate real-time, two-way communication between producers and consumers, enhance demand-side management, and optimize the balance between supply and demand. Emerging applications of artificial intelligence (AI) further contribute to system efficiency by enabling predictive maintenance, consumption forecasting, and dynamic optimization of energy flows. Collectively, these technological developments not only increase energy efficiency but also underpin the structural transformation of energy systems toward decarbonization. Nevertheless, the energy transition is not solely a technical undertaking. It is also a profoundly social and political process that demands inclusive and just policy design. Ensuring a fair transition involves implementing mechanisms that protect and support vulnerable populations and regions most affected by decarbonization (De Laurentis et al., 2021). These may include targeted subsidies and tax incentives for households investing in renewable energy installations, financial instruments that promote prosumer engagement, and retraining programs for workers displaced from carbon-intensive sectors such as coal mining and heavy industry (Inderberg et al., 2023). Moreover, energy poverty—still prevalent in many regions—must be addressed through comprehensive strategies encompassing building retrofitting, direct financial assistance, and public education initiatives aimed at increasing energy literacy and civic engagement. Crucially, fostering participatory governance—through meaningful public involvement in planning and decision-making processes—enhances both the democratic legitimacy and the long-term resilience of the transition (Macedo, 2021). International cooperation constitutes a third and indispensable pillar of a successful energy transformation. At the European level, this entails policy harmonization among Member States, the consolidation of an integrated energy market, and the coordinated implementation of climate targets in line with the European Green Deal and the Fit for 55 package (Westrom, 2020). Globally, it involves collaborative efforts to ensure secure and sustainable access to critical raw materials—such as lithium, cobalt, and nickel—that are essential for the manufacturing of batteries, photovoltaics, and other clean energy technologies. Strengthening international supply chains, investing in joint research and development programs, and expanding cross-border infrastructure are all fundamental to enhancing the resilience and scalability of clean energy systems (Kelly, 2024).

The energy trilemma thus highlights the necessity of adopting a systemic and long-term approach to energy policy—one that reconciles environmental imperatives with the practical realities of economic and geopolitical constraints. The success of the global energy transition will depend not only on technological progress but also on institutional innovation, social inclusiveness, and effective international coordination. (Oldenbroek et al., 2024). Moreover, resolving this trilemma requires efficient and multi-level governance of the energy transition—at local, national, and global scales. This involves not only the creation of legal and financial frameworks to support the transformation, but also continuous monitoring of progress,

the ability to respond to unforeseen challenges, and the alignment of sectoral policies (Hofman et al., 2021). Only through well-planned, adaptive, and coherent management will it be possible to balance the goals of the energy trilemma and achieve a fair, secure, and sustainable energy future.

4. Place-Based Governance as a Response to the Challenges of the Energy Transition Trilemma

Amid the intensifying climate crisis and the global imperative to reduce greenhouse gas emissions, the energy transition has emerged as one of the defining policy challenges of the 21st century. Achieving this requires not only technological advancement but also adaptive, territorially-sensitive governance mechanisms capable of managing the complexities and disparities inherent in the transition process. Centrally designed, top-down energy transition strategies—although efficient in setting overarching goals—often fall short at the implementation stage (Fischer et al., 2020). These shortcomings frequently manifest as regional disparities, limited policy effectiveness, and a lack of public acceptance, particularly in communities historically reliant on fossil fuel-based industries. In this context, the relevance of place-based governance is gaining momentum. This approach emphasizes the importance of tailoring policy interventions to the specific socio-economic, environmental, and institutional contexts of individual regions (Dobravec et al., 2021) Place-based governance is defined as a territorially embedded model of policy design and implementation, which engages local actors and mobilizes regional assets to co-produce context-sensitive solutions (Hendriks, 2008). It represents a paradigm shift away from universal, standardized policy approaches toward flexible, participatory, and place-sensitive governance (Soutaret et al., 2022). Key elements of this approach include the integration of local knowledge, responsiveness to spatial disparities, and the co-creation of transition pathways by engaging a broad array of stakeholders—ranging from municipalities and civil society to businesses and local energy cooperatives (Fujiwara, 2016).

A critical strength of place-based governance lies in its capacity to operationalize the energy transition within the realities of local conditions. This includes accounting for variations in energy potential (e.g., solar radiation, wind patterns, biomass availability), labor market characteristics, economic vulnerability, and social capital (Bedford et al., 2023). For example, while solar deployment may be more viable in southern European regions, wind power may be more feasible in coastal and northern areas. Moreover, former coal regions often require targeted interventions due to the cumulative effects of industrial decline, structural unemployment, and environmental degradation. Initiatives such as citizen assemblies, energy communities, and participatory budgeting further reinforce local legitimacy and reduce

resistance to change by fostering a sense of ownership over the transition process. To implement these principles, place-based governance relies on a diverse set of tools and instruments that enable localized action (Lennon et al., 2019). One such tool is the Territorial Just Transition Plan, mandated by the European Commission as a prerequisite for access to the Just Transition Fund. These plans require a detailed mapping of regional challenges and opportunities, including socio-economic indicators, environmental risks, and labour market data (Kelly, Mbah, 2024). Another key instrument is the creation of energy cooperatives and community energy schemes, which allow citizens to participate directly in the generation and governance of local energy systems (Anfinson et al., 2023). These models democratize access to energy, promote prosumer engagement, and strengthen social cohesion.

Further tools include local climate and energy action plans (SECAPs) developed under the EU Covenant of Mayors framework, which guide municipalities in setting decarbonization targets and mobilizing local investment. Spatial planning and zoning tools are also vital, as they determine land use priorities and enable the integration of renewable infrastructure into existing urban and rural landscapes (Kola-Bezka, 2023). Additionally, place-based innovation platforms—such as living labs and regional innovation hubs—facilitate experimentation, knowledge exchange, and stakeholder learning (Macedo, 2021). These mechanisms not only align technological pathways with community needs but also enhance the adaptive capacity of local institutions. From a theoretical standpoint, place-based governance is grounded in the fields of regional development and spatial planning. It recognizes that the effectiveness of public policy increases when it is embedded in local contexts, informed by regional specificities, and supported by decentralized institutional arrangements. It also aligns with the broader principle of multi-level governance in the European Union, which encourages coordination and subsidiarity across different layers of government. The need for territorially differentiated approaches is especially acute when viewed through the lens of the energy trilemma — the simultaneous pursuit of three interdependent but often competing objectives: environmental sustainability, energy security, and affordability (Schmieder et al., 2023). Balancing these goals requires trade-offs that are best negotiated at the local level, where the tensions are most immediately experienced (Segales et al., 2023). For example, while renewable energy deployment contributes to decarbonization, it may lead to increased costs in the short term, disproportionately affecting vulnerable households. Similarly, investments in energy security—such as grid resilience or domestic resource development—can trigger environmental concerns, particularly in resource-sensitive areas. Place-based governance offers a mechanism for managing these trade-offs in a context-sensitive, democratically legitimate, and socially just manner. The European Union has increasingly embraced place-based approaches in its climate and energy frameworks, particularly through instruments such as the Just Transition Mechanism (JTM) and the Just Transition Fund (JTF). These mechanisms allocate targeted funding to regions most affected by the low-carbon transition, with a focus on economic diversification, workforce retraining, and environmental remediation. The JTF,

with a budget of €17.5 billion for the 2021-2027 period, explicitly requires the development of Territorial Just Transition Plans, which integrate local governance structures and prioritize inclusiveness, transparency, and stakeholder engagement.

In this context, the European Commission has identified six core principles of good governance—transparency, participation, rule of law, equality and inclusiveness, efficiency, and accountability—as critical benchmarks for the success of regional energy transitions. Embedding these principles into policy implementation fosters not only procedural legitimacy but also policy effectiveness, by aligning climate action with cohesion policy and local development agendas (Young et al., 2023). The energy transition cannot be effectively delivered through technological and economic instruments alone. It requires a paradigm shift in governance—toward models that are participatory, adaptive, and sensitive to regional specificities. Place-based governance offers a strategic pathway to reconcile the goals of the energy trilemma by linking climate objectives with the needs, capacities, and aspirations of local communities (Jenkins, 2018). Through the use of tailored tools such as territorial transition planning, citizen engagement mechanisms, and spatial integration instruments, it enhances the resilience, equity, and long-term viability of the energy transition at both national and supranational levels. The European Union (EU) has developed several policy frameworks that emphasize place-based governance as a tool for facilitating the energy transition. Key documents and initiatives include:

Table 1.
EU Policy Documents and Initiatives Supporting Place-Based Governance in the Energy Transition

Title	Description	Institution/Source
Issue Paper on Place-Based Policies and Development Strategies	Highlights the importance of complementing national policies with place-based approaches. Promotes participatory methods in cohesion policy.	European Commission (2023)
ESPON – CleanEnergy4CE Project	Analyzes energy transition policy suitability across territorial levels in Central Europe. Emphasizes place-based acceleration toward climate neutrality.	ESPON (2022)
Covenant of Mayors	Supports sustainable energy policies at local level through cooperation among local and regional authorities. Aligns with EU energy goals.	European Commission (n.d.)
European Green Deal and Just Transition Mechanism	Strategic EU roadmap for climate neutrality by 2050. Just Transition Mechanism provides regional financial and technical support, tailored to local needs.	European Commission (2019, 2020)

Source: Own study.

5. Focus Group Research in Silesia Region

To support research on just transition governance and stakeholder engagement in the Silesia region, a focus group study was conducted as part of the broader investigation into the implementation of place-based approaches in energy transition policy. Focus groups represent a well-established qualitative research method in the social sciences, particularly well-suited for examining complex socio-political phenomena such as energy transition. They facilitate interactive discourse, enabling the capture of diverse perspectives, collective reasoning, and the socio-cultural meanings underlying stakeholder attitudes and behaviors. This method is especially relevant in the context of transition governance, where understanding local perceptions, expectations, and grievances is critical to designing inclusive and context-sensitive policy frameworks. Focus groups allow researchers to elicit a range of opinions without seeking consensus, instead fostering a dynamic environment where contradictions and convergences can surface (Hennink et al., 2011). This aligns with the core principles of participatory and place-based governance, which emphasize the value of local knowledge, deliberative processes, and social learning in shaping transition pathways. The focus group conducted for this study aimed to deepen understanding of how regional actors in Silesia perceive the governance of the energy transition, particularly in light of ongoing criticisms of top-down planning and insufficient stakeholder involvement. The discussion was moderated to encourage reflection on institutional trust, perceived fairness, and the extent to which local voices influence strategic decisions. Moreover, the group setting enabled observation of discursive patterns, power asymmetries, and the dynamics of inter-stakeholder interaction—adding an additional layer to the qualitative analysis. Participants (six in total) were selected via stakeholder mapping to ensure institutional diversity and relevance to the regional energy context. The group included high- and mid-level administrative officials, academic experts in energy poverty and transition studies, and a trade union representative—reflecting the interplay between policy, science, and labor that is central to the Silesian case. The session was conducted online using the Webex platform and recorded for systematic transcription and thematic coding. By applying this methodological framework, the research contributes to a more granular and empirically grounded understanding of just transition governance in one of the EU's most affected regions. It provides insights not only into individual stakeholder perspectives but also into the collective processes through which local legitimacy, resistance, and co-governance potentials are constructed in practice.

The reason for conducting the focus group research in the Silesia region, was to gain a deeper understanding of stakeholder engagement in the context of just transition governance, particularly with respect to the place-based approach (Pietrzak et al., 2021). The aim was to explore how local actors perceive and experience the governance of the energy transition and to identify challenges and opportunities for making this process more inclusive, transparent,

and effective. The research was reason to a research hypothesis that top-down governance approaches were insufficient and often disconnected from regional realities (Mrozowska et al., 2021). Therefore, the focus group was designed to "shed some further light" on how local voices could be more effectively included in the shaping of transition policies.

The specific objectives included:

1. Assessing the degree to which local stakeholders are engaged in the just transition process.
2. Investigating the extent of embeddedness of place-based governance principles in the planning and implementation of the energy transition.
3. Understanding perceptions of the effectiveness, transparency, and fairness of transition-related decision-making structures.
4. Identifying barriers to participation for different stakeholder groups (e.g., civil society, academia, business).
5. Gathering practical recommendations on how to institutionalize a place-sensitive, participatory, and equitable governance model.

During the research the following questions has been asked questions of the focus group are as follows:

1. What do you think are the key elements that should characterize just transition governance?
2. What are the biggest challenges for a sufficient quadruple helix (policy, business, academia, society) engagement?
3. What measures could be taken for a more active participation of the key local actors in just transition decision making?
4. How place-based approach could be further embedded in just transition governance model?

The aim of the study was to confirm research hypothesis that top-down governance approaches were insufficient and often disconnected from regional situations and realities. Therefore, the focus group was designed to "shed some further light" on how local voices could be more effectively included in the shaping of transition policies. The Silesia region in Poland was selected for the focus group research because it is one of the most emblematic and affected regions undergoing the process of just transition in Central and Eastern Europe (Christiansen et al., 2022). Silesia has been historically cantered around coal mining, energy production, and heavy industry. As such, it is deeply impacted by the EU's climate policies and decarbonization efforts (Tarasova, 2024). The region's economic, social, and cultural identity is strongly tied to fossil fuel industries, making it a critical case for analysing the socio-economic effects of transition. Silesia is one of the largest beneficiaries of the EU Just Transition Fund (Struś et al., 2023). It has received substantial financial allocations to support the transformation of its economy, labor market, and energy systems (Włodarczyk, Herczakowska, 2025). This makes it a priority territory for studying how place-based

governance is being implemented in practice. The region has faced public criticism for the limited transparency, inclusivity, and effectiveness of its just transition planning processes. Earlier studies and fieldwork revealed issues with centralized decision-making, insufficient civil society involvement, and limited coordination across governance levels—making Silesia a rich context for focus group analysis (Kaczmarek et al., 2022). Given the high number of jobs at risk due to coal phase-out, as well as strong trade union activity and local resistance to change, Silesia presents a complex and dynamic environment. The social consequences of transition here are more intense than in many other EU regions, underscoring the importance of investigating how local voices are being represented and integrated into transition governance. Findings from Silesia can offer transferable lessons for other carbon-intensive regions in Europe and globally. As one of the EU's "flagship regions" for transition, Silesia serves as a test case for policies aiming to balance environmental objectives with social equity and economic resilience.

5. Summary of Focus Group Outcomes on Just Transition Governance in the Silesia Region (Poland)

5.1. Key Elements of Just Transition Governance

Focus group participants from the Silesia region emphasized that just transition governance must extend beyond narrow economic or technological restructuring. It should be anchored in democratic principles, social justice, and place-sensitive planning. Several key elements were identified:

- Transparency and Participation: Participants expressed frustration over limited access to transition-related information and policy processes. They emphasized the need for transparent governance mechanisms and meaningful inclusion of a wide range of stakeholders—including trade unions, local NGOs, municipalities, and community leaders—at every stage of the transition.
- Social Justice and Equity: The governance framework must ensure protection for vulnerable populations, especially workers in carbon-intensive sectors and economically disadvantaged groups. Participants stressed that social protection and compensation mechanisms must be central to transition planning.
- Context Sensitivity (Place-Based Orientation): Uniform, top-down approaches were widely criticized as disconnected from Silesia's historical, economic, and environmental realities. Respondents advocated for regionally tailored policies that reflect the specific needs and capacities of Silesian communities.

- Integrated and Long-Term Planning: Participants called for long-term, coherent strategies that align national policy goals with regional implementation. They emphasized the need for measurable targets and sustainable funding streams beyond short-term political cycles.
- Education and Workforce Development: Upskilling, reskilling, and broader access to vocational education were seen as essential. Participants underscored the importance of aligning educational programs with projected green sector job opportunities in the region.
- Economic Diversification: There was a strong demand for proactive support for new industries, innovation clusters, and small and medium-sized enterprises (SMEs) to ensure that the region is not left economically vulnerable.
- Monitoring and Accountability: Effective governance, according to the focus groups, requires robust oversight mechanisms, including independent monitoring bodies and stakeholder-led evaluation processes to ensure that transition promises are met.

These reflections show a shared understanding of governance not as a top-down administrative process, but as a locally grounded, participatory, and dynamic system that balances technical coordination with democratic legitimacy.

5.2. Challenges for Quadruple Helix Engagement (Policy, Business, Academia, Society)

In the Silesian context, participants discussed at length the difficulties of implementing the quadruple helix model framework which emphasizes collaboration between public authorities, private sector actors, academic institutions, and civil society.

- Dominance of Government and Business: Governance processes in the region are often led by political and industrial stakeholders, while academia and especially civil society have limited influence. This power imbalance was described as a significant obstacle to inclusive decision-making.
- Lack of Structured Dialogue: There is a clear absence of institutionalized platforms for sustained constructive dialogue among helix actors. Where such platforms exist, they often operate in an ad hoc or purely consultative capacity.
- Communication Barriers: Stakeholders were reported to operate in "separate languages." Businesses prioritize efficiency and return on investment, while civil society focuses on social justice, and academia values long-term research. These divergent priorities can hinder cooperation.
- Uneven Access to Resources: Civil society organizations and academic partners frequently lack the financial, technical, and organizational capacity to participate on equal footing.

- Limited Representation: Youth, women, and minority voices are notably underrepresented in governance structures. Participants pointed to the overrepresentation of older male stakeholders from business and government sectors.

These challenges reveal a governance environment that, despite rhetorical commitment to inclusion, still requires substantial structural reform to facilitate genuine, multi-stakeholder co-production.

5.3. Measures for Enhancing Participation of Local Actors

Participants proposed numerous practical measures to ensure that Silesian communities and local actors have a meaningful voice in just transition governance:

- Access to Clear and Timely Information: Regional authorities must ensure that relevant documents, funding calls, and decisions are easily accessible to the public, and translated into non-technical language when needed.
- Institutionalized Participation Mechanisms: Participants advocated for the creation of formal structures such as regional citizen assemblies, community working groups, and local energy forums, with actual influence on decision-making.
- Capacity-Building Programs: Technical training and workshops should be offered to equip civil society organizations and local leaders with the tools to participate effectively in planning and oversight.
- Collaborative Governance Agreements: Municipalities should formalize partnerships with NGOs, universities, and community organizations to co-create projects and monitor implementation.
- Incentive Structures: Grants, recognition programs, and co-funding schemes can serve as motivation for broader local engagement.
- Inclusive Governance Structures: Representation must be expanded to include marginalized voices and underrepresented groups, particularly women, youth, and long-term unemployed workers.
- Feedback Loops: Participants highlighted the need for feedback mechanisms, such as public reporting and community evaluation panels, to ensure that citizen input is acknowledged and acted upon.

Collectively, these measures aim to move beyond superficial consultation and establish a model of active co-governance, in which local actors co-shape both policy and practice.

5.4. Embedding the Place-Based Approach in Just Transition Governance

Participants noted that place-based principles remain underdeveloped in the current governance framework for Silesia. Despite the rhetoric of territorial sensitivity, much of the strategic planning is still formulated and administered centrally.

To meaningfully embed the place-based approach, participants proposed the following reforms:

- Decentralization of Governance Structures: The region should establish empowered Just Transition Committees with decision-making authority and budgetary autonomy, rather than relying solely on national-level approvals.
- Context-Specific Transition Plans: These plans should be based on territorial diagnostics, including social vulnerability indices, green infrastructure mapping, and labor market projections specific to Silesia.
- Territorial Monitoring and Evaluation Systems: Metrics should go beyond emission reductions to include social justice indicators, such as job quality, public health impacts, and the redistribution of transition benefits.
- Establishment of Regional Transition Support Hubs: These centers would offer technical support, advisory services, and access to funding instruments tailored to local actors and municipalities.
- Valuing Local Knowledge: Participants called for governance systems that actively integrate local expertise, including that of former miners, social workers, and community activists—whose understanding of the region's history and needs is often neglected.

These proposals reflect a consensus that a just transition cannot be centrally imposed, but must be locally negotiated, co-managed, and grounded in the lived experience of communities.

6. Conclusion

The energy transition, understood as a systemic transformation in production, distribution, and consumption of energy, requires complex interventions across multiple levels of governance. This article analyzes the concept of place-based governance as an effective approach to implementing a just energy transition. It highlights the necessity of incorporating local context, engaging communities, and ensuring institutional flexibility as key conditions for managing change in a manner consistent with social and environmental justice. Improving place-based governance in the context of energy transition requires a fundamental rethinking of public policy design and implementation. Contemporary research highlights the importance of moving beyond top-down, uniform frameworks by promoting governance models that are territorially differentiated, inclusive, and responsive to local conditions. In this regard, several key policy-oriented recommendations have emerged.

First, multi-scalar policy mixes are essential to ensuring coherence and complementarity across different levels of governance—from the EU and national authorities to regional and local administrations. These mixes should integrate climate, energy, and spatial development policies to reflect local realities and unlock synergies between sectors.

Second, polycentric governance—defined by the presence of multiple, overlapping centers of authority—enables more flexible and adaptive responses to the complex challenges of decarbonization. This model is particularly effective in fostering innovation, stakeholder engagement, and resilience within regional governance ecosystems. Third, coherent, long-term planning is required to navigate uncertainty and guide investment decisions in infrastructure, workforce development, and energy systems modernization. This entails the formulation of long-range transition roadmaps, aligned with the EU's climate targets for 2030 and 2050.

Fourth, integrating energy strategies with land-use planning is crucial, particularly in regions undergoing rapid spatial and infrastructural transformation. Coordinated planning helps avoid conflicts over land use, optimize the siting of renewable energy infrastructure, and ensure environmental and social safeguards. Finally, reforms to institutional and administrative structures are needed to improve coordination across scales and policy domains. This includes clarifying competencies, enhancing data-sharing mechanisms, and promoting intergovernmental cooperation.

Table 2
Energy transformation management framework

Institutional Design and Innovation	Stakeholder Engagement Strategies	Emerging Governance Models for Energy Transitions
The establishment of multi-level learning frameworks, enabling feedback and knowledge transfer between local, regional, and national actors.	Utilizing participatory decision-making processes based on co-designed tools.	Accelerator-based transition platforms, which facilitate rapid policy and technological deployment through innovation clusters.
The creation of formal structures for innovation, such as climate action councils, transition task forces, and regional energy agencies.	Building collaborative platforms that encourage local ownership of the transition process and foster long-term commitment	Just Transition frameworks and polycentric governance structures.
The promotion of collaborative arenas or integrative action situations, which facilitate joint problem-solving across policy sectors	Recognizing and supporting the role of intermediary actors, such as NGOs and knowledge brokers, in mediating conflicts and facilitating dialogue.	Co-transformation governance, where citizens, institutions, and businesses collaborate to jointly define and implement transition pathways.

Source: Own study.

These models collectively emphasize the need for governance systems that are flexible, socially embedded, and technically informed, balancing top-down strategic oversight with bottom-up community agency.

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CONSUMER PROTECTION IN FACE OF MISSELLING: INSTITUTIONAL GAPS REVEALED BY THE RESTRUCTURING AND BANKRUPTCY OF IDEA BANK S.A.

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Purpose: The purpose of the publication is to examine the effectiveness of consumer protection for individuals who suffered losses due to misselling in the context of bank restructuring and bankruptcy. The publication focuses on the institutional framework of protection and the actual actions taken by state institutions.
Design/methodology/approach: The study draws upon the analysis of academic publications, decisions and communications issued by state institutions, national court rulings, press articles, and a case study based on the documentation of a bank client who fell victim to misselling.
Findings: Consumer protection for those harmed by misselling proves inadequate in the context of bank restructuring and bankruptcy. The current framework for consumer protection seems poorly adapted to such circumstances, while the established procedures present considerable barriers for affected individuals.
Research limitations/implications: Both the analyzed decisions of state institutions and the documents included in the case study are partially basing on statements from consumers, who may present events in a manner that is legally more advantageous to them. Additionally, the projection of the final loss in the case study lacks basis in measurable data, and therefore should be approached with great caution.
Practical implications: The publication can serve as a valuable resource for organizations dedicated to consumer protection, as well as for entities involved in shaping and drafting legislation related to consumer rights.
Social implications: The research findings highlight the variation in the strength and quality of protection among consumers, depending on the financial situation of the bank and the legal assessment of their circumstances. Utilizing these insights could contribute to the development of more equitable solutions.
Originality/value: The study reveals gaps in the protection of financial services consumers who have been harmed by misselling in cases of bank restructuring and/or bankruptcy. It also highlights the scale of the phenomenon and the extent of losses that consumers are exposed to.
Keywords: financial market, financial consumer protection, misselling, GetBack, Idea Bank.
Category of the paper: research paper, case study.

1. Introduction

The pursuit of profits by the financial sector, including banks, often leads to the phenomenon of widespread misselling. This involves the exploitation of the stronger position of financial institutions to offer consumers products that are not tailored to their needs and frequently expose them to above-average risks.

The state should not only counteract such phenomena but also provide instruments enabling consumers to recover lost funds after damage has occurred – especially if the misselling is carried out by institutions widely trusted by the public, and consumers have approached them seeking safe products.

A variety of consumer protection instruments are available, enabling the recovery of lost funds directly from the financial institution providing them. Academic publications predominantly explore the responsibility of financial institutions and the state's role in influencing their operations. However, there is a noticeable gap in research addressing the consumer's situation in the event of the bankruptcy of an unreliable institution.

Therefore, this publication aims to address how such protection is structured for bank clients in situations where the bank undergoes mandatory restructuring, ultimately leading to its bankruptcy. Idea Bank S.A. was not only the first major bank in Poland to be subjected to both the compulsory restructuring and bankruptcy procedures, but also widely offered investment products to consumers (related to GetBack S.A.) in a manner that raised serious concerns.

Consequently, publication focuses on the analysis of the situation of Idea Bank's clients (consumers), allowing for an evaluation of the effectiveness of consumer protection against an unreliable financial institution, as well as identifying potential law and institutional changes to improve such protection.

2. Methodology and adopted research hypotheses

The study was designed with two key stages in mind: 1) an analysis of available scholarly and source texts on consumer protection, misselling, and the operations of Idea Bank S.A. and 2) an examination of a specific case involving a client affected by misselling by a financial institution that declared bankruptcy.

As a first stage of the conducted research, a review of the literature and applicable legal regulations was first carried out in order to define the phenomenon of misselling in the context of financial consumer protection. Subsequently, the misselling of investment products associated with GetBack S.A. by Idea Bank was meticulously reconstructed, drawing upon academic publications, decisions and communications from state institutions, national court

rulings, and press articles. The focus was placed not only on the offering of these products by Idea Bank itself, but also on the behavior of other entities (particularly supervisory institutions), the consequences of these actions for the bank's clients (including the actions they could have taken), and the impact of this scandal on the financial market. The establishment of a theoretical and historical foundation paved the way for the next stage of research.

The second stage of the research focused on a case study involving a client of Idea Bank, who had been offered typical products tied to GetBack. To ensure a thorough analysis, various materials were utilized, including bank documents, the client's correspondence with the bank and other entities in the financial market, exchanges with the Bank Guarantee Fund, an opinion issued by the Financial Ombudsman during an amicable proceeding initiated at the client's request, selected documents from court cases involving the client (understood to include their legal representative), and, where specific data was unavailable, information directly obtained from the client. As part of the case study, the course of fund allocation, the invested amounts, the received payouts, the client's actions aimed at recovering the funds, and an attempt to estimate the final loss were outlined.

The following research hypotheses were presented:

- the actions of financial market institutions proved insufficient in ensuring the safety of financial service consumers in cases of bank restructuring and bankruptcy (hypothesis 1),
- the procedures related to bank restructuring and bankruptcy do not effectively protect the interests of financial service consumers (hypothesis 2).

The verification of the indicated hypotheses will allow an evaluation of the quality of consumer protection both in the context of the risk of restructuring and bankruptcy itself, as well as in terms of the procedural protection of their claims after such actions have been taken.

3. Misselling as an element of the consumer protection system for financial services in the case of bank restructuring and/or bankruptcy

Misselling occurs worldwide, including in Poland. It is understood as, in particular, the concealment or distortion of information important to the consumer, especially regarding the risks associated with a product, resulting in the sale of a financial product that is not suited to the consumer's needs. Misselling often leads to significant financial losses for consumers, including those affecting their life savings (Butor-Keler, 2017).

Under Polish law, the statutory definition of misselling is included in Article 24(2)(4) of the Act on the Protection of Competition and Consumers (2007). This regulation was introduced by the 2015 amendment to improve systemic consumer protection, limiting its scope exclusively to financial service consumers (Orlicka, 2015). The introduction of the ban on misselling exclusively in relation to financial service consumers is a result of recognizing the need for their special protection and the necessity of systematically strengthening consumer safeguards (Rutkowska-Tomaszewska, 2020).

According to this provision, offering financial products to consumers that are not suited to their needs constitutes an act of unfair competition. Financial institutions can engage in misselling in two primary ways. Firstly, a financial institution is obligated to assess the consumer's needs (for example, by obtaining information directly from the consumer) and then determine whether the offered product is suitable for those needs. Offering a product contrary to these needs would qualify as misselling. Secondly, misselling also includes offering a product in an inappropriate manner. This may involve, for instance, providing misleading information about the product's features or using inadequate means of communication, such as offering a complex product via remote communication methods (Sieradzka, 2024). In the literature, the ban on misselling is highlighted as a crucial element of consumer protection in financial services. It is also seen as a response to banks introducing sales plans that incentivize employees to unfairly offer products to consumers (Trzeciak, 2017).

Regardless of the fact that the aforementioned regulation is a result of the mentioned amendment to the act, it should be noted that the issue of misselling was not unfamiliar to Polish law even earlier. In 2012, the Polish Financial Supervision Authority addressed a letter to all supervised entities (particularly banks), in which it identified “questionable practices”. These included, among others, the sale of investment products not tailored to consumers' needs and providing unreliable information about product features (KNF, 2012).

While the literature contains numerous publications on consumer protection in financial services against misselling and the responsibility of financial institutions (such as those cited above), there is a noticeable lack of research focusing on the consumer's situation in cases of bank restructuring and/or bankruptcy. In fact, the only comprehensive publication addressing this issue in Poland is the work by Stopczyński (2024). However, it primarily focuses on systemic solutions, particularly the premises for initiating restructuring, rather than directly on the consumer's financial situation and the extent of their losses (including Idea Bank case described in the cited publication).

4. Misselling of financial products by Idea Bank S.A. and its consequences for consumers of financial services

4.1. The products connected with GetBack S.A. and offered by Idea Bank S.A

Idea Bank S.A., part of the Getin Group (owned by Leszek Czarnecki), was considered an innovative bank, building its market advantage on this reputation (Anielak, 2018). However, the bank expanded its consumer offerings to include a range of investment products, most commonly securities.

One of the entities whose securities were widely placed among non-institutional buyers was GetBack S.A., operating in the debt collection market. The company was established in 2012 within the Getin Group, and in 2016 it was acquired by the Abris fund (Rogowski, Gemra, 2018). As the fund's president stated in an interview for Forbes Poland, the existing management board was retained, as they believed in its competence and integrity (Gieryński, 2018).

In 2017, the company made its debut on the Warsaw Stock Exchange, backed by favorable recommendations from brokerage firms (Adamczyk, 2019). Following its debut, GetBack continued to be perceived as a trustworthy and appealing entity. Brokerage houses maintained buy recommendations for its shares, while its bond ratings consistently hovered around a B grade (Kaczmarczyk, 2018).

GetBack alternated between issuing public and non-public bonds with a total value of 2.59 billion PLN (Adamczyk, 2019). Notably, only a small portion of these issuances was public, amounting to 256.4 million PLN, which allowed the company to avoid significant reporting obligations (Moser, 2020). Consumers with no prior experience with bonds tended to mistakenly perceive them as risk-free products (Martysz, 2020).

Later proceedings revealed criminal activities committed within GetBack, including those harming individual holders of its securities (Adamczyk, 2019). The president of Abris also stated in an interview for Forbes Poland that while GetBack operated as a legitimate business at the time of its acquisition, the subsequent actions of its management aimed to mislead the fund (Gieryński, 2018).

The case of GetBack is cited in the literature as an example of fraud and manipulation in the Polish capital market (Iczetkin, Hernik, 2019), as well as a reason for the decline in consumer interest in the capital market (Czech, 2020). The company's securities, particularly its bonds, lost value within a relatively short period, after which trading was suspended (Kaczmarczyk, 2018).

Idea Bank was the main distributor of GetBack bonds, operating in collaboration with Polski Dom Maklerski S.A. (PDM). This cooperation involved Idea Bank employees persuading consumers to purchase GetBack bonds by presenting the offer in a manipulated manner. Consumer data expressing interest in the product was forwarded to PDM for the purpose of

finalizing the transaction (Kubacki, 2022). Additionally, Idea Bank offered its clients investment certificates for funds from the Trigon TFI group, also connected to GetBack, in a similarly manipulated way (Kosiński, 2019).

The inspection conducted by the Polish Financial Supervision Authority (Polish FSA) confirmed that Idea Bank was improperly involved in the sale process of GetBack bonds (Moser, 2020). Subsequently, due to irregularities related to the offering and sale of GetBack bonds, the Polish FSA on 13th November 2018 added Idea Bank to its public warning list for conducting capital market activities without the necessary authorizations (KNF, 2018).

In response to numerous reports of irregularities in the process of offering GetBack bonds, the President of the Office of Competition and Consumer Protection, in a decision dated 4th February 2019 also found that the contractual templates prepared by PDM included abusive clauses (UOKiK, 2019a). Subsequently, in a decision dated 1st August 2019, it was determined that the actions of Idea Bank violated collective consumer interests by misleading consumers during the bond offering process. This included disseminating false information about the guaranteed returns and safety of these bonds, as well as creating an impression of exclusivity and time-limited availability of the offer (UOKiK, 2019b).

On 3rd February 2020, the President of the Office of Competition and Consumer Protection issued another decision, determining that the practices of Idea Bank violated collective consumer interests. These practices involved offering GetBack bonds to consumers holding bank deposits, despite the fact that the risks associated with these products did not align with the consumers' needs, based on their previously purchased products and declarations made during the acquisition process. As a result, the bank was obligated to pay compensation amounting to 20% of the funds invested (UOKiK, 2020a). On 27th April 2020 a similar decision was made regarding GetBack itself. The company was found to have engaged in unfair market practices, such as misleading consumers about its financial situation, the risks associated with its bonds, and creating an impression of exclusivity and time-limited availability of the offer (UOKiK, 2020b).

In July 2020, President of Office of Competition and Consumer Protection issued two further decisions related to the misselling of investment certificates from funds within the Trigon group. In decision dated 10th July 2020, it was established that Idea Bank offered these certificates in the same manner as GetBack bonds, leading to the imposition of a requirement to provide compensation equal to 20% of the invested funds (UOKiK, 2020c). Additionally, in a decision dated 22th July 2020, it was found that the fund had misled consumers by providing false information about “full capital security” (UOKiK, 2020d). Finally, on 23th October 2020, a penalty was imposed on Getin Noble Bank S.A. for identical violations related to GetBack bonds. Getin Noble Bank operated within the same capital group as Idea Bank (UOKiK, 2020e).

In the literature regarding the GetBack case, it is emphasized that the protection of bondholders – both in legal and market terms – has proven insufficient, and there is a need to strengthen these mechanisms (Lepczyński, Pisarewicz, 2018a). One of the methods suggested for improving this protection is enabling the imposition of higher penalties, as well as penalizing employees who sell financial products in an unreliable manner (Czaplicki, 2021).

It is also significant that, as early as 19th December 2017, a whistleblower submitted a report to the Polish Financial Supervision Authority (Polish FSA), the Office of Competition and Consumer Protection, and the Warsaw Stock Exchange (WSE), indicating data manipulations in GetBack's reports and the characteristics of a financial pyramid. Only the Polish FSA reacted to this report by initiating an investigation, while the WSE awarded GetBack a prize in February 2018 for leveraging market opportunities offered by the stock exchange, which maintained the company's positive image (Moser, 2020). However, the first actual measures were only taken by the Polish FSA ex post, after GetBack published a false report regarding further financing (Lepczyński, Pisarewicz, 2018b).

4.2. Restructuring and bankruptcy of Idea Bank S.A.

Following GetBack's liquidity crisis, on 6th June 2019, the District Court in Wrocław approved a restructuring arrangement under which bondholders were to receive only 25% of their invested funds over an eight-year period (District Court in Wrocław, 2019). As a result, GetBack bondholders lost at least 75% of their capital. Problems also affected investors who had funds in securitization vehicles managed by GetBack, including those handled by Trigon, Altus, Boble, and Saturn (Rogowski, Gemra, 2018). In the case of Trigon funds, consumers were not only unable to recover their investments (Rudke, 2019), but on 5th November 2019, the Polish Financial Supervision Authority revoked Trigon TFI's license (operating under the name Lartiq at the time). The funds were subsequently transferred to other entities, primarily Ipopema TFI (KNF, 2020). Despite an appeal, this decision was ultimately deemed valid (KNF, 2024).

In this situation, consumers started filing claims directly against Idea Bank, with a particular focus on allegations of misselling practices. The most notable (and likely the first) judgment was issued by the Regional Court in Kraków on 20th July 2020. In this ruling, the court awarded compensation to the consumer, defined as the difference between the funds invested and the amount the consumer was expected to recover from GetBack under the restructuration arrangement. The consumer, an elderly individual, was led by Idea Bank to believe that GetBack bonds were zero-risk products with characteristics equivalent to a bank deposit (Regional Court in Kraków, 2020).

It should be noted that, over time, a more pro-consumer jurisprudence has emerged in cases involving banks. According to this approach, the misselling of a financial product may lead to the nullification of such an agreement. In such cases, the bank either bears joint liability with

the issuer (Court of Appeal in Kraków, 2022) or is responsible for the invested funds to the extent that they cannot be recovered from the issuer (District Court in Jastrzębie-Zdrój, 2023).

By a decision dated 30th December 2020, the Bank Guarantee Fund initiated forced restructuring proceedings against Idea Bank, citing the threat of bankruptcy as the basis. Following this decision, the majority of Idea Bank (particularly its deposit and credit operations) was taken over by Bank Pekao S.A., while selected part (including claims related to misselling) were transferred to a separated entity (BFG, 2020). It is indicated that such a division was a conscious decision by BGF, which was aware of the negative reception of this decision by consumers (Stopczyński, 2024). On 26th July 2022, the court declared the bankruptcy of this separated part of Idea Bank (KRZ, 2022). For clarity, it is worth noting that Leszek Czarnecki (the former principal shareholder of Idea Bank) has argued that there were no basis for initiating the restructuring of Idea Bank and that these actions were solely aimed at taking over the bank (Czarnecki, 2025). However, it should be mentioned that earlier academic publications had already identified Idea Bank as an entity at risk of bankruptcy (Firlej, Stanuch, 2020).

Notably, the very initiation of restructuring proceedings can influence ongoing legal cases. Firstly, it is not possible to initiate enforcement proceedings against a bank undergoing restructuring, and any previously initiated proceedings are discontinued. Secondly, court proceedings are also suspended at the request of the restructured bank (Stefańska, 2022). The announcement of bankruptcy leads to even more far-reaching consequences. The declaration of bankruptcy obligatory suspends legal proceedings against the bank, and a new issue can be started only once the bankruptcy procedure will be completed (Chrapoński, 2021). After the liquidation of the bankrupt entity's assets, the funds obtained will be distributed according to specified categories, meaning that some claims may not be satisfied at all or only to a minimal extent (Janda, 2023). It is important to emphasize that both the restructuring and subsequent bankruptcy have serious consequences for consumers of financial products, particularly resulting in the loss of the majority of their invested funds (Kaczmarczyk, 2024).

It should be noted that clients of a bank undergoing restructuring have the right to file a complaint against the decision of the Bank Guarantee Fund. As a result of the court's review of such a complaint, it may rule that the decision was made unlawfully (Mikliński, 2022). If such a verdict is issued, the Bank Guarantee Fund bears liability for damages up to the extent of the incurred loss (Chojecka, 2019). In a similar case concerning Getin Noble Bank, the Court of Justice of the European Union emphasized the need to address all submitted complaints and to examine whether conflicts of interest exist within the structure of the Bank Guarantee Fund (CJEU, 2024). Following the described ruling, the Supreme Administrative Court resumed proceedings regarding complaints about the forced restructuring of Idea Bank, but the case remains unresolved (Supreme Administrative Court, 2025).

5. Case study – client of Idea Bank S.A.

The case study focuses on a client of Idea Bank, operating under the Lion's Bank brand, who had a history of using the bank's services. The client, a young individual, used bank deposits or structured deposits (it is unclear whether the client was aware of the differences between these products), where they invested their life savings. Importantly, in the investment questionnaire valid for the analyzed period, the client indicated that they "accept a loss of up to 10% of the invested funds", although the manner in which this document was prepared is unknown.

In December 2016, a bank employee (the client's advisor) contacted the client and informed them of a more advantageous method of investing capital compared to their existing deposits. The capital was said to be fully guaranteed and withdrawable at any time, though the offer was very time-limited. As a result, on 21th December 2016, the client subscribed to an investment certificate in Trigon Profit XXIII Non-Standardized Securitization Closed-End Fund for a total amount of 193,800.00 PLN. At the end of March, since part of the client's funds were held in traditional deposits, the same employee contacted them again, presenting an allegedly better opportunity to invest their money (describing the product in the same manner as before). As a result, on 30th March 2017, the client subscribed to GetBack bonds with a total value of 50,000.00 PLN (referred to as "A"). This situation repeated a few months later, when, on July 13, 2017, the client subscribed to additional GetBack bonds, also valued at 50,000.00 PLN (referred to as "B"). Each time the client purchased these products, they either terminated an existing deposit or used funds from a recently matured deposit. The timeline of fund acquisitions is presented in Table 1.

Table 1.
Investing funds in products recommended by the bank in analyzed case

Date	Type of product	Value
21.12.2016	investment certificates – Trigon	193.800,00 PLN
30.03.2017	bonds – GetBack A	50.000,00 PLN
13.07.2017	bonds – GetBack B	50.000,00 PLN
	Total	293.800,00 PLN

Source: own work.

The provision of misleading information about the offered products was not the only fault in Idea Bank's actions in the analyzed case. Although the Trigon investment certificates were guaranteed, it is important to note that GetBack served as the guarantor – thus, there was unquestionably no genuine risk diversification. The client was sold products that were not only unsuitable for their needs (exposing them to greater risk than they found acceptable) but also largely reliant on the solvency of a single entity (GetBack). Undoubtedly, this case involved the misselling of investment products. Until GetBack's liquidity was lost, the client received regular payments, specifically 33,707.96 PLN from the Trigon fund and a total of 4,254.14 PLN

in interest from GetBack bonds. At the time payments ceased, the client had recovered only approximately 13% of the invested amount, with details presented in Table 2. It is worth noting that, in this case, the formal issuer was PDM, not Idea Bank. However, the client obtained the IP address used for the subscription on 13th July 2017 (earlier data was no longer stored), which pointed to directly Idea Bank.

Table 2.
Amount of payments received and the nominal loss before Idea Bank's bankruptcy in analyzed case

Type of product	Sum of all payments received	Nominal damage amount
investment certificates – Trigon	33.707,96 PLN	160.092,04 PLN (82,61%)
bonds – GetBack A	3.029,18 PLN	46.970,82 PLN (93,94%)
bonds – GetBack B	1.224,96 PLN	48.775.04 PLN (97,56%)
Total	37.962,10 PLN	255.837,90 PLN (87,08%)

Source: own work.

The client undertook a series of actions related to the threat to their invested funds, including submitting multiple complaints (on 07.02.2019, 04.03.2019, and 13.03.2019), as well as later issuing a declaration to withdraw from the effects of a statement made under error (on 19.10.2019). Following GetBack's submission of a restructuring application and its subsequent approval, resulting in a 75% loss in bond value, the client approached the Financial Ombudsman seeking an amicable resolution of the dispute with Idea Bank regarding the funds lost due to investments in GetBack bonds. The proceedings took place between 13th May 2019, and 27th May 2020, but did not result in a settlement. The Financial Ombudsman, in their opinion, highlighted several potential irregularities in the offering of the bonds. As a result, on 4th November 2020, the client filed a civil lawsuit against Idea Bank seeking the return of funds from GetBack bonds not included in the restructuring[1]. However, following the initiation of compulsory restructuring of Idea Bank, the proceedings were suspended at the request of the Bank Guarantee Fund on 19th February 2021.

Following the initiation of compulsory restructuring of Idea Bank, on January 4, 2021, the client submitted a complaint to the Provincial Administrative Court in Warsaw against the decision of the Bank Guarantee Fund. This complaint was not upheld as part of a collective judgment encompassing all complaints. The client did not file an appeal against the decision of the Provincial Administrative Court. Following the declaration of bankruptcy by a separated part of Idea Bank, the client, within the statutory 30-day period, submitted a free claim notification to the trustee. However, a year later, the trustee requested the client to supplement the notification by providing the case file reference number pending before the court. Due to the client's failure to provide the required information, the notification was ultimately

[1] It should be noted that, at the time, the prevailing view was that cases related to misselling did not fall under banking activities. Consequently, the court required the client to pay a lawsuit fee amounting to 5% of the claimed amount (over 3,700.00 PLN). Currently, the dominant view is that such cases pertain to banking activities, meaning the fee cannot exceed 1,000.00 PLN.

returned. It should be emphasized that the online bankruptcy system requires separate activation of an email address to receive notifications, which most consumers are unaware of. As a result, they are often not conscious of the deliveries made to them (as was in analyzed case). The client may submit the claim again; however, this involves a fee of 1,239.95 PLN. Furthermore, it should be noted that if the trustee acknowledges the claim (regardless of previous return), the client will not recover the costs of the civil proceedings, which will be discontinued.

It is currently not possible to determine the final amount of the loss incurred by the client, as the future payments they will receive are unknown. For this reason, an attempt has been made to estimate their amount. According to the available statements from GetBack (now Capitea S.A.), payments to bondholders are being made in accordance with the restructuring arrangement, and therefore it can be assumed that the client will receive amounts of 12,500.00 PLN each. It is more difficult to determine the potential amount the client could receive for the investment certificates they hold. Assuming it would also amount to 25% of the nominal value (190,000.00 PLN), this would correspond to an additional amount of approximately 47,500 PLN (variant I). However, based on data from similar cases (such as the previously cited judgment of the District Court in Jastrzębie-Zdrój), the total payout amount for funds holding so-called bad debts typically hovers around 33% of its nominal value. Therefore, in such a scenario, the client could expect to receive approximately PLN 62,700 in total, meaning an additional amount of about PLN 29,000 (variant II). Of course, it cannot be ruled out with certainty that the fund no longer holds any real assets, in which case the client would not receive any further payout (variant III). These data are presented in Table 3; however, it should be emphasized that due to the lack of adequate information regarding investment certificates, these are very imprecise estimates that should be approached with great caution.

Table 3.
Estimated final payments and nominal loss in the analyzed case involving Idea Bank

Type of product	**Sum of all payments received**	**Nominal damage amount**
investment certificates – Trigon (variant I)	81,207.96 PLN	160.092,04 PLN (82,61%)
investment certificates – Trigon (variant II)	62.700,00 PLN	131.100,00 PLN (67,65%)
investment certificates – Trigon (variant III)	33.707,96 PLN	160.092,04 PLN (82,61%)
bonds – GetBack A	15,529.18 PLN	34.470.82 PLN (68,94%)
bonds – GetBack B	13,724.96 PLN	36.275,04 PLN (72,55%)
Total (variant I)	110,462.10 PLN	183,337.90 PLN (62,39%)
Total (variant II)	91,954.14 PLN	201,845.86 PLN (69,72%)
Total (variant III)	62,962.10 PLN	230,837.90 PLN (78,54%)

Source: own work.

Thus, regardless of the limitations of the presented projection, it is quite likely that the client's nominal loss will amount to between 60% and 80% of the allocated funds. However, it should be emphasized that this is only a nominal loss, which does not account for lost interest (or inflation, or changes in the value of money over time), nor the range of additional costs incurred by the client due to legal actions.

6. Conclusions

First and foremost, it should be emphasized that most state institutions have taken appropriate measures concerning the misselling of investment products linked to GetBack. In particular, the Office of Competition and Consumer Protection properly identified such practices and issued relevant decisions, while the Financial Supervision Authority included Idea Bank on the list of public warnings. Moreover, courts adjudicating in individual disputes applied the law in a manner favorable to consumers, and in light of GetBack's insolvency (and entities associated with it), ruled on the financial liability of the actual issuer.

Thus, clients of banks that offered them products ill-suited to their needs and exposing them to excessive risk could ultimately hope to recover their entrusted funds (most often following a court dispute). However, the situation is different for clients of the analyzed Idea Bank. Shortly after the first, non-final verdicts, the bank underwent a forced restructuring and division. Regarding the part related to claims arising from misselling, compulsory restructuring was initiated, followed by bankruptcy. In such circumstances, clients of this bank effectively lost the ability to assert their rights for many years, as all civil proceedings cannot be conducted until the bankruptcy proceedings are concluded.

Undoubtedly, one may get the impression that all procedures and solutions aimed at protecting consumers from the effects of misselling focus solely on assigning responsibility to the offering entity, in this case, the bank. However, these solutions appear to entirely overlook the possibility of restructuring or bankruptcy of such an entity, thereby creating a significant gap in the consumer protection system in such situations. For this reason, the first hypothesis has been positively verified.

Serious concerns arise, in terms of consumer protection for financial services, regarding the possibility of isolating only a part of a bank, essentially destined for bankruptcy. It should be emphasized that, as evidenced by the analyzed decisions and rulings, at least a significant portion of Idea Bank's clients believed they were using traditional banking services, particularly deposits covered by the Bank Guarantee Fund. Undoubtedly, it was not their intention to choose products lacking such a guarantee.

The division of Idea Bank carried out by the Bank Guarantee Fund consequently led to significant disparities in the legal situation of consumers who expected the same service from the bank. At the same time, the protection of actual deposits, aimed at reducing systemic costs, was achieved at the expense of the bank's other clients, including those who became victims of misselling. The separation of the “healthy” part of the bank resulted in leaving primarily questionable-quality assets and claims of other clients in the bankrupt segment.

Equally important, as already indicated above, under the applicable regulations, the initiation of restructuring grants the Bank Guarantee Fund the right to unilaterally suspend all ongoing court proceedings, thereby preventing consumers from asserting their rights in

an impartial process. Such an opportunity only becomes available at a later stage, after bankruptcy is declared and the consumer has exhausted the complex procedure of filing claims.

Additionally, as demonstrated by the analyzed client's case study, the system requiring the filing of claims is also unintuitive, and a lack of professional knowledge in its operation can result in the rejection of the submitted claim. Furthermore, the regulations granting the trustee broad right to reject such a filing appear absurd, as in the examined case, the claim was rejected due to the absence of a court case number, in which the trustee's representative participates (and the trustee themselves is a party). This is information that trustee undoubtedly possessed.

Although consumers harmed by misselling may, in the future, have a potential claim against the State Treasury (Bank Guarantee Fund) for damages due to the issuance of unlawful decisions by the Bank Guarantee Fund, but firstly, no final verdict on this matter has been issued yet. Secondly, there is a lack of reliable case law on this issue (for instance, whether such compensation is only available to consumers who were parties in administrative court proceedings). Finally, such liability will be limited solely to the extent of the damage caused by the restructuring. Therefore, it will be necessary to hypothetically determine what funds the consumer would have received if the restructuring had not occurred, which may pose significant evidentiary challenges.

Thus, both the systemic assumptions of bank restructuring and bankruptcy can be assessed as being shaped in a way that is unfavorable to financial services consumers, and individual procedures seem burdensome and unintuitive for consumers, which can often lead to a limitation of their rights. For these reasons, the second hypothesis should also be regarded as positively verified.

One of the key methods for mitigating the effects of such events remains the increased education of financial service consumers, including raising awareness (especially among older individuals) of the necessity to verify claims made by financial institutions. It is also essential to explore solutions that enable state institutions to respond more swiftly to detected market irregularities and improving the effectiveness of these activities (for example, the FSA's public warning list, which is often overlooked by consumers).

In the author's opinion, also modifications of regulations on forced bank restructuring and bankruptcy are necessary to ensure greater protection for consumers who were only interested in safe financial products. Such protection could be enhanced by establishing a dedicated fund or extending deposit guarantee coverage to consumers who merely intended to deposit their savings but, due to the bank's actions, ended up acquiring a different type of financial product. Unfortunately, such solutions would likely entail significant costs for the banking sector.

7. Summary

In the final period of GetBack's operations, securities based on its activities were offered to clients of Polish banks (particularly those within the Getin group) on a massive scale. In the majority of cases, the sales were mismatched to the consumers' needs, representing a typical instance of misselling. Following GetBack's loss of liquidity and subsequent restructuring, consumers lost a significant portion of the funds they had invested in these products. For GetBack bondholders, in accordance with the approved arrangement, the recovery rate will be 75% (assuming full implementation). In other cases, the typical loss is expected to be approximately 60-80% (estimated according to the methodology adopted by the author in the publication).

In the case of Idea Bank's clients, it turned out that the restructuring of the offering entity, followed by its subsequent bankruptcy, effectively deprived consumers within foreseeable timeframes of the ability to recover funds beyond those disbursed in connection with the securities they held. It is not yet known whether the decision of the Bank Guarantee Fund will be deemed unlawful, and if so, what actual protection consumers affected by misselling will obtain as a result. Regardless, it must be acknowledged that in the event of a bank's bankruptcy, consumer protection has proven insufficient. At the same time, systemic solutions may prove too costly for the financial sector.

Further research is also necessary to monitor the situation, both in the case of those harmed by the misselling of GetBack products (including the extent of their final losses) and in evaluating the evolving regulations and their ability to prevent such incidents in the future. It is also desirable to seek systemic solutions that reduce the described risk while maintaining an acceptable cost for the sector.

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THE USE OF E-HEALTH DURING THE COVID-19 PANDEMIC BY OLDER ADULTS IN POLAND

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Purpose: The aim of this research is to analyze the use of e-health and assess its usefulness to older adults in Poland during the COVID-19 pandemic. It was also important to identify potential socio-demographic and health factors that may influence the use of e-health by older people.

Design/methodology/approach: In this article the quantitative research method was used. A survey was conducted with 400 respondents. One-way ANOVA and chi-square ($\chi 2$) test were used to analyze the relationship between e-health use and various socio-demographic characteristics of respondents.

Findings: The results show that several factors are associated with increased use of e-health services, including age, marital status, domicile, health, and education. Younger, married and better educated people, urban residents, and with better health are more likely to use various elements of e-health.

Research limitations/implications: The importance of e-health will grow as societies age and technology develops. In future research, it would be worthwhile to investigate problems in the practical application of telehealth that raise deep concerns among older people. The use of incentives could then be increased, increasing satisfaction with e-health systems.

Practical implications: Older adults should be considered the most important users of e-health, taking into account the fact that the way they use and perceive these systems is especially important for sustainable development.

Social implications: This finding should inspire policymakers, especially the Ministry of Health, to increase and expand the use of e-health systems by encouraging older patients with health problems, especially from rural areas, to use remote patient monitoring technologies and ICT devices to treat their diseases.

Originality/value: The use of e-health systems by older patients in Poland is on the whole inadequate. Most of these people have generally negative opinions and attitudes towards e-health services.

Keywords: e-health use; e-health usefulness, elderly; COVID-19.
Category of the paper: research paper.

1. Introduction

Electronic health (e-health) is one of the fastest-growing areas of healthcare in many countries, including Poland. Several factors contribute to this rapid increase, including an ageing population, patients' preference for care provided in their homes, and earlier discharges from intensive care units (Ma et al., 2022; Triantafillou et al., 2020). E-health systems are becoming increasingly popular as they allow them to maximise productivity and efficiency while reducing costs in home healthcare (Chae et al., 2001; Van Der Meij et al., 2016). The advantage of e-health is improving the availability and quality of healthcare between patients and healthcare providers and saving time. E-health breaks space-time constraints to deliver remote treatment and optimise the allocation of medical resources.

E-health is defined as the provision of any health service or information that involves the use of the Internet or other forms of information and communication (ICT) technologies (Alkawaldeh et al., 2023; Boogerd et al., 2015), including, for example, digital storage and transmission of medical records, consultations and medical training conducted via video conference (Ali et al., 2021).

Due to COVID-19, e-health has expanded to more patients to reduce unnecessary exposure and preserve personal protective equipment. Many organisations subsequently began to use the infrastructure to provide teleconsultations, including video teleconsultations, and to encourage patients to use mobile applications to monitor their health. An additional advantage of some applications of this type is that they take into account the user's perspective, using Human Centered Design (HCD) methodologies and collect data using various devices (e.g. data containing high-quality health information collected from various sources) (Park et al., 2022).

The literature emphasises that providing e-health services can particularly benefit older adults because they are more susceptible to chronic diseases. A rapidly ageing population entails a significant increase in the incidence of chronic diseases and their consequences, and thus, the need for increased care and well-being (Merrell, 2015). E-health could also prove helpful for people who have mobility problems and are more susceptible to infectious diseases such as COVID-19 (Jankowiak, Rój, 2023).

Based on the analysis of the literature on the subject (Bashshur et al., 2015; Chumbler et al., 2015; Lemay et al., 2013; Levine et al., 2014; Postma-Nilsenová et al., 2015), it can be concluded that the use of e-health systems exceeds the number of visits to the doctor's office due to diabetes, hypertension, pain, congestive heart failure, cancer treatment, stroke rehabilitation and dementia. Therefore, older adults have become one of the main target groups of telecare technologies. Telecare solutions provide new opportunities for diagnosis, treatment, education and rehabilitation, enabling monitoring of patients with many chronic diseases. They also reduce socio-economic disparities in care access and equalise patients' changes in urban and rural areas (Bujnowska-Fedak, Grata-Borkowska, 2015).

On the other hand, there is a widespread belief that older people cannot use advanced electronics and telecommunications due to their limited computer and technology skills (Merrell, 2015). It should be emphasised that older people could benefit much more from e-health if it were not for the fact that they often struggle with particularly high barriers to using new technologies (König et al., 2018; Poli et al., 2019).

The aim of this research is to analyse the use of e-health and assess its usefulness to older adults in Poland during the COVID-19 pandemic. It was also important to identify potential socio-demographic and health factors that may influence the use of e-health by older people.

Achieving the intended goal of the work requires answering three research questions:

1. To what extent have older adults used e-health systems during the COVID-19 pandemic?
2. How do older adults assess the usefulness of remote technologies in monitoring their health?
3. What socio-demographic factors predict the use of e-health among older people in Poland?

Research carried out so far has focused on the use and evaluation of e-health from the patients' perspective (Holtz, 2021; Isautier et al., 2020; Merrell, 2015; Powell et al., 2017), especially in terms of reliability (Lobacz et al., 2023; Zarate et al., 1997), cost-effectiveness (Doolittle et al., 1998), and patient satisfaction (Allen, Hayes, 2009; Mekhjian et al., 1999). However, such research has not been conducted in Poland and there is no detailed report on the use and experiences of e-health by older people. Moreover, to the authors' knowledge, no attempt has been made to empirically investigate the determinants of using specific e-health components among older adults. Previous studies have focused on the predictors of e-health adoption in general (Andrews et al., 2019; Jokisch et al., 2020; Menéndez Álvarez-Dardet et al., 2020). Among the telecare services aimed specifically at older adults, two main systems are in the lead: systems for remote monitoring of patients' health, including their vital signs such as heart rate, blood pressure, body temperature and glucose levels; support systems via ICT, e.g. teleconsultations, SMS reminders about appointments and prescribed medications (Barlow et al., 2007). It is therefore important to investigate the socio-demographic and health factors influencing older patients' use of these e-health components.

2. Materials and Methods

The survey regarding the use and perception of e-health systems by older people was conducted from September 13 to 27, 2021, i.e. during the COVID-19 pandemic, when the transition to remote medical care occurred. Survey research was carried out using a traditional form. The printed survey form was personally delivered to students of the University of the

Third Age and participants of Seniors' clubs in the Masovian Voivodeship (the voivodeship being the highest-level administrative division in Poland). Universities of the 3rd age are educational institutions for older adults. They are a form of activating seniors and create the opportunity to constantly expand their knowledge, make friends, and provide the opportunity to keep up their physical condition. Seniors' clubs, on the other hand, are facilities that are meeting places for older adults. These facilities do not provide treatment or care, but they focus on creating a friendly space for seniors where they can spend time together. Seniors' clubs often offer seniors a large selection of various activities tailored to each participant's interests. Available options include foreign language learning and computer workshops. When selecting the research sample, it was also assumed that students of the University of the Third Age have basic digital qualifications (they can use e-mail and an Internet search engine), which is reflected in the respondents' answers in this regard. Participants were informed that the survey was anonymous. The criteria for inclusion in the study were age over 60 and oral consent to participate in the study. No upper age limit was set. Patients could withdraw from the study any time or not answer all questions. A total of 550 surveys were submitted, of which 400 were returned. All the surveys received were filled out completely and correctly.

An original, structured survey questionnaire was used to conduct the survey. The survey contained questions grouped into two categories. The first concerned the use of IT systems and e-health. The second part concerned socio-demographic variables and the health status of older adults.

In the first part of the survey questionnaire, older adults were asked to answer survey questions regarding ICT use. The study used information related to ICT, such as access to ICT tools (e.g. computer, smartphone, RMP - remote patient monitoring devices) and the use of e-health services (electronic data exchange, teleconsultations, video advice, RMP). The variables for measuring access to ICT tools were binary variables that indicated whether the respondent used at least one type of ICT tool, including a computer and mobile phone, to access remote health services. Respondents were also asked to indicate specific tools for remote monitoring of the patient's health (RMP) that they used during the COVID-19 pandemic (e.g. thermometer, blood pressure monitor, heart rate monitor, telemedicine wristband, video monitoring, electronic camera, motion detectors, smart watches, activity band with geolocation). The level of use of E-Health systems in the era of the coronavirus pandemic was assessed on a five-point Likert scale ("very weak", "weak", "average", "good", "very good").

The second part of the questionnaire contained questions about the health status of older adults and key socio-demographic variables. The following explanatory variables were used in the study: age, education, and marital status. Respondents were also asked to self-assess their health on a five-point scale (very good, good, average, unsatisfactory, very unsatisfactory).

The relationship between e-health use and the studied socio-demographic variables was determined using the chi-square ($\chi 2$) test and ANOVA analysis. Data were calculated and analysed using Statistica software (version 13.3).

3. Results

3.1. Socio-demographic and health characteristics of the respondents

The socio-demographic and health characteristics of the respondents are shown in Table 1.

Table 1.
Socio-demographic and health characteristics of the respondents

Variable		Total		Women			Men		
		Number of responses	%	Number of responses	%	% Women	Number of responses	%	% Men
Sex	Woman	231	57.75						
	Man	169	42.25						
The level of use of e-Health by older adults in Poland during COVID-19	Very good	58	14.50	33	8.25	14.29	25	6.25	14.79
	Good	36	9.00	16	4.00	6.93	20	5.00	11.83
	Average	141	35.25	85	21.25	36.80	56	14.00	33.14
	Weak	87	21.75	49	12.25	21.21	38	9.50	22.49
	Very weak	78	19.50	48	12.00	20.78	30	7.50	17.75
The health assessment	Very good	13	3.25	6	1.50	2.60	7	1.75	4.14
	Good	98	24.50	59	14.75	25.54	39	9.75	23.08
	Average	109	27.25	53	13.25	22.94	56	14.00	33.14
	Weak	63	15.75	48	12.00	20.78	15	3.75	8.88
	Very weak	117	29.25	65	16.25	28.14	52	13.00	30.77
Age	60-64	93	23.25	56	14.00	24.24	37	9.25	21.89
	65-69	106	26.50	58	14.50	25.11	48	12.00	28.40
	70-74	106	26.50	65	16.25	28.14	41	10.25	24.26
	75 and above	95	23.75	52	13.00	22.51	43	10.75	25.44
Marital status	Bachelor/single	40	10.00	21	5.25	9.09	19	4.75	11.24
	Married	189	47.25	111	27.75	48.05	78	19.50	46.15
	Widower/widower	122	30.50	70	17.50	30.30	52	13.00	30.77
	Divorced	49	12.25	29	7.25	12.55	20	5.00	11.83
Domicile	City	337	84.25	196	49.00	84.85	141	35.25	83.43
	Village	63	15.75	35	8.75	15.15	28	7.00	16.57
Education	Primary education	48	12.00	23	5.75	9.96	25	6.25	14.79
	Vocational education	90	22.50	49	12.25	21.21	41	10.25	24.26
	Secondary education	167	41.75	109	27.25	47.19	58	14.50	34.32
	Higher education	95	23.75	50	12.50	21.65	45	11.25	26.63
Using RMP devices	Yes	303	75.75	171	42.75	74.03	132	33.00	78.11
	No	97	24.25	60	15.00	25.97	37	9.25	21.89
Using smartphones	Yes	400	100	231	57.75	100	169	42.25	100
	No	0	0	0	0	0	0	0	0

A total of 400 respondents participated in the survey, 50.25% of them over 70. Women made up 57.75% of the respondents. Almost half of the respondents (47.25%) were married, 30.50% were widows/widowers and 12.25% were divorced. Regarding education, 12% of respondents had only completed primary school, 22.50% had completed vocational school,

41.75% had completed secondary school, and 23.75% had completed higher education. Most of the survey participants came from a city (84.25%). Almost half of the respondents (45%) described their health status as unsatisfactory or very unsatisfactory, while only 3.25% described their health status as very good. The level of e-health use by seniors is average. The largest group of respondents (35.25%) assessed using e-health at an average level.

3.2. The assessment of the usefulness of e-health technologies

The respondents were asked to rate e-health usefulness in medical care on a scale of 1 (Very weak) to 5 (Very good). The responses to this question are shown in Figure 1.

Figure 1. The assessment of the usefulness of e-health remote technologies by older adults.

The average rating of the usefulness of remote e-health technologies for seniors is 2.57. As many as 45% of respondents rate the usefulness of e-health systems as unsatisfactory or very unsatisfactory. Such a rating indicates moderately negative feelings of the surveyed older people towards the technology. This shows an overall low satisfaction, which may imply that the majority of surveyed older people are not fully satisfied with the available solutions. Additionally, this may highlight the need to improve and develop e-health technologies to make them much more responsive to the needs of older people. Current technologies may be unintuitive, too complicated or not adapted to their requirements. In addition, such a low rating may indicate the emergence of barriers to their use and the need for education in this area. It is possible that older people need education and support to understand and effectively use e-health technologies. Despite the low average rating, 27.75% of respondents rated the usability of e-health systems as good or very good. This means that a group of older people who saw the benefits and value of using these technologies were surveyed.

3.3. The relationship between respondent characteristics and e-health use

The statistical study investigated the existence of a relationship between the socio-demographic and health characteristics of older people and e-health use. The authors tested the existence of an association between items related to various elements of e-health systems and

a specific characteristic of seniors with a one-way ANOVA analysis of variance and a $\chi 2$ test, formulating the following hypotheses - null (H0) and alternative (H1):

- H0: The characteristics of seniors affect the e-health use,
- H1: The characteristics of seniors do not affect the e-health use.

All cases in which the existence of a relationship between the characteristics of older people and the individual level of use of e-health systems during COVID-19, i.e. cases in which the null hypothesis was rejected, and the p-value is less than 0.05, are presented in Table 2.

Table 2.
Relationship between e-health use and participant characteristics

Characteristics of older people	Anova			$\chi 2$ test		
	e-health use	F	p-value	$\chi 2$ test statistic	Number of degrees of freedom	p-value
The health assessment	Life-saving wristband	3.01	0.02	11.84	4	0.02
Gender	Teleconsultation	9.8	0.00	9.62	1	0.002
Age	RMP monitoring devices	6.9	0.00	19.88	3	0.0002
	Video consultation	3.46	0.02	10.22	3	0.02
	Electronic camera	3.82	0.01	11.26	3	0.01
	mHealth apps	2.78	0.04	8.24	3	0.04
	Life-saving wristband	3.40	0.02	10.04	3	0.02
Marital status	Teleconsultation	4.87	0.00	14.24	3	0.003
	Electronic data exchange	2.75	0.04		No dependencies	
	RMP devices	3.32	0.02	9.81	3	0.02
Domicile	Electronic data exchange	4.03	0.05	4	1	0.045
Education	E-prescription	7.29	0.00	20.95	3	0.0001
	Electronic data exchange	4.53	0.00	13.27	3	0.004
	RMP devices	2.87	0.04	8.51	3	0.04
	Thermometer	3.03	0.03	8.99	3	0.03
	Pressure gauge	3.58	0.01	10.56	3	0.01
	Heart rate monitor	2.84	0.04	8.44	3	0.04
	Electronic camera	2.92	0.03	8.67	3	0.03
	mHealth apps	2.84	0.03	8.43	3	0.04

ANOVA and $\chi 2$ test indicate a correlation between health assessment and life-saving wristband use. The ANOVA suggests that respondents with a very good health assessment ($M = 0.46$; $SD = 0.51$) tend to use the life-saving wristband more frequently than respondents with a good evaluation ($M = 0.27$; $SD = 0.44$). In contrast, the $\chi 2$ test indicates that those rating their health very well (38.46%) use the life-saving wristband more frequently than those rating poorly (7.94%).

Both ANOVA and $\chi 2$ test indicate a strong relationship between gender and mobile phone use for teleconsultation. ANOVA indicates that men choose teleconsultation more often (M = 0.69; SD = 0.47) than women (M = 0.53; SD = 0.5). This is confirmed by the $\chi 2$ test (68.64% vs. 53.25%).

Another characteristic of seniors is age. One-way analysis of variance ANOVA and $\chi 2$ test indicate a relationship between age and use of RMP devices, video consultation, electronic cameras, and life-saving wristbands. The ANOVA indicates that those aged 60-64 tend to use a mobile phone (M = 0.59; SD = 0.49) and an electronic camera (M = 0.28; SD = 0.45) more frequently for health monitoring than those aged 75 and over (respectively: M = 0.29; SD = 0.46; M = 0.09; SD = 0.29). This is confirmed by and $\chi 2$ test (respectively: 59.14% vs. 29.47%; 27.96% vs. 9.47%). Those aged 60-64 tend to use RMP devices (M = 0.70; SD = 0.46) and electronic cameras for health monitoring more frequently (M = 0.22; SD = 0.41 than those aged 70-74 (respectively: M = 0.43; SD = 0.50; M = 0.08; SD = 0.27). This is confirmed by the $\chi 2$ test (respectively: 69.89% vs 43.40%; 21.51% vs. 7.55%). Those aged 65-69 tend to use a life-saving wristband (M = 0.11; SD = 0.31) and a mHealth application (M = 0.16; SD = 0.37) more frequently to monitor their health than those aged 70-74 (respectively: M = 0.02; SD = 0.14; M = 0.05; SD = 0.21). The $\chi 2$ test confirms a significant relationship in the case of the life-saving wristband (16.04% vs. 4.72%). In contrast, for using a miHealth app, the $\chi 2$ test shows that people aged 60-64 (10.75%) tend to use it more often than those aged 70-74 (1.89%).

One-way ANOVA analysis of variance indicates a relationship between marital status and mobile phone use for teleconsultation, electronic data exchange, and RMP devices. Those who are divorced tend to use the mobile phone more frequently for teleconsultations (M = 0.65; SD = 0.48;) than those who are single (respectively: M = 0.38; SD = 0.49;). Married people use RMP devices more often (M = 0.58; SD = 0.05) than divorced people (M = 0.35; SD = 0.48). $\chi 2$ test shows a relationship between marital status, mobile phone use for teleconsultation, and use of RMP devices. Married people use the mobile phone more often for teleconsultation (66.67%) than single people (37.50%). Married people use RMP devices more often (58.73%) than divorced people (34.69%). The $\chi 2$ test does not indicate a correlation between marital status and mobile phone use for electronic data exchange.

Another characteristic examined was the respondents' place of residence. Both ANOVA and $\chi 2$ test indicate a strong relationship between place of residence and computer use for electronic data exchange. Urban residents (M = 0.53; SD = 0.5) use the computer for electronic data exchange more often than rural residents (M = 0.40; SD = 0.49). This is confirmed by the $\chi 2$ (53.41% vs. 39.68%).

The following statistically tested characteristic of seniors was education. One-way analysis of variance ANOVA and $\chi 2$ test indicate that there is a relationship between education level and mobile phone use for e-prescription, electronic data exchange, RMP devices, remote patient body temperature monitoring, remote blood pressure monitoring, remote heart rate monitoring, electronic cameras and mHealth apps for health monitoring. The ANOVA indicates that those

with higher education tend to use their mobile phone more frequently for e-prescribing (M = 0.69; SD = 0.46) and electronic data exchange (M = 0.63; SD = 0.48) than those with primary education (respectively: M = 0.4; SD = 0.49; M = 0.33; SD = 0.48,). This is confirmed by and $\chi 2$ test (respectively: 69.47% vs. 63.16%; 39.58% vs. 33.33%). Those with higher education tend to use RMP devices (M = 0.6; SD = 0.49), the use of an electronic camera (M = 0.25; SD = 0.44) and mHealth applications (M = 0.19; SD = 0.39) for health monitoring than those with vocational education (respectively: M = 0.31; SD = 0.47; M = 0.42; SD = 0.5; M = 0.09; SD = 0.29; M = 0.06; SD = 0.23). This is confirmed by and $\chi 2$ test (respectively: 51.58% vs 31.11%; 60.00% vs. 42.22%;25.26% vs. 8.89%; 18.95% vs. 5.56%). Those with a secondary education tend to use a remote thermometer (M = 0.38; SD = 0.49), remote blood pressure system (M = 0.38; SD = 0.49) and remote pulse oximeter (M = 0.38; SD = 0.39) more frequently to monitor their health than those with vocational education (respectively: M = 0.22; SD = 0.42; M = 0.22; SD = 0.42; M = 0.22; SD = 0.42). This is confirmed by and $\chi 2$ test (respectively: 38.32% vs 22.22%, 38.92% vs. 21.11%, 37.72% vs. 22.22%).

4. Discussion

The COVID-19 pandemic rapidly increased access to e-health in many countries, including Poland. In this study, we were interested in using different e-health systems by older people from Poland. Based on surveys conducted during the COVID-19 pandemic, this study examined the use and opinions about e-health, and also the socio-demographic factors that influence the use of e-health from the perspective of older patients.

Due to the high potential risk of contracting the COVID-19 virus (Napitupulu et al., 2021), patients worldwide have become more willing to use online treatment (Kruse et al., 2017). Older patients in Poland also gained the opportunity to use e-health systems during the COVID-19 pandemic. However, the level of use of these systems by older people in Poland can be assessed as under average (mean = 2.77), which indicates that the use of e-health in Poland may not be effective. The largest group of respondents (35.25%) assessed using e-health at an average level. As many as 25% of older patients did not use RMP devices. However, it is worth noting that access to ICT devices is very high (smartphone - 100%) among the respondents. Similar research in Australia showed that although most older participants (around 88%) had access to ICT devices, few (only around 9%) had used e-health services (Ali et al., 2021). The results of another study conducted in Poland on the demand for telemedicine services for the ageing generation showed that it is low and concerns younger patients who accept information technologies as something useful in everyday life (Buliński, Błachnio, 2017). Among Polish seniors who declared their willingness to use specific telemedicine services, the oldest ones – those over eighty– were missing. Compared to the established

telemedicine market in the United States, Scandinavia, etc., the number of potential e-Health patients is, therefore, unsatisfactory, as documented in the results of other studies (Bujnowska-Fedak, Pirogowicz, 2014). The reason for the average use of e-health systems may be the digital divide among older people, which translates into limitations in the practical use of modern technologies in health monitoring and intergenerational communication (Sun Lim, Ling Tan, 2003). A limiting health problem is older people's auditory and visual content processing. The deteriorating hearing sensitivity constitutes a medical block to the use of, for example, teleconsultation (Sugawara et al., 2004). Technological illiteracy among the oldest age groups further exacerbates communication difficulties. Digital marginalisation condemns older people, particularly a lack of accessibility to advanced health monitoring methods and tools (Wong et al., 2014).

Most people in the study showed very negative attitudes towards e-health systems. Our study showed that 45% of older people believed that e-health systems were of little use in the medical care of patients. Such poor assessments can be explained by limited trust in e-services, in which the senior does not have a personal relationship with the service provider. They may also result from the limitations of seniors in using e-health due to the high costs, complexity in use and implementation of some telemedicine services (Buliński, Błachnio, 2017). A detailed analysis of the responses provided by Polish participants regarding e-health documents their selective interest in specific services. From the wide range of available services, Polish seniors found four useful: online registration of visits, receiving reminders about visits via text messages, biometric telemonitoring, and remote access to patient portals (Buliński, Błachnio, 2017). Patients receive prescriptions and referrals for laboratory and imaging tests on such portals, access educational information and order services. Previous research has shown that patient portals can improve medication adherence, provide better patient-provider communication, and enable the detection of medical errors (Dendere et al., 2019). This form of access gives patients more control and encourages them to be active users of the e-health systems (Nestlerode et al., 2022). Our results regarding the weak assessment of e-health usefulness by older patients contradict those conducted among healthcare workers. For example, studies conducted in China showed relatively positive evaluations and attitudes towards e-health, where only less than 5% of participants believed telemedicine did not help reduce the medical burden on patients (Ma et al., 2022).

Our results showed that health status, gender, age, marital status, place of residence, and education level are associated with using e-health services. The study showed that health status is an important factor influencing the use of telehealth systems because the patients with good and very good health declared a higher level of e-health use than those with poor or very poor health. In contrast, other studies have shown that people in good health are less likely to use e-health services based on ICT technologies (Andreassen et al., 2007; Huang et al., 2020; Wagner et al., 2004). The patients with health problems were more likely to use remote health monitoring, and this finding was supported by studies conducted in Ethiopia (Kassaw et al.,

2024), Australia (Bonner et al., 2018), China (Dai et al., 2017), Greece (Bonner et al., 2018), and Kenya (Miller, Himelhoch, 2013). However, this was based on survey data from the general population, not older people in particular. Further research is needed in this area.

Our study indicated a strong relationship between gender and mobile phone use for teleconsultation and that men choose teleconsultation more often. Results from other studies have shown that, in general, women were relatively less likely to use teleconsultations compared to men (Vera Cruz, Dlamini, 2021). One possible explanation for this difference may be that women are generally more likely to have complex health problems requiring special physical examination (e.g. gynaecological health problems), privacy, support and guidance compared to their male counterparts (Albrecht, Afshar, Illiger, Becker, Hartz, Breil, Wichelhaus, von Jan, 2017). For this reason, women may feel more need for face-to-face consultations than men.

The study showed that age is an important factor influencing the use of telehealth systems because the oldest respondents (>75) declared a lower level of e-health use compared to younger groups. As age increases, the individual use of e-health systems is lower. This is confirmed by the results of other studies, which showed that older people are less able than younger people to use electronic devices such as telerehabilitation platforms and mobile applications (Cimperman et al., 2016), and the oldest elderly are particularly digitally impaired (Zambianchi et al., 2019). Therefore, the patient's willingness to use remote health monitoring decreases with age. A possible reason for this may be that older patients are less willing to use new technologies than younger patients due to fear of use and concerns about information security and costs, as seen in studies conducted in Ethiopia (Kassaw et al., 2024), Germany (Albrecht et al., 2017; Illiger et al., 2014), Australia (Bonner et al., 2018), China (Dai et al., 2017), and Canada (Seto et al., 2010).

In many cases, older people are less likely to take advantage of digital technologies (König et al., 2018) and, therefore, risk being disadvantaged by the digital transformation in healthcare. For older adults, lack of technological competence is a significant challenge in adapting to e-health systems. Older adults often struggle with unfamiliar technology, preventing many from using telemedicine (Choi et al., 2023). However, it is unclear whether this finding is mainly influenced by life stage, associated with greater challenges in implementing new technologies due to chronic diseases or age-related personality changes. Digital impairment may also result from the fact that many e-health systems were introduced after the retirement of the oldest people (Zambianchi et al., 2019). Therefore, further research is needed to understand the causes of age-related digital impairment. Our findings regarding age are consistent with previous results on the determinants of eHealth use (Ali et al., 2020; Knapova et al., 2020; Vroman et al., 2015). Therefore, service providers should offer the oldest patients timely online or telephone support, especially in the form of concise user manuals, help and guidance for older users to understand e-health systems (Chan et al., 2023; Lee, Rho, 2013). To help older adults adopt new technologies, e-health systems should be designed with maximum user-friendliness

(Narasimha et al., 2017). For example, easy-to-use interfaces and simple instructions with larger on-screen fonts can help older adults use telemedicine to monitor chronic conditions during the COVID-19 pandemic.

Our study showed that marital status also influences the use of e-health systems. Married people use these systems much more often than people with other marital status. In our opinion, this may be due to the better mental health of people who still have their life partners. Previous research in the UK has shown that symptoms of poor mental health can impact readiness to use technology, and depression is likely to exacerbate difficulties in using digital technologies (Andrews et al., 2019). Further research would be necessary to more fully understand these relationships, such as examining how much depression or anxiety causes a lack of technology engagement among older adults.

Another characteristic that impacts e-health use by older adults is the respondents' place of residence. Urban residents use e-health systems more often than rural residents. For older adults living in rural areas, the digital infrastructure required to provide telemedicine services may be less robust than that in urban areas. However, given the long distances needed to reach hospitals and clinics, e-health systems can benefit residents of these regions (Guo et al., 2018).

Our results show people with higher education use e-health services more often than the elderly with primary and vocationally education. This finding is consistent with previous work on the impact of education on e-health use (Alam et al., 2019; Ali et al., 2020, 2021; Elliot et al., 2014; Menéndez Álvarez-Dardet et al., 2020; Salwin et al., 2022). Higher educational attainment may have provided older adults with general skills or specific ICT knowledge that facilitates the use of e-health (Elliot et al., 2014). However, people with lower levels of education may lack knowledge about e-health tools and, therefore, have no motivation to use such technologies (Alam et al., 2019; Elliot et al., 2014). The importance of education highlights the need to address the digital disadvantages older people face cross-cuttingly.

This study makes some key contributions to the literature. First, it focuses specifically on older adults rather than broader age groups. This is the first study on a group of older people conducted in Poland. The study's strengths include the ability to capture the current perspective of older Polish patients on telehealth systems after the pandemic outbreak. Unlike previous studies showing broad acceptance of telemedicine among the general patient population, our study focused on older adults and examined various e-health systems, not just telemedicine.

In practice, the research can have several implications for policy priorities in the field of ICT technologies regarding healthcare. First, our finding that older people have poor access to e-health tools such as RMP systems suggests that further programs to increase their accessibility are important. Second, our findings regarding education suggest that digital literacy is also important. Finally, our findings that the oldest people (over 75) are more disadvantaged than younger groups suggest that attention should be paid to this group, particularly in ensuring access to e-health and digital skills. The generational digital divide can be solved through interventions that promote the use and, above all, the personal experience of perceiving the

usefulness of e-health among older people who are less familiar with new technologies (Laganá et al., 2011).

5. Conclusions

Older adults should be considered the most important users of e-health, taking into account the fact that the way they use and perceive these systems is especially important for sustainable development. However, the use of e-health systems by older patients in Poland is on the whole inadequate. Most of these people have generally negative opinions and attitudes towards e-health services.

The study examined the determinants of e-health use among older adults in Poland. The level of use of e-health by respondents varied in terms of socio-demography and health. We found that gender, age, education, marital status, place of residence, and health status impact the use of various e-health systems by older people in Poland. Our study indicates that men and married people use teleconsultation more often. On the other hand, the systems for remote monitoring of patients' health are more popular among married people, with higher education, aged 60-64, with better health status. Urban residents use the computer for electronic data exchange more often than rural residents.

This finding should inspire policymakers, especially the Ministry of Health, to increase and expand the use of e-health systems by encouraging older patients with health problems, especially from rural areas, to use remote patient monitoring technologies and ICT devices to treat their diseases. The importance of e-health will grow as societies age and technology develops. In future research, it would be worthwhile to investigate problems in the practical application of telehealth that raise deep concerns among older people. The use of incentives could then be increased, increasing satisfaction with e-health systems.

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SOFT DETERMINANTS OF THE DEVELOPMENT OF AN AGILE ORGANIZATION IN THE ASPECT OF OWN RESEARCH

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Purpose: The aim of the article is to identify soft factors perceived as key to the development of organizational agility and to analyze their interrelationships in the context of the perception of organizational participants, to determine the importance of interpersonal relations, cooperation and safety culture as foundations supporting flexible and adaptive organizational structures.
Design/methodology/approach: The study was conducted using a diagnostic survey method in the form of a survey on a sample of 312 respondents in 2024. The collected data was statistically analyzed using multivariate correspondence analysis (MCA), which allows for the identification of response patterns and hidden relationships between variables.
Findings: It was found that factors such as avoiding aggression, striving for a common goal and searching for common solutions are most often considered important for organizational agility. High consistency of answers indicates strong rooting of the values of cooperation and psychological safety in the perception of organizational development.
Research limitations/implications: The study was cross-sectional and based on subjective opinions of respondents, which limits the possibility of generalizing the results. Another limitation is the lack of consideration of hard indicators of organizational effectiveness and contextual variables, such as the specificity of the industry.
Practical implications: The results can constitute a basis for designing development and cultural activities supporting organizational agility, in particular in the area of relationship management, strengthening shared responsibility and developing soft skills.
Social implications: The importance of creating a working environment based on trust, openness and cooperation was highlighted, which promotes operational efficiency as well as employee well-being and social integration in the workplace.
Originality/value: The article brings value by empirically demonstrating the role of soft determinants of organizational agility and by using MCA analysis as a tool for identifying perceptual patterns. The presented conclusions have practical significance for organizations operating in a dynamic and unpredictable environment.
Keywords: agile organization, soft development determinants, business environment.
Category of the paper: research paper.

1. Introduction

Modern organizations operate in a dynamic, turbulent, unpredictable environment. It requires flexibility, quick response, and the ability to continuously learn. In this aspect, organizational agility becomes one of the key conditions for maintaining competitiveness and adaptability. Although this concept is increasingly widely used, there is still a need for a better understanding of the factors supporting its development in organizational practice (Routledge, 2020; Sajdak, 2021; Brosseau, Ebrahim, Handscomb, Thaker, 2019).

Taking up the topic of the conditions for the development of an agile organization results from the need to deepen knowledge about the perception and importance of selected factors by the participants of the organization. The article consists of a theoretical, methodological and empirical part, which presents the results of the survey and their interpretation using multidimensional correspondence analysis (MCA).

The aim of the article is to identify factors perceived as key to organizational agility and to show their mutual dependencies. The added value is the combination of a theoretical perspective with the analysis of empirical data and the formulation of practical recommendations for organizations operating in a changing environment.

The originality of the presented material stems from the combination of a theoretical approach with the analysis of empirical data collected through an original study conducted in 2024. This research focuses on identifying soft developmental factors that support organizational agility. Its distinguishing feature is the application of multivariate correspondence analysis (MCA) as a tool for identifying perceptual patterns among organizational participants. The article contributes new value to the scientific discourse by highlighting the relational and psychological aspects of organizational functioning in a dynamic environment, as well as their practical significance for shaping a culture that supports agility. Previous studies have rarely addressed these issues in a synthetic manner based on the direct perceptions of organizational members, which makes the presented analysis a valuable addition to the existing literature.

1.1. Agile organization in theoretical approach

Theoretically, an agile organization has become a response to the growing complexity and dynamics of the environment in which modern enterprises operate. In the literature, agility is defined as the ability of an organization to respond quickly to changing market conditions, as well as to take advantage of emerging opportunities and effectively manage uncertainty (Doz, Kosonen, 2008; Atkinson, Moffat, 2005; Cooke, 2012). This concept is derived from the agile management trend. This trend had its origins in the IT industry, but over time it was applied in the broader context of managing organizations, covering structures, processes, organizational

culture and the way of making decisions (Nath, Agrawal, 2020; Kocot, Rogozińska-Mitrut, Kwasek, 2024).

In theoretical terms, an agile organization is perceived as an open system that is also capable of dynamically adapting to changes by using the knowledge, competences, and commitment of employees. Its operation is based on shortening the planning and implementation cycles, decentralizing responsibility, promoting cooperation between teams, and continuous learning and improvement (Akkaya, 2021; Chen, Li, 2021; Mrugalska, Ahmed, 2021). Organizational culture is of integral importance here. It is based on trust, transparency, openness to experimentation, and readiness to accept feedback (Fiddler, 2017; Gao, Zhang, Gong, Li, 2020; Kurnia, Chien, 2020).

Theoretical models of organizational agility also indicate the need to integrate activities in various areas of the organization's functioning. These include knowledge management, innovation, customer relationships, and digital technologies (Prieto, Talukder, 2023). Agility therefore requires both flexibility, but also the ability to predict and shape the future by actively adapting strategies and operating models (Rahimi, Mansouri, 2019). The ability to make decisions under conditions of uncertainty plays a special role. The ability to manage change in a way that engages and supports people is also important (Bremer, Rylander Eklund, Elmquist, 2025).

Certainly, contemporary approaches to agility also emphasize the importance of a balanced approach. In this understanding, flexibility does not oppose stability, but is its functional complement. An agile organization, while maintaining high operational efficiency, can also quickly reconfigure its resources and processes. In this way, it responds better to new challenges. In this sense, agility is understood as a strategic competence that conditions long-term development and maintaining a competitive advantage.

1.2. Organization in the modern business environment

The contemporary business environment is characterized by a high level of turbulence, unpredictability, dynamism and interconnectedness. They significantly affect the way organizations function. Globalization, the development of digital technologies, social and cultural changes, as well as the growing pressure related to environmental and social responsibility mean that companies must constantly update their operating models. This environment provides impulses for transformation and at the same time forces a redefinition of the existing roles and relationships between organizations and their stakeholders (Prieto, Talukder, 2023).

In the face of complexity and constant transformation, organizations can no longer rely solely on stable, long-term strategies that are based solely on forecasting. The ability to adapt to changing conditions is becoming increasingly important. It is also important to make decisions in short planning cycles. This means the need to move from rigid hierarchical structures to flatter and more flexible organizational systems. They undoubtedly facilitate the

exchange of knowledge, faster flow of information, and increase the ability to cooperate between teams (Nath, Agrawal, 2020).

Modern organizations are subject to growing competitive pressure and increasingly higher customer expectations. They demand quality and speed, but also an individual approach and transparency. The response to these challenges is the implementation of strategies based on customer value, personalization of the offer and the use of data to make good decisions. The speed of response, the ability to iteratively change and close contact with the end user can be considered the distinguishing features of organizations able to compete on the market (Doz, Kosonen, 2008; Djurayeva, 2024).

The transformation of the environment also affects the internal logic of the organization's functioning. Work models are being redefined as a result of the popularization of remote and hybrid work and the development of team autonomy (Chen, Li, 2021; Akkaya, 2021; Djurayeva, 2024). Traditional boundaries between organizational functions are being blurred. More and more often, interdisciplinary teams are taking the initiative in designing and implementing solutions. Working in such conditions requires the development of new technical skills. However, the development of soft skills is also becoming important (Mrugalska, Ahmed, 2021; Djurayeva, 2024). These include the ability to communicate, adapt, and share responsibility.

The business environment also shapes new forms of organizational responsibility. More and more attention is paid to ethics, transparency, sustainable development, and social involvement (Djurayeva, 2024). When assessing the functioning of an organization, not only financial results are important. The success of an organization must be perceived through the prism of how it affects the environment, the local community, and its employees. This means that a modern enterprise must skillfully balance economic goals with social and regulatory expectations. At the same time, it is also important to maintain the ability to innovate and compete in real time (Gao, Zhang, Gong, Li, 2020; Djurayeva, 2024).

As a result, the contemporary business environment requires organizations to be permanently ready for transformation. Resilience, adaptability, and flexibility are becoming essential elements to stay on the market. It is in response to these requirements that organizational models based on agility emerge. They offer a framework for effective functioning in conditions of constant variability, time pressure, and high quality expectations (Djurayeva, 2024).

1.3. Soft factors influencing the development of an agile organization

In the scientific literature on organizational agility, it is increasingly emphasized that its foundations are primarily soft factors. These are subtle but extremely important aspects of relationships, communication, and work culture. Modern organizations operating in a dynamic environment require the creation of an environment that promotes flexibility, rapid information flow, mutual support, and readiness to respond jointly to changes. It is in this aspect

that determinants such as interpersonal relations, avoidance of aggression, cooperation, autonomy, and work atmosphere appear. These are determinants that have a decisive impact on the organization's ability to operate effectively in changing conditions (Arcos-Medina, Mauricio, 2020; Shahane, Jamsandekar, Shahane, 2014).

Good interpersonal relationships certainly play an important role in shaping a climate of trust, openness and a sense of mutual understanding. These relationships facilitate communication, shorten the distance between team members. They also support a sense of belonging to the organization (Kumar, Goel, 2012). The lack of interpersonal tensions reduces the risk of conflicts and allows for collective actions. In practice, this strengthens the ability to react quickly and work effectively as a team. Another important element supporting organizational agility is avoiding aggression. This should be understood as consciously shaping an environment free from dominant, violent or exclusionary behaviors. Such a climate promotes the creation of a safe space for experimentation, sharing ideas and openly expressing opinions without fear of judgment. Psychological safety becomes a consequence of the lack of aggression. It is necessary for taking initiatives, innovation and cooperation between individuals with different competences and experiences (Palopak, Huang, 2024; Bransby, Kerrissey, Edmondson, 2024).

Agile organizations are structures that promote common pursuit of a clearly defined goal instead of hierarchical control (Sudhakar, Farooq, Patnaik, 2011). This pursuit integrates the activities of organization members around common values, facilitates decision-making. In addition, it reduces the fragmentation of activities. This shortens the response time to changes and allows maintaining high operational coherence. The common goal is a point of reference that motivates, organizes actions and increases the sense of collective responsibility (Kumar, Goel, 2012). The atmosphere prevailing in the organization is often underestimated in quantitative analyses. However, it should be noted that it is fundamental for the functioning of teams in conditions of pressure, uncertainty and variability. A friendly work environment promotes creativity, commitment and professional satisfaction. The right atmosphere increases employees' willingness to share knowledge. In addition, it strengthens relationships and reduces the emotional costs resulting from working in an environment of high intensity of change (Law, Charron, 2005; Ahmad, Gustavsson, 2024).

Partnership and cooperation are also key areas that support the promotion of agility. Instead of competition, attitudes based on trust, mutual support and responsibility distributed among team members dominate here. In such conditions, problems can be solved effectively. It is also possible to create lasting organizational bonds. They increase the organization's resilience to crises and support long-term learning. The ability to search for common solutions is revealed especially in situations requiring a quick reaction, compromise or reassessment of previous methods of action. A culture of co-decision, willingness to negotiate and respect for different points of view support decision-making processes. Moreover, they strengthen the commitment

of organization members to the implementation of common tasks. (Sudhakar, Farooq, Patnaik, 2011)

Meeting common needs, both functional and social, builds bonds between members of the organization. It also strengthens their identification with the goals of the institution. This translates into greater team stability, higher motivation, and readiness to make additional efforts for the common good. Taking care of community needs also translates into better adjustment of organizational processes to employee expectations. And this supports the adaptability of the organization as a whole (Kumar, Goel, 2012).

The ability to self-manage, the last of the factors analyzed, is becoming an indispensable element of agile structures. Employees and teams that have autonomy in making decisions react faster to changes, are able to flexibly adapt to new circumstances and take responsibility for the results of their work. Self-management, however, requires clear rules, trust and access to information that allows for making good decisions without having to refer to hierarchical structures.

2. Methods

For the purposes of the empirical research, the concept of organizational agility was defined as the organization's ability to adapt, respond flexibly to change, and maintain coherence of action in a dynamic environment. The operationalization of this concept was carried out through the identification and measurement of selected soft development factors. According to the literature, these factors constitute the foundations that support agility. They include: the quality of interpersonal relationships, avoidance of aggressive behavior, striving for a common goal, work atmosphere, partnership and cooperation, seeking common solutions, meeting shared needs, and the ability to self-organize. Each of these factors was assessed by respondents in terms of its importance for the functioning of the organization in the context of agility. This made it possible to empirically reflect the components of organizational culture that foster flexibility and adaptability.

The aim of the conducted research was to determine which soft development factors are perceived by the participants of the organization as important for building organizational agility and how they affect the adaptability and culture of cooperation. The aim was to identify the relationship between the subjective assessment of specific aspects of the organization's functioning and the general perception of its agility potential.

A research hypothesis was adopted, assuming the existence of a significant relationship between the assessment of selected soft factors and the organization's willingness to implement practices characteristic of the agile approach. It was assumed that a high assessment of factors

such as interpersonal relations, cooperation or psychological safety would be associated with a positive perception of an organizational culture that supports agility.

The research questions focused on which factors are most often recognized by respondents as conducive to agility, how the importance of cooperation, innovation and self-organization is perceived, and whether it is possible to distinguish characteristic patterns of responses reflecting preferences and expectations towards the organization.

The diagnostic survey method was used in the form of a survey conducted in 2024 on a sample of 312 respondents representing various economic sectors and employment levels. The questionnaire was based on a five-point Likert scale, which allowed for capturing both clear opinions and neutral attitudes.

In order to interpret the results in more detail, multivariate correspondence analysis (MCA) was conducted to identify hidden connections between the responses and the variables analyzed. This analysis allowed for a visual representation of the data structure, localization of similarities and differences in the perception of individual factors, and capturing perceptual patterns characteristic of the study sample.

The results of the multivariate correspondence analysis indicate that some highly rated variables (such as "partnership and cooperation" or "work atmosphere") are perceived less unequivocally in the factor space. This may stem from differences in respondents' individual experiences or from inconsistent understanding of these concepts in organizational practice. A high declarative rating does not always translate into clear associations with organizational adaptability. This provides an important cue for further analysis.

It is also worth noting that a strong culture of cooperation, although generally perceived positively, may carry certain risks. Excessive emphasis on agreement can foster conformity and limit open exchange of ideas. Therefore, when fostering a collaborative climate, it is essential to also support space for diverse viewpoints and critical thinking.

In response to the need for a broader contextualization of the findings within the socio-organizational background, the characteristics of the study sample (N = 312) are presented below. The respondents primarily represented service-oriented enterprises (65.1%), as well as trading (25.6%) and manufacturing companies (9.3%). In terms of size, the sample included both micro-enterprises (23.1%) and large organizations employing over 1000 people (18.9%), allowing for perspectives from various structural levels to be captured. The respondents operated in organizations with local, regional, national, and international reach, with the largest share representing internationally operating firms (36.2%). The majority of participants held higher education degrees (57.1%) or secondary education qualifications (33.7%). In terms of age distribution, the dominant group consisted of individuals aged 20-30 (48.4%), which may indicate a strong representation of younger participants in the labor market—particularly relevant in the context of developing agile competencies.

3. Results

The research aimed to determine the importance of selected soft development factors in the context of the functioning of agile organizations. Eight variables that may influence the development of an organizational culture conducive to agility were analyzed (see Table 1).

Table 1.
Soft development factors of an agile organization

Variable	Definitely NOT	I don't think so	I have no opinion	Probably YES	Definitely YES
Good personal relations	17	25	39	139	92
Avoiding aggression	19	10	26	113	144
Striving for a common goal	18	14	37	120	123
The atmosphere between employees	19	21	49	135	88
Partnership and cooperation	23	24	52	118	95
Searching for a common solution	16	23	39	119	115
Meeting common needs	19	18	54	128	93
Ability to self-manage	15	31	48	125	93

Source: Own study based on research.

In the case of “good personal relations”, the largest number of respondents – 139 people – expressed probable support for this value, and another 92 people definitely considered it important. A relatively small group – 17 people – definitely questioned its importance, and 25 did not consider it important. 39 respondents had no opinion on this matter. For the variable “avoiding aggression”, the largest number of answers (144) fell into the category of “definitely yes”, while 113 respondents chose the answer “rather yes”. Only 19 people definitely disagreed with the thesis about the importance of this feature, and 10 considered it of little importance. 26 respondents did not take a clear position.

“Striving for a common goal” was met with great appreciation – 120 respondents selected the answer “rather yes” and 123 “definitely yes”. 18 people were of the opposite opinion, and 14 expressed a moderate lack of support. In this group, 37 people indicated no opinion.

In relation to the "atmosphere between employees", positive answers dominate - 135 people indicated "rather yes" and 88 - "definitely yes". 19 respondents strongly disagreed with the importance of this factor, 21 chose the answer "rather no", and 49 had no opinion. "Partnership and cooperation" were assessed as rather important by 118 respondents and as definitely important by 95. A small group of respondents - 23 people - chose the answer "definitely no", while 24 people - "rather no". No opinion was declared by 52 respondents.

“Searching for a common solution” was assessed positively: 119 people considered it rather important, and 115 as definitely important. 16 people expressed a strong rejection of this value, while 23 people indicated a moderate lack of approval. 39 respondents had no opinion. In the case of “meeting common needs”, the most responses were in the categories of “rather yes” – 128 and “definitely yes” – 93. 19 people completely disagreed with the importance of this variable, 18 chose the answer “rather no”, and 54 people had no opinion. “Ability for self-

management" was assessed as rather important by 125 respondents, and as definitely important by 93 people. 15 respondents indicated "definitely no", 31 – "rather no", and 48 declared no opinion.

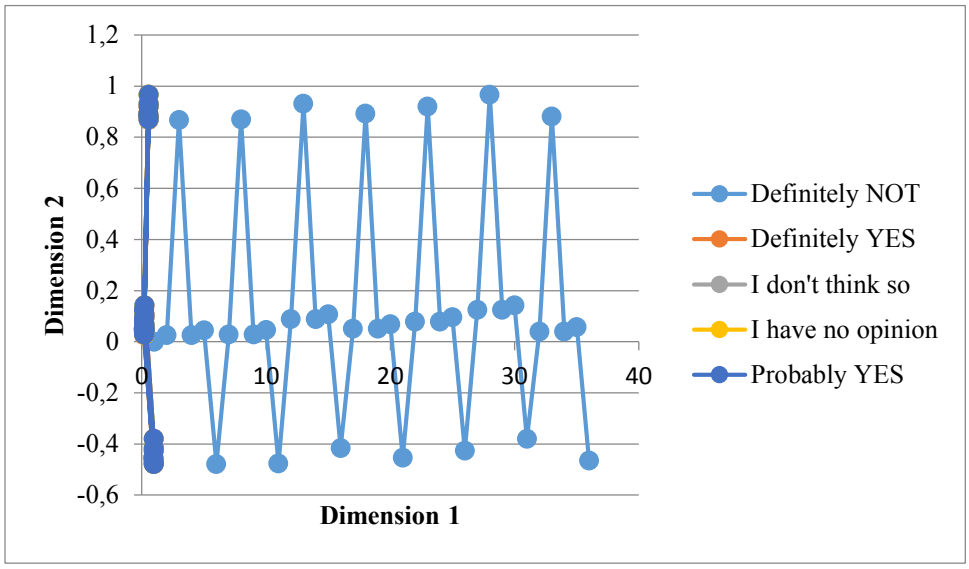

Figure 1. MCA Analysis of soft factors in agile organization.

Source: own work.

Figure 1 on soft development factors of an agile organization is an in-depth illustration of the data presented in Table 1, showing hidden relationships between respondents' assessments and the analyzed variables. The factor space created as a result of correspondence analysis allows for identifying which of the soft aspects of the organization's functioning are perceived in a similar way and which clearly differentiate the attitudes of the study participants.

In Figure 1, there is a clear concentration of "Definitely YES" responses in the vicinity of variables such as "Avoiding aggression", "Striving for a common goal" and "Searching for a common solution". This indicates a clearly positive reception of these aspects as elements supporting the development of organizational agility. The high frequency of extremely positive assessments for these variables is also confirmed by the tabular data, where the values of "Definitely YES" are among the highest in the entire comparison. This phenomenon suggests that the values based on cooperation, peaceful resolution of disputes and joint commitment to achieving goals are of key importance to the study participants.

Chart shows variables such as "Atmosphere between employees" or "Partnership and cooperation" in a slightly more dispersed arrangement. Although they received a predominance of positive assessments, their greater dispersion in the MCA space indicates a varied perception of their importance. This may suggest that their practical implementation in organizations is less clear-cut or depends on the internal context of a given institution.

The variable "Ability to self-manage" was also rated relatively high, but its position on the graph may indicate a more moderate identification of this feature with a direct impact on agility. It can be assumed that although self-management is important, without a clear framework of

joint action and a culture of cooperation it can be treated as an element requiring additional system support.

It is also worth paying attention to the distribution of "I have no opinion" responses, which are concentrated in the area of several variables, which may indicate ambiguity in their interpretation or their weaker rooting in the respondents' professional experience.

The results of the conducted analyses are consistent with the previously discussed theoretical approach. In theoretical terms, organizational agility is understood as the ability to act flexibly under conditions of change and uncertainty. This is particularly evident in relation to categories such as cooperation, shared goals, and psychological safety—elements that the literature identifies as key to building agile structures. The empirical approach thus confirms the validity of the theoretical assumptions and indicates that soft cultural factors indeed form practical foundations for organizational adaptability.

4. Discussion

The collected literature and empirical material indicate the unequivocal importance of specific soft development factors for building organizational agility. The results of the study clearly indicate that relational and cooperative factors, such as avoiding aggression, striving for a common goal and searching for a common solution, are perceived by the participants of the organization as the most conducive to the development of agility. These variables were assigned the most "definitely yes" ratings. This fact indicates their strong rooting in the perception of the effective operation of the organization, which has to function in a changing business environment. Both the analysis of the distribution of answers and the results of the multidimensional correspondence analysis (MCA) confirm the existence of clear perceptual patterns. Aspects related to the culture of cooperation, emotional security and joint commitment are located close to each other in the factor space. This confirms their mutual connection and consistent reception among the respondents. Factors such as "atmosphere between employees" and "partnership and cooperation" were also assessed positively. However, their more diffuse position in the MCA space suggests that they may be more strongly dependent on individual experiences and organizational context. Their importance is not denied. It may, however, be perceived as less clear-cut in comparison to factors with a more clearly pro-adaptive character.

The variable “self-management ability” received high support. This indicates the growing importance of employee autonomy as a component of modern organizational models. At the same time, its location in the analysis space, in order to truly support agility, may indicate that employee autonomy requires appropriate systemic support and being embedded in a culture of cooperation.

Some of the variables for which a relatively high percentage of "I have no opinion" responses were recorded may indicate a lack of clear experiences of respondents or insufficient rooting of these aspects in organizational practice. This may also indicate the need to clarify them in communication and development activities within the organization. The overall interpretation of the results allows us to state that organizational agility is based to a large extent on soft determinants related to interpersonal culture, cooperation style and common goal orientation. These factors create the foundations for effective action in conditions of uncertainty and variability.

The research conclusions confirm theoretical theses regarding the importance of soft aspects of the organization's functioning as key to building agile structures. They also indicate the need to further strengthen the culture of cooperation and psychological safety. They can be considered elements that condition the organization's readiness to adapt and act innovatively.

Based on the results of the study, it is recommended that organizations systematically strengthen the culture of cooperation, trust and mutual respect. It is certainly interpersonal factors that are most conducive to building agility. It is advisable to create a work environment free from aggression, in which employees feel safe and can freely express their opinions. It is necessary to promote joint goal setting and involving teams in decision-making processes. This increases their sense of responsibility and commitment. It is also worth developing the ability to work based on cooperation and joint problem solving. These activities facilitate adaptation to change. At the same time, it would be necessary to support the development of employee autonomy by introducing elements of self-management, while maintaining a clear organizational framework and clear rules of cooperation. It is also worth conducting educational and communication activities that increase awareness of the importance of soft aspects of the organization's functioning for its long-term effectiveness in a changing environment.

The interpretation of the results should take into account the limitations of the study. It was cross-sectional in nature and based on respondents' subjective opinions, without including hard performance indicators or industry-specific context. Nevertheless, the findings are consistent with previous research emphasizing the importance of cooperation, psychological safety, and shared goals in building agility. The use of correspondence analysis is a novel element, allowing for the identification of hidden perceptual patterns. Further research is recommended, taking into account contextual differences and more in-depth comparative analysis.

5. Conclusions

The results of the conducted research fit into the broader trend of analyses concerning the conditions for the development of organizational agility. In many aspects, they are consistent with the findings of other authors. The identified importance of interpersonal relations, cooperation and common goal as key determinants of agility is confirmed in the literature on the subject. Brosseau, Ebrahim, Handscomb and Thaker (2019) emphasize that successful transformations towards agility require a strong culture that is based on trust, cooperation and continuous communication. Similarly, Gao, Zhang, Gong and Li (2020) showed that organizational flexibility develops best in environments that foster cooperation and joint problem solving.

The importance of avoiding aggression and building a safe work environment correlates with the conclusions of Bremer, Rylander Eklund, and Elmquist (2025). They emphasize the importance of psychological safety and ethical leadership in creating space for innovation and learning. In turn, Mrugalska and Ahmed (2021) analyzed the determinants of agility in the context of Industry 4.0. They pointed to the need to develop soft skills as a foundation for effective implementation of organizational changes.

The positive assessment by respondents of the pursuit of a common goal and partnership within the organization is also confirmed by the analysis of Doz and Kosonen (2008), which showed that the coherence of the direction of action and a common strategic vision increase the ability of the organization to react quickly to changes. Additionally, Chen and Li (2021), using the example of hospital management during the COVID-19 pandemic, noted that teams based on trust and cooperation were much more effective in adapting to the crisis situation.

The results regarding the importance of self-management indicate the need to combine it with a clearly defined framework and systemic support. This is consistent with the conclusions of Nath and Agrawal (2020). These authors point out that employee autonomy brings the expected results only in the context of properly designed processes and organizational culture.

The convergence of research results with the findings of other Authors confirms that effective organizational agility requires the simultaneous development of soft skills, as well as an environment of cooperation and strategic coherence. Such an approach can be considered an effective adaptation tool. It can also be considered a key competence that determines the resilience and long-term development of the organization in a dynamic environment.

Future research directions may focus on an in-depth analysis of the impact of soft development factors on the effectiveness and efficiency of implementing agile practices in different types of organizations and in different industries and sectors. It is worth taking into account cultural and industry differences, which may affect the perception and effectiveness of cooperation, self-organization or building psychological safety activities. It is also reasonable to conduct longitudinal studies. They can enable observation of how the role of soft skills

changes over time and in crisis conditions or accelerated digital transformation. It may also be important to extend the research to include the perspective of leaders and managers. It is also worth exploring the relationship between soft factors and hard indicators of organizational effectiveness, such as innovation, employee retention or customer satisfaction.

The conducted research, while contributing new knowledge to the discourse on organizational agility, also has its limitations. Its cross-sectional nature and reliance on respondents' declarative assessments may limit the generalizability of the results. The omission of hard indicators of organizational effectiveness and the lack of industry-specific context represent weaker aspects of the analysis. Nevertheless, the empirical data obtained, combined with correspondence analysis, enabled the identification of hidden perceptual patterns and confirmed theoretical assumptions regarding the role of relational and psychological factors in building agile structures. The research findings can be further used as a basis for designing development initiatives that support a culture of collaboration, psychological safety, and autonomy in organizations operating in a dynamic environment.

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NAVIGATIONAL RISK ANALYSIS IN THE AREA OF THE NEW CONTAINER TERMINAL IN ŚWINOUJŚCIE

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Purpose: The purpose of this study is to analyse and assess navigational safety in the area of the planned container terminal project in Świnoujście. Due to the strategic importance of the project, the safety assessment requires a multi-faceted approach, including mathematical modelling and simulation methods. The premise of the analysis is that the level of navigational risk in the analysed area depends on the intensity and structure of vessel traffic in the designated survey sectors. The hypothesis is based on the assumption the level of collision risk is strongly correlated with the number and type of vessels registered in the AIS data for each sector.
Design/methodology/approach: The research used a quantitative analysis of AIS (Automatic Identification System) data acquired for the Baltic Sea area for 2019-2022. The data was used to estimate the level of risk in terms of potential collisions and manoeuvring errors. The study is of a practical nature and is based on empirical data and analysis of local shipping conditions.
Findings: The use of simulation led to results that identified high-risk sectors and could form the basis for recommendations on navigational safety and the development of future maritime traffic management strategies.
Practical implications: The study aims to analyse current AIS data and local shipping conditions, which limits its application to wider geographical contexts. Further research is needed including forecasts of changes in traffic volumes and the impact of meteorological conditions. The analysis can be the starting point for more advanced risk simulations and cost-benefit analyses for shipping infrastructure investments.
Originality/value: The article brings new value by analysing navigational risk based on AIS data in a specific investment context. It identifies practical steps to enhance navigational safety in one of the key transport areas in the region. It is aimed at both decision-makers responsible for port infrastructure development and professionals involved in maritime safety and spatial planning.
Keywords: navigational safety, navigational risk analysis, AIS data, approach track, vessel traffic intensity, port spatial planning, port infrastructure, VTS.
Category of the paper: Viewpoint.

1. Introduction

Maritime transport in the Baltic Sea has been growing rapidly in recent years. Every year, more and more ships pass through this body of water and ports handle an increasing number of cargoes. This development necessitates investment in modern port infrastructure, especially in countries such as Poland, which have strategic access to the sea and want to maintain their position in a competitive market.

One of the key projects in this trend is the planned construction of a deep-water container terminal in Świnoujście. The new infrastructure is expected to enable the handling of the largest container vessels operating in the Baltic Sea and significantly increase the port's handling capacity. This is a major step forward from the point of view of the maritime economy, but also a challenge in terms of navigational safety in a busy area.

The South Baltic region, including the Świnoujście area, is one of the key intersections of shipping routes in this part of Europe. Based on AIS data from 2019-2022 (Figure 1), several major maritime corridors are clearly visible, leading, among others, through the Danish Straits to Western European ports, as well as routes connecting Poland, Sweden, Lithuania, Russia and Germany. Particularly intensive traffic is observed on the approaches to the Gulf of Gdansk, around Copenhagen and on the Karlskrona-Gdynia/Gdansk route. This traffic includes commercial vessels as well as passenger ferries and local vessels. In addition, there is increased recreational traffic during summer periods. The concentration of multiple vessel types, variable hydrometeorological conditions and the need to manoeuvre in a narrow approach lane means that the Świnoujście area requires special attention in terms of navigational safety.

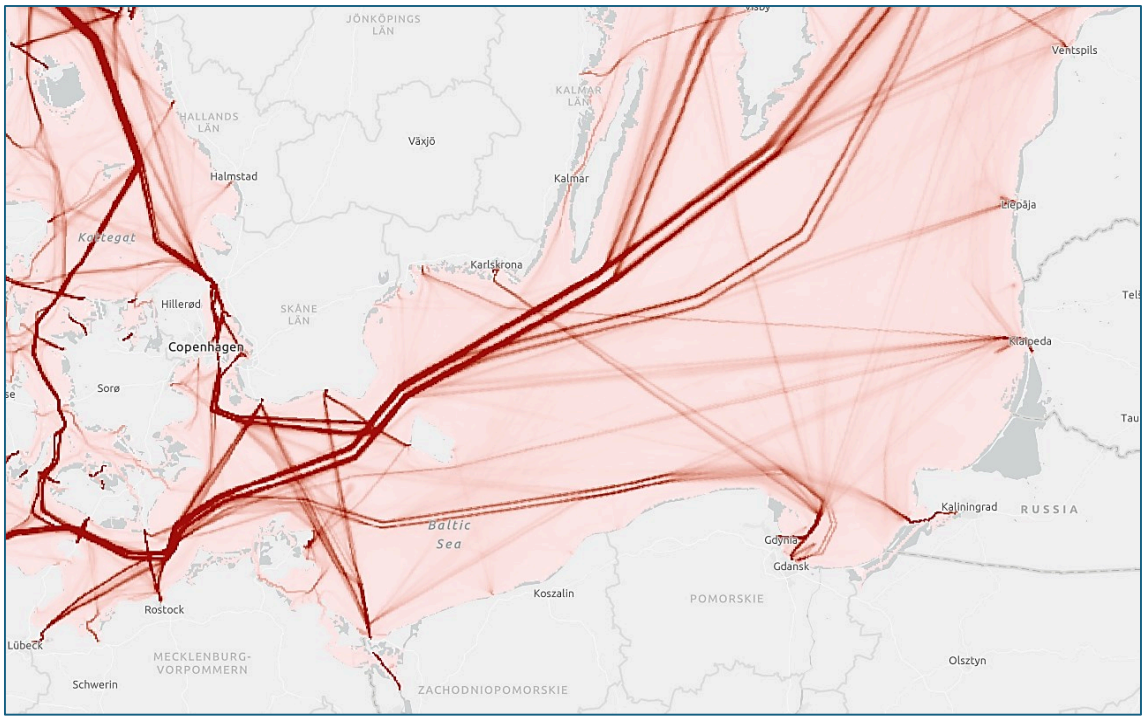

Figure 1. Main shipping routes in the Baltic Sea in 2019-2022 (compiled from AIS - Helcom data).

The planned construction of the container terminal will have a direct impact on the layout and intensity of ship traffic in the area. Consequently, it will not only be necessary to adapt the hydrotechnical infrastructure - such as the modernisation of the fairways or the construction of new breakwaters - but also to strengthen the maritime traffic management systems. This includes the expansion of the VTS system, the adaptation of pilotage procedures and the potential implementation of dynamic traffic separation systems (TSS) to safely integrate the new terminal with existing shipping traffic.

The new terminal is intended to serve as a significant transhipment hub, capable of handling the largest container vessels that can call at Baltic ports. This investment, while essential from an economic and logistical point of view, also poses serious challenges in terms of the organisation of maritime traffic and the safety of shipping. This is particularly important in the context of the current load on the waterways in the Świnoujście area, which is already characterised by a high volume of ferry, commercial and local traffic.

This article attempts to provide a comprehensive assessment of the potential risks associated with the operation of a container terminal. The analysis focuses on navigational safety and risks along different sections of the port approach route. Based on available AIS data, spatial and hydrographic analyses, as well as vessel traffic regulations, an assessment of the level of risk in the different sectors of the basin has been carried out. The conclusions of this analysis can be helpful for both the developer and the institutions responsible for maritime traffic management in the region.

The originality of the study stems from its practical and interdisciplinary nature. Given the dynamic development of the maritime infrastructure of the Polish Baltic coast - exemplified by the planned construction of the container terminal in Świnoujście - analyses are required that not only identify potential hazards, but also propose specific actions to enhance maritime safety. The article primarily responds to the need, which combines the analysis of AIS data with an assessment of local spatial and hydrographic conditions and existing regulations.

The study is characterised by dividing the study area into four survey sectors for which a separate risk assessment was carried out. In this way, local differences in traffic and spatial conditions were taken into account, and variability in the data was treated as a signal of possible risks. This approach allows the actual risks to be assessed and adjusted measures and recommendations to be proposed, which may be relevant in the context of the planned container terminal in Świnoujście.

2. Literature review

Shipping safety is a rapidly developing field that combines engineering practice with risk analysis and new technologies such as VTS systems or predictive tools based on AIS data. Increasingly, there is a shift away from purely traditional methods, with researchers and practitioners introducing probabilistic solutions, machine learning models and advanced analysis of vessel trajectories. One important aspect influencing the safety of manoeuvring in ports is adequate manoeuvring support, which significantly reduces the risk of collision and improves the efficiency of vessel berthing, especially in difficult hydrometeorological conditions (Paulauskas, et al., 2021). Such measures are complemented by advanced risk models based on fuzzy logic, which enable collision risks to be assessed taking into account the angle of intersection of vessel routes and the characteristics of the navigational environment (Shi et al., 2022).

Due to their intensive operation and the nature of passenger transport, ferries are among the units for which safety analysis must be carried out in a way that specifically considers operational risks. The models used in this context take into account both technical aspects and human factors (Hsu et al., 2022). A similar approach has been adopted in analyses for container ships, where Bayesian networks have been used to identify critical risk points along the operational chain (Zhou et al., 2022).

In inland waters, as the example of the Songhua River in China shows, navigational risk is particularly dependent on local hydrographic conditions and the intensity of vessel traffic. Methods for risk assessment in such environments are based on historical data and adverse event analysis (Xia et al., 2023). An interesting approach has also been proposed for the analysis of AIS data - by comparing vessels involved in accidents with those that avoided incidents, key risk indicators have been identified (Aalberg et al., 2022). Another factor affecting safety levels is the presence of hydraulic works. Studies have shown that construction works carried out in the vicinity of shipping lanes can temporarily increase navigational risk, which requires detailed analysis and compensation measures (Paulauskas et al., 2023).

Particular importance is also given to incidents that are not accidents, but only potentially dangerous situations detected by analysing AIS data. This approach allows hazards to be identified before an actual incident occurs, thus increasing the effectiveness of prevention efforts (Du et al., 2020).

The Baltic Sea region, especially its northern part, has also been the subject of maritime risk analyses based on AIS data. The results of these studies point to the need to adapt maritime traffic management systems to regional specificities (Du et al., 2021). Similar conclusions have been drawn from studies of navigation in Arctic waters - conditions there require particularly precise decision support tools (Yang et al., 2021).

There are also studies in the literature that focus on the accessibility of selected sites in the southern Baltic Sea region, which are relevant to the planning of environmental studies (Kubacka et al., 2024), and on the risks associated with marine traffic in the vicinity of wind farms (Rutkowski, Kubacka, 2023). Developed Bayesian network methods (Kong et al., 2024), as well as artificial intelligence techniques that can support analyses for different transport modes (Tselentis et al., 2023), are effectively used for risk assessment in such cases.

There is also no shortage of multi-criteria approaches, such as FAHP-entropy-VIKOR, used for risk management at container terminals (Khorram, 2020), or synthetic reviews of available risk assessment methods in maritime transport (Huang et al., 2023).

From a port risk management perspective, the organisation and operation of container terminals is of significant importance. Pallis (2017) draws attention to the specificity of risk management in these units, pointing out the need to integrate multiple sources of information and implement operational safety procedures. In addition, it is worth citing studies dedicated to the impact of the shore effect on fairway width, which show the importance of precise hydrodynamic analysis to ensure the safe passage of vessels with fragile hulls (Baric et al., 2019).

In recent years, increasing attention has been paid to the development of tools to enable ongoing safety management. Li et al. propose an integrated vessel traffic management system based on dynamic collision risk analysis in congested ports and fairways (Li et al., 2023). This approach significantly improves the efficiency of traffic management and allows rapid response to changing conditions. In automated container terminals, a significant challenge is the allocation of storage yards - an issue addressed by He et al. who proposed a dynamic allocation algorithm that indirectly affects the safety of port operations (He et al., 2022).

Li and co-authors, on the other hand, provide an overview of wharf management methods, showing how modern approaches can improve the operation of marine terminals while enhancing their safety (Li et al., 2023). An interesting perspective is presented by Yu et al. who proposed optimising ship routes taking into account local traffic patterns, resulting in increased predictability and safety in ports (Yu et al., 2021).

Documents from the PIANC organisation provide a series of design guidelines for channels leading to ports and how they deal with the impacts of climate change and unpredictable weather events - which is crucial for long-term port infrastructure planning (PIANC, 2014a, 2014b, 2020). This is complemented by USACE design guidelines, which apply to both deepwater navigation and general coastal engineering (USACE, 2006, 2018).

Authors such as Gucma have developed a number of tools to assist in the analysis of fairway shunting safety. Kinematic and simulation approaches for determining the width of fairway bends have been developed (Gucma et al., 2020, 2022; Artyszuk et al., 2016), as well as comprehensive approaches for formal assessment of shunting safety (Gucma, Ślączka, 2018). Their work contributes significantly to the development of methodologies for the design and assessment of waterway infrastructure in the Baltic Sea region (Gucma et al., 2022).

Zalewski presented an analytical concept for determining fairway design parameters, based on algorithms that can be useful under conditions of limited data availability (Zalewski, 2012). On the other hand, Artyszuk and co-authors presented methods for optimising the width of fairway bends using computer simulation, which allows the infrastructure to be fine-tuned to meet the requirements of specific vessel types (Artyszuk et al.,2016).

Rodrigue's work presents a systems analysis of container terminal layouts, focusing on their functional layout and its impact on operational safety (Rodrigue, 2025). Similarly, Emery analyses the costing approaches used by the USACE in estimating dredging works, which is relevant to sound investment planning (Emery, 2024).

Autonomy is playing an increasingly important role in modern approaches to collision avoidance in confined waters, with research by Cho et al. showing how autonomous systems can operate in accordance with maritime regulations while ensuring safe manoeuvring in tight spaces (Cho et al., 2023)

The development of port infrastructure in Poland is also becoming an important topic of analysis, especially in the context of increasing competitiveness and increasing the potential of transshipment (Ministry of Infrastructure, 2023). It is also worth noting that textbook economic approaches, such as the one presented by Mankiw, can also provide a useful background for assessing the profitability of investments in maritime transport safety (Mankiw, 2020).

3. Navigation analysis methodology

The navigational analysis was based on AIS (Automatic Identification System) data acquired for the Baltic Sea area in the period 2019-2022. The data contained information on the positions, direction and time of passage of vessels through spatially defined survey gates, distributed in four sectors (A-D). QGIS software was used to preprocess and visualise the spatial data, while further analytical and statistical operations were carried out using the Python language (libraries: pandas, numpy, scipy, matplotlib).

A probabilistic approach was used to quantify collision risk, where the primary measure was the expected value of the number of collisions for a given vessel type. Risk (R) was defined as:

$$R = N \times Pk, \tag{1}$$

where N is the number of vessel passages through the sector in the year under consideration and Pk is the assigned probability of collision, estimated on the basis of HELCOM reports and the contribution of the vessel type in question to the total number of marine casualties in the region.

Due to the random nature of collision events, a Monte Carlo simulation was used to map the distributions of the potential number of collisions. For each year and unit type, 10,000 samples were generated from a Poisson distribution in which the mean corresponded to R. The simulations made it possible to estimate not only mean risk values, but also standard deviations, minimum-maximum ranges and detection of outliers, indicating potentially extreme cases.

The results of the collision risk analysis carried out are directly dependent on the number of vessels passing through the measurement area, reflecting the volume of maritime traffic in sectors A-D. Collision probability values (Pk) were estimated based on the number of recorded accidents involving specific vessel types in the sectors analysed, according to AIS data provided by HELCOM. This approach takes into account the empirical proportions between traffic volume and the frequency of incidents involving specific vessels. Thus, the Monte Carlo simulation was based on realistic assumptions regarding traffic patterns and recorded incidents, ensuring the reliability of the results obtained. The accuracy of AIS data can affect the location and identification of maritime traffic, but the HELCOM system provides high data reliability due to its dense network of land-based receiving stations, as documented in official HELCOM material (2024)

The results of the analyses were presented in graphical form (e.g. bar, scatter and box plots), which enabled clear interpretation of spatial and temporal patterns of collision risk and comparison of the dynamics of change between sectors and classes of units.

4. Characteristics of the study area

The study area is located in the western part of the southern Baltic Sea, in the immediate vicinity of the planned container terminal in Świnoujście. The basin is characterised by varied bottom morphology, dynamic hydrometeorological conditions and increased vessel traffic, which makes it particularly important from the perspective of assessing navigational conditions.

In the area in question, the prevailing factor shaping the hydrodynamic conditions is the winds, particularly from the west and south-west. Storm events, especially in winter (December-February), lead to a significant increase in wave intensity and intensification of coastal currents. Maximum wind speeds during this period exceed 30 m/s, resulting in waves over 5 m high and significant displacement of bottom sediments and variability of coastal zones (Dąbrowska, Torbicki, 2024). Data from long-term observations indicate an increasing intensity of westerly winds, which is associated with an increase in the unidirectional transport of debris along the shore - from west to east (BioConsult Ltd., 2022). The currents in this area are longshore in nature and are strongly dependent on meteorological conditions, especially with winds exceeding 5°B (BioConsult Ltd., 2022).

Observations in the vicinity of the future container terminal indicate that local variability in the direction of currents - due to the curved shoreline, among other things - can lead to the formation of areas of sediment accumulation or flushing. In the context of navigational safety, this is crucial, as it affects the risk of shoal formation and changes in bathymetry, which can lead to collisions or subsidence of ships (BioConsult Ltd., 2022).

According to the analysis in the environmental report, the average annual wind speed in the Świnoujście area is about 5.9 m/s, while maximum speeds recorded in winter reached 30-35 m/s. Wave heights in the coastal zone are typically 1-2 m, while during storms they exceed even 5 m. Seasonally, the greatest hazards occur from November to February (BioConsult Ltd., 2022).

In terms of the characteristics of coastal currents, it is worth noting that in the south-western part of the Baltic Sea, the average speed of currents is between 0.1 and 0.4 m/s (i.e. about 0.2-0.8 knots), and these values can increase in strong winds (Krek et al., 2016). Coastal sea currents, shaped mainly by wind waves, directly influence sediment transport and changes in shoreline shape. The variability of these processes - especially in the Świnoujście area - is important from the point of view of navigational safety, as it may lead to local shallows, increasing the risk of collisions or grounding of vessels.

In order to carry out a detailed analysis of the navigational risks associated with the planned construction of the container terminal in Świnoujście, the fairway area was divided into four separate sectors, corresponding to the successive stages of the ship's approach to the port. This division allows for a differentiated assessment of risks depending on the characteristics of a given section of the route and the prevailing navigational conditions there.

For each sector, two basic risk parameters were identified: the probability of a hazardous event (P) and the potential consequences of that event (S). The assessment was carried out qualitatively, based on available source data, including vessel traffic intensity maps (HELCOM AIS 2019-2022), hydrometeorological characteristics (IMGW), operational data (VTS, szczecinpilot.pl) and reports of the State Commission for the Investigation of Marine Accidents (GDPWM). The values assigned to the two parameters are illustrative and form the basis for further, more precise analysis based on quantitative data.

In the analysis of navigational safety, it is also necessary to take into account the number of maritime accidents in the time period from which the data for the study was extracted. An area was delimited on the map, which covered four sectors A-D.

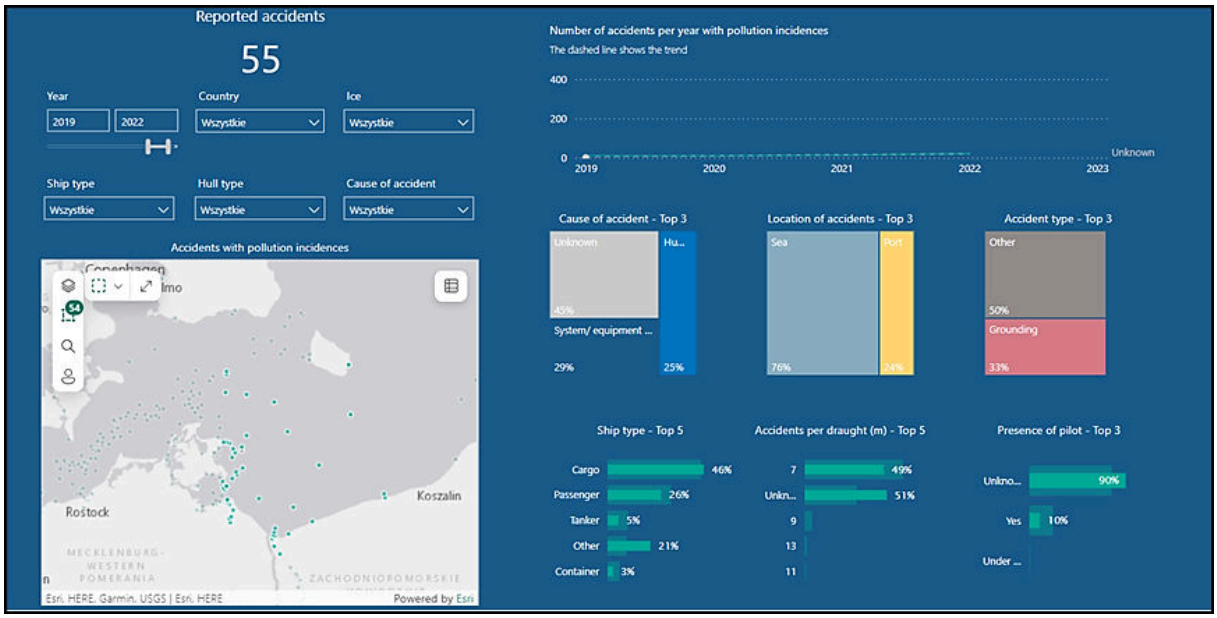

Figure 2. Characteristics of marine incidents with pollution incidents 2019-2022.

Source: HELCOM.

Figure 2 shows a map of the intensity of ship traffic in the southern Baltic Sea, based on AIS data from 2019-2022. This data enables the identification of the main shipping routes, the points of concentration of vessels and the places where sea routes cross. As part of this study, four distinct approach sectors to the port of Świnoujście were marked on the map, which were used to carry out a navigational risk analysis in the context of the planned construction of the container terminal (Figure 3).

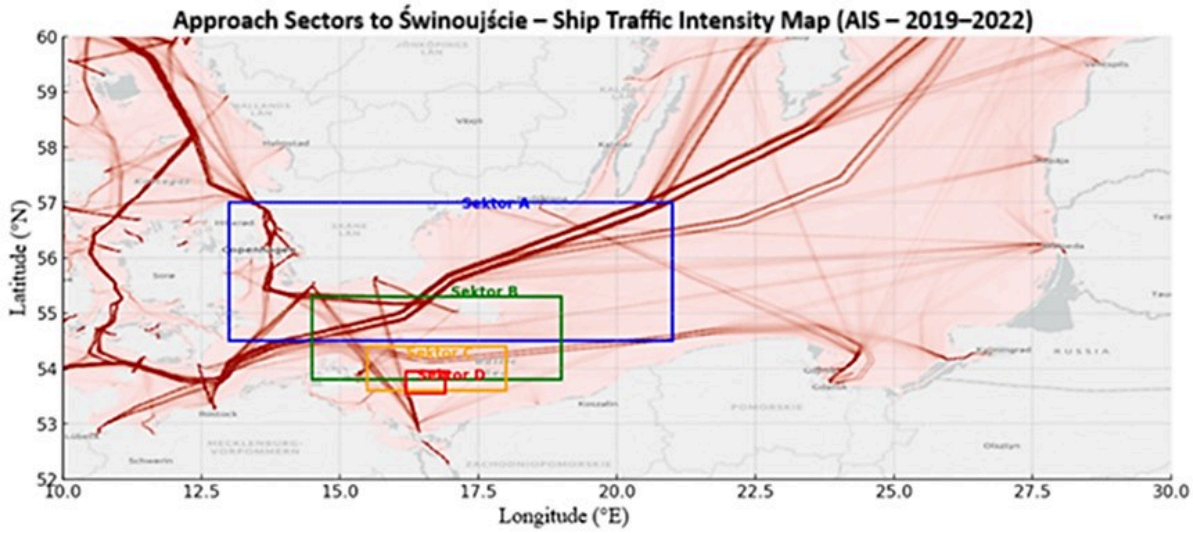

Figure 3. Map of vessel traffic intensity in the southern Baltic (AIS 2019-2022) with a breakdown of the four approach sectors to Świnoujście.

Source: HELCOM.

This division makes it possible to take into account the different navigational conditions in the different parts of the route, which differ in terms of traffic density, hydrographic conditions, infrastructure and typical manoeuvres carried out by vessels. The approximate geographical coordinates for each sector are summarised below, together with a brief description of their functions, which are presented in table 1.

Table 1.
Gate coordinates for each sector

Sector	Gateway	Latitude	Longitude	Description
A - open sea	**Gate 1:** between the western exit of Sassnitz and the northern point towards Bornholm (near Arkona).	Goal start position: 54,5546 N	Position of start of goal: 013.7076 E	Main trade routes, high volume of transit traffic
		Goal end position: 55,139 N	Goal end position: 014,8186 E	
B - external approach	**Gate 2:** between Kolobrzeg and the exit to Rønne/ Bornholm.	Goal start position: 54,9931 N	Starting position of goal: 015.1226 E	Region of convergence, approach manoeuvres
		Goal end position: 54,5007 N	Goal end position: 016,3496 E	
C - track approach	**Gate 3:** East of Świnoujście in the direction Greifswald (for local traffic/ Pommeranian Bay).	Goal start position: 54,3433 N	Goal start position: 013,800 E	Narrow track leading to Swinoujscie, heavy ferry traffic
		Goal end position: 54,3437 N	Goal end position: 014,2569 E	
D - internal track	**Gate 4** (if any): At the entrance to the fairway to Swinoujscie (for port traffic).	Goal start position: 53,9920 N	Goal start position: 14,1880 E	Approach to the terminal, impact of the weather. Mooring manoeuvres
		Goal end position: 54,0003N	Goal end position: 014,3503 E	

The analysis of vessel traffic on the basis of AIS (Automatic Identification System) data is an important element of modern shipping monitoring. The use of measurement gates makes it possible to quantify the intensity of maritime traffic in selected sections of water bodies. This technique makes it possible not only to count passing vessels, but also to classify them according to type and direction of flow (IN/OUT). Figure 4 shows four survey gates that have been placed at key locations in the approach to Świnoujście harbour and in the transit areas of the Pomeranian Bay and the western Baltic Sea. Each of the gates will be used to carry out an analysis of the intensity of vessel traffic in a given cross-section, based on AIS data.

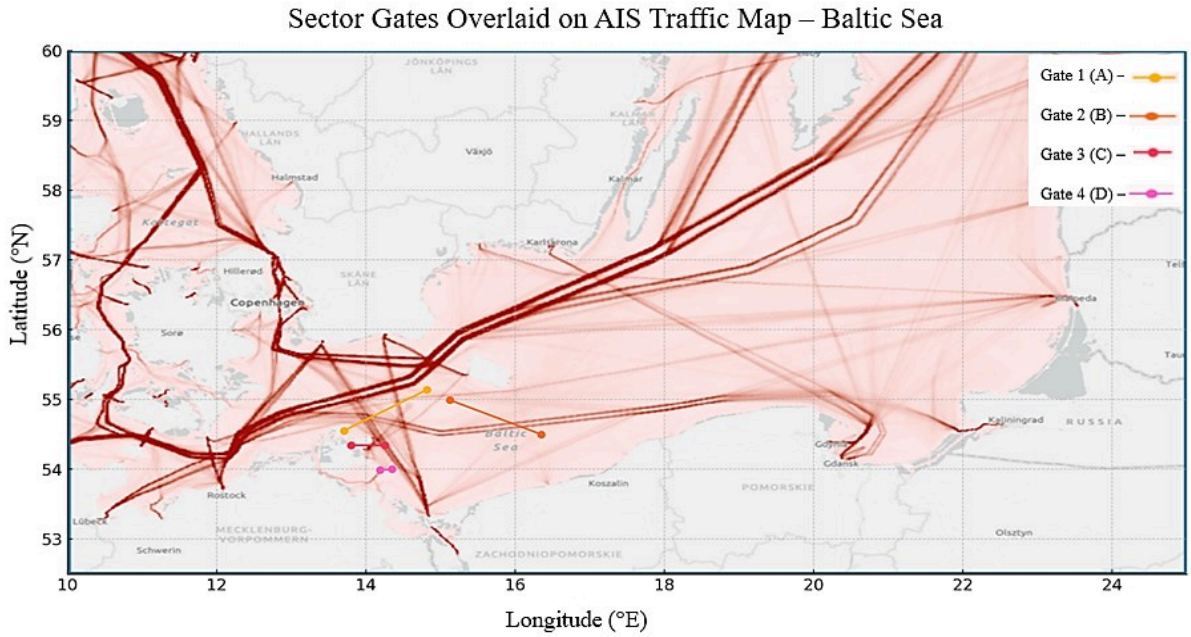

Figure 4. Distribution of sector gates on the background of the AIS traffic map in the Baltic Sea. Source: HELCOM.

For each survey gate, a detailed analysis of the intensity of vessel traffic is carried out. Firstly, the number of vessels that crossed a given gateway during the analysed period is determined - this includes the number of unique vessels identified by the AIS signal. The survey also takes into account the direction of movement of vessels. Vessels are classified as either inbound (IN) or outbound (OUT) to determine the predominant directions of navigation in the port approach area.

Another aspect is the breakdown of vessels by type, using the classification used in AIS. A distinction is made between passenger ships, commercial vessels, tankers, fishing vessels, and special vessels such as tugboats or rescue craft. Yachts and smaller recreational craft are also analysed in a separate group.

The analysis also includes the temporal distribution of traffic - data can be aggregated on a daily, weekly or monthly basis to identify cyclical patterns and seasonality in traffic volumes.

The use of survey gates is not only aimed at monitoring and forecasting the volume of maritime traffic in approach and transit areas, but also at identifying potential collision points and bottlenecks in the shipping system. The data also support the processes of manoeuvre planning, traffic control and environmental management, especially in specially protected areas (e.g. Natura 2000). The results of the analysis can be successfully used in maritime traffic surveillance (VTS) systems and operational management of seaports.

5. Results

This section presents the results of an analysis of ship collision risk in selected shipping sectors in the Baltic Sea. The tabular and graphical summaries show the variation in risk over time and between vessel types. The highest values were recorded for passenger and cargo ships, reflecting their dominant share of maritime traffic. The results presented allow for a better understanding of the distribution of risks and identify areas requiring special attention in the context of navigational safety.

5.1. Sector A - Gate 1

Sector A comprises one of the key shipping sections, characterised by a high proportion of passenger and cargo type vessels. This area is characterised by stable and intensive maritime traffic, which makes it particularly relevant for collision risk assessment. Figure 5 shows the number of ship crossings through Sector A in 2019-2022, broken down by vessel type (e.g. container ships, passenger ships, service ships, etc.).

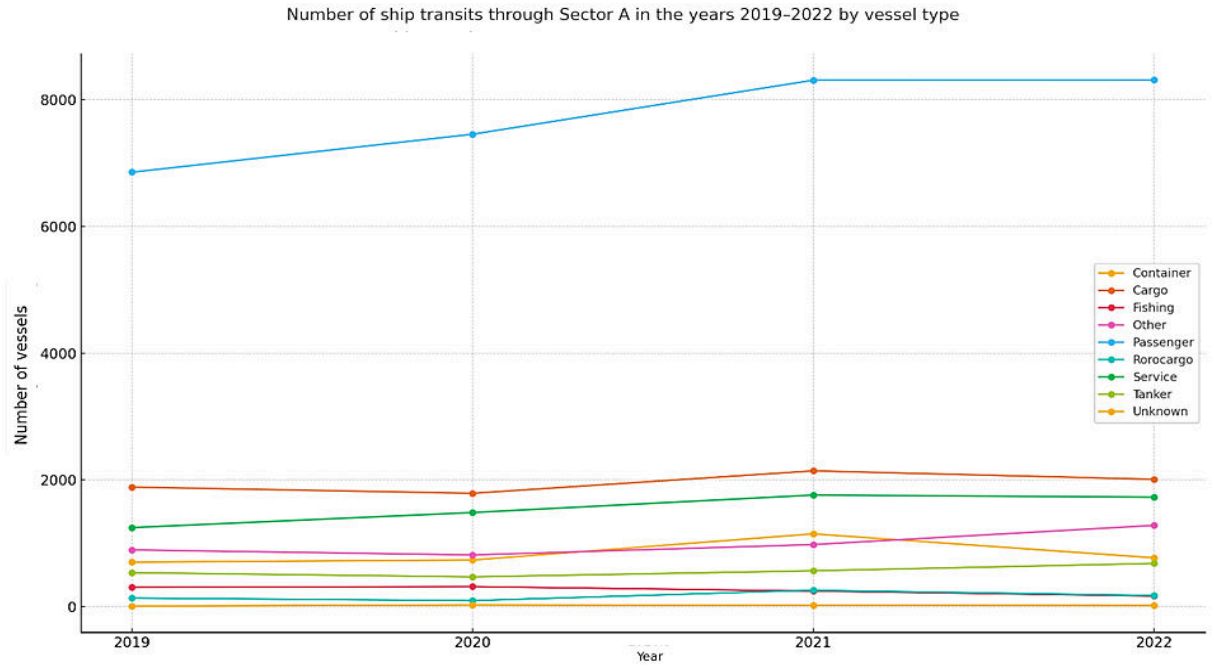

Figure 5. Number of vessel transits through Sector A in 2019-2022 by vessel type.

Source: own compilation based on AIS data.

- Passenger units are the dominant type, with overruns of more than 8000 per year (peak in 2022).
- Cargo and service units also have a significant share, with service traffic growing steadily.
- Tanker and container units show moderate increases with minor fluctuations.
- The 'Unknown' and 'Rorocargo' units appear less frequently, but their numbers are also increasing.

The increase in the number of vessel passages, especially passenger and service types, translates into an increased likelihood of collisions in the sector under study. It was therefore important to estimate the collision risk for individual vessel types, taking into account both their numbers and their variability over time. A statistical summary (Table 2) is presented below, taking into account the average risk values, standard deviations and minimum and maximum ranges for the years 2019-2022.

Table 2.
Summary of average collision risk values, standard deviations and minimum and maximum values for Sector A for the period 2019-2022

Collision risk statistics by vessel type for 2019-2022 for sector A				
Ship type	**Average**	**Deviation std.**	**Min**	**Max**
Cargo	6,325	0,495745341	5,781009585	6,925571885
Container	0,4125	0,102430898	0,345165622	0,56477171
Fishing	0	0	0	0
Other	2,8875	0,594322831	2,369977313	3,729657172
Passenger	3,575	0,328203004	3,169561423	3,842480851
Rorocargo	0	0	0	0
Service	0	0	0	0
Tanker	0,6875	0,108475112	0,5730187	0,832591273
Unknown	0	0	0	0

Monte Carlo simulations confirmed that cargo and passenger ships are among the groups of vessels most vulnerable to collisions, as a result of their relatively high unit collision probability Pk. The Pk value for cargo vessels remained at 0.0034 in all years, representing a 0.34% risk of collision for each passage through Sector A. Similarly, for passenger vessels, the Pk was 0.0026, or 0.26% per passage. Moderate Pk values were observed for other (0.0028) and container vessels (0.0020). In contrast, units such as rorocargo (0.0018), service (0.0015) and tanker (0.0018).

Figure 6 shows the results of the Monte Carlo simulation, illustrating the distribution of the number of potential collisions for different vessel types in Sector A from 2019 to 2022. The highest risk values and their variability were observed for passenger and cargo (Cargo) vessels, which is related to their dominant share of maritime traffic. The graph also shows the presence of outliers, indicating incidentally increased risk. Tanker and Container vessels show moderate risk, while the other types have minimal exposure to collisions. The results highlight the need for further analyses of shipping safety in the context of traffic intensity and vessel typology.

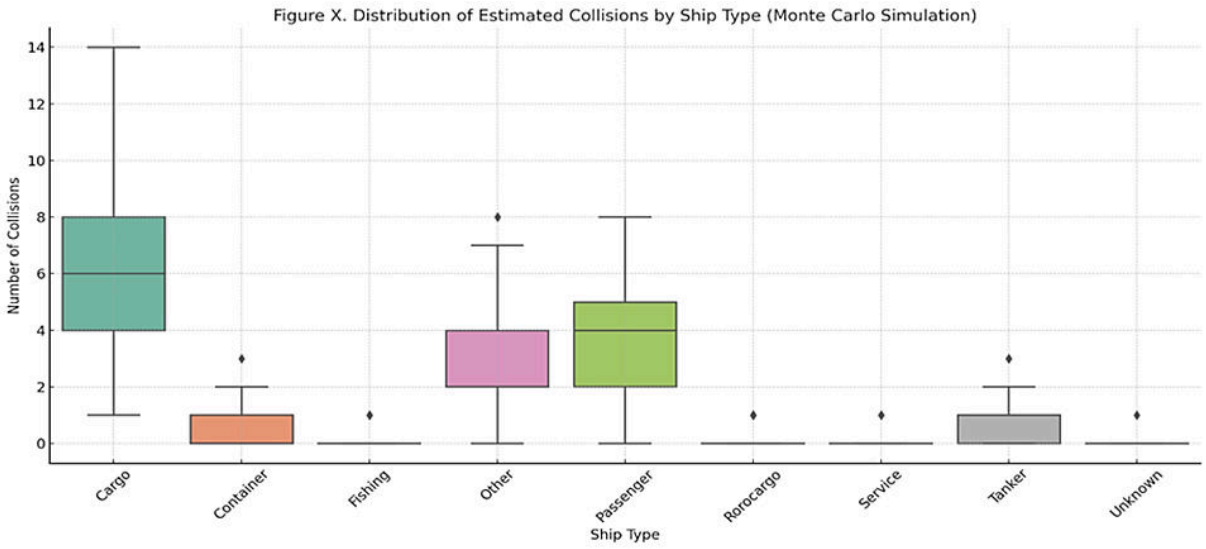

Figure 6. Distribution of number of simulated collisions by vessel type in sector A (Monte Carlo method).

5.2. Sector B - Gate 2

The maritime traffic in Sector B is characterised by a greater diversity of vessel types, with a distinct proportion of cargo, passenger and service vessels. Compared to Sector A, there is slightly less traffic here, but greater annual variability. Figure 7 shows the number of ship transits through Sector B from 2019 to 2022 by vessel type (e.g. container ships, passenger ships, service ships, etc.). The data has been mapped from the table provided by you and the vessel types have been visualised as separate series.

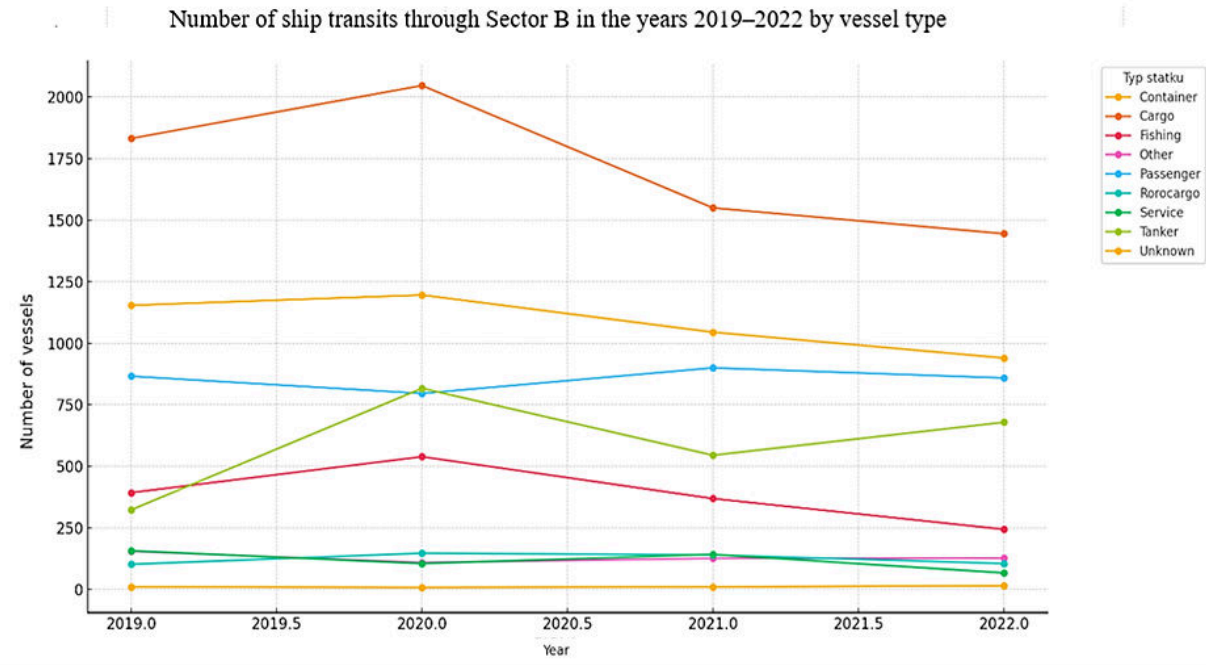

Figure 7. Number of vessel transits through Sector B in 2019-2022 by vessel type.

Source: own compilation based on AIS data.

Below is Table 3 with the results of the Monte Carlo simulations for each vessel type in Sector B, calculated using data from 2019-2022. It includes the average numbers of potential collisions, standard deviations and minimum and maximum values from the 1000 trials carried out.

Table 3.
Summary of average collision risk values, standard deviations and minimum and maximum values for Sector B for the period 2019-2022

Collision risk statistics by vessel type for 2019-2022 for sector B				
Ship type	**Average**	**Deviation std.**	**Min**	**Max**
Cargo	5,927	0,474	5,311	6,801
Container	0,373	0,096	0,312	0,503
Fishing	1,334	0,313	1,011	2,088
Other	2,018	0,475	1,671	3,193
Passenger	2,959	0,278	2,622	3,611
Rorocargo	0,426	0,107	0,351	0,579
Service	0,406	0,104	0,312	0,551
Tanker	1,994	0,283	1,732	2,602
Unknown	0,036	0,015	0,016	0,064

The probabilistic analysis carried out for sector B using Monte Carlo simulation confirmed the variation in collision risk levels between the different types of units, with the assessment based on the value of the unit collision probability Pk, regardless of the average number of events R.

The highest Pk values throughout the 2019-2022 period were consistently attributed to cargo vessels, for which the probability of collision per passage remained at 0.0034, or 0.34%. Similarly, passenger vessels were characterised by a value of Pk = 0.0026 (0.26%). Moderate probability values were present for container (0.0020) and other (0.0028) units. Units such as rorocargo (0.0018), service (0.0015) and tanker (0.0018). In contrast, units such as unknown and fishing, with Pk = 0.0005.

Below is Figure 8 showing the results of the Monte Carlo simulation for Sector B, showing the distribution of the number of potential collisions between 2019 and 2022 by vessel type.

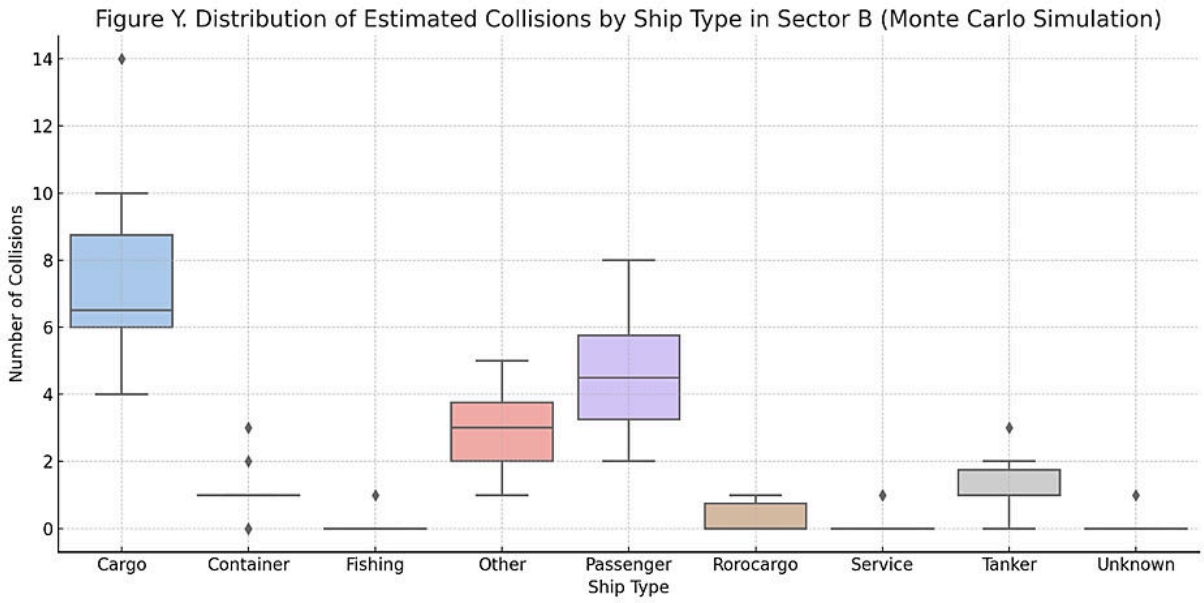

Figure 8. Distribution of number of simulated collisions by vessel type in sector B.

As can be seen in the graph, the highest collision risk values in Sector B were observed for Cargo and Passenger units, which is consistent with their high presence in the study area. Outliers can also be seen, especially for Cargo units, indicating possible incidental increases in risk. In contrast, types such as Service, Fishing and Unknown are characterised by minimal exposure to collision risk.

5.3. Sector C - Gate 3

Sector C comprises a region of moderate traffic volume, where transit passenger and freight units dominate. In the years under review, characteristic fluctuations in the number of crossings and an increase in the share of specialised vessels could be observed. Figure 9 shows the variation in the number of transits of the different vessel types (e.g. Container, Cargo, Passenger, etc.) in Sector C from 2019 to 2022. The data shows the dominant presence of passenger and cargo vessels, with varying trends in other vessel types.

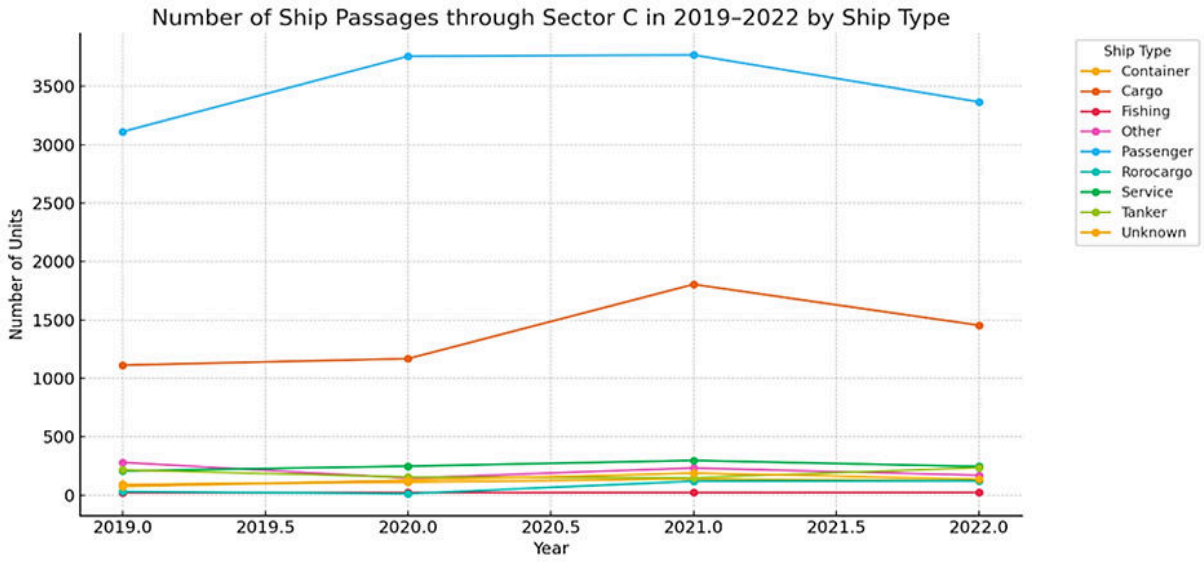

Figure 9. Number of vessel transits through Sector C in 2019-2022 by vessel type.

Source: own compilation based on AIS data.

Table 4 presents collision risk statistics for different vessel types from Monte Carlo simulations for Sector C (years 2019-2022).

Table 4.

Summary of average collision risk values, standard deviations, and minimum and maximum values for Sector C from 2019 to 2022

Vessel type	Average	Deviation std.	Min	Max
Cargo	6,371	0,498	5,789	7,125
Container	0,405	0,092	0,321	0,512
Fishing	1,041	0,267	0,851	1,988
Other	2,176	0,441	1,651	3,305
Passenger	3,182	0,307	2,682	3,709
Rorocargo	0,448	0,112	0,336	0,574
Service	0,367	0,085	0,295	0,522
Tanker	2,275	0,299	1,734	2,823
Unknown	0,043	0,013	0,021	0,067

For cargo vessels, for the entire period analysed (2019-2022), a collision probability of Pk = 0.0034 or 0.34% per passage was assigned. Passenger vessels showed a collision probability of Pk = 0.0026. For container vessels Pk = 0.0020 while for the other class Pk = 0.0028. These vessels had collision probabilities assigned between 0.0015-0.0018. For fishing vessels Pk = 0 while for unidentified vessels Pk = 0.0005.

The following Figure 10 shows the distribution of the number of estimated collisions by vessel type in Sector C, based on a Monte Carlo simulation (1000 trials). The values were generated from the number of vessel transits and the collision probabilities assigned to them. There is a clear dominance of passenger and cargo (Cargo) vessels in terms of risk of collisions, which is reflected in the wide range of values and numerous outlier points.

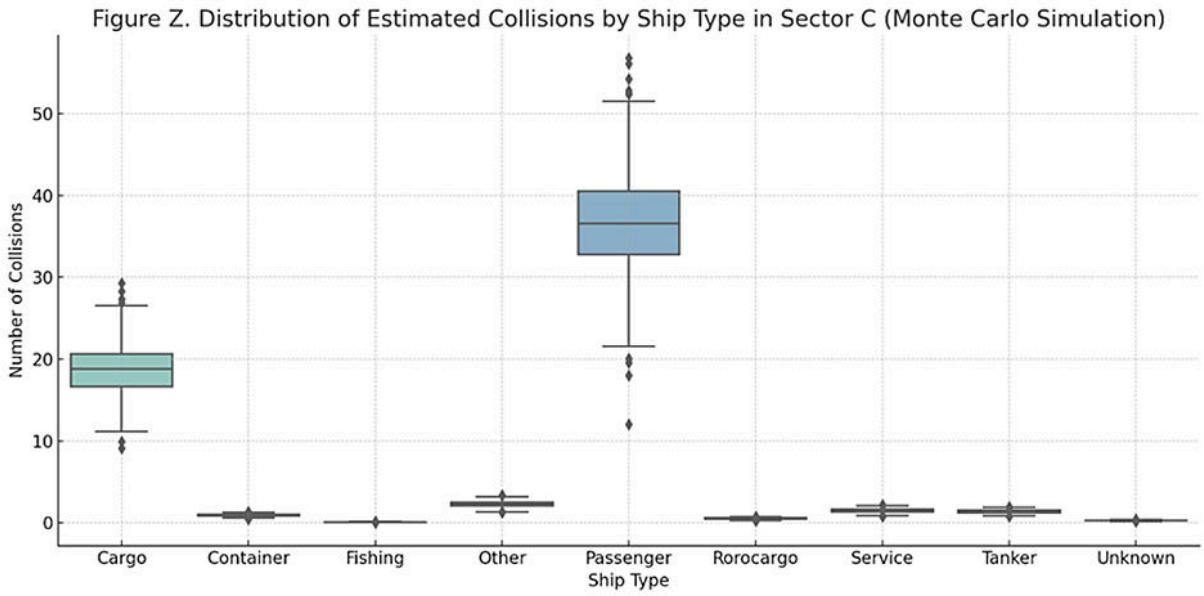

Figure 10. Distribution of number of simulated collisions by vessel type in sector C.

5.4. Sector D - Gate 4

Sector D is the most heavily trafficked section of those analysed, with the dominant presence of large passenger vessels. The high intensity of shipping in this area is reflected in the values of the estimated collision risk.

Below Figure 11 shows the variation in the number of vessel transits through Sector D between 2019 and 2022 by vessel type. Passenger vessels dominate the traffic, showing a clear increase. Types such as 'Cargo' and 'Unknown' also present significant changes, while 'Fishing', 'Rorocargo' and others show little variation.

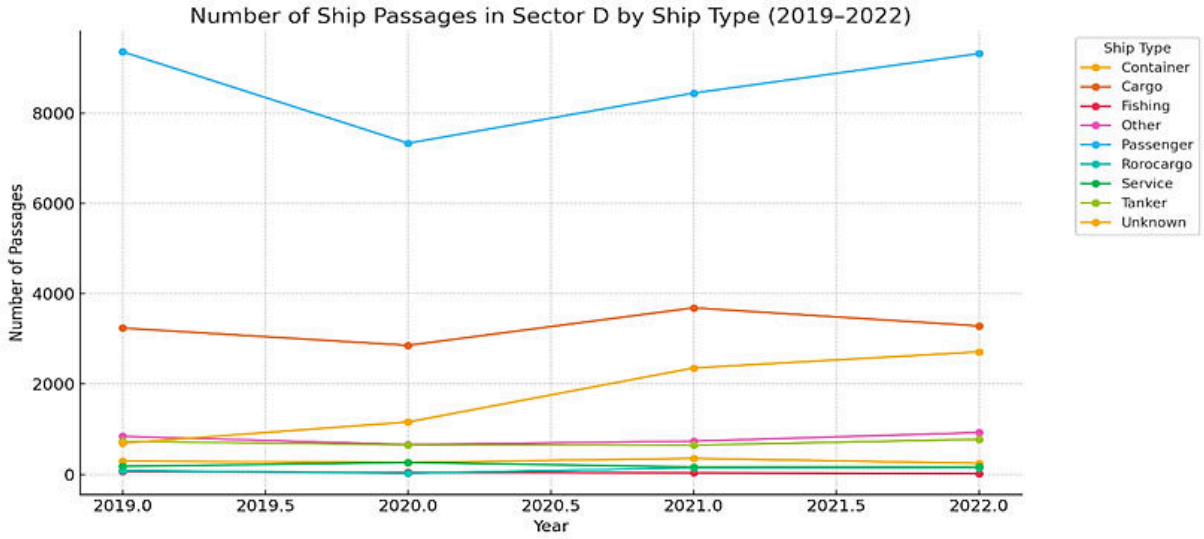

Figure 11. Number of vessel transits through Sector D in 2019-2022 by vessel type.

Source: own compilation based on AIS data.

Table 5 illustrates how the collision risk developed for the different vessel types in Sector D, based on the results of the 2019-2022 Monte Carlo simulations.

Table 5.
Summary of average collision risk values, standard deviations and minimum and maximum values for Sector D from 2019 to 2022

Vessel type	Average	Deviation std.	Min	Max
Container	2,324	0,226	1,556	3,028
Cargo	44,699	4,546	30,309	59,836
Fishing	0,162	0,016	0,114	0,212
Other	8,917	0,855	6,107	11,82
Passenger	89,262	9,09	57,49	122,83
Rorocargo	0,74	0,075	0,479	0,996
Service	1,161	0,114	0,799	1,564
Tanker	5,094	0,492	3,653	6,939
Unknown	3,468	0,352	2,509	4,507

Analysis of the data for Sector D from 2019 to 2022 reveals that cargo and passenger vessels showed the highest collision probability values. For cargo vessels throughout the analysis period, Pk = 0.0034, or 0.34%. Passenger vessels with an assigned probability of Pk = 0.0026. Their abundance (e.g. more than 9300 passages in 2019 and 2022) makes them one of the key categories in the hazard structure. Values of Pk = 0.0020 (for container ships) and Pk = 0.0028 (for the other category). Due to the different number of crossings (e.g. 927 in other in 2022). Rorocargo, Service, Tanker have assigned collision probabilities ranging between Pk = 0.0015 and 0.0018. Fishing vessels have the lowest Pk = 0.0005 values, while some unknown (unidentified) vessels also have Pk = 0.0005.

Below is Figure 12 showing the variation in collision risk for different vessel types between 2019 and 2022. The box plot shows the estimated collision risk by vessel type in Sector D between 2019 and 2022, based on Monte Carlo simulations. The highest and most variable risk values were observed for passenger and cargo (Cargo) vessels, while the other vessel types had low and stable risk levels.

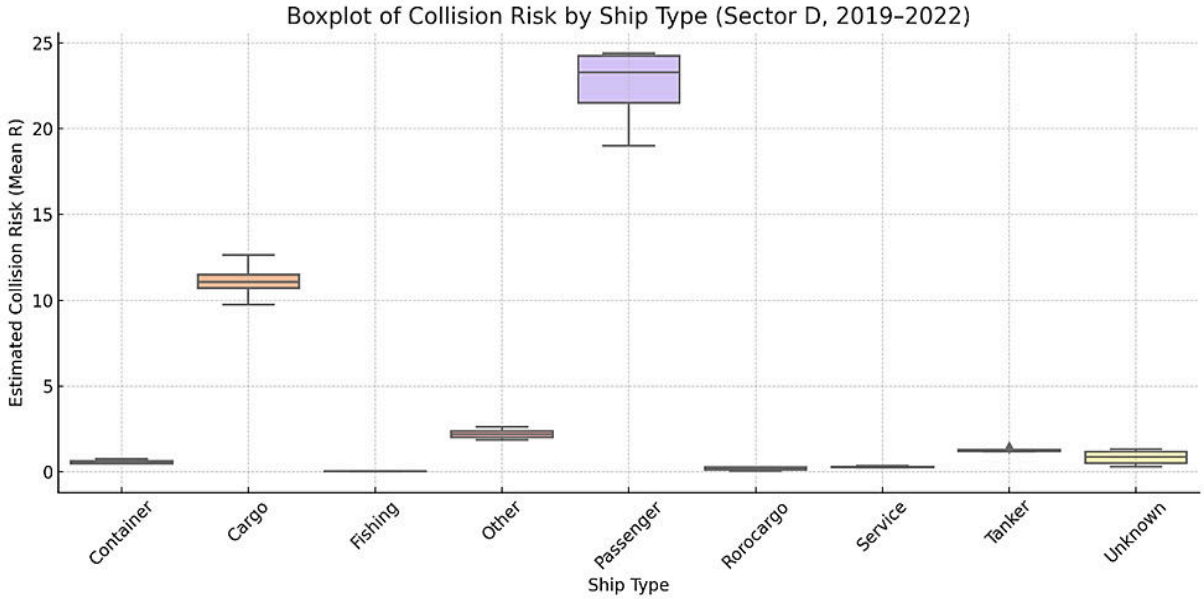

Figure 12. Distribution of number of simulated collisions by vessel type in sector D.

6. Recommendations for maritime traffic management and prevention activities

The results of the analysis carried out indicate a number of areas where it is possible and reasonable to implement measures to improve maritime traffic management and reduce the risk of vessel collisions. First of all, due to the high risk values attributed to passenger and cargo vessels, it is recommended to focus preventive measures on these two types of vessels. This is particularly the case in Sector D, where the volume of traffic and the variability of risk parameters were the highest.

As a first step, it is advisable to implement dynamic traffic management systems (Vessel Traffic Services - VTS), with priority given to the most congested and sensitive sections of the fairway. Such systems should be integrated with real-time analysis of AIS data, enabling automatic identification of potential collision hazards and provision of shunting recommendations. In parallel, the introduction of speed restriction zones (Traffic Separation Schemes) in the most congested sectors is recommended, especially for vessels with high tonnage and less maneuverability. Reducing speed at sensitive points can effectively reduce both the likelihood and consequences of potential collisions.

An important preventive aspect should also be the provision of regular education and training campaigns for vessel operators, with particular emphasis on the crews of passenger craft and vessels serving busy ports. Training should include elements of situational awareness, interpretation of navigational data and emergency procedures in collision situations.

In addition, due to the observed variability of risk over time, it is advocated that collision risk maps should be updated periodically, using both historical data and current observations of maritime traffic. Such maps can be a valuable tool to support shipping route planning and the allocation of patrol and rescue services.

Finally, consideration should be given to the further development and integration of predictive tools, based on Monte Carlo simulations and machine learning models, which will enable risk forecasting depending on weather conditions, seasonality or infrastructure changes. Implemented on a continuous basis, these solutions can make a real contribution to increasing shipping safety and reducing maritime accidents in the Baltic Sea region.

7. Discussion

The analysis of collision risk in Sectors A-D of the Baltic Sea shows a clear correlation between traffic intensity and risk level. Passenger and cargo vessels were found to be particularly vulnerable to collisions, the dominant presence of which in the surveyed sectors

translates into the highest risk values. The highest risk intensity was identified in Sector D, which may be due to its geostrategic importance and traffic concentration.

Although marginal vessels - such as fishing or service vessels - generate little risk, their impact in certain situations (e.g. limited visibility or navigational errors) should not be underestimated. This suggests the need for an in-depth qualitative analysis that also includes human factors and the operational context.

Dynamic variables such as weather conditions, seasonality or the technical condition of vessels are worth considering in further studies. Extending the model to include data from radar systems, onboard sensors and real-time observations could significantly improve the accuracy of risk forecasting.

From a practical point of view, the results of Monte Carlo simulations can be used as a basis for decision support in maritime traffic management, port infrastructure planning or the deployment of VTS systems. In the future, it is worth considering the use of hybrid predictive models, combining statistical analysis with artificial intelligence methods, which can help to improve the safety of shipping and the resilience of maritime transport systems to disruptions.

Given the calculated values and the potential concentration of risk at selected spatial points, it makes sense to use module 4 of the IWRAP (Geographical Risk Mapping) system in further detailed studies to identify local collision foci and the spatial distribution of risk, which will enable precise planning of countermeasures as part of navigation safety management.

8. Conclusions

An analysis of AIS data from 2019-2022, supplemented with statistical indicators from HELCOM reports, allowed the estimation of vessel collision risk in selected sectors of the Baltic Sea. The study used a Monte Carlo simulation, the results of which were directed at estimating collision probabilities for individual vessel types. A Poisson distribution, suitable for rare events such as marine accidents, was used as the basis for modelling.

Calculations were carried out separately for the four sectors (A-D), based on the number of passes of the units through the survey gates and the collision probability factors assigned to them. The risk value was defined as the product of the number of passes (N) and the collision probability (Pk), individually assigned to each type of unit.

Sector A showed a clear predominance of passenger units with more than 8000 crossings per year. The high volume of traffic in this category translated directly into elevated collision risk values at the peak (2022). Significant values were also recorded for cargo units. Fluctuations in the results, especially the presence of outliers, indicate the occurrence of incidental situations.

Sector A showed a clear predominance of passenger units with more than 8000 crossings per year. The high volume of traffic in this category translated directly into elevated collision risk values at the peak (2022). Significant values were also recorded for cargo units. Fluctuations in the results, especially the presence of outliers, indicate the occurrence of incidental situations immediate action, but should be taken into account in long-term marine traffic safety planning. In contrast, vessels with the smallest share of traffic - such as fishing vessels or indeterminate vessels - have a very low probability of collision, allowing them to be considered as a category with a negligible impact on overall safety in the sector.

Despite their relative stability, the high deviations in some groups of units may suggest periodic increases in risk, linked, for example, to seasonal increases in traffic or complex route patterns. This points to the validity of an in-depth spatial analysis to identify areas of particular risk and tailor preventive measures accordingly. Such an approach is in line with the recommendations of international standards for the analysis of shipping safety.

Sector C saw intensive traffic of cargo and passenger units, which were assigned collision probabilities of 0.0034 and 0.0026 respectively. Although these are the same values as in the other sectors analysed, their consequences in terms of spatial conditions and local traffic distribution have a noticeable specificity. Although these are the same values as in the other sectors analysed, their consequences in terms of spatial conditions and local traffic distribution have a noticeable profile - Sector C is characterised by lower total traffic intensity but higher variability in risk scores, which may indicate local route intersections, limited manoeuvring space or seasonal traffic congestion. The large variation in results is indicative of dynamic factors such as variability in traffic volumes over time, route intersections, manoeuvring restrictions or seasonality. Although many vessel types - including container ships, tankers, service vessels or ro-ro - remain in the moderate risk range, the elevated variability in the data for the dominant groups can be considered a warning signal. It is also a worrying feature of the C-sector that the unit risk remains within limits that are considered by international analyses to be elevated or in need of further control, even if the average number of collisions does not exceed the limits (Čorić et al., 2021). Further analysis of the operational context of the sector is therefore recommended, taking into account geographical and temporal factors that could explain the observed volatility.

Sector D showed the highest level of collision risk of all the areas analysed. This was mainly due to the intensive volume of passenger and freight units, which dominated the traffic pattern and had a high probability of collision. Although the risk levels attributed to these classes of units remained consistent with the other sectors, their impact was particularly noticeable due to the very high number of crossings during the period analysed. This situation indicates the need for special consideration for this sector in the context of planning shipping safety measures and given the proximity of the planned container terminal in Świnoujście. In addition, the simulations carried out showed considerable variability in the results, suggesting the presence of complex traffic configurations - such as route intersections, uneven distribution of

activity over time or spatial constraints. The distribution of uncertainty observed in these analyses indicates that sector D may contain local danger points with increased collision risk, which require more in-depth assessment. For other vessel types, such as support vessels, fishing vessels or unspecified vessels, the risk was assessed as relatively low and stable, with no significant impact on the risk level. Due to the dominance of passenger and cargo traffic, this sector should be treated as a priority area for future analytical work

The analysis clearly shows that passenger and cargo vessels play a key role in determining the level of collision risk in the Baltic Sea areas studied. Regardless of the sector studied, it is these two types of vessel that generate the highest risk values, due to both their numbers and the intensity of use of the main shipping lanes. This relationship is particularly pronounced in Sector D, which, due to the highest cumulative risk values and high variability of results over time, requires special attention from maritime safety institutions. This may imply the need to implement additional preventive measures, reorganise navigational infrastructure or improve traffic management systems.

The results of the analysis made it possible to formulate priority recommendations that can support the maritime traffic management policy in the area of the planned investment. In terms of immediate actions, it is recommended to implement additional AIS monitoring in the areas with the highest traffic and to introduce local procedures for separation of vessel traffic with high collision risk (e.g. passenger and cargo vessels).

In the long term, on the other hand, it is recommended to include risk modelling in cyclical assessments of the impact of infrastructure investments on maritime safety and to develop digital decision support systems for port managers and navigational operators that are based on AIS data and predictive analyses. This approach is in line with the direction of EU policy development on intelligent maritime transport systems and adaptive safety management.

In conclusion, the Monte Carlo-based simulation methodology used has proved not only accurate, but also flexible and effective in the context of maritime collision risk modelling. The results obtained not only allow the identification of high-risk sectors, but also provide a sound basis for making recommendations on shipping safety and designing future maritime traffic management strategies.

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STRATEGIC AND MARITIME IMPLICATIONS OF THE PLANNED FSRU TERMINAL IN GDAŃSK: A COASTAL INFRASTRUCTURE PERSPECTIVE

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Purpose: The purpose of this study is to assess the impact of the planned location of the FSRU (Floating Storage Regasification Unit) terminal in the waters of the Gulf of Gdańsk with respect to the safety of navigation. The analysis is focused on determining the intensity of traffic of different classes of sea vessels in the approach area to the port of Gdańsk, indicating an increased risk of potential collision scenarios. The study covers the frequency of vessel passage through the two control gates, allowing the application of probabilistic risk assessment models for future LNG transhipment operations.
Design/methodology/approach: The study used in the article consisted of examining how the intensity and structure of traffic of various types of vessels in the approach channels to the Port of Gdańsk affect the collision risk level in the context of maritime safety of the planned FSRU terminal construction.
Findings: Probabilistic modelling of the number of collisions between vessels based on AIS gate data showed that cargo and container vessels pose the greatest collision risk due to their frequent movements and variable traffic intensity. The possibility of manoeuvring collisions involving passenger, service and fishing vessels was also identified. The study points to the need to implement flexible traffic management and tools for safety prediction and management.
Research limitations/implications: The probabilistic models used are effective in the overall assessment of dynamics, but do not fully reflect the complexity of interactions between ships and the impact of hydrometeorological conditions. The assumptions made about the randomness and independence of events do not take into account actual operational procedures, such as entry schedules or pilotage. In the future, it would be worthwhile to broaden the approach to the issue by including models that take into account seasonal variations in vessel traffic and environmental data in order to increase the accuracy of hazard forecasting and support safety decisions in the FSRU terminal area.
Practical implications: The results of the study can be used in the planning and organisation of maritime traffic in the Port of Gdańsk area, particularly in the context of integration with the operation of the FSRU terminal. The proposed approach makes it possible to predict potential collision situations. The implementation of such a model can improve navigational safety, increase fairway capacity and reduce the risk of congestion or incidents. For port operators and

traffic management institutions, such as VTS, this means more efficient resource management and better preparation for handling special vessels, such as LNG.
Originality/value: The paper presents the application of probabilistic models based on AIS data to assess navigational safety in the area of the planned FSRU investment. The value of the study lies in its practical approach to navigational safety analysis with a view to the future operation of the terminal. The results may be useful for maritime traffic management authorities, port planners and teams responsible for assessing the impact on the marine environment. The method developed can also be used in other ports with a similar traffic structure.
Keywords: FSRU, LNG terminal, maritime safety, navigational risk, coastal infrastructure, LNG import security, floating energy infrastructure.
Category of the paper: Viewpoint.

1. Introduction

With the dynamic changes in the energy sector, LNG infrastructure, including floating FSRU terminals, is becoming increasingly important. However, this requires not only an assessment of their importance to the gas supply system, but also an in-depth analysis of the potential impact on shipping safety. The planned FSRU investment in Gdansk, to be located at one of the most strategic points in the Baltic Sea, raises the need for an interdisciplinary look at the issues of risk, technology, location and maritime traffic management.

Studies show that the LNG sector has an elevated risk profile, particularly in the areas of port and coastal operations. A review of the literature on risk analysis in the marine LNG sector indicates a wide range of risks: from collisions, explosions and spills to operational errors due to human and environmental factors (Abdelmalek, Guedes, 2023). Attention was drawn to the need for a systematic approach to safety, which becomes particularly relevant in light of the planned location of the FSRU in the Gulf of Gdansk.

The drive to enhance energy security through diversification of gas sources is reflected in the use of multi-criteria decision-making methods that support the planning of efficient and safe LNG infrastructure (Devaraj et al., 2021). The use of FSRU terminals in this context increases the flexibility of energy systems, but requires a careful assessment of the hydrographic and operational conditions of the basin in which the unit is to be sited.

In this context, criteria for the selection of the terminal location - developed taking into account navigational and hydrotechnical considerations, especially in areas with heavy traffic and extensive port infrastructure, such as the Bay of Gdansk (Mrozowski, 2024) - are of particular importance. An appropriate location method, taking into account both navigational safety and cost optimisation, is the key to minimising operational risk. At the same time, to ensure an adequate level of operational safety, the use of autonomous monitoring systems is increasingly being proposed to support risk assessment and enable rapid response in emergency situations. Solutions of this type are proving particularly useful in areas of limited visibility and

intensive maritime traffic - i.e. conditions typical of the area of the planned FSRU terminal in Gdansk (Miętkiewicz, 2021).

An understanding of the technological specificities of such facilities is essential for the correct identification of risks. Knowledge of regasification processes, mooring systems and connections to onshore transmission infrastructure provides the foundation for building realistic risk scenarios and designing effective safety measures for offshore operations (Beadnall, MacHardy, 2025). The implementation of state-of-the-art offshore technologies, such as innovative safety and processing systems for installation components, is playing an increasingly important role in enhancing navigational safety in the FSRU infrastructure environment (Shipley et al., 2021). These improvements allow for better operational control, faster response to emergency situations and reduced risk of maritime traffic disruptions, which is particularly important in areas of heavy shipping.

In the context of the increasing intensity of maritime traffic in the area of the planned FSRU terminal, technological solutions to ensure the stability of the vessel in changing hydrodynamic conditions are important. Innovations in maintaining the position of offshore units, including FSRUs, have a direct impact on reducing the risk of disruption to navigation and improving the predictability of their behaviour in the navigation space (Xuanze et al., 2024).

Under conditions of increased maritime traffic, it becomes crucial to take into account potential disruptions resulting from emergencies associated with FSRU operations. Scenarios such as uncontrolled unit drift, regasification failures or gas releases can significantly affect the safety of shipping in the immediate terminal environment. Risk analysis models are used not only to identify possible critical events, but also to design safety systems and response procedures in line with the ALARP (As Low As Reasonably Practicable)-approach of reducing risk to a reasonably acceptable level (Xiao et al., 2024).

The analysis of threats within Polish ports points to significant problems related to the concentration of vessel traffic, the limited effectiveness of surveillance systems and the lack of consistency in institutional responsibility for safety (Christowa, 2023). Data acquired from AIS reveals clear patterns of accumulation of vessels at critical approach points, which can lead to overloading of the navigation infrastructure. The introduction of FSRUs in such a busy environment requires not only the upgrading of the physical port infrastructure, but more importantly the integration of traffic management systems and the strengthening of operational cooperation between port services, the Maritime Search and Rescue Service and terminal operators.

The introduction of this type of terminal in the Gdansk area should be considered not only as a local infrastructure investment, but as part of a sensitive LNG value chain that includes extraction, sea transport, regasification and distribution. Each of these stages represents a potential source of risk. Its disruption can have serious economic and environmental consequences (Shingan, 2024). Locating the FSRU in a strategic port further highlights the importance of coordinated risk management - both locally and systemically. In an environment

of intensifying maritime traffic, dynamic factors such as course changes, current and wave action and hydrodynamic interactions between vessels become particularly important. These parameters are crucial in modelling collision scenarios and analysing spatial hazards in the immediate vicinity of the FSRU (Goksu, Arslan, 2024). Their inclusion in risk analyses becomes indispensable, especially in spatially restricted areas such as the Gulf of Gdansk, where even small manoeuvring deviations can lead to serious disruptions in navigational traffic.

One of the key tools supporting the assessment of navigational safety around LNG terminals are formal risk assessment methods, based on quantitative analysis and the opinions of maritime and gas safety professionals (Wang et al., 2024). These methods make it possible not only to identify the direct hazards associated with terminal operations, but also to consider their potential secondary effects - both on the marine environment and on the operation of port infrastructure. Of particular importance here is the comprehensive analysis of the consequences of accidents, such as explosions, fires or uncontrolled gas releases. Consequence models indicate the need for planning buffer zones, isolation measures and effective evacuation procedures, especially in the context of an urbanised and intensively exploited area such as the Gdańsk port region (James, Renjith, 2025). The wider context of the planned investment also points to the geopolitical and regulatory implications of the presence of the FSRU in the Baltic Sea space. According to infrastructural analyses of the region, the development of LNG terminals may foster the process of the so-called securitisation of the maritime space - in which technical elements are closely associated with political and military aspects (Berling et al., 2023). The location of the FSRU in Gdansk fits into this trend, raising the importance of precise planning, institutional coordination and risk management not only on a local, but also on a regional scale.

Based on the available literature on collision and risk assessment in shipping, the use of advanced predictive and probabilistic models is growing Based on the available literature on collision and risk assessment in shipping, the use of advanced predictive and probabilistic models is growing in importance. Work (Vukša et al., 2022; Xin et al., 2021) shows the effectiveness of combining AIS data with a Monte Carlo simulation approach to realistically represent collision scenarios in port conditions. A systems approach to risk assessment in multi-element vessel traffic has been developed in studies (Perkovič et al., 2024; Bakdi et al., 2020) which highlight the importance of integrating analytical methods with adaptive safety frameworks. The importance of implementing effective technical measures and behavioural analyses has been documented in (Ma et al., 2022; Wang et al., 2025) among others, where an attempt has been made to assess the influence of operational factors on collision risk levels. Stochastic models, as highlighted in (Faghih-Rooh et al., 2014; Nguyen, 2018), play a fundamental role in estimating the probability of incidents while taking into account spatial and temporal uncertainties. Further studies (Huang, Ung, 2023; Wang et al., 2023) show that the variability of trajectories and the manoeuvring constraints of vessels have a significant impact on the risk dynamics in approach sectors. In an intensive port environment, AIS data

analysis integrated with GIS spatial models (Li et al., 2019) and artificial neural network (RNN)-based approaches (Liu et al., 2020) enables the location of critical areas and the dynamic tracking of risk changes in real time. Furthermore, the development of classification methods based on semantic and statistical analysis - as outlined in (Ma et al., 2023) - opens new perspectives in the context of predictive vessel traffic management, including FSRUs, in areas of high vessel density.

2. Materials and Methods

2.1. Scope of the study and geographical context

The study focuses on the analysis of navigational hazards in the area of the approach to the Port of Gdansk, where the construction of the FSRU terminal - a floating unit for the reception and regasification of liquefied natural gas - is planned in the coming years. At the same time, the area remains a key shipping hub due to the intensive operation of the Baltic Hub container terminal. Of particular importance here is the harbour entrance area, which - as one of the busiest shipping locations in the southern Baltic - requires precise identification of potential risks associated with the co-existence of different ship classes.

The planned FSRU terminal investment will be located in the north-eastern part of the Port of Gdańsk, in the waters of the Gulf of Gdańsk. The terminal will be adapted to handle two FSRUs, each with a capacity of up to 174,000 cubic metres of LNG. The construction will also include a specialised quay with a length of approximately 520 metres, which will enable two units to be moored simultaneously. The entire infrastructure will be located approximately 3.3 kilometres from the shore, and gas will be transported to land via a subsea pipeline connected to the national transmission system (Kiejzik-Głowińsk, 2023). Figure 1 shows the area of the planned project.

The area of the Gulf of Gdansk is covered by the TSS (Traffic Separation Scheme), under the supervision of the VTS Gulf of Gdansk. The TSS includes dedicated lanes to order traffic and prevent collisions in busy shipping conditions (UMG, 2023). The fairway leading to the Northern Port, including access to strategic terminals such as the Baltic Hub (formerly DCT) and the planned FSRU terminal, is one of the most advanced hydrotechnical basins in the Polish coastal zone. Thanks to a series of modernisation works, this track has been adapted to handle the largest commercial vessels sailing the Baltic.

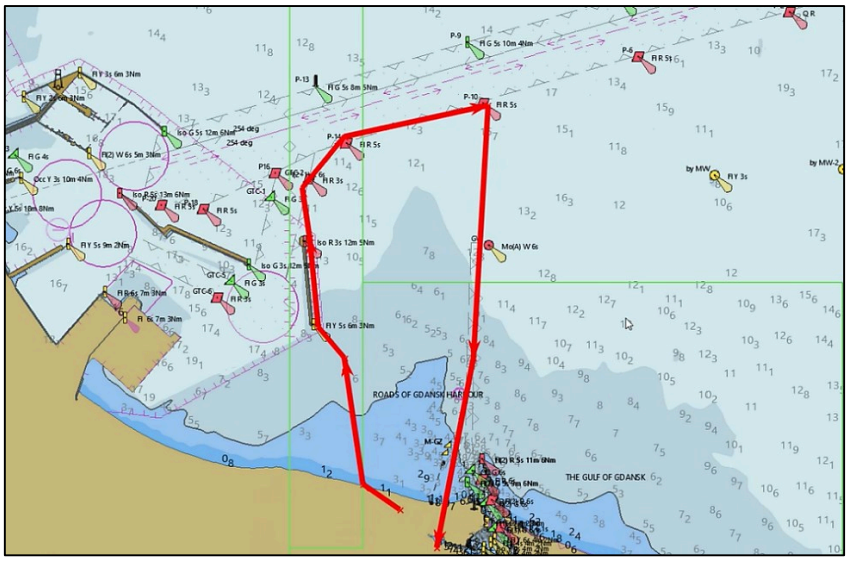

Figure 1. Designated operational area of the FSRU area in the Gulf of Gdansk.

Source: Own development using the OpenCPN electronic map programme.

In terms of length, the track extends for more than 11 kilometres, providing sufficient manoeuvring space for the entry and exit of ocean-going vessels. It has a bottom width of up to 600 metres, which - combined with a suitable cross-section profile - allows two-way navigation. This is very important in terms of maintaining traffic flow and maximising the use of port slots. The most important navigational parameter, however, is depth. The technical depth of the track reaches 18 metres, which allows vessels with a draught of up to 15 metres to navigate safely. It is worth noting here that the minimum actual depths - depending on the section - vary between 11.00 and 11.70 metres, due to bathymetric differences and local geological conditions of the seabed. On the track it is possible to navigate vessels of up to 355 metres in length and up to 60 metres in width, which in practice means a full service for ULCS-class container ships. Thanks to these parameters, Gdańsk has become one of the few Baltic ports able to directly accommodate the most powerful ships without the need for transhipment in the roadstead. The entire navigation infrastructure is under the day-to-day supervision of the Maritime Office in Gdynia and the VTS system Gulf of Gdansk (UMG, 2023, Port of Gdansk, 2024). Vessel traffic within the Gulf of Gdansk, especially on the approach to the Northern Port in Gdansk, follows strict navigational rules. Due to the intensive traffic of commercial vessels, including container ships and tankers, specific speed limits are in place to ensure the safety of navigation, to protect the hydrotechnical infrastructure and to minimise hydrodynamic impacts on the environment and the shore. Below is a summary of the allowable ship speeds on key sections of the fairways in the Port of Gdansk area, according to the current Maritime Authority Order (Table 1).

Table 1.
Summary of permitted vessel speeds on key fairway sections in the Port of Gdansk area

Track section / Zone	Description	Maximum permitted speed
Reda of the Gulf of Gdansk	Anchorage and manoeuvring area before entering the harbour	9 knots[1]
Manoeuvre with remote control (manoeuvring/ passing)	Replacement of the ship's sea pilot	6 knots
Approach track to the harbour heads	Entrance area - last section before the harbour	7 knots
Waterway from headwaters to sluice gates	Internal section of track along quays	4 knots
Lock steering wheel and lock itself	The most precise manoeuvring section, requiring caution	safe speed, max. 3 knots

Source: (Regulation No. 11 of the Director of the Maritime Office in Gdynia of 8 September 2022).

The analysis used maritime traffic data from 2019-2022, collected based on two gates - virtual control cross sections mapped in the area of the approach to the ports of the Gulf of Gdansk. Their purpose was to capture the directions of vessel movements, traffic volume and shipping structure, including the main waterways and their intersections (Figure 2).

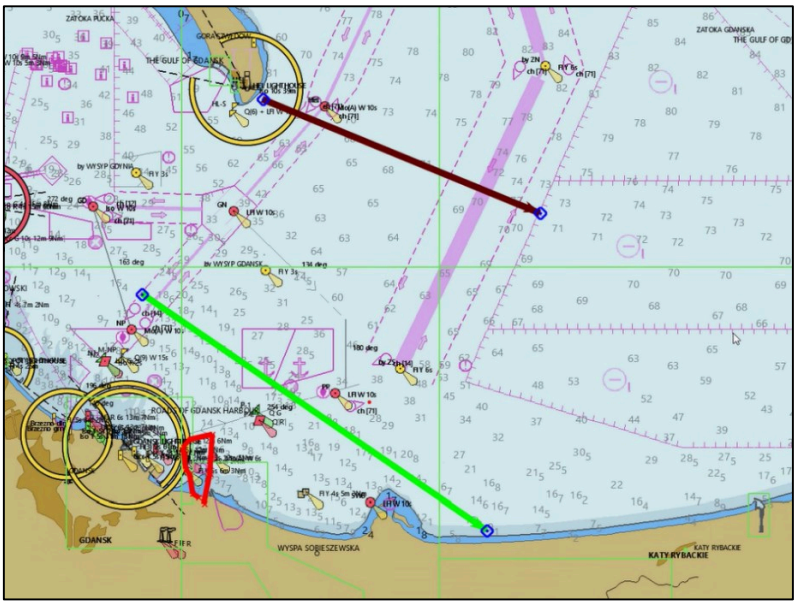

Figure 2. Designated control gate lines for vessel traffic monitoring in the context of FSRU impacts.
Source: Own development using the OpenCPN electronic map programme.

Gate 1 (green) comprises the track leading to the main approach track to the Baltic Hub and the future FSRU, passing through the TSS (Traffic Separation Scheme) "Gulf of Gdansk". The geographical position of this gate is defined by the following coordinates of two interconnected points:

Point 1: 54°29′04.8″N, 018°42′42.7″E

Point 2: 54°21′06.3″N, 019°02′43.9″E

[1] 1 knot [kn] = 0,51(4) m/s.

Gate 2 (brown) refers to the less frequented alternative track, located within the Traffic Separation Scheme (TSS) "Gulf of Gdansk". The geographical coordinates of the gateway have been defined by points respectively:

Point 1: 54°35′38.9″N, 018°49′43.4″E

Point 2: 54°31′48.6″N, 019°05′50.2″E

This gate runs across the axis of the approach track from the south-east, crossing the expected route of LNG-carriers and other commercial vessels heading to the container terminals and the planned FSRU.

The two gates act as analytical tools to carry out an assessment of traffic flow, the structure of vessel types, the directions of entrances and exits from the port area, as well as potential route collisions and navigation conflicts.

2.2. Applied navigation survey methodology in the area of the two gates

The navigational analysis in the area of the approaches to the Port of Gdansk was based on collected data acquired for the Baltic Sea area between 2019 and 2022. The data included information on the position, time and type of vessels crossing two spatially defined survey gates, located in the water traffic sectors within the approach fairway.

The QGIS environment was used to process the spatial data, while the quantitative analysis was carried out using Python programming tools. To map the variability and uncertainty of collision risk, a Monte Carlo simulation was used, generating 10,000 samples for each unit type and year from a Poisson distribution whose mean corresponds to the expected value. The results made it possible to define ranges of minimum values, maximum values and standard deviations, which allowed the identification of potentially extreme cases (outliers) and risk accumulation sites.

In addition, a mathematical model based on a Poisson distribution was used to estimate the average vessel traffic volume in the area under study. This is a classical approach used to describe the number of independent events (e.g. vessels passing through control gates) occurring per unit time, provided that these events do not influence each other's occurrence and are randomly distributed in time. The adoption of a Poisson distribution was justified by the nature of the observed AIS data, in which the successive arrivals of vessels into the survey sector are dispersed in time and occur independently of each other. This made it possible to determine not only the average traffic intensity (expressed as the number of vessels per hour), but also to model the probability of occurrence of a certain number of vessels in a given time interval. The average vessel traffic intensity was modelled as a Poisson process, for which the probability of occurrence of exactly n vessel passes through the survey gate (1 or 2) at time t is described by the relation (Ross, 2014):

$$P(n;\lambda t) = \frac{(\lambda t)^n e^{-\lambda t}}{n!} \quad (1)$$

where:
P(n; λt) - probability of exactly nnn events occurring at time ttt,
λ - average number of events per unit time (here: vessels per hour),
t - length of the observed period (e.g. 1 hour),
e- Euler's constant (≈ 2.71828),
n! - the strong of the number nnn (Ross, 2014).

The data obtained enabled quantitative characterisation of maritime traffic intensity and identification of patterns of vessel transits through sensitive sectors of the approach track. This provided a starting point for further collision risk modelling and analysis of the co-occurrence of vessels of different classes in the study area.

The navigation research methodology used in the area of two defined AIS measurement gates is characterised by accuracy and reliability thanks to the use of data from the AIS system. The data used in the study comes from HELCOM sources based on numerous signal reception stations located along the Baltic Sea coast. The accuracy of the data depends on several factors, such as signal quality, reporting frequency and data processing procedures. HELCOM uses data processing procedures that include:

- Removal of duplicates and erroneous records (e.g. incorrect IMO or MMSI numbers).
- Filtering data according to parameters such as speed over ground (SOG) and course over ground (COG).
- Standardisation of data formats in accordance with IEC 61162-1.

These processes ensure high data quality and consistency, which are essential for the creation of traffic density maps and statistical analysis (HELCOM 2024).

3. Results

3.1. Probabilistic modelling of the number of vessel collisions based on gated data

As a result of the Monte Carlo simulations (10,000 trials) for selected ship classes, it was found that the highest values of expected collision risk occurred for cargo and container vessels. For these groups, the average risk exceeded the 1.5 event level, with values even several times higher than the average observed in some draws, indicating high variability. Passenger vessels were also characterised by a noticeable level of risk, although slightly lower and more stable. For smaller vessels, such as fishing or service vessels, the risk remained low, but their share of risky situations may increase as a result of co-occurrence with larger vessels with limited manoeuvrability. The scatter of results (analysed as range and standard deviation) was

particularly evident in the cargo and container groups, suggesting potentially irregular waves of traffic or periods of increased activity in these sectors of the approach track.

To illustrate the variation in collision risk by unit type, a box plot was drawn up to show the distribution of the number of potential collisions, taking into account the median, interquartile range and outliers (Figure 3). The line inside the box indicates the median value, i.e. the most typical result among the samples. The height of the box corresponds to the interquartile range (IQR- Interquartile Range), indicating the variability of results within the middle 50% of values. "Whiskers" on the graph delineate the range of data with no outliers and cover the interval from the minimum value to the maximum value within 1.5 IQR. Points outside this range are outliers - rarer but possible scenarios with higher risk.

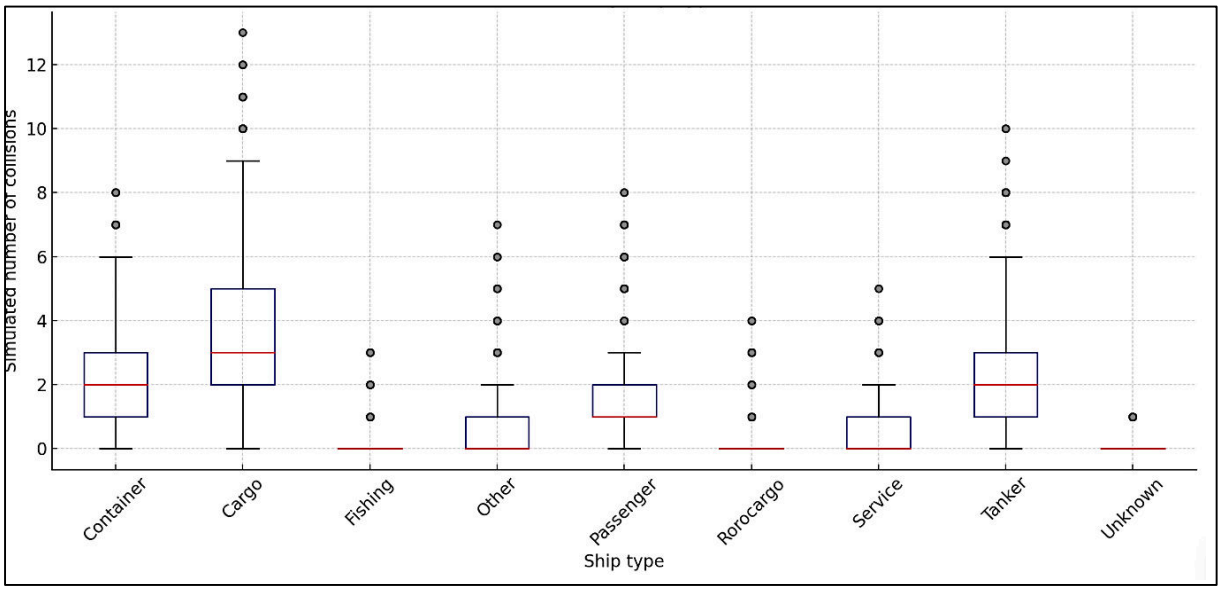

Figure 3. Distribution of the number of potential collisions, taking into account the median, interquartile range and outliers.

Source: Own development.

The box plot shows the variability and characteristics of simulated collision risk for each class of vessel. Cargo and Container vessels stand out for having the highest medians and the widest interquartile range (IQR), indicating their dominant share of traffic, the highest overall level of collision risk and the significant instability of this risk over time. The greatest spread and high level of unpredictability of risk was observed for Cargo vessels and, to a lesser extent, Tanker vessels. The presence of long 'whiskers' and numerous outliers indicates the possibility of periods of significant traffic congestion. Outliers in these groups signal potentially rare but particularly dangerous scenarios - such as the accumulation of several collisions in a short time frame. Passenger, Service and Fishing vessels, on the other hand, are characterised by relatively narrow boxes and short whiskers, indicating a low and stable level of risk. In their case, the risk increases mainly when co-occurring with large vessels with limited manoeuvrability. Although these vessels are of less systemic importance in terms of direct collisions, their presence remains important for human safety and environmental protection.

3.2. Modelling of the intensity of unit movements at the measuring gates (gate 1 and gate 2)

A Poisson process model was used to assess the volume and structure of maritime traffic on the approach fairway to the Port of Gdansk. The passage of vessels through the two defined measurement gates was treated as independent events occurring in time. The determined values of traffic intensity (λ) for individual ship classes were the basis for further modelling of the co-occurrence of vessels and collision risk analysis.

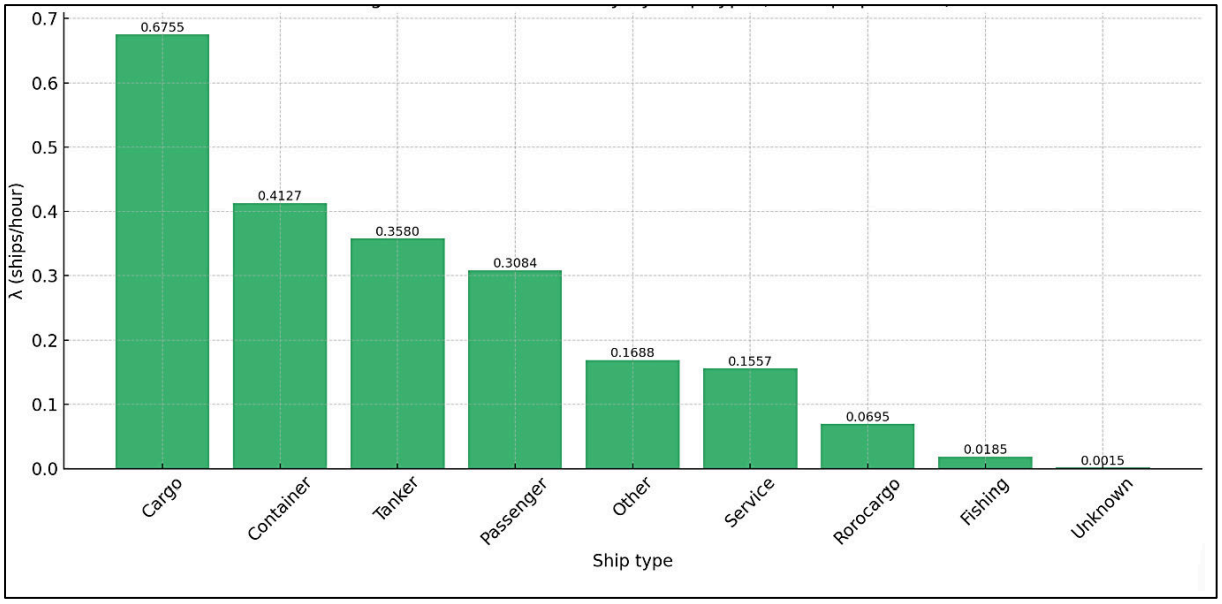

Figure 4. Average unit traffic (λ).

Source: Own development.

Figure 4 shows the average unit traffic volume (λ), expressed as number of crossings per hour. Values were estimated using AIS data from 2019-2022, covering the total number of crossings through both survey gates. Following a probabilistic approach, the model assumed stationarity and independence of events over time, typical of a Poisson process. The analysis showed that the highest traffic intensity is found in the groups of Cargo and Container units, which confirms their dominant share in the service of the approach track to the Port of Gdansk. Their average intensity exceeds 0.5 vessels per hour, which means that a vessel of this class passes through the surveyed sector on average every 1-2 hours. The λ values for Tanker, Passenger and Service vessels are moderate, while for Fishing, Rorocargo and Unknown vessels indicate activity of an irregular or episodic nature.

The estimated traffic intensities are crucial in the context of further analyses - both for modelling the real-time co-occurrence of units and for assessing local sector congestion. The λ parameters can also form the basis for planning slot schedules, designing approach infrastructure and optimising traffic management systems in areas with higher collision risk.

The analysis refers to a box plot, which provides relevant information to identify critical situations, the height of the boxes and the length of the 'whiskers' visualise the level of variability and the extent of typical risk. The dots indicate rare but potentially negative scenarios and can be the basis for considering critical cases.

The λ values obtained provide a starting point for the overall assessment of traffic volume, but also for the identification of 'congestion points' in the navigational structure of the Port of Gdansk. An indication of the types of vessels dominating in a given spatio-temporal sector allows the design of risk scenarios targeting actual traffic configurations. The data can also be used to simulate the efficiency of time slot planning for LNG carrier vessels in the context of current traffic volumes in the approach fairways.

4. Discussion

In the context of the planned start-up of the FSRU terminal in the Northern Port area, special attention should be paid to future changes in the structure and intensity of vessel traffic. The impact of large LNG carriers - characterised by significant draught, limited manoeuvrability and the need to operate in specific hydrometeorological conditions - may significantly increase the load on the approach track, especially in the area of intersections with container and cargo traffic. The situation will require adjustments to both infrastructure and traffic management - taking into account forecasts of co-occurrence of vessels and dynamic allocation of shunting slots. The probabilistic approach used in this analysis, based on the Poisson process and Monte Carlo simulations, has allowed a quantitative assessment of traffic intensity and collision risk in typological terms. In contrast to static indicators of the number of calls, these methods allow the modelling of dynamic navigational phenomena - such as an increase in the risk of co-occurrence of vessels, stoppages, or local congestion in the fairways. Of particular cognitive value is the possibility to consider time as a random variable and move to a description of the system as a sequence of events with variable intensity, which opens the way for further predictive analyses. In port practice, the results obtained can form the basis for:

- estimating the capacity of the approach infrastructure,
- planning the time allocation of the impacts of LNG vessels and container ships,
- the development of models to support the operational decisions of VTS services,
- and building early warning systems based on AIS data and risk scenarios.

In the perspective of FSRU development, it seems reasonable to extend the current model with dynamic components (e.g. heterogeneous Poisson process, Cox model) and to use machine learning methods to classify high-risk situations. This would allow for more efficient real-time traffic management and the creation of separation and prioritisation strategies for operationally critical units.

The results of the analysis indicate a high intensity of ship traffic, with the co-occurrence of large-capacity vessels, such as tankers and container ships, having a direct bearing not only on local navigational safety, but also on the achievement of the state's strategic energy goals. The planned FSRU terminal in the Gulf of Gdansk is an element of critical infrastructure that supports the diversification of natural gas supplies and contributes to independence from eastern energy supplies. Therefore, the assessment of navigational risk in the area, although based on quantitative data, is part of a broader geopolitical context related to energy security and the functioning of the trans-European transmission networks.

5. Conclusions

The analysis carried out with the use of probabilistic models and automatic ship identification system data enabled a holistic view of the operation of the approach fairway to the Port of Gdansk - from the perspective of both traffic intensity and the associated collision risk. The particular value of this methodology is the ability to model navigational phenomena as a dynamic process, based on time and the co-occurrence of different types of vessels, which significantly extends the scope of classical static analyses. The results clearly show that the greatest operational risk is generated by Cargo and Container vessels. It is their abundance, variability in intensity of occurrence and dominance in traffic patterns that cause the greatest strain on the fairways, especially in the context of sharing space with other classes of vessels. Importantly, this risk is not due to one-off anomalies, but to the typical dynamics of port operations and the characteristics of commercial traffic. In addition, service, passenger and fishing vessels - despite lower volumes - may enter into a manoeuvring collision in situations of intersection with traffic of vessels with limited manoeuvrability. From the point of view of port practice, these results indicate the need for:

- develop a flexible traffic management system based on real data and co-occurrence scenarios,
- implementation of dynamic slot allocation, especially for maximum and LNG vessels,
- and to strengthen the role of predictive models in assessing current and projected loading on the fairways.

In the context of the commissioning of the FSRU terminal in the Northern Port, it is recommended that the current model be supplemented with elements of temporal variability (e.g. non-homogeneous Poisson processes), the inclusion of hydrometeorological conditions and the development of data analysis algorithms using machine learning. Future LNG units will operate in a strict weather and time frame, which requires a strict separation of their trajectories from container traffic and increased separation at hotspots such as track crossings and towing zones.

From a scientific point of view, the work confirms the effectiveness of the applied probabilistic and simulation methods in the analysis of real maritime traffic, while opening up perspectives for further research towards integrated predictive models. Well-calibrated stochastic approaches, combined with up-to-date AIS data and decision support systems, can provide a solid foundation for future solutions for navigational safety and efficient use of port infrastructure.

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MODEL SCARF AND TEACHER ENGAGEMENT IN MITIGATING MANAGEMENT PARADOXES IN HIGHER EDUCATION

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Purpose: The purpose of this article is to examine the impact of satisfying the five basic psychosocial needs defined in the SCARF model (Status, Certainty, Autonomy, Relatedness, Fairness) on the level of engagement of academic teachers in both teaching and research work. Additionally, the aim is to indicate how taking these needs into account can help mitigate key management paradoxes in higher education.
Design/methodology/approach: The study was conducted among 416 academic teachers from Polish universities. A proprietary questionnaire based on the SCARF model and the UWES scale for measuring work engagement were used. Data were analyzed using descriptive statistics methods, regression analysis, and thematic analysis of open-ended responses. The main research questions concern the relationship between the fulfillment of SCARF needs and the level of academic teachers' engagement, as well as their ability to cope with management paradoxes. Three hypotheses were formulated, the key one stating that satisfying SCARF needs positively influences engagement and facilitates balancing conflicting institutional expectations.
Findings: All five SCARF needs showed a statistically significant relationship with the level of engagement ($p < 0.05$), with the greatest impact observed for the needs of Relatedness and Status. Meeting these needs fosters higher engagement in both teaching and research activities among academic teachers. The qualitative analysis confirmed the quantitative findings, revealing real-life examples of how these mechanisms operate.
Practical implications: The results indicate that considering SCARF needs not only supports the individual motivation of academic teachers but also contributes to creating a more balanced work environment. Employing an approach that addresses the psychological needs of academic staff in management may provide an effective solution to management challenges in higher education, leading to increased organizational effectiveness and job satisfaction among teachers.
Originality/value: The article offers a new perspective in research on higher education management by combining the SCARF model with an analysis of organizational paradoxes. The findings have theoretical significance, highlighting the importance of psychosocial needs in academic work, as well as practical value by providing guidance for university leaders on building a supportive work environment and mitigating organizational tensions.
Keywords: SCARF model, work engagement, higher education, management paradoxes, academic autonomy.
Category of the paper: Research paper.

1. Introduction

Higher education operates in an environment characterized by increasing complexity and dynamism. Universities must simultaneously contend with the pressure to achieve scientific and teaching excellence, limitations resulting from available resources, and the necessity to implement innovations that respond to the needs of contemporary society (Cieciora, 2017; Liang, 2024). At the heart of these challenges lie fundamental management tensions, which affect both the functioning of institutions and the motivation and well-being of academic staff.

Striving to balance various, often conflicting, organizational priorities requires university authorities to make difficult decisions that respect the independence of academic teachers, promote collaboration, and guarantee measurable outcomes. Such an approach necessitates consideration of psychological factors that determine how academics engage with their work. In this context, the SCARF model, grounded in neuroscience, provides a perspective that enables a better understanding of the mechanisms influencing motivation and effectiveness in academic work.

The SCARF model defines five key needs that play a crucial role in professional environments such as higher education. Implementing principles derived from this model in university management can not only improve employee well-being but also impact their engagement, which manifests as energy, emotional involvement, and focus on task completion (Campbell et al., 2022). This approach offers a new perspective on the challenges of university management, enabling the mitigation of key tensions and the creation of more harmonious work environments.

The purpose of the article is to examine the impact of satisfying the five basic psychosocial needs defined in the SCARF model on the level of engagement of academic teachers in both teaching and research work. In addition, the aim is to indicate how taking these needs into account can help mitigate key management paradoxes in higher education. The article offers a new perspective in research on higher education management by combining the SCARF model with an analysis of organizational paradoxes. The findings have theoretical significance, highlighting the importance of psychosocial needs in academic work, as well as practical value by providing guidance for university leaders on building a supportive work environment and mitigating organizational tensions.

This article consists of five sections, an introduction, and a conclusion. The first section explains the theoretical foundations concerning the SCARF model, academic staff engagement, and management paradoxes. The second section presents the research methodology. The third section showcases the results of a survey conducted among academic teachers regarding the impact of satisfying the needs defined in the SCARF model on their engagement in research and teaching. These results indicate that taking these needs into account not only supports individual motivation but also contributes to the creation of a more balanced work environment.

The fourth section contains key findings and discussions. The article concludes with recommendations for university leadership and authorities to adopt a management approach that considers the psychological needs of academic teachers, enabling the creation of a work environment conducive to engagement and effective management of paradoxes present in the academic setting.

2. Theoretical background

2.1. SCARF model in the context of higher education

The SCARF model, developed by David Rock (Rock, 2008). The SCARF acronym stands for the five domains (needs): Status, Certainty, Autonomy, Relatedness, and Fairness (Rock, 2015). This model is a useful tool for analyzing human behavior in organizational contexts. It allows to identify psychosocial needs that determine how individuals function in social and professional relationships (Rock, 2008; Manjaly et al., 2024; Evans, 2025). In the academic environment, where interactions between teachers, students, and administration are especially important, taking these needs into account can significantly improve the working atmosphere, motivation, and effectiveness of academic staff (Rock, 2008).

Below, it was presented the key domains of the SCARF model.

Status, as the first need listed in the SCARF model, refers to the recognition of an individual within a community. In the context of universities and scientific institutions, status is manifested through the acknowledgment of academic achievements, such as scientific publications, grants obtained, awards received, or professional promotions. As Rock (2008) demonstrates, status is one of the key factors determining engagement and effectiveness in the workplace, and its absence can lead to demotivation, decreased identification with the institution, and reduced innovation (Dobele et al., 2014). Research conducted by Jordan et al. (2011) showed that the perception of social status in the workplace has a significant impact on employee engagement and productivity (Deng et al., 2019; Eka, Anik, 2020). Employees with higher perceived status exhibited greater job satisfaction and were more engaged and productive (Liu et al., 2021).

The next need is **certainty**, which in the academic environment comes down to clear communication from university authorities regarding institutional goals, expectations of academic staff, and career paths. As Musselin (2013) notes, non-transparent criteria for evaluating academic achievements, ambiguous requirements for promotion, and changing regulations in the higher education system can increase the sense of uncertainty and limit the long-term engagement of scholars (Kwiek, Antonowicz, 2015). Certainty in the academic environment is crucial for effective talent management, as it enables employees to better plan

their careers and take a strategic approach to scientific and teaching activities (Teichler, Höhle, 2013). Furthermore, research by Kezar (2018) suggests that academic institutions implementing transparent evaluation and promotion policies not only reduce stress levels among staff but also foster the development of an organizational culture based on mutual trust and cooperation. As a result, transparent institutional policies positively influence the quality of scholars' work and their readiness to take on new research and teaching challenges.

Autonomy, or the sense of freedom in decision-making, is particularly important for academic teachers who value independence in choosing research topics, scientific methodologies, and teaching methods (Gagne, Bhave, 2011; Prichard, Moore, 2016). When employees feel they have influence over their work and the ability to make choices and introduce changes in their positions (Hughes, Lewis, 2020), they are more creative (Sia, Appu, 2015), more likely to engage, and increase their effectiveness (Bindl, Parker, 2011). Autonomy supports innovation and the undertaking of scientific risks, which are essential for knowledge development (Orakci, 2025; CSEE-ETUCE, 2024; Woelert et al., 2020; Trevelyan, 2001). At the same time, limiting this freedom, for example through excessive regulation, can lead to frustration, decreased motivation, and reduced scientific potential (Woelert et al., 2020; Trevelyan, 2001; Bate, 2023).

An equally important need is **relatedness,** which in the academic context is manifested in collegial relationships and the sense of belonging to the academic community (Kurek, 2014). Building strong interpersonal ties and promoting interdisciplinary collaboration positively affect academic staff engagement and job satisfaction (McGrath et al., 2017) as well as interactions with the broader community and stakeholders (Orazbayeva et al., 2021). Scientific sources confirm that the sense of isolation, especially among young academics, can lead to burnout and reduced work engagement (Boone et al., 2022; Sabagh et al., 2018; Kelly et al., 2024).

The final element of the SCARF model is **fairness**, which refers to the perceived equity in the distribution of resources, duties, and opportunities. In higher education, where resources such as research funding, time for research, and access to training are often limited, fair allocation is crucial. Academic staff who feel treated unequally may experience frustration, which negatively affects their engagement and motivation (Dobele et al., 2014; Malhotra et al., 2020). In contrast, transparent and fair decision-making procedures strengthen trust in the institution and support better functioning of the entire academic community (Hnat et al., 2015; Rock, 2008; Evans, 2025; Crom-Jonson, 2025; Smith, 2024).

In summary, the SCARF model provides valuable guidance for management in the academic environment, pointing to the fundamental psychosocial needs whose fulfillment can significantly improve the well-being and engagement of academic staff. Each domain of the model plays a key role in shaping the employee experience in the workplace and their level of work engagement. Taking these needs into account in university management strategies can not only alleviate tensions resulting from key management paradoxes but also create a more

harmonious and productive work environment for academic teachers (Rock, 2008; Crom-Jonson, 2025).

2.2. Academic staff work engagement

Work engagement is one of the key factors determining the success of higher education institutions in fulfilling their educational and scientific missions. In the literature, it is defined as a positive, satisfying psychological state characterized by vigor, dedication, and full absorption in one's tasks (Schaufeli et al., 2002; Bakker, Demerouti, 2008; Evitha et al., 2021; Saks, Gruman, 2014). In the academic environment, this engagement plays a particularly important role, as academic staff simultaneously fulfill many functions-from teaching and research to administrative and social roles (Zając, 2012). Employees who are engaged in their work demonstrate higher levels of effectiveness, and their attitude translates into the success of both themselves and the entire institution (Bozeman, Gaughan, 2011; Fernandez, 2020; Khamzina et al., 2024).

One of the significant effects of academic staff engagement is its positive impact on student satisfaction and their learning outcomes (Morales et al., 2016). An engaged academic teacher conducts classes with greater enthusiasm, creating an atmosphere conducive to knowledge acquisition and involving students in active learning (Zhao, You, 2024). The use of active learning methods, such as team projects or simulations, requires additional engagement and resources from both lecturers and students. Research indicates that teachers who display strong engagement are more likely to employ innovative teaching methods tailored to students' individual needs. In this way, they contribute to improving the quality of the educational process, which directly translates into students' academic achievements (Xiong, Yuan, 2024). Engaged teachers also invite students to participate in research or co-author scientific articles, which supports or stimulates their motivation to develop research interests (Mägi, Beerkens, 2016; Kowalczuk-Walędziak, 2017).

Another important aspect is the relationship between engagement and research productivity and innovation (Cadez et al., 2017). Academic staff who are deeply engaged in their work show greater motivation to undertake new research challenges (Alhija, Majdob, 2017) and to seek innovative solutions (Ulla et al., 2017). Engagement fosters striving for high quality in research, which is reflected in the number of publications, obtaining research grants, and participation in interdisciplinary projects (Khan et al., 2018; Batool et al., 2021). Moreover, engaged academics are more open to collaboration and knowledge exchange with other researchers, which supports the development of innovative solutions in science and technology (Farooqi et al., 2019).

Work engagement is also a crucial factor supporting the resilience of academic teachers in the face of institutional challenges. Dynamic changes in higher education, such as legal reforms, financial constraints, or increased social expectations, can generate stress and lead to professional burnout (Schaufeli et al., 2009; Han et al., 2019). However, engaged employees are more likely to perceive these challenges as opportunities for growth rather than threats.

Their positive attitude and strong sense of purpose in their work allow them to cope more effectively with pressure and difficulties, as well as persist in pursuing their goals (Akcoltekin et al., 2017; Kundi et al., 2021).

In summary, work engagement in the academic environment is a fundamental element supporting the effectiveness of academic staff in teaching and research, as well as their ability to survive and adapt in changing institutional conditions (Hilliger et al., 2020). A high level of engagement benefits both individuals and entire institutions, contributing to the creation of an environment conducive to academic excellence and knowledge development (Caingcoy, 2020). In the context of this article, academic staff engagement is linked to the SCARF model, which illustrates how satisfying basic needs can strengthen this key attitude.

2.3. Theoretical approach to management paradoxes in higher education

Higher education, as a form of organization, presents numerous challenges for management scholars and practitioners, stemming from its specific character (Szromek, Wolniak, 2020; Maquidato, Bayani, 2024). The work of academic staff, which combines both teaching and research, requires consideration of the unique dynamics of relationships and organizational goals, making traditional management theories often insufficient in this context (Houston et al., 2006; Hu et al., 2016). One of the most significant management issues, widely discussed in the literature, is the presence of key paradoxes that define the contemporary university environment (Lewis, 2000; Leja, 2011; Smith, Lewis, 2011; Miron-Spektor et al., 2017; Lee, 2018; Doyle, Brady, 2018; Kallio et al., 2021).

This article adopts the terminology proposed by J.D. Ford and R.W. Backoff (1988, p. 89), which serves to analyze key paradoxes in university management. The authors define a paradox as "an object constructed by individuals when opposing tendencies are brought together as a result of reflection or interaction" (Mesjasz, 2016, p. 407).

Below, the key paradoxes in the work of academic staff that should be considered in university management are presented in a synthetic manner.

The first paradox concerns the tension between autonomy and accountability (Drennan et al., 2020). Due to the nature of their work, academics place great value on intellectual freedom and the ability to make independent decisions regarding research, as well as the choice and design of teaching methods and materials. However, in recent decades, there has been increasing pressure to deliver measurable outcomes, assessed by various performance indicators such as the number of publications, grants obtained, or student evaluations. Academics often have to adapt to funding priorities for their research topics, university policies, or societal expectations. Moreover, in teaching, they must also meet specific program objectives, accreditation standards, and administrative requirements. The literature emphasizes that while such an approach is necessary from a management perspective, it can reduce the motivation and creativity of academic staff if not properly balanced (Stroebe, 2020; Kayas, 2020; Schwab et al., 2023).

A second key tension is the difficulty in reconciling teaching requirements with expectations regarding research productivity. Universities, as both educational and research institutions, face the challenge of ensuring high-quality teaching while also contributing to knowledge development through research. Academic staff are thus forced to divide their time and resources between these two areas, often leading to conflicts of interest. In many academic institutions, promotions and employee evaluations are strongly dependent on research achievements, such as the number of publications or grants secured. This can marginalize the role of teaching and reduce engagement in the educational process. Furthermore, research is time-consuming and requires continuous commitment. Simultaneously conducting classes, preparing materials, and grading can result in work overload and a decline in the quality of both research and teaching. The literature highlights that prioritizing one of these functions without supporting the other can negatively affect the development of both individual employees and the institution as a whole (Leisyte et al., 2009; Spook, Raghoebar, 2022). A lack of adequate administrative or financial support may exacerbate the difficulty of balancing these two roles (Kahn, 2017).

Paradoxes in university management are particularly evident in the tension between striving for individual excellence and the necessity of teamwork (Macfarlane, 2017; Ofori, 2024). On the one hand, the academic system rewards individual achievements, such as publications in prestigious journals, individual research grants, or scientific awards, which enhance a scholar's position in the global knowledge network (Kezar, 2018). On the other hand, the growing complexity of research problems and the interdisciplinarity of modern science require effective collaboration in research and teaching teams (Finkelstein et al., 2016; Vangrieken et al., 2017). As Kezar (2018) points out, excessive emphasis on individual excellence can lead to competition rather than synergy, weakening the organizational culture of the university and reducing its capacity for innovation and adaptation. Conversely, a team-based approach, while promoting knowledge exchange and joint project development, can create difficulties in assessing individual contributions and blur responsibility for outcomes (Finkelstein et al., 2016). Balancing these two perspectives is one of the key challenges in contemporary higher education management.

Another important issue discussed in the literature is the relationship between stability and change in the university environment. Higher education institutions, with their deeply rooted intellectual traditions, often face the challenge of preserving their identity and values while responding to a dynamically changing environment (Denek, 2013; Karo, Drechsler, 2024). The literature emphasizes that effective university management requires simultaneously respecting traditional foundations and being open to adaptation to social, technological, and economic changes (Maassen, 2017; Hayter, Cahoy, 2018; Doyle, Brady, 2018; Klofsten et al., 2019). A lack of proper balance between these two aspects can result in both a loss of identity and difficulties in adapting to contemporary challenges.

Research on higher education management suggests that these paradoxes are not problems that can be fully resolved. Rather, they are a permanent feature of academic institutions, requiring appropriate management and balancing of conflicting interests. The literature review indicates the need for an integrated approach that considers both organizational aspects and the individual needs of academic staff (Bohunovsky et al., 2023). In this context, the SCARF model, based on neuroscience research, may serve as a valuable tool for managing these tensions, which will be discussed later in the article.

3. Methods

3.1. Purpose and assumptions of the study

The aim of this study is to analyze the impact of fulfilling the needs described in the SCARF model on the engagement of academic teachers in both teaching and research. In particular, the research focuses on identifying the relationship between the fulfillment of individual SCARF needs and the level of engagement in various aspects of academic activity.

The researchers aim to answer the following research questions:

1. Main question: How does the fulfillment of the basic psychosocial needs defined in the SCARF model affect the level of academic teachers' engagement in teaching and research?
2. Supporting questions:
   1) Which of the five SCARF needs have the strongest impact on academic teachers' engagement?
   2) How can fulfilling SCARF needs support academic teachers in coping with management paradoxes in higher education, such as autonomy vs. accountability, teaching vs. research, and individual excellence vs. collaboration?

Based on the available literature and the SCARF model, the following research hypotheses were formulated:

1. Main hypothesis (HM): The fulfillment of the basic psychosocial needs defined in the SCARF model significantly affects the level of academic teachers' engagement in teaching and research.
2. Supporting hypotheses:

   HS1: Individual SCARF needs differ in the strength of their impact on academic teachers' engagement, with relatedness and status being the most significant.

   HS2: Fulfilling SCARF needs facilitates academic teachers in coping with management paradoxes in higher education, such as autonomy vs. accountability, teaching vs. research, and individual excellence vs. collaboration.

The SCARF model provides a theoretical framework for analyzing human behavior in social and organizational environments. Moreover, the SCARF domains are measurable and can be empirically tested, which ensures methodological strength when designing teacher engagement instruments (Rock, 2008; Rock, Cox, 2012). In contrast to traditional psychosocial models, such as Maslow's hierarchy of needs or Herzberg's two-factor theory, the SCARF model is grounded in cognitive neuroscience, offering direct insight into social threats and rewards that shape behavior in complex institutional systems, such as higher education institutions. In higher education, where social interactions, professional autonomy, and hierarchical structures play a key role, the needs described in this model become particularly significant. Status, certainty, autonomy, relatedness, and fairness are fundamental factors influencing the motivation of academic teachers, their ability to cope with stress, and their work engagement (Li, Foung, 2019; Javadizadeh et al., 2022; Newman, Purnell, 2023; Gkintoni et al., 2023).

The analysis of studies shows that engagement in academic work contributes to greater student satisfaction, higher research innovation, and staff resilience in the face of institutional challenges (Hajdarpasic et al., 2015; Perkmann et al., 2020). At the same time, many studies point to the presence of paradoxes in university management, such as the tension between autonomy and accountability (Kallio et al., 2021), or the conflict between individual achievement and the need for teamwork (Koeslag-Kreunen et al., 2018). In this context, examining the relationship between the fulfillment of SCARF needs and work engagement is of both practical and theoretical importance.

A survey-based study conducted among academic teachers allows for an understanding of how the fulfillment of psychosocial needs affects key aspects of their work. The results may provide practical guidance for university authorities, enabling them to create a work environment conducive to engagement and effective management of the paradoxes present in the academic setting.

3.2. Research instrument and data collection procedure

The survey was chosen as the main research instrument due to its ability to efficiently collect data from a diverse group of respondents. This choice enabled the researchers to reach a wide range of academic teachers representing various higher education institutions, scientific disciplines, and professional roles, resulting in highly representative findings. The structure of the survey was designed to allow both quantitative and qualitative analysis of academic teachers' perceptions regarding their work engagement and the fulfillment of needs defined in the SCARF model.

The questionnaire was divided into three sections:

1. **Section A** concerned the measurement of need fulfillment according to the SCARF model. This section included 19 questions developed by the study authors based on a review of the literature on the SCARF model. The questions addressed the five key

psychosocial needs. The questions were closed-ended and rated on a 7-point Likert scale, where 1 meant "strongly disagree" and 7 "strongly agree". This scale enabled a quantitative assessment of the degree to which each need was fulfilled.

2. **Section B** focused on measuring work engagement. This section used the Utrecht Work Engagement Scale (UWES©), developed by W. Schaufeli and A. Bakker. The use of this tool was justified by its widespread use in research on work engagement and its confirmed reliability and validity (Schaufeli et al., 2006). The questionnaire consisted of 17 questions assessing engagement across three dimensions: vigor (energy and psychological resilience at work), dedication (identification with work, sense of purpose, and inspiration), and absorption (deep focus and complete immersion in duties) (Schaufeli, 2013; Kulikowski, 2017). As in Section A, responses were rated on a 7-point Likert scale, allowing for quantitative analysis of academic teachers' engagement levels.
3. **Section C** concerned demographic and professional data. This section gathered basic demographic information such as gender, age, academic degree, type of institution, and details regarding professional experience.

Combining SCARF-related questions with the UWES instrument allowed for a comprehensive examination of the relationship between psychosocial need fulfillment and the level of academic teachers' engagement in teaching and research activities.

The questionnaire included both closed and open-ended questions. Closed questions provided measurable indicators for statistical analysis, while open-ended questions enabled a deeper understanding of the mechanisms and reasons behind the fulfillment or lack thereof of individual SCARF needs and their impact on engagement.

The development and validation process for Section A of the questionnaire (19 SCARF-related questions) involved several stages:

1. Literature review. The question development began with an analysis of the scientific literature on the SCARF model, which enabled the identification of key constructs and variables to be included in the questionnaire.
2. Focus group study. A meeting was held with a group of academic teachers representing the study's target population. Participants assessed the clarity, relevance, and comprehensiveness of the questions, and their feedback was used to refine the questionnaire content.
3. Expert review. Several experts in psychology and research methodology evaluated the questionnaire for content accuracy, clarity of wording, and alignment with the SCARF model. Their comments were used to further refine the questions.
4. Pilot study and reliability testing. The revised questionnaire was tested on a pilot sample representative of the target population. The Cronbach's alpha coefficient calculated for Section A was 0.936, indicating high internal consistency and reliability of the instrument.

5. Data collection was conducted online (using the Computer Assisted Web Interview, CAWI, technique) via a secure platform, ensuring broad participation and representativeness of respondents. The survey was anonymous and confidential, which encouraged honest responses. The study was approved by the University Research Ethics Committee (KEBN/71/0044/D29/2023), confirming compliance with ethical standards.
6. The carefully developed and validated research instrument enabled a comprehensive examination of the relationship between SCARF need fulfillment and academic teachers' engagement. The mixed approach, combining closed and open-ended questions, provided both measurable statistical data and in-depth qualitative insights, allowing for a thorough analysis of the results.

3.3. Selection and characteristics of the research sample

The research sample consisted of 416 academic teachers employed at Polish higher education institutions, representing a variety of scientific disciplines, professional positions, and stages of academic careers. The vast majority of respondents were employed at public universities (94.2%), while a minority came from non-public institutions (5.8%). In terms of professional roles, research and teaching staff dominated (81.5%), reflecting the nature of most higher education institutions in Poland. A smaller group consisted of staff employed exclusively in teaching positions (17.8%), and an even smaller percentage held research-only positions (0.7%).

The sample was diverse in terms of demographic and professional characteristics, which increases the reliability and representativeness of the obtained results.

Below is the demographic structure of the sample according to various criteria:

1. Gender – women constituted 50.5% of the group, men 47.1%, and 2.4% of respondents did not disclose their gender.
2. Age – the most numerous age group was employees aged 41-50 (35.3%), followed by those aged 51-60 (28.4%). The smallest group was respondents under 29 years old (4.3%).
3. Work experience – the largest portion of respondents had 21-30 years of professional teaching experience (36.3%), while those with less than 5 years of experience constituted the smallest share (10.8%).
4. Professional structure of the sample: (1) position type – the largest group in the sample were assistant professors (48.3%), followed by associate professors (26.4%) and assistants (16.8%). Professors and lecturers were represented in smaller percentages (5.5% and 2.4%, respectively); (2) managerial roles – most respondents (84.9%) did not hold managerial positions, while 15.1% (63 individuals) held managerial roles in their institutions; (3) scientific disciplines – the sample was dominated by representatives of social sciences (78.1%), while the humanities, engineering, natural sciences, and exact sciences were represented to a lesser extent (a total of 11.9%).

The sampling was purposive, meaning that respondents were selected based on specific criteria related to the aim of the study. The survey was addressed to academic teachers via the rectors of higher education institutions in Poland. Official letters were sent to the rectors, requesting that they forward the survey to their staff. This made it possible to reach a wide group of teachers from various institutions, increasing the diversity and representativeness of the sample. The study was conducted between November 2023 and February 2024.

Although the study included a broad group of academic teachers, certain limitations may have influenced the final results:

a) due to purposive sampling, the sample is not fully random, which limits the possibility of generalizing the results to the entire population of academic teachers in Poland;
b) the high percentage of respondents from public institutions (94.2%) may have resulted in a less representative analysis of the perspectives of teachers from non-public institutions;
c) for younger respondents and teachers with shorter professional experience (e.g., less than 5 years), their low participation in the sample may limit the ability to fully understand their experiences and perspectives.

The analyzed research sample constituted a diverse and representative group of academic teachers, allowing for a comprehensive examination of the impact of SCARF need fulfillment on their work engagement. Although certain limitations related to sampling may affect the generalizability of the results, the purposive recruitment method and the demographic and professional diversity of respondents increase the reliability and practical value of the conducted analyses.

3.4. Methods of quantitative and qualitative data analysis

The selection of techniques and tools for data analysis was tailored to the nature of the research questions and the type of data collected, both quantitative and qualitative. The aim of the data analysis was to identify the relationships between the fulfillment of SCARF needs and academic teachers' work engagement, as well as to uncover patterns in the perception of management paradoxes in the academic environment.

Quantitative analysis was conducted on data obtained from the closed-ended questions in the survey. Preliminary data analysis was carried out using Microsoft Excel, which was used to organize the data, verify its accuracy, and perform basic statistical calculations such as means, standard deviations, and frequencies.

For more in-depth statistical analysis, the Statistica software package, version 13.3, was used. This analysis included regression analysis, which made it possible to determine which SCARF model variables have the greatest impact on academic teachers' engagement in teaching and research. The results of the regression analysis provided information on the relative importance of each SCARF need in predicting the level of engagement.

The use of this method made it possible to determine the relationship between the fulfillment of basic psychosocial needs and work engagement, while also providing statistical evidence supporting the formulated hypotheses.

In parallel, qualitative analysis was conducted on data obtained from the open-ended survey questions. Qualitative responses were subjected to thematic analysis, aimed at identifying recurring patterns and areas in the perception of management paradoxes by academic teachers.

The thematic analysis process included the following steps:

- data coding – all responses were coded to identify key themes and categories. Each response was analyzed for content related to the perception of the impact of SCARF need fulfillment,
- pattern identification – based on the coded data, dominant patterns were identified, such as the impact of autonomy on creativity in research work or the importance of fairness in building relationships in the academic environment,
- interpretation of results – conclusions were drawn regarding the mechanisms influencing the perception of management paradoxes and the ways in which the fulfillment of SCARF needs supports work engagement.

Qualitative analysis enabled an in-depth understanding of the reasons underlying the observed quantitative relationships. Open-ended responses provided detailed insights into how academic teachers perceive their work environment and how the fulfillment of their psychosocial needs may influence the resolution of key management paradoxes.

4. Results

4.1. Descriptive statistics of the studied variables

The analysis of the results was preceded by an assessment of descriptive statistics for six key variables related to the professional experiences of academic teachers: status, certainty, autonomy, relatedness, organizational fairness, and level of engagement. The aim of this stage was to determine the central tendencies, distribution of responses, and the degree of variability of each variable in the studied sample. Detailed numerical data are presented in Table 1. All variables were measured on a seven-point scale (0-6 or 1-7), and the sample size in each case was N = 416.

Table 1.
Descriptive statistics of the variables N = 416

Variable	M	Confidence -95.000%	Confidence 95.000%	Me	Min	Max	Q1	Q3	SD
Status	3.85	3.701972	4.004759	4	1	7	3	5	1.57
Certainty	4.41	4.275032	4.547084	5	1	7	3	5	1.41
Autonomy	5.30	5.177551	5.418603	5	1	7	5	6	1.25
Relatedness	5.23	5.115541	5.336382	5	1	7	5	6	1.15
Fairness	4.28	4.127948	4.424937	4	1	7	3	5	1.54
Engagement	4.02	3.918002	4.120460	4	0	6	3	5	1.05

Legend: M – mean, Me – median, Q1 – lower quartile, Q3 – upper quartile, SD – standard deviation.

Source: Own elaboration based on empirical research results.

The mean level of **Status** was assessed at M = 3.85 (SD = 1.57), with a median of 4 and quartile values Q1 = 3 and Q3 = 5. This indicates a moderate sense of status among the respondents, with a wide range of responses (min = 1, max = 7) and relatively high variability (SD = 1.57).

The variable **Certainty** obtained a mean value of M = 4.41 (SD = 1.41), with a median of 5. This means that respondents rate their sense of certainty in the professional environment as moderately high, although significant variability in responses was also observed here (range from 1 to 7).

Autonomy achieved the highest mean value among the analyzed variables (M = 5.30, SD = 1.25), suggesting that academic teachers largely perceive their work as autonomous. The median of 5 and the distribution of responses concentrated between Q1 = 5 and Q3 = 6 indicate a relatively consistent perception of this feature within the sample.

A similar mean level was recorded for the variable **Relatedness** (M = 5.23, SD = 1.15), which indicates a high evaluation of the quality of interpersonal relationships in the academic work environment. The low standard deviation suggests relatively little variation in assessments in this area.

For the variable **Fairness,** the mean was M = 4.28 (SD = 1.54), which may indicate a moderate sense of organizational fairness among respondents. The spread of responses, as in the case of status and certainty, was considerable.

The variable **Engagement** obtained a mean of M = 4.02 (SD = 1.05) and a median of 4. Although the minimum value was 0 and the maximum was 6, the distribution of responses is concentrated between Q1 = 3 and Q3 = 5, indicating a moderate level of engagement among the academic teachers surveyed, with relatively lower variability than in the case of status or fairness.

The values of the 95% confidence intervals indicate high precision of the mean estimates for each variable. These results serve as a starting point for further analyses of the relationships between the individual variables comprising the SCARF model and the level of academic teachers' engagement in teaching and research work.

4.2. The impact of SCARF needs on work engagement

The study showed that the fulfillment of needs described in the SCARF model has a significant impact on the level of academic teachers' engagement in teaching and research work. The results of the linear regression analysis, presented in Table 2, confirm that all five SCARF variables are statistically significantly related to the level of work engagement ($p < 0.05$).

Table 2.
Relationships between SCARF model needs and work engagement (simple linear regression model)

N = 416, p < 0, 000001

Variable	parameter (β)	R^2
Status	0.362438	0.13136097
Certainty	0.296982	0.08819818
Autonomy	0.263455	0.06940838
Relatedness	0.398851	0.15908186
Fairness	0.313851	0.09850214

Legend: p – statistical significance, β – simple regression coefficient.
R^2 – coefficient of determination.

Source: Own elaboration based on empirical research results.

The strongest predictor of work engagement was **Relatedness** ($\beta = 0.398851$, $R^2 = 0.1591$), indicating that a sense of belonging and support in the academic environment plays a fundamental role in motivating teachers. Strong relationships, both collegial and mentoring, foster the development of a supportive work environment, especially for younger academic and teaching staff at the beginning of their careers. Respondents indicated that collaboration within research teams and a sense of support from supervisors significantly affect their morale and willingness to take on new challenges. These results are consistent with previous studies highlighting the importance of interpersonal relationships in academic work (Van den Broeck et al., 2008; Owens et al., 2016; McGrath et al., 2017).

Status, defined as recognition for achievements, was the second strongest predictor of work engagement ($\beta = 0.362438$, $R^2 = 0.1314$). Respondents who felt that their contribution to the development of the institution was appreciated (e.g., through promotions, awards, or positive feedback) demonstrated higher motivation to engage in both teaching and research activities. In line with the findings of Deci and Ryan (2009), recognition and a sense of value in the workplace are integral to supporting motivation and engagement, emphasizing the importance of status as a psychological need (Deng et al., 2019). Conversely, a lack of recognition was identified as a factor lowering motivation and leading to professional frustration.

Certainty ($\beta = 0.296982$, $R^2 = 0.0882$) was the third significant factor influencing engagement. Higher education employees who had clarity regarding institutional goals, promotion rules, and role requirements reported a greater ability to focus on their tasks (Pan et al., 2015). The results indicate that a lack of communication from university administration can increase uncertainty and destabilize the motivation of research and teaching

staff. Other studies confirm that certainty reduces stress and anxiety, facilitating focus on productive tasks (Hirsh et al., 2012). By reducing ambiguity and supporting a predictable work environment, organizations can increase employee engagement (Hwang, Lee, 2015).

Autonomy ($\beta = 0.263455$, $R^2 = 0.0694$) was identified as a critical need, particularly in the context of research activity. Respondents emphasized the importance of academic freedom in choosing research topics, teaching methods, research team composition, and ways of carrying out their tasks. Autonomy enables the development of creativity, innovation, and risk-taking, which are especially important in academic work (Woelert et al., 2020). Limiting autonomy, for example through excessive administrative regulations, was identified as a significant barrier to engagement and effectiveness. Greater autonomy promotes a sense of personal engagement and responsibility for one's work, leading to intrinsic motivation (Tang et al., 2020; Itzchakov et al., 2022), satisfaction (Worth, Van den Brande, 2020), and encourages employees to take initiative (Lartey, 2021).

Fairness ($\beta = 0.313851$, $R^2 = 0.0985$) was also a significant predictor of engagement. Respondents who perceived the allocation of resources, workload distribution, and decision-making processes as fair reported higher morale and greater engagement in their professional duties. Conversely, a sense of unfairness in university management led to reduced job satisfaction and lower willingness to collaborate with others. According to the justice theory by Colquitt and other researchers (2001), the perception of fairness and equity is closely linked to employee attitudes and behaviors, including engagement (Blakely et al., 2005; Nojani et al., 2012).

The linear regression analysis confirmed that all SCARF needs have a significant impact on the level of work engagement, although their strength of influence varies. The variables **Relatedness** and **Status** had the greatest impact, playing a key role in creating a supportive work environment. The study's results suggest that fulfilling these needs is essential for building academic teachers' engagement, which in turn translates into better teaching and research outcomes and greater resilience to institutional challenges. These conclusions may serve university authorities as a basis for developing management strategies that promote the fulfillment of key psychosocial needs and support the development of an engaging organizational culture.

5. Conclusions

5.1. Key findings from the study

This study demonstrates that the fulfillment of basic psychosocial needs, in accordance with the SCARF model, can significantly enhance the motivation and professional activity of

academic staff (Daumiller et al., 2020). Meeting these needs requires a holistic approach aimed at cultivating an environment in which teachers feel valued, secure, empowered, integrated, and treated fairly. Such efforts are not only crucial for the well-being and satisfaction of academic teachers (Hesli, Lee, 2013; Szromek, Wolniak, 2020), but are also essential for fostering an academic environment conducive to innovation, collaboration, and excellence (Mgaiwa, 2023).

Main Hypothesis (HM): The fulfillment of the basic psychosocial needs defined in the SCARF model significantly influences the level of academic teachers' engagement in teaching and research work. Linear regression analysis confirmed that all SCARF needs have a significant impact on the level of engagement in teaching and research (see Table 1). The main hypothesis (MH) was positively confirmed.

Supporting Hypothesis (HS1): Individual SCARF needs differ in the strength of their impact on academic teachers' engagement, with relatedness and status being the most significant.

The study showed that the strength of the impact of individual SCARF needs on academic teachers' engagement varies (see Table 2). In particular, Relatedness and Recognition (Status) proved to be key for maintaining a high level of engagement in research and teaching duties. These results were further reinforced by qualitative analysis, which provided concrete examples confirming the importance of fulfilling these needs. Thus, supporting hypothesis HS1 was fully confirmed.

5.2. Management paradoxes from the perspective of academic teachers

Managing higher education institutions involves the necessity of balancing conflicting priorities and expectations, which often leads to the emergence of key paradoxes. Survey responses indicated that the principles of the SCARF model can play a significant role in resolving these tensions, enabling a more harmonious functioning of the academic environment. Three key paradoxes were identified as particularly important: autonomy vs. accountability, teaching vs. research, and individual excellence vs. collaboration.

The **Autonomy** and **Accountability Paradox** reflects the tension between the need for academic freedom and the necessity to hold teachers accountable for their performance. On one hand, academic teachers value the freedom to choose research topics, teaching methods, or ways of carrying out their tasks (Vangrieken et al., 2017; Woelert et al., 2020). On the other hand, institutions require them to adhere to performance indicators and institutional goals (Miri, 2014).

Survey responses indicate that autonomy and accountability can be effectively harmonized through the application of the **Autonomy** principle in the SCARF model. Allowing lecturers to set their own goals within the general guidelines of the institution increases both their sense of freedom and their willingness to take responsibility for their work outcomes. Such a balance fosters creativity and innovation, while also supporting the long-term goals of the university.

The Teaching vs. **Research Paradox** reflects the difficulty of reconciling the demands of teaching and research activities (Borg et al., 2014; Macfarlane, 2017). Modern universities expect excellence in both areas, yet limited time and financial resources often mean that one is achieved at the expense of the other (Smithers et al., 2022).

Applying the principles of the SCARF model, particularly **Status** and **Fairness**, helps to reduce this tension. Respondents emphasized that recognition of achievements in both teaching and research (e.g., through awards, promotions, or additional funding) motivates teachers to engage equally in both areas. The perception of fairness in the allocation of resources, such as time and budget, further strengthens the willingness to meet demands in both fields, creating a more balanced academic culture (Malhotra et al., 2020).

The Individual Excellence vs. **Collaboration Paradox** involves the need to balance the promotion of individual achievements (e.g., academic degrees, promotion-related works-monographs, individual grants, participation in international academic exchanges, roles as experts or reviewers, conference participation, editorial board membership) with building the collective success of research and teaching teams (e.g., joint research, projects, publications, organizing conferences or workshops, cooperation with business) (Macfarlane, 2017; Ofori, 2024).

According to the survey results, the principle of **Relatedness** plays a key role in resolving this paradox. Respondents indicated that building a sense of belonging through interdisciplinary research teams and opportunities for collaboration with other academic teachers fosters collective success while also enabling individual development. Creating support mechanisms, such as mentoring, also helps reduce the sense of competition and builds a more harmonious atmosphere in the academic environment.

Supporting Hypothesis (HS2): Fulfilling SCARF needs facilitates academic teachers in coping with management paradoxes in higher education, such as: autonomy vs. accountability, teaching vs. research, individual excellence vs. collaboration.

Paradoxes such as autonomy vs. accountability or teaching vs. research were present in respondents' answers, but the results show that they can be effectively managed by addressing SCARF needs. This model also prove useful in building a supportive work environment, which is crucial for balancing expectations in both teaching and research. Thus, supporting hypothesis (HS2) was positively verified.

Management paradoxes in higher education are an inherent element of university functioning, but the study results show that applying the principles of the SCARF model can significantly alleviate tensions arising from these contradictions. Autonomy, Status, Relatedness, and Fairness are key elements supporting the harmonization of seemingly conflicting goals, such as academic freedom and accountability, teaching and research excellence, as well as individual achievements and collaboration. Implementing these principles in university management practice can not only increase academic teachers'

engagement but also contribute to building a more supportive and effective organizational culture.

5.3. Satisfaction of SCARF needs and engagement – a qualitative perspective

In order to understand how the satisfaction of SCARF needs influences academic teachers' engagement in their research and teaching work, as well as how it alleviates tensions resulting from university management paradoxes, open-ended responses from the survey were analyzed. These responses made it possible to identify specific examples illustrating both positive and negative experiences of research and teaching staff related to the fulfillment or lack of fulfillment of their SCARF needs (see Table 3).

Table 3.
Selected examples illustrating research and teaching staff experiences in meeting SCARF needs

Needs	Description of academic staff experiences
1. Status	Academic teachers indicated that their engagement in teaching and research work increases when their achievements are recognized and appreciated. An example statement is: *Publishing in prestigious journals, participating in conferences, and receiving scientific awards contribute to the professional prestige of an academic teacher.* A high sense of status contributed to motivation to continue research and teaching work at a high level. However, many respondents pointed out that the lack of transparent promotion mechanisms and differences in salaries for the same positions caused frustration and lowered their morale.
2. Certainty	Respondents emphasized the importance of stable and clear work rules, especially in the context of career advancement. One academic teacher noted: *Unclear promotion criteria and changing regulations regarding employee evaluation cause uncertainty and discouragement.* The unmet need for certainty increased feelings of stress, which negatively affected the ability to focus on research and teaching work. On the other hand, stable working conditions, such as permanent contracts, were indicated as a factor that alleviates stress and enables greater engagement in duties.
3. Autonomy	Freedom in choosing research topics and ways of conducting classes was often highlighted as a key factor influencing the engagement of university staff. An example statement is: *The greater the autonomy in the workplace, the better the results, both individual and team.* A teacher performs their teaching and research duties best when they are not constantly monitored. A lack of autonomy, such as being assigned courses outside one's area of expertise or being forced to collaborate on unwanted projects, was a source of frustration and reduced engagement.
4. Relatedness	Constructive relationships with colleagues and students played a significant role in building a supportive work environment. It was noted in the responses that: *Collaboration, knowledge and experience sharing, and collegial support are essential for the professional and personal development of a teacher.* Strong relationships within research teams fostered the implementation of interdisciplinary projects and increased motivation for collaborative work. Conversely, distant relationships with supervisors, lack of institutional support, and growing competition within departments led to feelings of isolation and professional burnout.
5. Fairness	The perception of fairness in the allocation of resources and distribution of duties was crucial for the morale of the teachers surveyed. Among the numerous responses, one stood out: *The lack of transparency in assigning classes and roles within the department makes long-term engaged staff feel unappreciated, while new employees receive positions thanks to connections.* Satisfying the need for fairness-for example, through transparent rules for assigning duties and mechanisms for recognizing achievements-had a significant impact on the level of engagement among those employed in higher education.

Source: Own elaboration based on empirical research results.

Qualitative analysis showed that the fulfillment of SCARF needs has a significant impact on academic teachers' engagement in their research and teaching work. Examples of respondents' positive experiences indicated that recognition of achievements, clear work rules, autonomy, constructive relationships, and fairness in resource allocation foster increased motivation and professional effectiveness. Conversely, the lack of fulfillment of these needs led to decreased morale, increased stress, and a sense of unfairness, which can contribute to professional burnout and a decline in work quality in higher education.

6. Summary

6.1. Guidelines for higher education management staff

To effectively support academic staff engagement, leaders managing higher education institutions should focus on actions addressing the key needs outlined in the SCARF model. First and foremost, it is essential to develop transparent rules regarding promotion, task allocation, and employee evaluation, which will help reduce stress and increase the sense of stability at work. As examples have shown, unclear promotion criteria and fluctuating regulations are a frequent source of frustration and decreased engagement. Another important element is supporting autonomy by limiting micromanagement and ensuring academic freedom, which enables teachers to decide on research directions and methods of conducting classes (Woelert et al., 2020). Respondents emphasized that autonomy is a key factor supporting creativity and effectiveness (Tang et al., 2020).

The importance of relationships in the workplace should not be overlooked (Rock, Cox, 2012). Supporting collaboration through mentoring programs, interdisciplinary projects, and informal integration initiatives plays a significant role in building a supportive work environment. Strong relationships motivate and at the same time help to alleviate tensions arising from conflicts of interest between individual and team goals (McGrath et al., 2017). The status of academic teachers also requires special attention. It can be enhanced by recognizing both teaching and research achievements, through formal awards, grants, or promotions, as well as informal gestures of recognition, such as praise from supervisors, and administrative support in both spheres of academic activity.

In the context of ensuring certainty about future events and expectations, it is crucial to develop clear and easily accessible communication channels through which academic teachers can receive up-to-date information about changes in policies, administrative procedures, and institutional development. Such actions, ensuring transparency in decision-making processes, can significantly reduce the level of uncertainty (Pan et al., 2015). Certainty can be enhanced by open and transparent management practices, predictable and fair policies and

procedures, following through with promises and agreements, breaking down complex projects into smaller parts, and clear communication (Schmidt et al., 2014; Kezar, 2018). Open communication of goals, decisions, and strategic rationales helps build trust and better manage tensions.

Last but not least is ensuring fairness, especially in the distribution of resources, assignment of teaching duties, and allocation of administrative workloads. Respondents repeatedly pointed out that perceived unfairness is demotivating and leads to workplace conflict (Schmidt et al., 2014; Malhotra et al., 2020). Focusing on these elements will allow leaders to create an environment that supports the engagement and satisfaction of academic staff, thereby contributing to improved quality in both teaching and research (Smith, 2024). In this context, it is important to implement strategies oriented not only towards the university's success but also towards the broader common good and social justice.

The research results suggest that actions aimed at improving status, enabling greater autonomy, supporting positive social relationships, and ensuring fairness can collectively contribute to greater engagement among academic staff. This study has both practical and policy implications for university management. From a management perspective, these findings mean that higher education leaders need innovative, distinctive, and adaptive strategies, as well as desirable work environments that ensure teachers at all academic levels are satisfied with their work.

In addition to the actions previously indicated, in order to strengthen the engagement of academic staff, meet their needs, and mitigate the negative effects of existing paradoxes, leaders in higher education should attempt to implement the following exemplary solutions:

1. Integrated performance assessment models, utilizing, among others, Data Envelopment Analysis (DEA) to measure the relative efficiency of academic units based on multiple indicators (e.g., financial inputs, research outputs), benchmarking through inter-university comparisons to identify best practices and areas for improvement, or cyclical (e.g., five-year) evaluation plans with clearly defined KPIs, including regular data collection and reporting (Wildani et al., 2023; Abdullah, Ramlan, 2023; Luangpaiboon et al., 2024; Almeida et al., 2024);
2. Participatory management tools, such as organizing regular meetings (discussion forums, panels, feedback collection) with various stakeholder groups, establishing councils and committees with representatives from different stakeholder groups (joint decision-making on strategy, curricula, university policies), decentralized decision-making, participatory budgeting (deciding on the allocation of part of the financial resources to selected projects or initiatives), organizing leadership training in inclusive management, or introducing feedback platforms (e.g., regular surveys, discussion panels) to ensure continuous information flow between the academic community and university authorities (Da Silva et al., 2017; Makki et al., 2023; Vallon, 2024; Roza de França, 2025);

3. Institutional support and continuous improvement, for example by developing transparent evaluation procedures that involve staff in defining assessment criteria (e.g., co-creation workshops for indicators), providing adaptive mechanisms that allow for modifications to systems in response to the changing needs of the university (e.g., annual process reviews), or using quality frameworks (e.g., the Baldrige framework) to link performance assessment with long-term strategic goals (Da Silva et al., 2017; Makki et al., 2023; Vallon, 2024; Roza de França, 2025).

6.2. Proposed framework for balancing paradoxes by meeting needs

Management paradoxes, such as Autonomy vs. Accountability or Teaching vs. Research, are an inherent part of higher education functioning (Leja, 2013). In response to these challenges, there is a growing emphasis on the potential of the SCARF model (Rock, 2008) as a tool to support the mitigation of tensions arising from conflicting expectations placed on academic teachers. One of the key elements conducive to balancing paradoxes is flexibility, which allows academic teachers greater control over their responsibilities. This approach allows for effectively reconciling individual employees' goals with institutional requirements (Noorda, 2013). Equally important is transparency, which consists of establishing clear rules regarding evaluation, promotion, and task allocation. This reduces tensions related to perceptions of unequal treatment, ultimately fostering a more harmonious work environment (Ramirez-Cardona, Calderón-Hernández, 2024). Moreover, it is also important to involve teachers in creating transparent policies, codes of conduct, and procedures at the university, as this can improve their sense of control and acceptance of imposed standards (Day, 2023), as well as regularly discussing and updating them in dialogue with the entire academic community (EUA, 2025).

Managers should support academic self-governance initiatives but also maintain a balance between freedom and responsibility towards the community and the external environment (Noorda, 2013). It is also crucial to organize training sessions on time management, effective teaching, or grant acquisition, which can help academic teachers effectively combine research and teaching responsibilities (Uaciquete, Valcke, 2022).

It is essential for university managers to create a work environment in which both aspects of academic work are valued and supported, recognizing their interconnections and significance for the quality of education and scientific progress (Lewis, Smith, 2024). Furthermore, universities can introduce policies promoting a balance between research and teaching, such as recognizing teaching achievements in promotions or providing flexible work schedules (Khan, 2017). It is also necessary to introduce more flexibility than before in shaping the proportion between teaching and research activities for individual academic staff, as well as supporting academic staff in administrative tasks (e.g., grant applications-submission, accounting). It is also important to maintain transparent and fair reporting and evaluation systems for teaching and research activities (Atanaw et al., 2025), to make these outcomes public,

e.g., through financial statements and reports on the implementation of the university's development strategy (Raza, 2009; Pawłowska, 2021), and to develop and apply monitoring and evaluation mechanisms such as quality management systems, internal and external audits, and benchmarking with other universities.

Another important aspect is inclusiveness, which involves building the academic community through interdisciplinary collaboration, mentoring programs, integration initiatives, and sharing best practices in teaching and research (Li et al., 2023). Shaping an organizational culture based on academic values-conscientiousness, objectivity, independence, openness, and transparency (Pawłowska, 2021) – is also crucial. Such actions not only strengthen team relationships but also help alleviate tensions resulting from diverse individual and team goals.

Implementing the SCARF model into university management practice can bring long-term benefits for both teachers and the institution itself. Increasing academic staff engagement will translate into higher quality research and teaching, which in the long run will strengthen the university's position in the competitive higher education environment. However, achieving these benefits requires commitment from management, openness to change, and a willingness to listen and respond to the needs of academic teachers (Rasmussen, Andreasen, 2020).

A supportive, transparent, and inclusive work environment can become the foundation for building a sustainable future for universities (Alexander, Manolczew, 2020). In this way, higher education institutions will be better prepared to face the challenges of the modern world, while supporting the development of both individuals and entire academic teams (Algazo, Suraiya, 2024).

Paradoxes related to higher education management are unlikely to disappear, but they can be effectively mitigated by meeting the basic needs of academic teachers.

The SCARF model provides a useful framework which, although not an exhaustive theory, helps to better understand and manage interpersonal relationships as well as organizational tensions (Baby et al., 2024). However, attention is drawn to its limitations, especially in the cross-cultural context, where differences in the meaning of particular domains, such as autonomy or status, may affect the effectiveness of applied strategies (Carson, 2014). SCARF, as a model originating from an individualistic, Western paradigm, does not always correspond to the cultural conditions prevailing in Asian, African, or Eastern European countries, where different values and social hierarchies dominate.

Therefore, SCARF should be treated as a conceptual heuristic that can support management practice, but requires supplementation with theories that better account for the structural, political, and economic complexity of academic institutions. In future research, it is advisable to strive for integration of the SCARF model with organizational theories and to adapt methodologies to the cultural and institutional context. Only such an approach can ensure the validity and effectiveness of strategies applied in diverse higher education systems.

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COMPARATIVE ANALYSIS OF THE INNOVATION STRUCTURE OF EUROPEAN UNION COUNTRIES IN 2017-2024

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Purpose: The aim of this work is to analyze and assess the innovativeness of EU countries and regions in the years 2017-2024, which allows for determining its level and comparing it in various aspects.
Design/methodology/approach: The work uses a number of research methods, including the method of analysis and criticism of literature, statistical methods and the method of analysis and logical construction.
Findings: The article presents the results of a comparative analysis of the level of innovation of the European Union Member States. It indicates the leaders of innovation in the group of countries and regions and presents the growth and decline in the most important dimensions. The analysis shows that the leaders of innovation in the EU are: Denmark, Sweden, Finland and the Netherlands, with the largest increase in the summary innovation indicator recorded in Lithuania, Cyprus and Poland (EIS 2024).
Research limitations/implications: In the future, the analysis could be expanded to include a comparison of the level of overall innovation with the level of eco-innovation in individual countries. Such an approach would allow for a better understanding of how EU countries cope with implementing innovations that support environmental protection and sustainable development.
Practical implications: The presented analysis of the innovativeness of the European Union countries allows not only to identify the strengths and weaknesses of individual countries, but also to indicate possible directions of development, the implementation of which may contribute to increasing their competitiveness and efficiency. The conclusions drawn from the analysis also support better use of the research and development potential in practice, supporting the implementation of innovative solutions in the area of economy and environment.
Social implications: The analysis of innovation in the European Union states indicates areas requiring support and development, which are key to improving the quality of life of citizens. Research enables better use of research and development potential, which translates into economic progress, environmental protection and increased innovation in society.
Originality/value: The article brings new value to the analysis of innovation in EU countries and regions, presenting the level of innovation in EU Member States over the years 2017-2024. Analysis of the level of innovation in individual countries, based on appropriate indicators, allows to identify areas requiring intervention and assess the effectiveness of previous actions

for the development of innovation. Thanks to this, it is possible to indicate specific directions of development and recommendations that can contribute to increasing the competitiveness of individual countries on the international arena.
Keywords: innovations, European Innovation Scoreboard, Regional Innovation Index.
Category of the paper: Research paper.

1. Introduction

Innovations are used in all areas of human activity, from product development, management methods, ways of performing work, etc.

The concept of innovation was introduced to economic sciences by J.A. Schumpeter at the beginning of the last century (Schumpeter, 1912). Joseph Schumpeter defined innovation as a key factor of economic change, emphasizing that innovation, entrepreneurship and market power are central to development. He considered innovation as one of the basic factors driving competitiveness (Porter, 1999). He believed that innovation is "a process of industrial mutation which continually revolutionizes the economic structure from within, continually destroying the old, continually creating the new" (Schumpeter, 1939). J.A. Schumpeter's views on the definition of innovation have changed, but in his works he has always emphasized the unique role of innovation in economic and civilizational development. There are many definitions of innovation **(**Rowe et al., 1974; Drucer, 2014; Kogabayev et al., 2017). The definition still seems to be relevant and comprehensive. „Innovation consists of the generation of a new idea and its implementation into a new product, process or service, leading to the dynamic growth of the national economy and the increase of employment as well as to a creation of pure profit for the innovative business enterprise. Innovation is never a one-time phenomenon, but a long and cumulative process (..)" (Urabe et al., 1988). According to Twiss, „innovation is a process that combines science, technology, economics and management, as it is to achieve novelty and extends from the emergence of idea to its commercialization in the form of production, Exchange, consumption (Twiss, 1989). Tohidi introduces innovation as the creation, development and successful introduction of products, processes or new services (Tohidi, 2011). Kalinowski presents innovation as "the introduction of new things, ideas or methods of conduct into use. Colloquially, innovation is most often identified with technical changes and understood as conducting research and development activities by economic entities, the result of which are inventions, which are then introduced to the market" (Kalinowski, 2010). According to Repetowski "(...) the concept of innovation is understood as a certain complex of processes and phenomena covering not only the creation and implementation of innovation, but also its economic and social effectiveness" (Repetowski, 2008). Innovations do not lend themselves to strict classification; they are often the result of a combination of many different types of innovations (including technological, marketing and organizational), an example of which is the Apple iPod (Śpionek, 2010). Gybenz's concept, innovation in companies is the

application of ideas for companies, regardless of whether they were used in products, processes, services, marketing systems or management.

In a broad sense, innovations are understood as deliberately introduced changes consisting in replacing existing solutions with others, improved ones that bring economic and social benefits (Kaczmarska et al., 2018; Chapman et al., 2001) Innovation is the key to success for an organization. Enterprise innovation can be defined as the ability and motivation of enterprises to search for and commercially exploit all the results of scientific research, new concepts, ideas and inventions leading to an increase in the level of modernity and strengthening the competitive position of enterprises or realization of the technical ambitions of the entrepreneur (Łuczka et al., 2010).

Innovations translate into an increase in revenues, the number of customers, and thus the competitiveness of the enterprise, and their role in the development and coordination of the market is enormous. The measurement of innovation has long been a serious challenge and has been the subject of extensive scientific research. There are various definitions and measures of innovation, and each approach to measurement has its limitations. There are many ideas for measuring innovation. Some authors believe that innovation at every stage should be measured and assessed. Some authors suggest assessing new and improved products (Elenkov, Manev, 2009), others recommend measuring improvements in processes and methods (Akgüni et al., 2009), and still others (Czarnitzki, Kraft, 2004) they talk about the market success of innovation, suggesting measuring innovation as „ratio of innovative product sold in the market to Total sales".

Innovation research is carried out at three levels of the economy: macro, meso and micro (Kałowski, Wysocki, 2015). Macro-level research focuses on innovation at the level of the entire country. It aims to assess the innovation performance of individual countries, emphasizing what conditions are conducive to innovation at the state level (European Commission, 2024; Gierulski et al., 2013). They may concern government policy, R&D spending, education levels, research infrastructure, and general economic conditions. The aim of such studies is to create rankings based on general indicators, such as the summary innovation index, which measures the innovative competitiveness of countries.

Meso-level studies focus on individual regions or sectors of the economy. Their aim is to analyze the level of innovation in individual regions. Analysis at this level includes indicators such as investment in R&D in a given region, the availability of a skilled workforce, or cooperation between universities and enterprises (European Commission, 2023; Kumor-Sulerz, 2021).

Micro-level research focuses on the innovativeness of individual companies. It assesses the ability of companies to implement innovations, their innovation strategies, and internal processes supporting the development of new products, services, or technologies. The aim is to diagnose the state of innovation of the company and to determine the factors that affect its innovativeness. Examples of indicators include research and development expenditures, the number of patents filed, the pace of introducing new products to the market, or the level of

cooperation with other companies and research institutions (Kaczmarska, 2015; Kumor-Sulerz, Michta, 2022; Kumor-Sulerz et al., 2021).

Each of the above levels of research presents the issue of innovation from a different perspective, using different indicators and measurement mechanisms. Contemporary approaches to innovation often combine results from different levels to obtain a more comprehensive picture of the dynamics of innovation in the economy.

The aim of this work is to analyze and assess the innovativeness of EU countries and regions in the years 2017-2024, which allows for determining its level and comparing it in various aspects. The work uses a number of research methods, including the method of analysis and criticism of literature, statistical methods and the method of analysis and logical construction.

Due to the fact that the innovativeness of countries and regions is characterized by high variability and multi-level factors influencing it, its analysis is of great importance. In the analysis of innovativeness, various aspects can be taken into account. The authors presented an analysis of the innovativeness of countries and regions in an original way, selecting the assessment parameters that are important to them.

2. Materials and methods. EIS research methodology

The general innovation studies presented in the literature allow for the assessment of the state of innovation on an international scale, focusing on individual countries and regions. Such studies aim to present the current level of innovation of a given country, enable the comparison of results of different countries and the assessment of the effectiveness of their innovation policy. An example of such a study is the European Innovation Scoreboard (EIS), which in the years 2010-2015 was published under the name Innovation Union Scoreboard (IUS). It allows for the assessment of the innovation of the European Union member states, as well as selected countries outside the EU, such as the USA, Japan, Croatia, Turkey, Iceland, Norway and Switzerland. The main objective of the EIS is to monitor and compare the results of innovation activity in different countries, which allows for the assessment of the effectiveness of the innovation policy of countries and regions in local, regional and global terms.

In this methodology, the innovativeness of countries is assessed based on the Summary Innovation Index (SII). This is an indicator calculated as a weighted arithmetic average of partial indicators that concern various factors conducive to the development of innovation, such as research and development expenditure, the number of patents, the level of education or the availability of capital for innovation. Finally, the SII is compared with the average indicator for the EU, and on its basis, a ranking of the innovativeness of countries is created, which are classified into one of four groups (so-called performance groups). This allows for the assessment of their position in the context of the development of innovation in Europe and the

world. Thanks to such studies, it is possible not only to indicate the leaders in the field of innovation, but also to analyze which countries need to improve their position to achieve better results in this area. The EIS methodology is characterized by high dynamics of changes in terms of the indicators used. For the analysis in the first edition of the EIS in 2000, 16 indicators were adopted, in 2004 the number of indicators was increased to 22, in 2007 to 26, and in the last edition from 2024 to 32 (European Commission, 2024). In the 2024 edition of the EIS, the indicators were grouped into 12 dimensions of innovation and 4 main types of activity (Table 1).

Table 1.
EIS 2024 Indicators

EIS 2024 Indicators			
1. Framework conditions – include factors that influence innovations that are beyond the company's control. They take into account three dimensions of innovation	**2. Investments – means public and private investments in research and innovation. They take into account three dimensions**	**3. Innovation activities – reflect innovation efforts at the enterprise level, encompassed in three dimensions of innovation**	**4. Impact – the effects of innovation activities in three areas of innovation**
1.1. human resources, 1.1.1. people who have obtained a PhD in science, technology, engineering and mathematics (STEM) per 1000 inhabitants aged 25-34, 1.1.2. percentage of people with higher education in the age group 25-34, 1.1.3. percentage of people aged 25-64 participating in education or training to improve their skills and competences, 1.2. attractive research systems, 1.2.1. number of international publications per million inhabitants, 1.2.2. scientific publications among the 10% most cited publications in the world as a percentage of all scientific publications in the country, 1.2.3. foreign doctoral students as a percentage of all doctoral students, 1.3. digital transformation, 1.3.1. enterprises providing training to develop or upgrade ICT skills of their employees, 1.3.2. ICT specialists (as a percentage of total employment), 1.3.3. broadband penetration (% share), 1.3.4. people who have general digital skills above basic (% share)	2.1. financing and support, 2.1.1. share of public expenditure on R&D as a percentage of GDP (gross domestic product), 2.1.2. Venture capital investments as a percentage of GDP, 2.1.3. direct government funding and government tax support for R&D of enterprises (percentage of GDP), 2.2. business investment, 2.2.1. share of business expenditure on research and development as a percentage of GDP, 2.2.2. other business expenditure on innovation as a percentage of total turnover, 2.2.3. businesses providing training to develop or improve employees' IT skills, 2.3. use of information technologies, 2.3.1. number of patent applications per billion GDP, 2.3.2. number of new Community trademarks per billion GDP, 2.3.3. number of new Community designs per billion GDP	3.1. innovators, 3.1.1. share of small and medium-sized enterprises (SMEs) introducing product innovations, 3.1.2. share of small and medium-sized enterprises (SMEs) introducing innovations in the business process, 3.2. linkages, 3.2.1. share of innovative SMEs collaborating with others in innovation, as a percentage of all SMEs, 3.2.2. number of public-private publications per million inhabitants, 3.2.3. mobility of workers in science and technology, 3.3. intellectual assets, 3.3.1. number of patent applications per billion GDP, 3.3.2. number of new Community trademarks per billion GDP, 3.3.3. number of new Community designs per billion GDP,	4.1. impact on employment levels, 4.1.1. share in basic knowledge activities as a percentage of total employment, 4.1.2. share in innovative ventures, 4.2. impact on sales volume, 4.2.1. share of exports of medium and high-tech products in the trade balance, as a percentage of total exports, 4.2.2. exports of services requiring specialized knowledge, as a percentage of total exports of services, 4.2.3. share of sales of new or modernized products in total sales of enterprises, 4.3. impact on environmental sustainability 4.3.1. resource efficiency measured as domestic material consumption (DMC) in relation to GDP, 4.3.2. Air emissions of particulate matter (PM 2.5) in industry, 4.3.3. development of environmental technologies, percentage of all technologies

Source: Own study based on (European Commission, 2024).

3. Results and discussions

The EIS 2024 study uses 32 indicators presented in Table 1. Based on the summary SII and its share in relation to the average EU indicator, EU Member States are assigned to one of four groups: Innovation Leaders, Strong Innovators, Moderate Innovators and Emerging Innovators (Table 2). Innovation Leaders – these are countries that achieve the highest level of innovation in the EU. They are characterized by the highest SII results. These are countries that make the best use of innovation opportunities by investing in research, development and modern technologies. Strong Innovators – these are countries that achieve results above the EU average, but not as high as innovation leaders. They have a strong economy based on innovation, although there may still be areas requiring improvement. Moderate Innovators – countries whose innovation performance is around the EU average. They may be less developed in terms of technology and research compared to innovation leaders, but they still show some progress in this area. Emerging Innovators – countries that are below the EU average in terms of innovation. Their SII is lower and their innovation-based economy is only just beginning to develop. They often have less access to the resources needed to support innovation. According to the EIS 2024 study, the innovation leaders in the EU are: Denmark, Sweden, Finland and the Netherlands (Fig. 1). The remaining countries are assigned to groups according to Table 2 (European Commission, 2024).

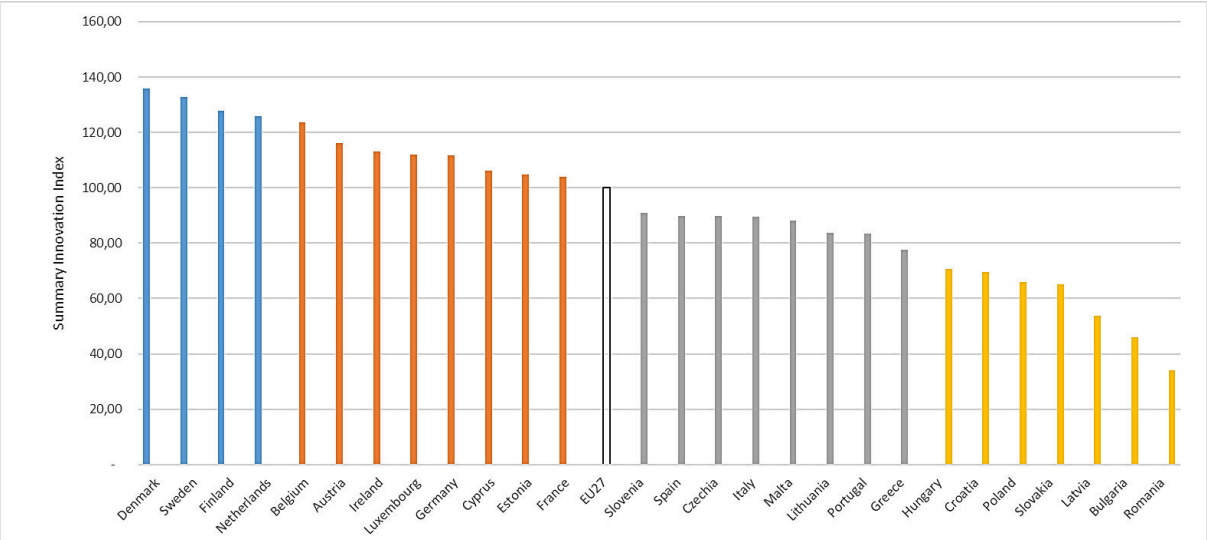

Figure 1. Innovation of EU countries in the EIS 2024 study.

Source: Own study based on (European Commission, 2024).

Table 2.
EIS 2024 Results

Group	Countries
Innovation leaders Summary innovation index above 125% of the EU average	Denmark, Sweden, Finland, Netherlands
Strong innovators Summary innovation index in the range of 100-125% of the average indicator for the EU	Belgium, Austria, Ireland, Luxembourg, Germany, Cyprus, Estonia, France
Moderate innovators Summary innovation index in the range of 70-100% of the average indicator for the EU	Slovenia, Spain, Czech Republic, Italy, Malta, Lithuania, Portugal, Greece, Hungary
Beginning innovators Summary innovation index below 70% of the EU average	Croatia, Poland, Slovakia, Latvia, Bulgaria, Romania

Source: (European Commission, 2024).

Denmark, like last year, is the leader in innovation among the European Union countries, overtaking Sweden, which was in first place in the ranking in 2017-2022. The largest increase compared to 2017 was recorded in Estonia. It advanced from the group of moderate innovators to become a strong innovator (11th place in the EIS 2024 ranking). The broader analysis of the EIS survey, covering other European countries and selected global competitors, shows that Switzerland has consistently been the most innovative European country since 2017, and South Korea has remained the most innovative global competitor since 2017, while China has surpassed Japan and is gradually closing the gap with the EU. The EU has an advantage over China, Japan, Brazil, Chile, India, South Africa and Mexico, but has a lower level of innovation than South Korea, Canada, the United States and Australia (Figure 2) (European Commission, 2024).

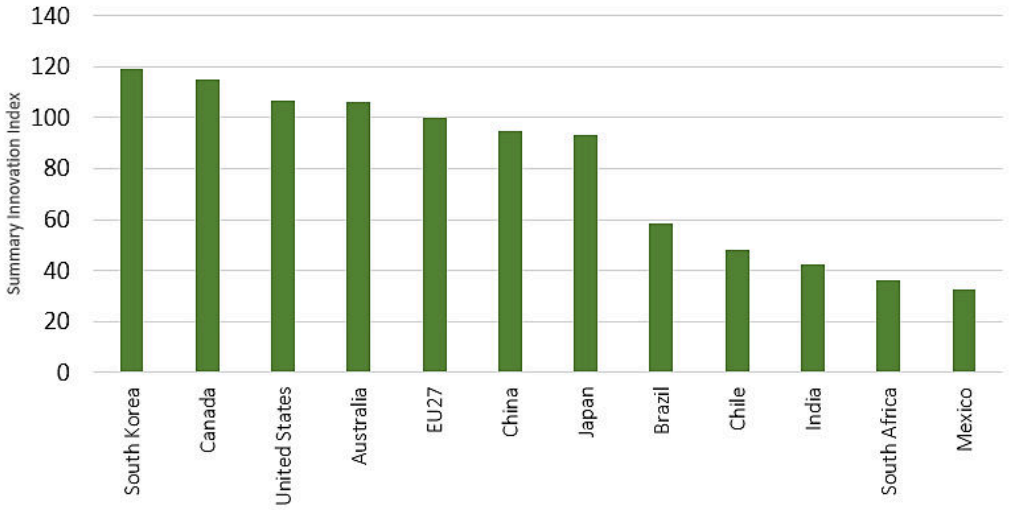

Figure 2. EU innovation performance compared to other countries in the EIS 2024 study.
Source: Own study based on (European Commission, 2024).

Analyzing the innovativeness of EU countries over the years 2017-2024, it can be noticed that the SII for the EU is constantly growing (Figure 3) (European Commission 2017a-2024).

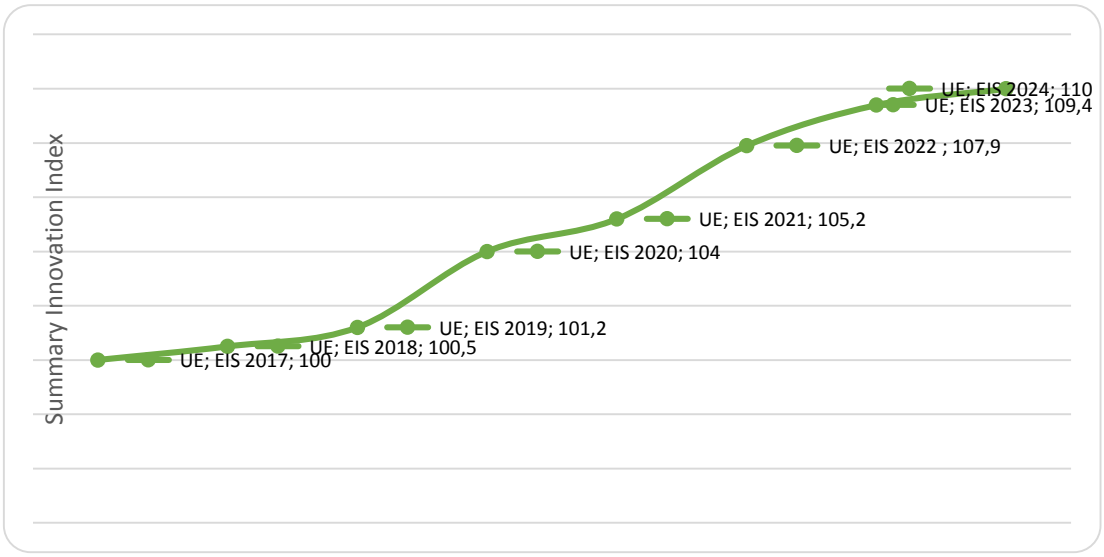

Figure 3. EU innovation in EIS 2017-EIS 2024 studies.

Source: Own study based on (European Commission, 2017a-2024).

In the EIS 2024 survey, the summary innovation index increased in 11 Member States compared to the previous year. The largest increases were recorded in Lithuania, Cyprus and Poland (Figure 4).

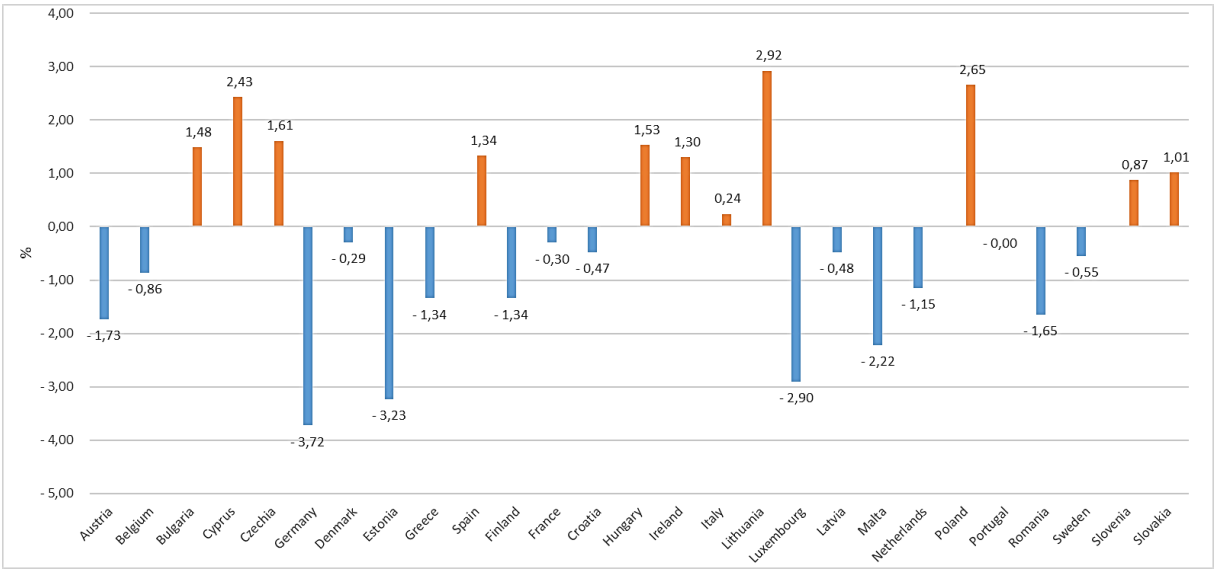

Figure 4. Dynamics of changes in the level of innovation of EU countries in the EIS 2023-EIS 2024 studies.

Source: Own study based on (European Commission, 2017a-2024).

Analyzing the summary innovation index over the years 2017-2024, the largest increase in this indicator can be seen in Cyprus, Estonia, Lithuania and Greece (Figure 5). Thus, countries with a low level of innovation record greater increases in the summary innovation index than countries that achieve higher results.

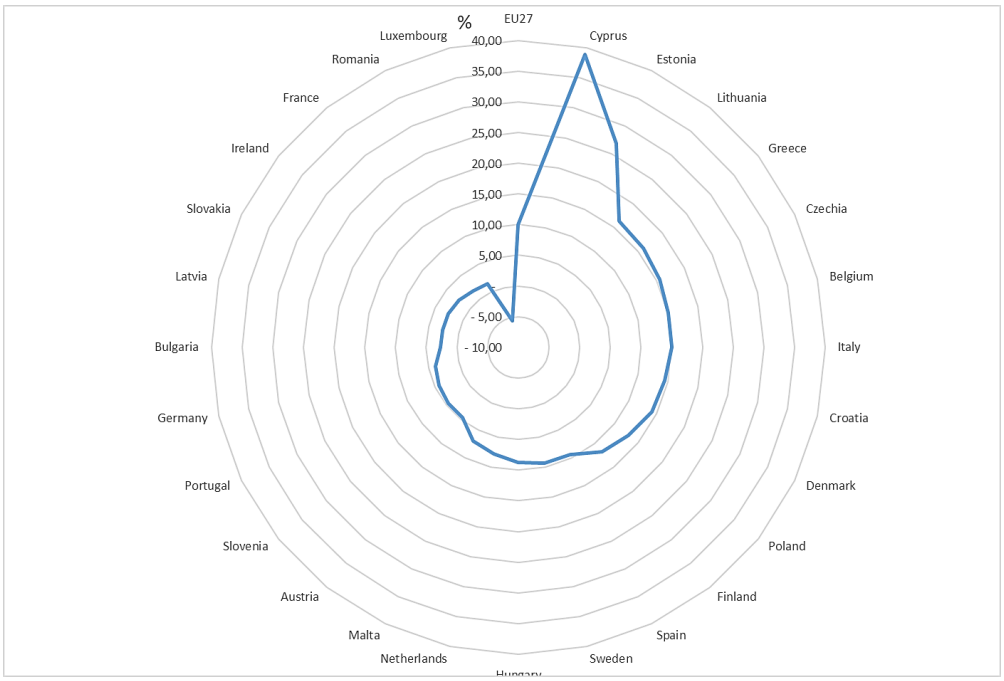

Figure 5. Growth of the EU countries' summary innovation index in the EIS study over the years 2017-2024.

Source: Own study based on (European Commission, 2017a-2024).

Analyzing the individual dimensions of innovation, it can be seen that in most dimensions the EU countries achieved better results compared to 2017. Only in the Intellectual assets dimension the result worsened compared to 2017 (Figure 6).

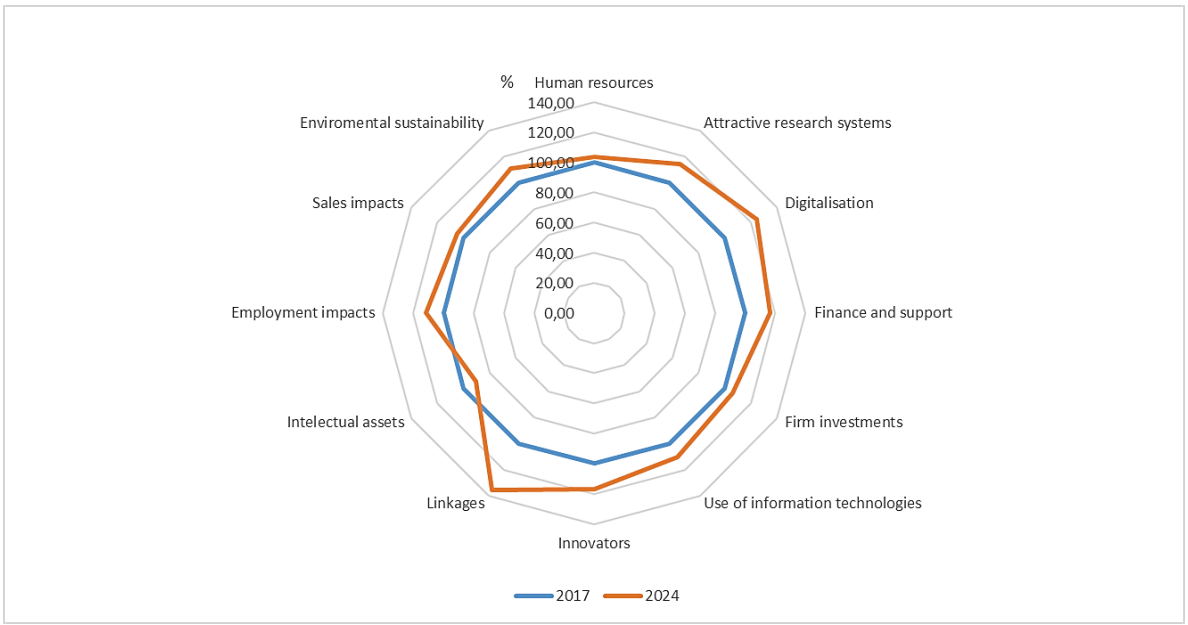

Figure 6. Dimensions of EU innovation in the EIS 2017 and EIS 2024 studies.

Source: Own study based on (European Commission, 2017a-2024).

Some countries, although not innovation leaders in the EIS 2024 ranking, were highly rated in terms of innovation in selected indicators. For example, in the EIS 2024 study, Romania is a leader among EU countries in the indicator - enterprises conducting training to develop or

improve employee skills in the field of ICT, and Lithuania is a leader in the categories – other innovation expenditures of enterprises as a percentage of total turnover and employee mobility in the field of science and technology (Figure 7).

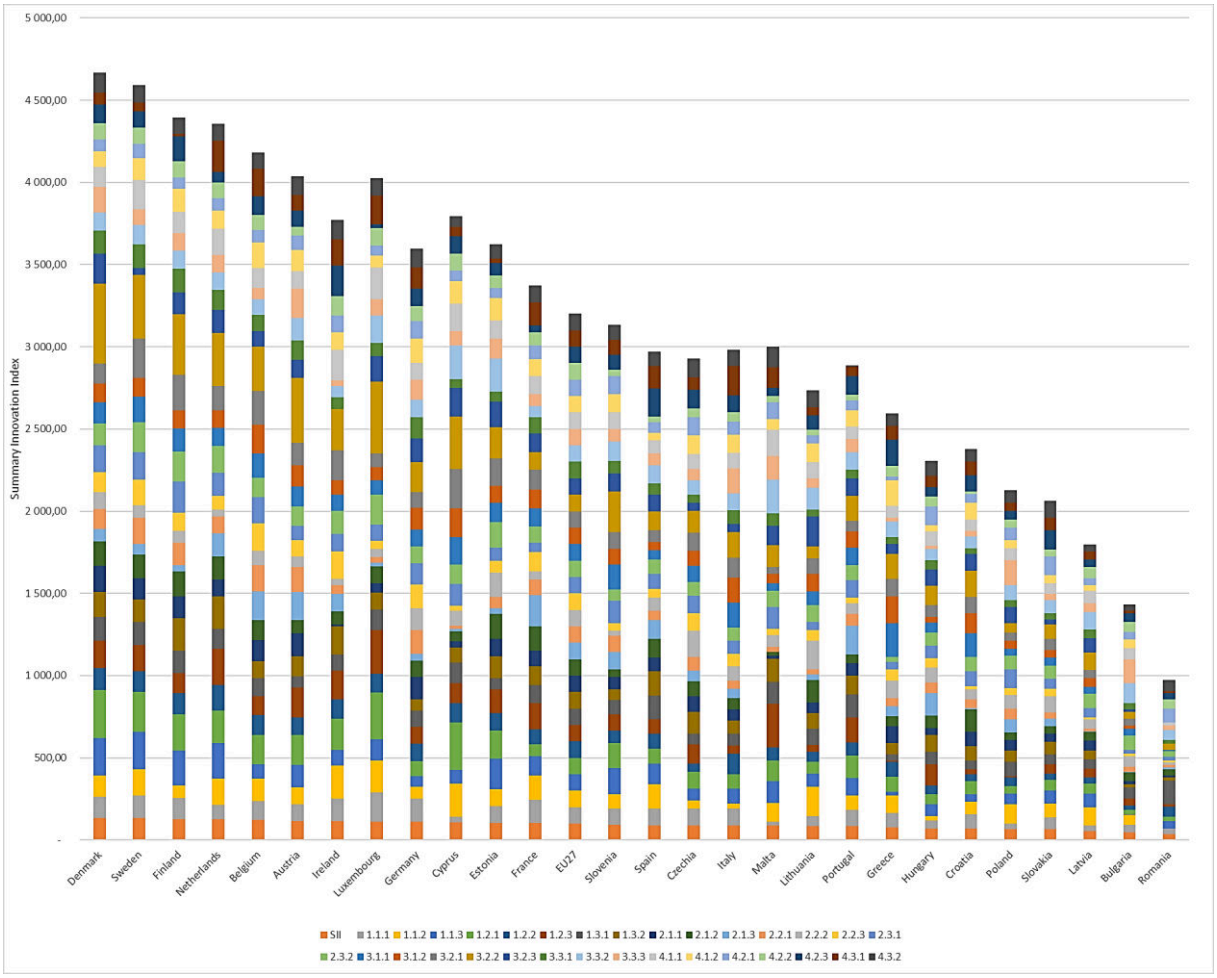

Figure 7. Dimensions of innovation in EU countries in EIS 2024 studies.

Source: Own study based on (European Commission, 2024).

Regional Innovation Scoreboard (RIS) is an extension of EIS research, focusing on the assessment of innovation in individual regions of the European Union. Similarly to EIS, RIS uses an innovation indicator, which allows for the assessment of the innovation capacity of regions in the EU. In the case of RIS, this assessment is carried out using the Regional Innovation Index (RII), which is calculated as the arithmetic mean of standardized partial indicators. In a similar way as in EIS, the RII indicator is analyzed in the context of the EU average, which allows for assigning the region to the appropriate category. Thanks to this, a ranking of regional innovation is created.

The RIS studies tried to achieve the greatest possible compliance with the EIS in order to maintain consistency in the assessment of innovation at the national and regional levels. However, due to the limitations of available data, the scope of indicators in the regional studies was smaller than in the EIS. A certain weakness of the conducted analysis is the fact that the

results of the RIS study are published with a certain delay in relation to the EIS study, which makes their analysis and comparison difficult.

The first edition of the study took place in 2002, covering 148 regions of the EU-15 (i.e. 15 Member States before the enlargement of the EU). In subsequent years, as new data became available and the methodology developed, the study expanded both the number of regions and indicators, which allowed for a more precise assessment of the innovation performance of EU regions. Thus, in the RIS study, the number of indicators was increased to 13 in 2003, to 16 in 2009, and in the last edition from 2023 to 21 (European Commission, 2017b-2021b).

The RIS 2023 study covers 239 regions from: 22 EU countries, Norway, Serbia, Switzerland and the United Kingdom. Smaller EU countries such as Cyprus, Estonia, Latvia, Luxembourg and Malta are treated as one region in the RIS study (European Commission, 2021b). Similar to the EIS study, the indicators in the RIS 2023 study were grouped into 12 dimensions of innovation and 4 main types of activity. Based on the RII index and its share in relation to the average EU indicator, the European regions were divided into 4 groups: Innovation Leaders, Strong Innovators, Moderate Innovators and Emerging Innovators (Table 3) (European Commission, 2023b). 36 regions were assigned to the group of innovation leaders, 72 regions to the group of strong innovators, 71 regions to the group of moderate innovators and 65 regions to the group of early innovators.

Table 3.
RIS 2023 results

Group	**Regions**
Innovation leaders Regional innovation index above 125% of the EU average	Région lémanique, Ostösterreich, Limburg, Stuttgart, Östra, Mellansverige, Gelderland, Praha, Trøndelag, Région de Bruxelles-Capitale/Brussels, Hoofdstedelijk Gewest, Île de France, Nordjylland, Noord, Brabant, Mittelfranken, Vlaams Gewest, South East, Tübingen, Oslo og Viken, Köln, Ostschweiz, Zuid-Holland, London, Utrecht, Sydsverige, Hamburg, Noord-Holland, Nordwestschweiz, Västsverige, Ticino, Midtjylland, Karlsruhe, Zürich, Berlin, Stockholm, Oberbayern, Helsinki-Uusimaa, Hovedstaden
Strong innovators Regional innovation index in the range of 100-125% of the average indicator for the EU	Saarland, Friesland, Provincia Autonoma Trento, Jihovýchod,, Friuli-Venezia Giulia, Emilia-Romagna, Budapest, Drenthe, Comunidad Foral de Navarra, North East, Grad Zagreb, Brandenburg, Sostinės regionas, Provence-Alpes-Côte d'Azur, Bretagne, Småland med öarna, Northern and Western,North West, Schleswig-Holstein, Sjælland, Southern, Zahodna Slovenija, Zeeland,Thüringen, WalesCataluña, Comunidad de Madrid, Hannover, Koblenz, Schwaben, Scotland, Yorkshire and The Humber, Nord-Norge, Arnsberg, País Vasco, Occitanie, Düsseldorf, Agder og Sør-Østlandet, Detmold, Auvergne - Rhône-Alpes, Oberfranken, Oberpfalz, West Midlands, Syddanmark, East Midlands, Vestlandet, Région Wallonne, Unterfranken, Bremen, Westösterreich, Övre Norrland, Südösterreich, South West , Overijssel, Flevoland, Leipzig, East of England, Rheinhessen-Pfalz, Etelä-Suomi, Darmstadt, Pohjois- ja Itä-Suomi, Espace Mittelland, Zentralschweiz, Länsi-Suomi, Eastern and Midland, Dresden, Gießen, Braunschweig, Freiburg, Groningen

Cont. table 3.

Moderate innovators Regional innovation index in the range of 70-100% of the average indicator for the EU	Alentejo, Vidurio ir vakarų Lietuvos regionas , Peloponnisos, Andalucía, Illes Balears, Thessalia, Valle d'Aosta/Vallée d'Aoste, Åland, Calabria, Basilicata, Normandie, Dytiki Ellada, Puglia, Región de Murcia, Principado de Asturias, Cantabria, Molise, Ipeiros, Castilla y León, Kentriki Makedonia, Malopolskie, Galicia, Jihozápad, Campania, Belgrade, Hauts-de-France, Kriti, La Rioja, Aragón, Mecklenburg-Vorpommern, Centro, Vzhodna Slovenija, Norte, Moravskoslezsko, Střední Morava, Severovýchod, Provincia Autonoma Bolzano/Bozen, Centre - Val de Loire, Střední Cechy, Liguria, Abruzzo, Sachsen-Anhalt, Bourgogne - Franche-Comté, Attiki, Trier, Bratislavský kraj, Norra Mellansverige, Nouvelle-Aquitaine, Kassel, Weser-Ems, Innlandet, Toscana, Grand Est, Mellersta Norrland, Comunidad Valenciana, Northern Ireland, Warszawski stoleczny, Piemonte, Pays de la Loire, Niederbayern,, Lüneburg, Münster, Lombardia, Lazio, Veneto, Umbria, Chemnitz, Marche, Lisboa
Beginning innovators Regional innovation index below 70% of the EU average	Sud-Est, Sud-Vest Oltenia, Sud – Muntenia, Centru, Severozapaden, Vest, Yugoiztochen, Nord-Vest, Ciudad Autónoma de Ceuta, Nord-Est, Severoiztochen, Mazowiecki regionalny, Severen tsentralen, Yuzhen tsentralen, Swietokrzyskie, Lubuskie, Ciudad Autónoma de Melilla, Corse, Opolskie, Šumadija and Western Serbia, Southern and Eastern Serbia, Zachodniopomorskie, Warminsko-Mazurskie, Észak-Alföld, Notio Aigaio, Região Autónoma dos Açores, Kujawsko-Pomorskie, Ionia Nisia, Západné Slovensko, Wielkopolskie, Podkarpackie, Canarias, Voreio Aigaio, Slaskie, Dél-Dunántúl, Podlaskie, Észak-Magyarország, Lubelskie, Lódzkie, Dél-Alföld, Bucuresti – Ilfov, Nyugat-Dunántúl, Közép-Dunántúl, Panonska Hrvatska, Yugozapaden, Região Autónoma da Madeira, Stredné Slovensko, Východné Slovensko, Vojvodina, Régions ultra-périphériques françaises, Extremadura, Severozápad, Pomorskie, Jadranska Hrvatska, Castilla-la Mancha, Pest, Sicilia, Algarve, Sjeverna Hrvatska, Anatoliki Makedonia, Thraki, Sterea Ellada, Dytiki Makedonia, Dolnoslaskie, Sardegna

Source: Own study based on (European Commission, 2023b).

Analyzing the RIS results over the years 2017-2023, it can be seen that Europe's innovativeness has increased (Fig. 8). In the latest RIS 2023 study, the most innovative region in Europe is Hovedstaden in Denmark. In the previous edition of RIS 2021, the most innovative region was Stockholm in Sweden, and in RIS 2019 – Zurich (Switzerland) (European Commission, 2019b-2023b).

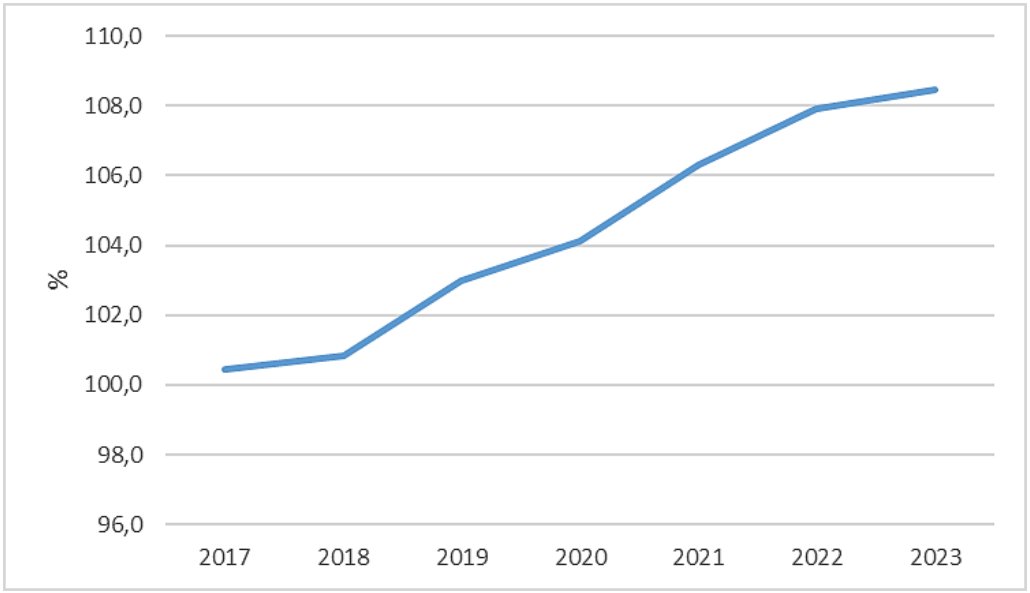

Figure 8. Innovation of EU regions in the RIS study in 2017-2023.

Source: Own study based on (European Commission, 2017b, 2019b, 2021b, 2023b).

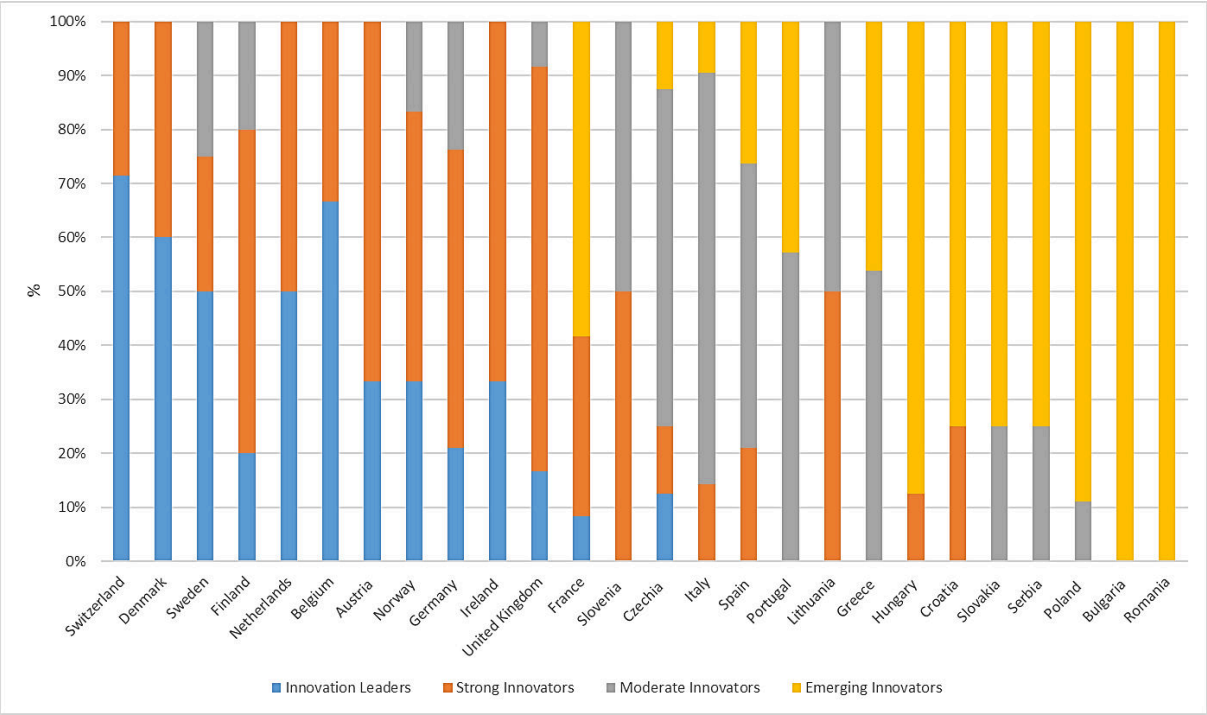

Figure 9. Innovation of European countries and regions in the RIS 2023 study.

Source: Own study based on (European Commission, 2023b).

In most European countries, the most innovative regions are located in the most innovative countries (Figure 9). However, in some countries that are classified in the EIS study as Moderate Innovators, there are regions that show a clear advantage in innovation and are considered regional Strong Innovators, e.g. Spain, which as a country is classified as a moderate innovator, but regions such as Catalonia or Madrid are considered strong innovators due to their developed economy based on innovation, numerous technology parks, start-ups, as well as developed cooperation with the academic and industrial sectors (Figure 10) (European Commission, 2023b). In the RIS study, similarly to the EIS study, it can be seen that regions with a low level of innovation record greater increases in the regional innovation indicator than the so-called regional innovation leaders.

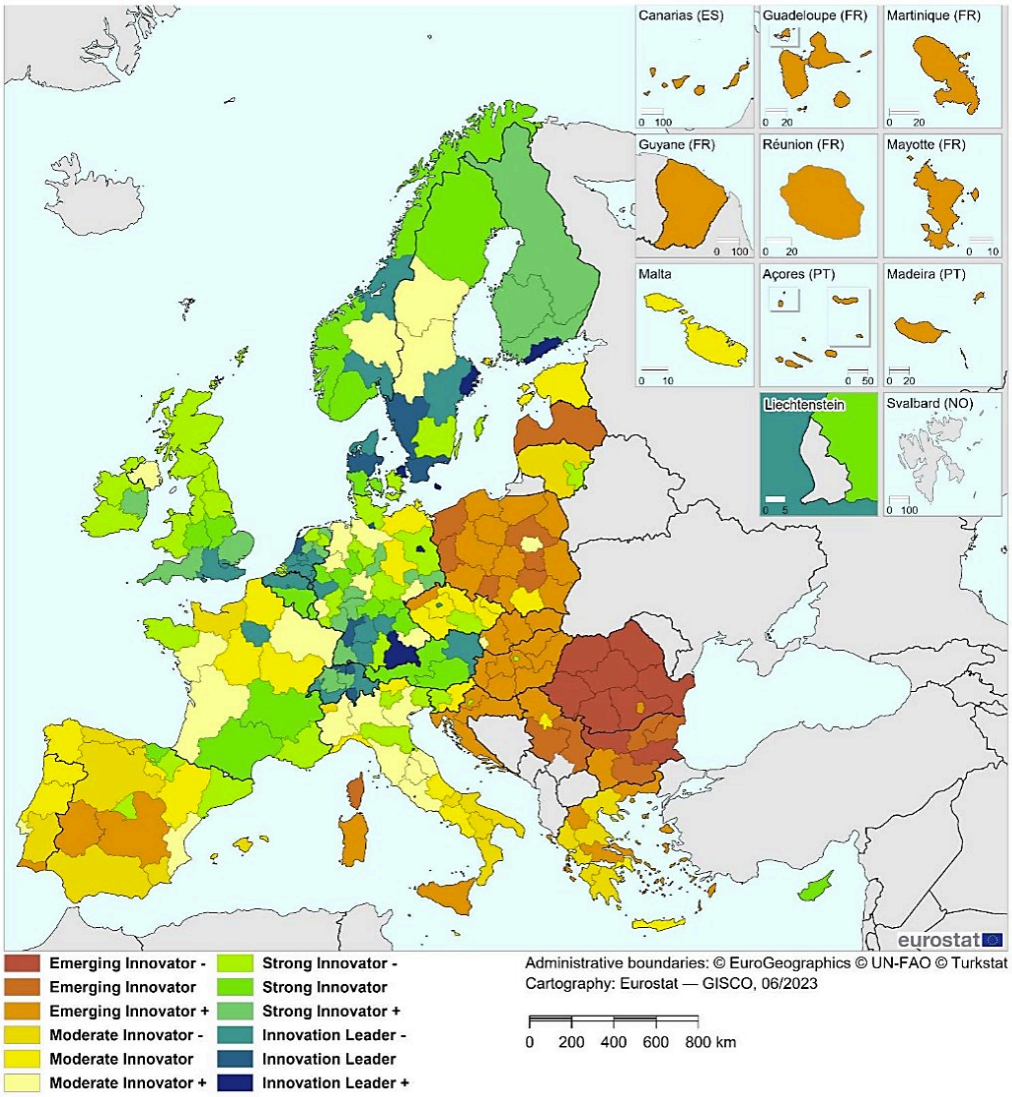

Figure 10. Regional innovation in the RIS 2023 study.

Source: (European Commission, 2023b).

There are also regions that, although they are not innovation leaders, were highly rated in terms of the innovativeness of selected indicators - for example, the Warsaw region in the EIS 2019 study was first among EU countries in the number of people aged 25-34 with higher education.

4. Conclusion

The analyses presented show that the innovation leaders in the EU are: Denmark, Sweden, Finland and the Netherlands. Denmark is the innovation leader of the European Union countries for the second year in a row, overtaking Sweden, which was in first place in the ranking in 2017-2022. Switzerland has been the most innovative European country since 2017. Estonia

has advanced from the moderate innovators group to become a strong innovator, which gives it 11th place in the EIS 2024 ranking. The analyses carried out show that the European Union has an advantage over China, Japan, Brazil, Chile, India, South Africa and Mexico, and the SII index for the EU is growing year by year. It is worth noting that in the EIS 2024 study there was an increase in the summary innovation index in 11 member states compared to the previous year. The largest increase was recorded in Lithuania, Cyprus and Poland. Analyzing the individual dimensions of innovation, it can be seen that EU countries achieved better results compared to 2017 in the following dimensions: human resources, attractive research system, digitalisation, finance and support, firm investments, use of information technologies, innovators, linkages, employment impacts, sales impacts, environmental sustainability. Only in the Intellectual assets dimension has this result deteriorated compared to 2017. It happens that a given country is highly rated in terms of innovation only in selected indicators, e.g. Romania is the leader among EU countries in the indicator - companies conducting training to develop or improve employee skills in the field of ICT, and Lithuania is the leader in the categories - other business expenditure on innovation, as a percentage of total turnover and employee mobility in the field of science and technology. The analysis of the innovation of European regions shows that it is also growing year by year. In the latest RIS 2023 study, the most innovative region in Europe is Hovedstaden in Denmark, ahead of Stockholm in Sweden and Zurich (Switzerland). Most often, the most innovative regions are located in the most innovative countries. However, in countries classified in the EIS study as Moderate Innovators, there are regions that show a clear advantage in innovation and are considered regional Strong Innovators, e.g. Catalonia in Spain. The analysis of the research shows that regions with a low level of innovation record greater increases in the regional innovation index than the so-called regional innovation leaders (RIS research). Both in micro and macro terms, innovative activities must be subject to verification and evaluation in order to speak of their beneficial impact on the creation of competitive advantages and the economic development of entities or countries.

Based on the innovation assessment indicators presented in the article, in accordance with the European Innovation Scoreboard (EIS) and Regional Innovation Scoreboard (RIS) research methodology, recommendations can be formulated for countries lagging behind in terms of innovation. In particular, these countries should focus their activities on the following areas:

- Strengthening investments in research and development (R&D).
- Improving cooperation between science and industry.
- Development of human capital - investing in the education system and programs supporting the development of future competences.
- Implementation of digital technologies and development of infrastructure.
- Development of financial support programs for startups and SMEs.

Implementation of the above recommendations will increase the level of innovation in these countries and contribute to their better competitiveness on the global market.

The article presents a comprehensive analysis of the level of innovation in countries and regions in the years 2017-2024, taking into account both changing economic, social and technological conditions and the dynamics of innovation policies. This analysis allows not only to identify the strengths and weaknesses of individual countries, but also to indicate possible directions of development, the implementation of which can contribute to increasing the competitiveness and efficiency of individual countries and better use of research and development potential in practice.

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COMPARATIVE ANALYSIS OF THE ECO-INNOVATION STRUCTURE OF EUROPEAN UNION COUNTRIES IN 2014-2024

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Purpose: The aim of this paper is to analyse and assess the eco-innovation of the European Union Member States in the years 2014-2024, which will allow for determining its level and making comparisons in various aspects.
Design/methodology/approach: The work uses various research methods, such as analysis and criticism of the subject literature, statistical methods, and logical analysis and construction.
Findings: The article presents the results of a comparative analysis of the level of eco-innovation in the European Union Member States over the years 2014-2017. The analysis of the level of eco-innovation in individual countries, based on appropriate indicators, allows for the identification of areas requiring intervention, assessment of the effectiveness of environmental policy and comparison of achievements and the pace of development between countries. The article indicates the leaders of eco-innovation in the group of countries and presents the growth and decline in the most important dimensions. The analyses carried out show that the leaders of eco-innovation in the EU are: Finland, Denmark, Austria, Luxembourg, Sweden, Italy, France, Germany, Netherlands, and the largest increase in the summary eco-innovation index compared to 2014 was recorded in Lithuania, Ireland and Malta (EIS 2024).
Research limitations/implications: In the future, it will be possible to compare the level of eco-innovation of European Union countries with their overall level of innovation, which will allow for a better understanding of the relationship between innovation and actions for sustainable development.
Practical implications: The practical value of the publication is particularly important for public authorities, institutions responsible for shaping environmental policy and decision-makers at national and EU level. It may also be of interest to analysts, researchers and international organizations dealing with sustainable development.
Social implications: The research presented in the article provides knowledge that can contribute to improving the quality of life of European Union citizens by more effectively shaping the environmental policies of EU Member States and supporting sustainable development. By identifying the strengths and weaknesses in the field of eco-innovation in individual countries, the article can support the creation of more precise, fair and effective public strategies.
Originality/value: The article brings new value to the analysis of eco-innovation of EU countries, presenting the level of eco-innovation of EU Member States over the years 2014-2024. Analysis of the level of eco-innovation in individual countries, based on appropriate indicators, allows to identify areas requiring intervention, assess the effectiveness of

environmental policy and compare achievements and the pace of development between countries.
Keywords: innovations, eco-innovation, Eco-Innovation Index and Scoreboard.
Category of the paper: Research paper.

1. Introduction

The concept of eco-innovation emerged in the 1990s as a result of the growing role of innovation in the processes of economic development and the deepening problems related to the degradation of the natural environment. This term, like the concept of innovation itself, is complex and multidimensional. One of the first definitions of eco-innovation was proposed by C. Fussler and P. James in 1996, defining it as products and processes that reduce the negative impact on the environment, while creating added value for both the company and the consumer (Fussler, James, 1996). Contemporary literature contains many definitions of eco-innovation, which often complement each other, emphasizing different aspects of this concept. According to Kemp and Person, eco-innovation is a new production method, resource exploitation, method of providing services, or a management method for an organization, which take into account the environmental aspect throughout the life cycle of a given product or service. They reduce the consumption of raw materials and the emission of pollutants into the environment, and are less harmful to the environment compared to other alternative sources (Kemp, Person, 2008).

Eco-innovation is the process of introducing a new or significantly improved product, process, organizational change or marketing solution, which results in a reduction of raw material consumption and a reduction of harmful substances emissions into the environment throughout the product life cycle (EIO, 2013). Wielewska I. defines eco-innovation as a direction of thinking and action, defining basic development paths, called sustainable development. Such actions carried out in enterprises may be of a corrective or preventive nature (Wielewska, 2013). According to the Oslo Manual, eco-innovation is a new or improved product or process (or their combination) that is significantly different from products or processes made available to potential users (product) or introduced for use (process) and which aims to reduce the negative impact on the environment (OECD, Eurostat, 2018).

The analysis of the concept of eco-innovation shows that its main effect is the reduction of the negative impact on the environment – regardless of whether this action was intentional or a side effect of other processes. In recent years, the approach to eco-innovation has undergone a significant transformation: from reactive actions aimed at reducing pollutant emissions, the emphasis has shifted towards preventive actions focused on the rational use of resources, minimizing energy consumption and preventing waste generation (Sulerz, Rybaczewska-

Błażejowska, 2017; Rybaczewska-Błażejowska, 2019; Rybaczewska-Błażejowska et al. 2022; Czajkowska, Ingaldi, 2022).

In the 1990s, eco-innovation gained importance in the pursuit of a sustainable economy. Therefore, developing indicators and methods for measuring eco-innovation became a significant challenge. Despite the fact that eco-innovation research is still in its early stages of development, several concepts of a methodological approach to this issue have already been developed. Eco-innovation research can be conducted at three levels: macro, meso and micro. Analyses at the macro and meso levels focus on assessing eco-innovation on a national or regional scale. These are general eco-innovation studies. Their aim is to identify factors that support the development of environmental innovations at a systemic level, as well as to compare the effectiveness of individual countries or regions. These studies may include, among others, analysis of public policies, expenditure on research and development, the structure of the economy, support systems for green technologies and the availability of infrastructure that supports sustainable development. A key element of such analyses is the creation of eco-innovation rankings based on aggregated indicators – an example is the summary eco-innovation index, which allows for comparing the level of advancement of ecological innovations between countries (Kumor-Sulerz et al., 2021).

Eco-innovation research at the micro level focuses on the activities of individual enterprises. Their aim is to assess the ability of companies to implement environmental innovations, analyze innovation strategies and identify internal processes supporting the development of new pro-ecological products, services and technologies. Such research allows for the diagnosis of the state of innovation of the enterprise and the identification of key factors influencing its innovation potential (Kaczmarska, 2015; Kumor-Sulerz, Michta, 2022).

Each level of research presents the issue of eco-innovation from a different perspective, based on different indicators and measurement methods. Modern analyses increasingly integrate data from the macro, meso and micro levels, which allows for a more complete and multidimensional picture of innovation processes taking place in the economy.

The aim of this work is to analyze and assess the eco-innovation of the European Union Member States in the years 2014–2024, which allows for determining its level and making comparisons in various aspects. The work uses various research methods, such as analysis and criticism of the subject literature, statistical methods, and logical analysis and construction. Due to the high variability of eco-innovation of countries and the multitude of factors influencing this process, its analysis is extremely important. Eco-innovation research can take into account various aspects. The article presents an original analysis of eco-innovation of countries, in which the Author selected the key, in his opinion, assessment parameters.

The following research hypothesis was adopted in the article: There is an upward trend in the European Union countries in terms of eco-innovation over the years 2014-2024.

2. Materials and methods. Eco-IS research methodology

The most important general studies on eco-innovation include, among others, the Eco-Innovation Index and Scoreboard (Eco-IS), Measuring Eco-Innovation (MEI) and the Community Innovation Survey (CIS). These are tools used to assess the level of eco-innovation at the macro level – both national and regional – and to observe trends and changes occurring in this area. In contrast, detailed studies focus on the level of enterprises (micro) and are most often based on original approaches of researchers specializing in the subject of eco-innovation.

The Eco-Innovation Index and Scoreboard (Eco-IS) is a methodology developed in 2010 by the Eco-Innovation Observatory (EIO), created as a supplement to existing tools for examining economic innovation. Eco-innovation is measured using 12 indicators, grouped into 5 key categories, which allow for a comprehensive assessment of the level of eco-innovation (Table 1).

Table 1.
Eco-IS 2024 Indicators

Eco-IS 2024 indicators				
Eco-innovation inputs - include financial, human and institutional resources allocated to the development of eco-innovations.	**Eco-innovation activities -** refer to the implementation of innovations in processes, products and organizational models.	**Eco-innovation outputs -** concern the direct effects of innovative activities, such as new technologies or products.	**Resource efficiency outcomes -** assess the impact of eco-innovations on savings and rational use of natural resources.	**Socio-economic outcomes -** measure the impact of eco-innovation on the economy, including job creation and improved competitiveness.
Governments environmental and energy R&D appropriations and outlays. Total R&D personnel and researchers.	Number of ISO 14001 certificates.	Eco-innovation related patents. Eco-innovation related academic publications.	Material productivity Water productivity (GDP/total fresh water abstraction) Energy productivity GHG productivity.	Exports of environmental goods and service sector. Employment in environmental protection and resource management activities. Value added in environmental protection and resource management activities.

Source: Own study based on (European Commission, 2024).

3. Results and discussions

The Eco-IS 2024 study uses 12 indicators presented in Table 1. Based on the aggregated indicator – the Eco-Innovation Index (EII), which is calculated as an unweighted arithmetic average of partial indicators and then compared with the average value for the entire European Union, an eco-innovation ranking of EU member states is created. This classification allows for assigning individual countries to one of three categories: eco-innovation leaders, Average EI Performers and countries catching up with EI (Table 2).

Eco-innovation leaders group – these are countries that achieve the highest level of eco-innovation in the EU. They are characterized by the highest results of the EII index. These countries are distinguished by advanced pro-ecological solutions, effective policies supporting environmental innovations, as well as a high level of investment in the development of environmentally friendly technologies. They are usually also characterized by strong cooperation between the public, private and scientific sectors, as well as ecological awareness of society, which favors the implementation of eco-innovations on a large scale. Average EI Performers group – these are countries that achieve results in the range of 90-125% of the average indicator for the EU. These countries are characterized by an average level of implementation of eco-innovations. In many cases, they lack a coherent strategy that would combine the efforts of the public and private sectors, but they have the development potential and the ability to enter the group of leaders with appropriate support and investments. They may be less developed in terms of technology and research compared to innovation leaders, but they still show some progress in this area. Eco-innovation Catching- up group – these are countries that are below the EU average in terms of eco-innovation. Their SII is below 90% of the EU average. These countries often struggle with insufficient financing for pro-ecological activities, limited institutional support and a lower level of ecological awareness. According to the results of the Eco-IS 2024 study, the leaders of eco-innovation in the EU are: Finland, Denmark, Austria, Luxembourg, Sweden, Italy, France, Germany, Netherlands (Figure 1). The remaining countries are assigned to groups according to Table 2 (European Commission, 2024).

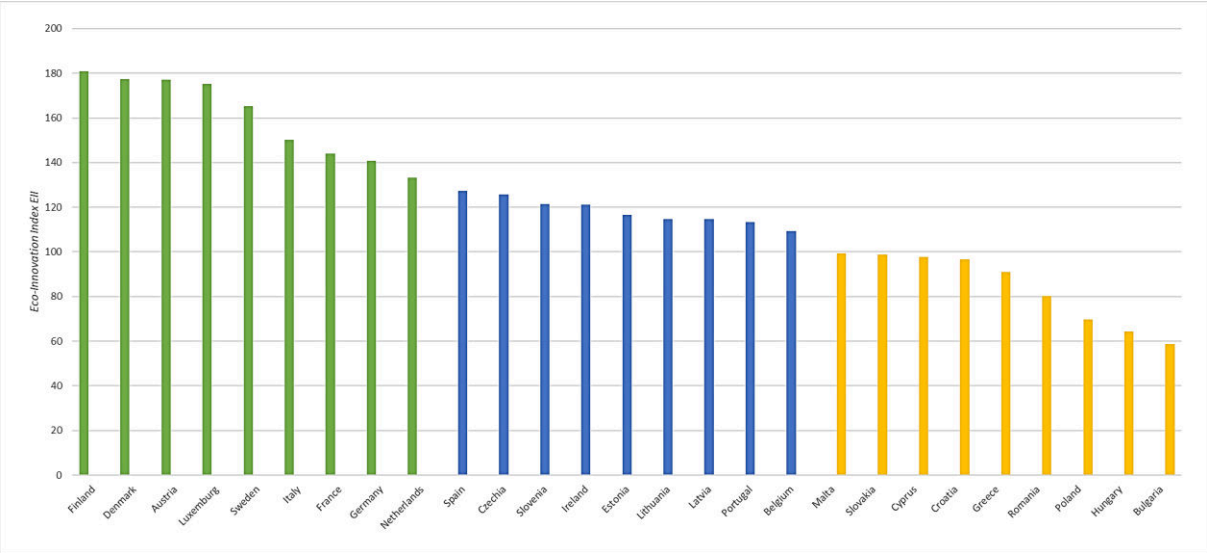

Figure 1. Eco-innovation of EU countries in the EIS 2024 study.

Source: own study based on (European Commission, 2024).

Table 2.
Eco-IS 2024 results

Group	States
Eco-innovation leaders Summary eco-innovation index above 125% of the EU average	Finland, Denmark, Austria, Luxembourg, Sweden, Italy, France, Germany, Netherlands
Average EI Performers Summary eco-innovation index in the range of 90-125% of the average indicator for the EU	Spain, Czechia, Slovenia, Ireland, Estonia, Lithuania, Latvia, Portugal, Belgium
Catching up eco-innovators Summary eco-innovation index below 90% of the EU average	Malta, Slovakia, Cyprus, Croatia, Greece, Romania, Poland, Hungary, Bulgaria

Source: (European Commission, 2024).

Finland maintained its position as the leader in the field of eco-innovation among the European Union countries both in the years 2014-2018 and in the period 2020-2024. In 2019, the leader was Sweden, which currently ranks 5th in the ranking. The largest increase compared to 2014 was recorded in Lithuania, Ireland and Malta. Only in Romania, a decrease in the EII index was noted (Figure 2). The largest increase compared to 2014 was recorded in Lithuania, Ireland and Malta. Only in Romania, a decrease in the EII index was noted. Therefore, countries with a lower level of eco-innovation record larger increases in the summary eco-innovation index than countries that are in the group of eco-innovation leaders.

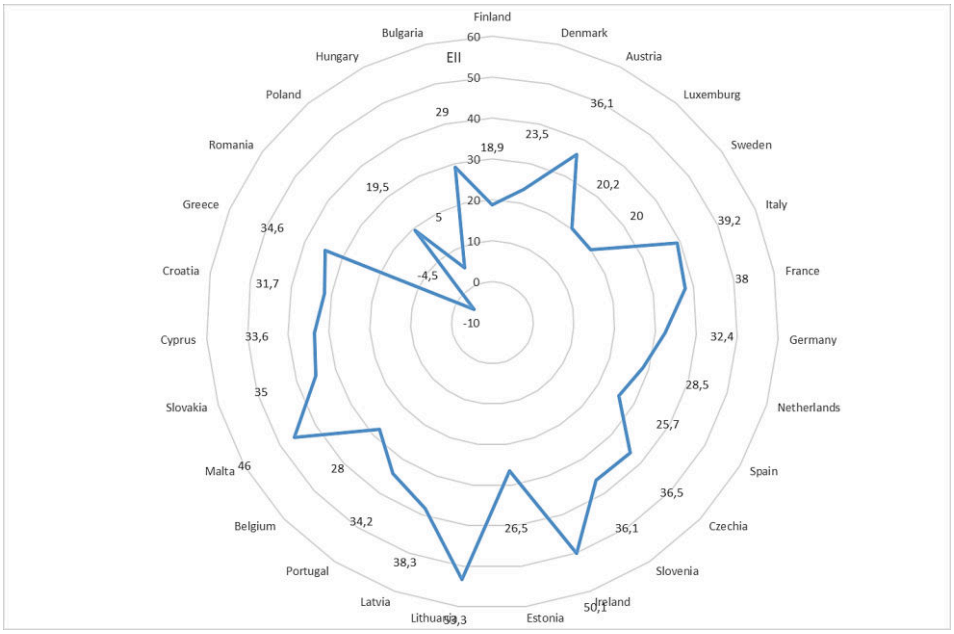

Figure 2. Growth of the EU countries' summary eco-innovation index in the Eco-IS study over the years 2014-2024.

Source: own study based on (European Commission, 2014-2024).

The analysis of eco-innovation in the European Union countries in the years 2014-2024 indicates a general upward trend in the value of the summary eco-innovation index (EII) for the entire EU (Figure 3) (European Commission, 2024). The only exception was 2017, when a decrease in the average EII value was noted at the EU level. The decrease in this indicator occurred in nine Member States, with the greatest regression observed in Romania, Denmark, Estonia and Bulgaria. However, in recent years, a slight upward trend has been noted, which can be attributed, among others, to the actions of enterprises aimed at reducing production costs, tightening legal regulations in the field of environmental protection, access to external financing of eco-innovation projects, as well as the growing importance of ecological products and processes as a source of competitive advantage.

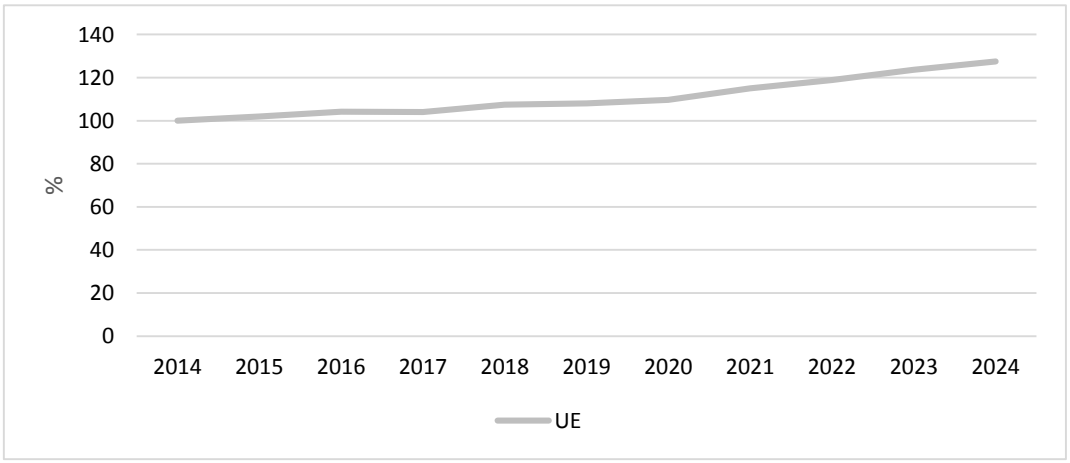

Figure 3. EU eco-innovation in the Eco-IS 2014–Eco-IS 2024 studies.

Source: own study based on (European Commission, 2014-2024).

In the Eco-IS 2024 study, compared to the previous year, there was an increase in the summary eco-innovation index in 22 Member States. The largest increases were recorded in Italy, Lithuania and the Netherlands, while a decrease was recorded in Estonia and Sweden (Figure 4).

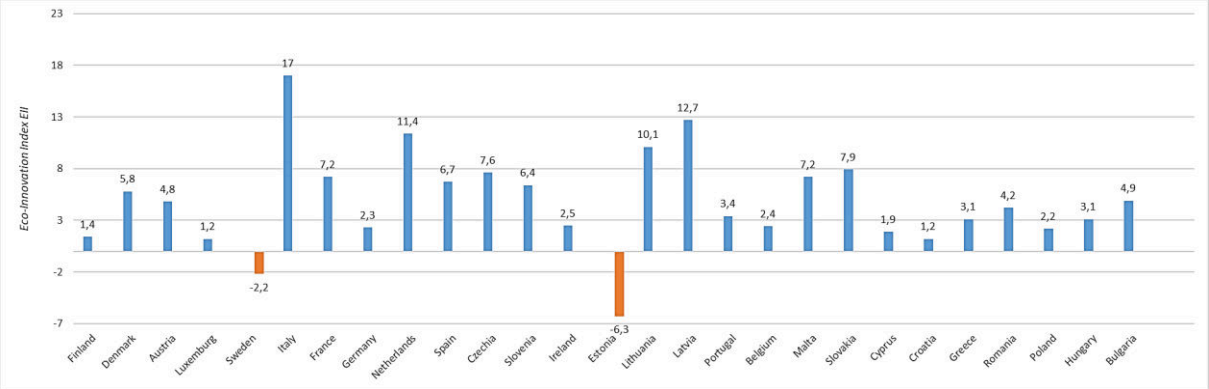

Figure 4. Dynamics of changes in the level of eco-innovation of EU countries in the Eco-IS 2023–Eco-IS 2024 studies.

Source: own study based on (European Commission, 2023-2024).

In the Eco-IS ranking for 2024, Poland was ranked low, falling into the group of countries catching up in terms of eco-innovation. Figure 5 and Figure 6 illustrate the detailed values of Poland's eco-innovation indicators in individual categories against the EU averages.

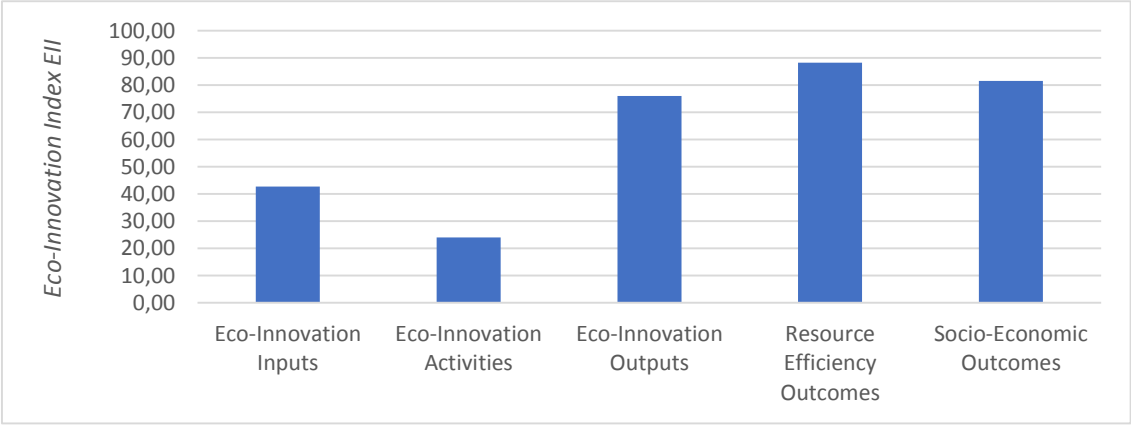

Figure 5. Poland's eco-innovation in the Eco-IS 2024 study for individual categories.

Source: own study based on (European Commission, 2023-2024).

The analysis of individual indicators shows that for eight indicators Poland recorded an increase compared to 2014. Four indicators showed a deterioration in results compared to the 2014 level, i.e. Governments environmental and energy R&D appropriations outlays, Exports of environmental goods and service sector, Eco-innovation related patents and Value added in environmental protection and resource management activities (Figure 6).

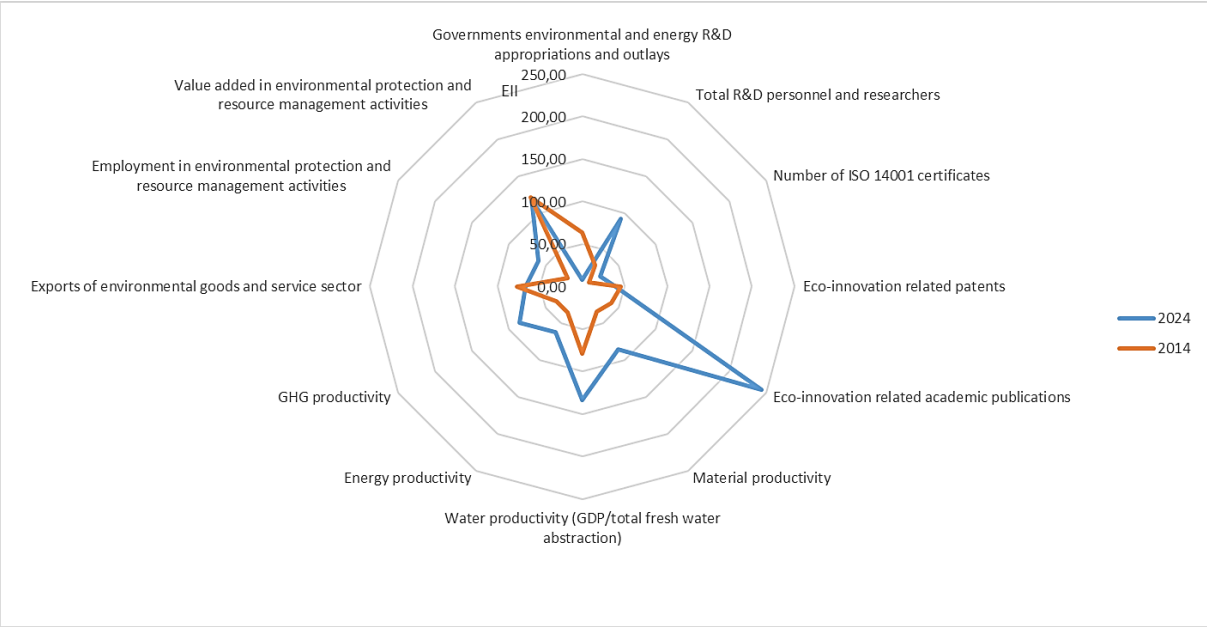

Figure 6. Poland's eco-innovation indicators in Eco-IS 2014 and Eco-IS 2024 studies.

Source: own study based on (European Commission, 2014-2024).

Compared to 2023, Poland recorded growth. Four indicators showed a deterioration in results compared to the 2014 level, i.e. Governments environmental and energy R&D appropriations outlays, Exports of environmental goods and service sector, Eco-innovation related patents and Value added in environmental protection and resource management activities (Figure 7).

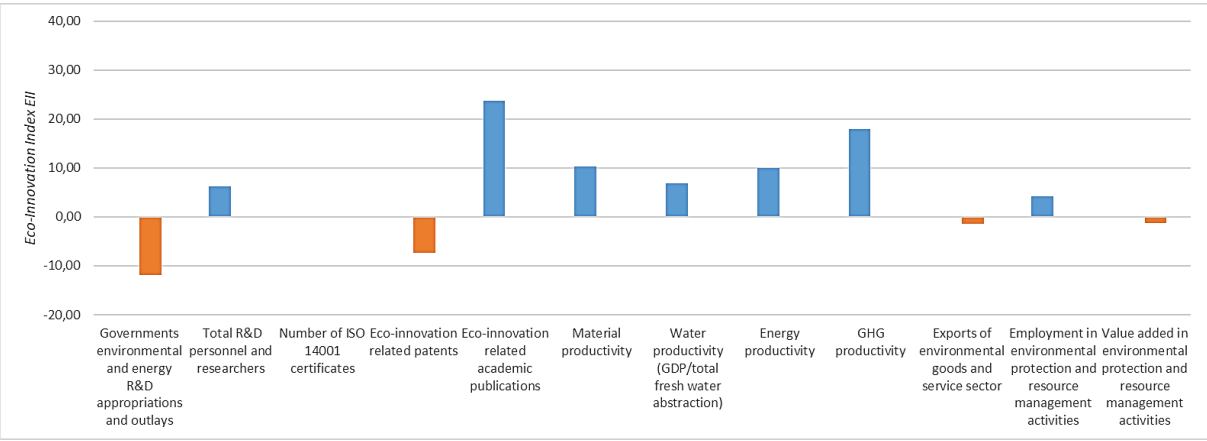

Figure 7. Dynamics of changes in Poland's eco-innovation indicators in the EIS 2023 and EIS 2024 studies.

Source: own study based on (European Commission, 2023-2024).

The level of eco-innovation in Poland remains significantly lower than in countries in the group of eco-innovation leaders. Poland achieved results lower than the EU average in all analysed indicators. Figure 8 shows Poland's eco-innovation indicators compared to Finland - the leader of the Eko-IS 2024 ranking.

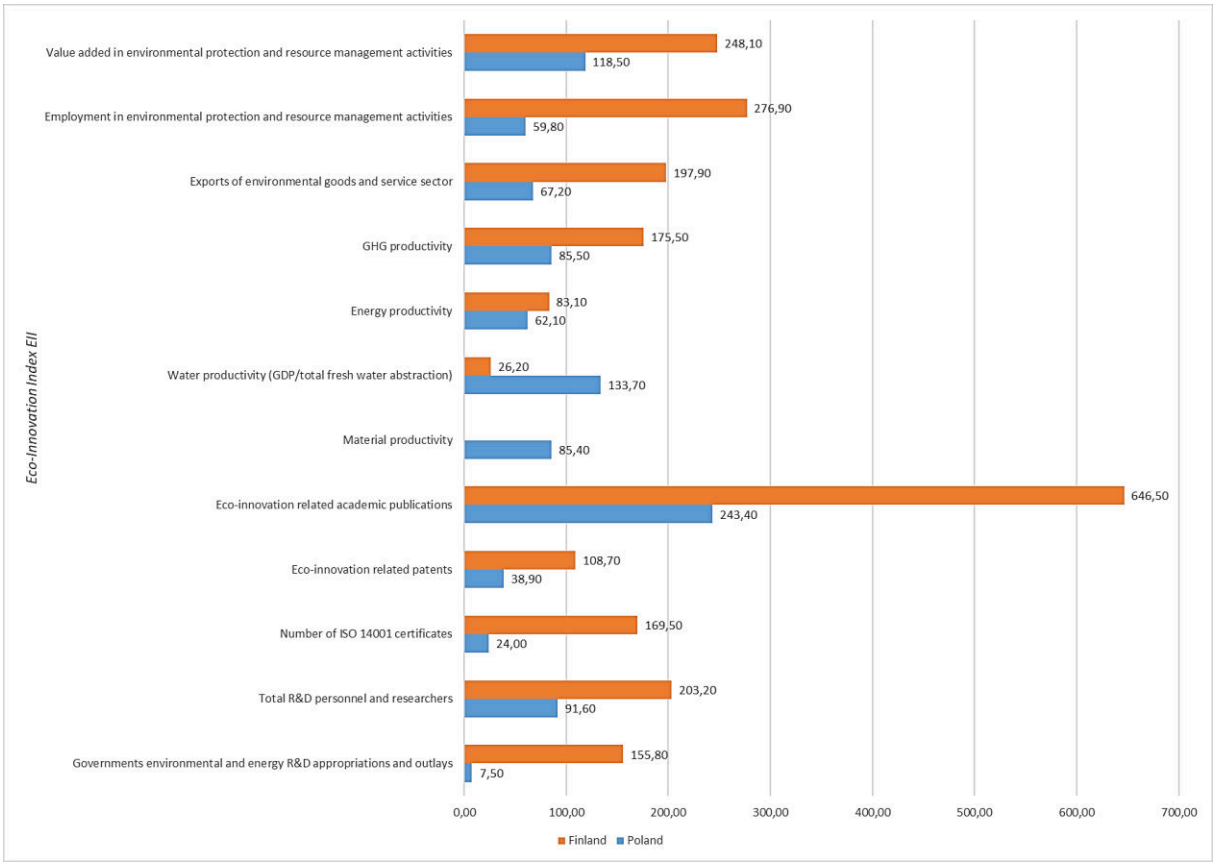

Figure 8. Eco-innovation indicator values for Poland and Finland in the EIS 2024 study.
Source: own study based on (European Commission, 2024).

Although some countries did not make it to the top of the Eco-IS 2024 ranking, they nevertheless achieved high results in selected eco-innovation indicators. For example, the Czech Republic took first place in the European Union in terms of Number of ISO 14001 certificates, while Estonia and Luxembourg became the leader in the category of Employment in environmental protection and resource management activities (Figure 9 and Figure 10) (European Commission, 2024).

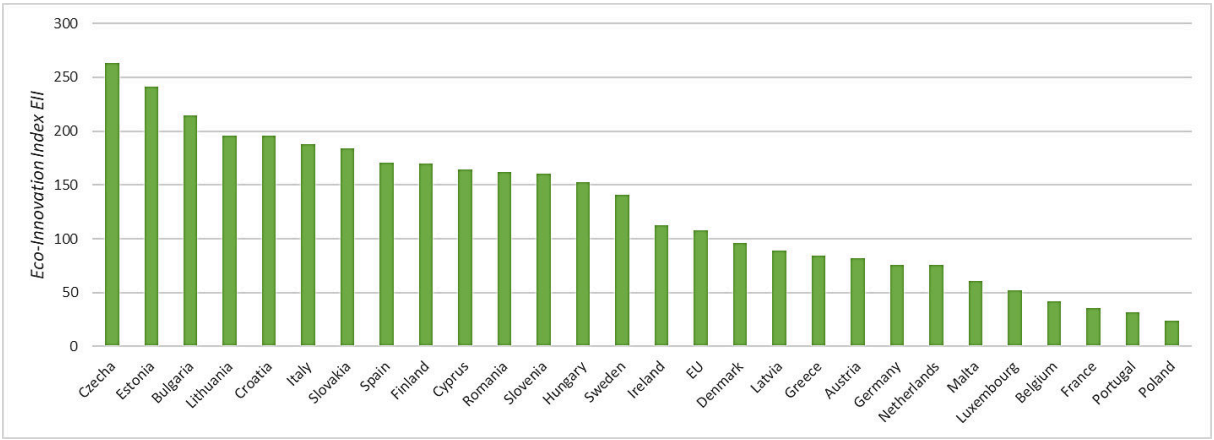

Figure 9. Values of the number of ISO 14001 certificates indicator in the Eco-IS 2024 study.
Source: own study based on (European Commission, 2024).

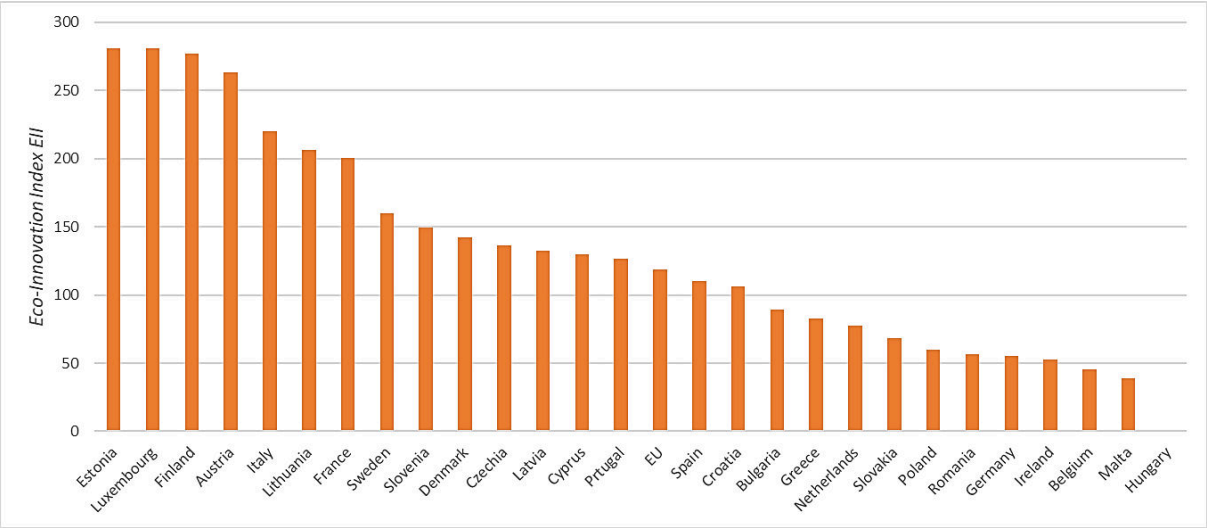

Figure 10. Values of the employment indicator in environmental protection and resource management activities in the Eco-IS 2024 study.

Source: own study based on (European Commission, 2024).

4. Conclusion

The Eco-innovation can be analyzed at three levels: macro, meso and micro. The presented analyses show that the leaders of eco-innovation in the EU are Finland, Denmark, Austria, Luxembourg, Sweden, Italy, France, Germany, and the Netherlands. Over the last 10 years, Finland has been the leader of eco-innovation in the European Union nine times. Only in 2019 did Sweden overtake Finland, taking first place in the ranking.

Analysis of the level of eco-innovation in the European Union countries in the years 2014-2024 reveals a general upward trend in the value of the summary eco-innovation index (EII) on a EU scale. The research hypothesis was confirmed: There is an upward trend in the European Union countries in terms of eco-innovation over the years 2014-2024. The most dynamic increase in the EII indicator compared to 2014 was observed in Lithuania, Ireland and Malta. The exception was 2017, when a decrease in the average EII level was observed in nine member states – the strongest regression was observed in Romania, Denmark, Estonia and Bulgaria. In the following years, however, a gradual improvement was visible, which may be the result of, among others, the actions of companies aimed at reducing production costs, tightening environmental regulations, increased access to external financing for eco-innovation purposes, as well as the growing importance of ecological solutions as a factor building a competitive advantage.

Available research shows that Poland is doing very poorly in terms of eco-innovation compared to other European Union countries. For 10 years, it has consistently been in the group of catching up eco-innovators. This group also includes countries such as Malta, Slovakia,

Cyprus, Croatia, Greece, Romania, Hungary, and Bulgaria. Therefore, the key challenge is to identify the reasons for such a low level of development in this area. The use of policy instruments – for example green subsidies or tax breaks for R&D – can explain the different performances achieved by Member States. Countries that rank among the top countries, such as Finland, Denmark and Austria, have more developed public support systems that effectively stimulate innovation and ecological transformation, while others struggle with budget constraints, weak institutional coordination or lower efficiency of policy implementation, such as Bulgaria. Green subsidies can support investments in renewable energy sources, energy efficiency or sustainable transport, accelerating the transformation towards a low-carbon economy. Tax breaks for R&D can in turn stimulate the private sector to develop new technologies and products, which helps to increase competitiveness and create jobs. The different performances may also be due to different economic structures, levels of technological development and administrative capacities. Countries with strong institutions, stable legal frameworks and a high innovation culture are usually better prepared to use public policy instruments effectively, which translates into better results in areas such as energy transformation, digitalisation and sustainable development. Poland's low position is primarily due to the general deficit of innovation in the economy. The Polish economy is characterized by high energy intensity, a low share of energy from renewable sources, and inefficient resource management, which is manifested, among others, in the low level of recycling and reuse of materials (Rybaczewska-Błażejowska, Mastenak-Janus, 2018; Kumor-Sulerz, Dziedzic-Jagocka, 2023). Despite these challenges, the country has significant potential for improvement, resulting from the growing involvement in climate action, access to financial resources from EU funds, and increasingly stronger integration with the green technology market. The analysis of eco-innovation of countries allows not only to identify their strengths and weaknesses, but also to indicate potential directions of development. In order to reduce disparities between Member States and increase the effectiveness of the implementation of EU climate policy, it is necessary to take actions supporting the transformation in a more sustainable way. One of the priorities should be to increase financing for sectors with a high potential for emission reduction – which could significantly accelerate the transformation in the most emission-intensive areas of the economy. At the same time, it is worth expanding the scope of tax relief for small and medium-sized enterprises involved in the development of green technologies to stimulate innovation and increase their participation in the energy transformation process. It would also be important to introduce a common regulatory framework and create mechanisms supporting the exchange of experiences and proven solutions between Member States. In the case of regions with a lower level of economic development, it would be important to use equalisation tools – such as special funds supporting their adaptation to new challenges. In addition, it is necessary to strengthen administrative capacities in countries that have difficulties with effective management of public funds, which would allow for more effective implementation of policies and fuller use of available funds.

Effective implementation of these strategies can lead to improved competitiveness and increased economic efficiency.

In the future, it will be possible to compare the level of eco-innovation of European Union countries with their overall level of innovation, which will allow for a better understanding of the relationship between innovation and actions for sustainable development.

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COGNITION, CONSCIOUSNESS AND INTUITION IN PROJECT MANAGEMENT

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Purpose: This paper proposes a shift in the educational paradigm of project management towards fostering over-consciousness-based intuition and intuitive decision-making. The author argues that such a transformation increases the likelihood of developing sense-making intelligence, a critical attribute distinguishing successful project leaders. The study aims to stimulate further research and influence curriculum development.
Design/methodology/approach: Adopting a pragmatic research paradigm, this study assumes that effective project managers prioritize intuitive judgment and sense-making over rigid theoretical models. The research methodology included: (a) collecting unbiased experiential accounts from practitioners; (b) modeling their decision-making processes; (c) identifying phenomenological interdependencies; and (d) situating these insights within an appropriate theoretical framework.
Findings: The results suggest that successful project managers exhibit advanced sense-making intelligence and make extensive use of intuitive reasoning. A phenomenological classification, based on the TCI (Theme-Centered Interaction) model, contextualizes the role of intuition within a broader theoretical perspective. Cybernetic principles and the ORCH-OR theory further support and validate these findings.
Research limitations/implications: While rooted in well-documented practice, the study highlights the need for further empirical research to define the boundary conditions and mechanisms of intuition-based decision-making. It also challenges the dominance of discursive, linear reasoning in current project management standards, which may be inherently limited when applied to complex, NP-complete project environments—where exhaustive, rational decision-making is computationally infeasible and prone to error.
Practical implications: Endorsing intuitive decision-making may significantly improve project outcomes. Drawing on extensive practical experience, the author heuristically estimates a potential performance gain of at least 10% when intuition is integrated into managerial practice.
Social implications: The acceptance of intuitive decision-making reflects a cultural shift towards trust and openness in leadership. It may influence societal views on project success factors and lead to broader performance gains at organizational and systemic levels.
Originality/value: Existing project management methodologies overwhelmingly emphasize rational, discursive approaches. Research on the role of intuition remains limited. This paper offers a novel contribution by bridging theoretically grounded intuition-based decision-making with its demonstrated effectiveness in successful project management practice.

Keywords: Intuition in projects, human brain decision-making process models, mental models, cognition, consciousness, project success.
Category of the paper: empirical construction of a model.

1. Introduction

Projects are inherently dynamic and complex (Lent, Gadomski, 2017). Project manager has to cope with approximately 5000 activities during project life cycle, each demanding several decisions. He frequently encounter NP-complete problems, that means that the problem cannot be solved within a finite (polynomial) time (Alzalg, 2024; Garey, Johnson, 1979; Stanescu, 2024). This imply, that the discursive approach may not lead to the desired solution. Sooner or later the intuitive decisions are on demand.

Practitioners apply more or less consciously their ability to deploy their intuition. Several researchers analysed the external impact of the intuitively made decisions and willingness of the project managers to decide intuitively (Sadler-Smith, 2023; Liebowitz, 2023; Henke, 2021; Ilgen, 2019; Thome, 2017; Elbanna, 2015; Kahneman, 2012; Bousquet, 2009; Leybourne, Sadler-Smith, 2006).

Complexity in projects is primarily determined by the human acting in project and by stakeholders. So the authors of the well-known Nonaka-Yamaguchi knowledge exchange model discuss profoundly the role of the intuition in the empathy and people interrelation (Nonaka et al., 2022).

In all above mentioned researches intuition is evaluated by the decisions taken by the human.

The following considerations aim specifically to identify the internal factors, which influence the intuition, leading to possibly conscious development of the intuition capabilities and further research in this area.

2. Research Paradigms, Hypothesis and Applied Research Methodology

2.1. Conceptualization of the Methodology

The methods chosen in this research origin from the basic aim of the author to stimulate further research by indicating the successful practice and positioning it within the theoretical background. The conclusions shall help ambiguously the researchers as well as practitioners to set the right accents and priorities in their work. The balanced strategy of the European Commission broad research programs: EI2 HORIZON 2020 determined the choice of the

methods: Real impact of the research, balanced with the professional project management, have driven this work (EC, 2019).

Basic epistemological assumption is, that it is rather the successful practitioner with a proven track of records, who applies the right tools and sets correctly the priorities in leading the people, who does it right, than any, even most sophisticated, theoretician. It is ontological expresis verbis that the reality is equivocal, but grounded in terms of language, history and culture (Klenke, 2008). Woolcott (2002) consider this approach as a core of qualitative research. The interpretive non-categorical approach let us to formulate the **research question as follows** (Thorne, 1997): Most management theories solicit practice which justify them. Will the reverse approach: mapping of the real (project) managers' decision making onto the theoretical background expose any particularities?

The pragmatic **paradigm set up for our research sounds**: Successful project managers trust their intuition and sense making intelligence rather than any coherent theory. The central **hypothesis** of this study is that intuition-based decision-making contributes to improved project outcomes in complex environments.

Based on these considerations the following research steps were performed:

- Collect the unbiased abstract descriptions of intuition based decisions from the acknowledged practitioners.
- Draw the decision process model and its composites.
- Design the phenomenological interdependences between the model and intuition.
- Choose the theoretical background which focus on specific terms.
- Draw conclusions.

With this approach the ontologically, epistemologically and methodologically congruent standards for the research are achieved (Woolcott, 2002).

2.2. Theoretical Background

Projects are dynamic systems. Finite models of dynamic systems are limited in their predictability leading to the unavoidable imprecision. Due to the phenomenon of chance, predictability is bound to the probability and hardly deterministic in such systems (Stewart, 2002). Yet, the short term predictability is nevertheless feasible (Bousquet, 2009), so it makes sense to try to exercise the project management.

Project Management decisions are equivocally concerning management as well as leadership. Management covers basically the administrative processes (Lent, 2014), where discursive decision process is appropriate and efficient, due to the well known facts and data. The human factor processes concern peoples, whose behaviour in interaction with the environment is too complex to get described by algorithms (Gödel theorem, Hoffman, 2024), solvable in a finite time (NP-complete problem, Garey, Johnson, 1979; Stanescu, 2024). Therefore the human factor area subject mainly to intuitive decision making, and this leads to the considerations of leadership capabilities of project manager.

Most leadership theories view leadership as a unidirectional process of leaders influencing socially their team members (e.g. Avolio, 2007; Fiedler, 2005; Verma, 1996). Few recognize that it is rather a mutual dynamically evolving relationship and leader has first to create the way to perform for the team, than win the team (dyadic theories) and that the leader himself develops with the task execution, taking the context into account (Fiedler, 2005; Cragan et al., 2009). An overview of the leadership theories, relevant in project management may be found in Lent (2014).

Our research question focus on "What?" and "How?" leaving purposely the causal and conditional "Why?" for further research (Meredith, 1988). No claim of completeness, neither orthogonality is raised in this paper. The criteria behind the selected theories further referred to, are:

a. Is there a theory explaining the intuition origins in a good leadership of practitioners? and

b. If there is not a single one, which other than matches the best a given term?

In the term assessment, the intentions of the practitioner are given the priority over the pure semantics. Excluded are the issues of multicultural impact, as well as gender, age and position aspects (Chipulu et at., 2014).

The project management relevance is evaluated under the criterion whether practitioner applies a process approach. This is detected by analysing whether any attributes named by the practitioner match at least one of the holistic four stages model of leadership LEAD (Lent, 2014):

L = Launch (Initialization of the project Leadership)

E = Engage (Motivate and empower the project team)

A = Act (Handle the daily leadership)

D = Deliver (Assure the BSC - balanced score results)

Particular attention is given to the issue of feed backing. Feedback is considered crucial to the project success and forms the principle of the cybernetic approach to the project management (Lent, 2014):

I. order cybernetic feedback through the project (actions cause intended reaction of the project).

II. order feedback: outstanding issues and the optimization goals in each process.

III. order: the human decision process feedback from the reactions upon taken actions.

Similar approach, yet not explicitly identifying the III order cybernetic feedback may be found in Mesjasz et al. (2022) and Rowbotham (2021).

2.3. Phenomenological classification

Elbanna (2015) examined the impact of the environment on intuition and III order cybernetic feedbacking on project outcome. Involved are team members and project goal. Therefore, Team Centred Interaction model TCI has been chosen as a comprehensive behavioural reference to an individual, placed in social and material environment (Cohn, 2021).

In this model, person focuses the personal orientation either on personal topics ("I"), on interaction with others ("We" replaced here for differentiating purposes with "Team", T) or on common goal ("It", replaced for the same reason with "Goal" G). The environment ("World", W) is taken under considerations in closest as well as in broad meaning into account, while considering each of the perspectives. The cognitive processes permanently rotate: while focusing on "I" we influence our "Team" thinking, "Team" thinking leads to common goal focusing ("Goal") and goal oriented thinking influence back our egocentric orientation. All biased by the "World". According to Cohn an individual and the team are successful when for each team member, including the leader, all items are in balance (Cohn, 2021, 1975). This justifies the choice of TCI for the phenomenological classification. On the other side our engagement stipulated by this cognitive process is conditioned by: a) the Willingness/Courage, b) our Capabilities/Potential and c) Feasibility to act (Ion, Brand, 2009).

The correlation of both: the cognitive process and the engagement conditions resulted in the matrix presented in the Table 1 further down. For space delimitation is this table given already with the superimposed results of the analysis of the practitioner's views.

3. Models of cognition process of the III order cybernetics

3.1. Overview of the Cognition process

The cognition process in von Foerster Observer (von Foerster, 1974) is depicted in Figure 1.

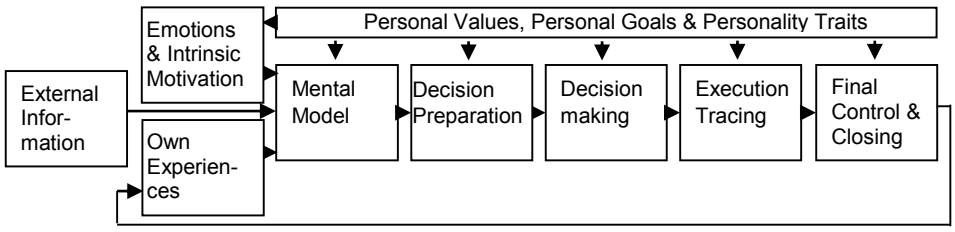

Figure 1. Decision process of project manager.

Source: Lent (2014).

It holds true for all decisions taken by project manager in any project management process. Managers see the system as linear one and try to master the corrective feedback loop (e.g. by increasing the frequency of project progress control) imposing order (Figure 2).

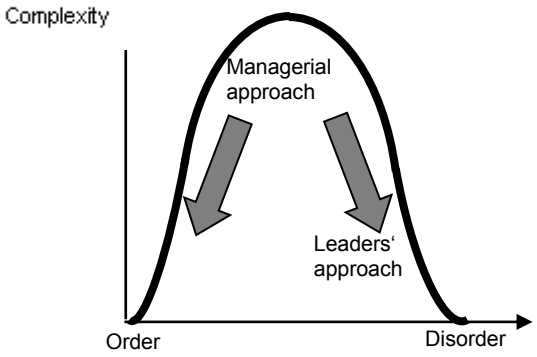

Figure 2. Decision process of project manager.

Source: Lent (2014).

The leaders, oriented towards dealing with the uncertainty of nonlinear systems, focus on adaptive feedback. They let the system to certain degree freely float or even intentionally destabilize, to learn the equilibriums and the resistance to change around those points. This adaptive learning let leaders to develop the cognitive intuition (Bousquet, 2009). This operation on the verge of chaos is viewed by several authors as the most successful strategy to deal with the nonlinear systems (Bousquet, 2009; Kaufmann, 1955; Singh, Singh, 2002). The right approach is that of manager and leader: to keep balance between positive and negative feedbacks (Bousquet, 2009).

We lend credibility to Singh and Singh (Singh, Singh, 2002), who conclude that project managers have to balance between linear (management) systems and non-linear systems, effective in chaos and complexity management. The high degree of the complexity at the edge of chaos is simultaneously the biggest chance: the management systems handling these situations are most flexible and creative, best suited to adapt for a contingent operation and handle the unpredictability (Bousquet, 2009) To handle the last, an awareness of context and relations, even anticipation of their possibility, may be crucial to project success. Linear systems focus on quantitative analysis and project controls limiting the capability of the perception of deviations or stochastic occurrences with impact on the project fate, what may explain, why today's project are not better managed than 20 and 20 ye**a**rs ago.

Authors own experience lead to observation, that in stress situations, typical in any project day life, it is rather the problem solving approach, than the systematic development of understanding, evaluation of alternatives, and risk analysis. We act mostly instantly and spontaneously, without questioning assumptions or implications of our action. This reaction comes from our sense making capability in view of non-linear system encounter, paired with the intuition (Thomas, Mengel, 2008). The findings of Kahneman (2011) confirms this experience.

3.2. Mental model

The key issue in sense making intelligence plays mental model of the situation, depicted in Figure 3.

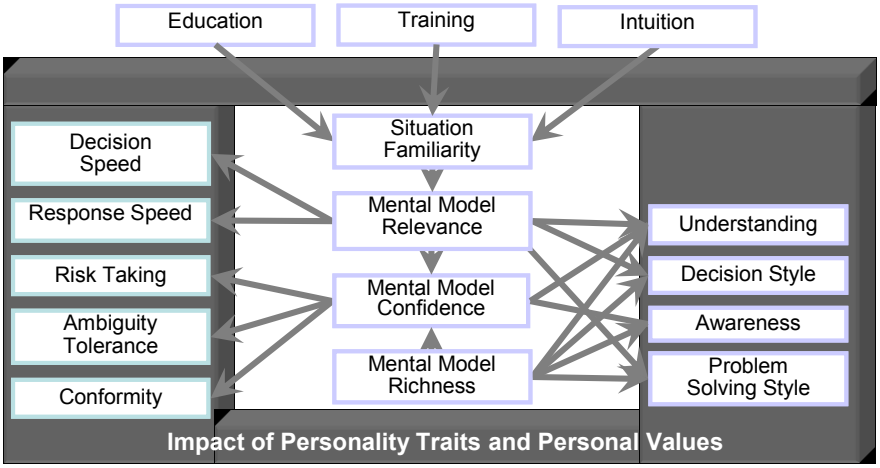

Figure 3. Mental Model Components in decision process of project manager.

Source: extended and adapted on the base of RTO (2007).

In this model, derived from RTO (2007) we extend the sources of situation familiarity with intuition (Antoniou et al., 2013) and impact of personality traits and personal values (Motta, Vascencelos, 2010). Whereas education and training are mainly impaired through discourse, intuition is shaped by self-reflections (Morgenstrahl, 2019).

3.3. Decision making model

Our brain is the best democratic behaviour example. In the decision making is never a single cell deciding. The mechanism of weighting between the groups of cortex cells decide about the choice of strategy: cooperation or confrontation (Philippe et al., 2024). Pre-frontal cortex (working memory) communicate with hippocampus (long-term memory). The voting system between the amygdala and cortex (in particular pre-frontal cortex) leads to the elaboration of the decision (Berkowitz, 2016). In Cortex we exercise the discursive process with traceable decisions. Amygdala hosts our emotions, with dominating fear. As amygdala is stronger and better interconnected with neighbouring cells, our decisions are rather induced by the emotions than rational elaboration.

Our brain makes about 20’000 decisions daily – 90% of them beside our consciousness (Pöppel, 2008), vastly based on unconsciously collected and stored in long term brain memory (Henke, 2021).

4. Consciousness

Baars and Gage (2019) see the cognition is a biological process in our brain of conscious combination of perception and memory. Many researchers (see comprehensive survey in e.g. Sattin et al., 2021) question this finding. Morsella (2016) expressis verbis consider the consciousness as a middle-man. Yet all agree, that it is a biological process in our brain.

In above models, the activity of a brain, communication between the cells, and voting, they all demand energy. Author consider the Orch-OR Theory (ORCHestrated Objective Reduction) of Penrose and Hameroff (2014) as currently best explaining the consciousness and the relation to the cognition, in context of Clapson (2016) theory, that consciousness is related to the fundamental time-space geometry, making our brain to work rather like quantum, than von Neumann computer. The proof of the Orch-OR Theory is yet to be brought.

According to ORCH-OR theory, in each of our 85 billions neural cells in the brain another millions of microtubules oscillate in bipolar states with a frequency of about 10 MHz. Each microtubule is simultaneously in two instable states (e.g. when we consider alternatives: apple or pear?). The spiral currents (spikes) moves the bipolar states in a three steps automatic leading to computations and choices. When the neural cells finally choose apple, the "pear" – states disseminate and gradually dissolve.

Microtubules needs energy to oscillate. Therefore, Penrose and Hameroff consider consciousness as a combination of the information (in memory cells) and energy. The information never disappear. However, when the microtubules do not get energy (e.g. as a consequence of the death), the quantum-state of the microtubules disappear. Authors conclude that our consciousness makes us the only existing world, all alternative worlds, disappear being unstable. Similar conclusion drafted Moser (1989) almost four decades earlier!

5. Intuition

Some 130 years ago, Rudolf Steiner (1893, 2020) formulated the thesis, that the choice of action, undertaken by a human is most of all depending on how his/her intuition capabilities can handle the concrete situation.

Leybourne and Sadler-Smith (2006) define the intuition as "a cognitive conclusion based on decision maker's previous experiences and emotional inputs". Morgenthaler (2019) sees the intuition capabilities in a direct relation to the degree of consciousness development. Our reaction to the intuition impulses upon received inputs decide about the development and efficiency of the intuition. As we absorb and store unconsciously inputs (e.g. perception of body language of our interlocutor) the intuitive conclusion based on broader information base,

than our discursive thinking. Katharina Henke proved, that human stores the unconsciously collected information in their long term memory in brain (Henke, 2021). Therefore Morgenthaler call it justified "over-consciousness".

This over-consciousness, paired with ones' own brain energy optimization, lead to spontaneous, intuitive, heuristic decision making, which proved to be efficient in solving complex problems (Kahneman, 2011; Thome, 2017). Ilgen (2019) consider intuition particularly relevant in strategic decisions.

Yet, cognitive biases in our thinking may negatively affect the outcomes of intuitively formed decisions (Smith, Griffin, 2024; Gigerenzer, 2023; Shedletsky, 2021; Kahneman, 2011). In this context, awareness of potential biases can support a more critical assessment of intuition-based decisions (Smith, Griffin, 2024).

6. Results discussion

6.1. Intuition in praxis

Natural sciences follows two axioms: Logics (clarity, freedom from contradiction, justification) and experiment (reproducibility, quantification, analysis). These exclude the spiritual and mental phenomena, thus intuition (Morgenstrahl, 2019).

According to the study of Parikh et al (1994), 13'000 american CEOs said, that they owe 80% of successful decisions to their intuition. Several papers, analysing the role of the intuition in management success may be found in Liebowitz (2023). Graf (2025) explicitly states, that he decides intuitively in his practice. Roeder (2011) broaden it in project management context.

Intuition require less cognitive efforts than discourse. As cognition is related to consciousness and the last to the information and energy, the shorter intuition based decisions use less energy than the discursive one. Thus intuitively deciding managers manage better their limited cognitive resources.

Intuition and discourse as two complementary processes. Keller and Sadler-Smith (2019) include the part of the discourse: the analysis in their Paradox Theory, which explores the synthesis of both the intuition and an analysis (Paradox: persistent contradiction between interdependent elements (Schad et al., 2016). Otherwise, this combination is called also dual process theory, developed in the last 25 years and successfully applied in management decisions (Kahneman, 2011; Haoye et al., 2021).

In the experiment of Leybourne with 521 project managers (Leybourne, Sadler-Smith, 2006) intuitive decision making was closely related to the improvisation capabilities of project managers. Managers with focus on external factors ("We" and "World"-dimensions) deployed

more often the intuitive thinking. And lastly more experienced managers decided more often intuitively than less experienced managers.

As intuition bases on over-consciousness, it comprises in the decision making more inputs, both internal and external, that the purely analytical cognition. Therefore it is more successful in complex management decisions, in particular in relation to inter-human relations and is a prerequisite of innovation (Wempe, 2021).

6.2. LEAD-Perspective

Launching of a project demands meticulous elaboration of the project foundations and certain, scheduled interaction with the stakeholder in the Environment. So the dimensions Goal and Environment dominate, without an urgency of problem solving. Intuition is here helpful, but rather Kahneman slow thinking is beneficial.

It changes in the next two following phases: Engage and Act. Here the human factor dominates the occurrences. Project Manager is well advised to listen to his "over-consciousness" and intuition. Capability to perceive the intuition impulses let him fast and proper react, thus reducing firstly the conflict potential, secondly to reduce the project risks impact. Dimensions We and Goal dominates.

The last phase: Deliver is again Goal and World oriented. Decisions in this phase are less intuition dependent and has more discursive character, relevant to the future users of the product.

6.3. Phenomenological Perspective

Leaders cognition processes consume less resources, are more flexible and relay on mental shortcuts. Perception formation and risk taking characterize the powerholders (Wang, 2024).

Table 1.
Phenomenological classification of the main decision impact factors

Dimension	**(Me) Leader personality orientation**	**(We) Working place relationship leader orientation**	**(Goal) Attitude towards the goal**	**(World) Environment leadership orientation**
WILLINGNESS/ COURAGE	Intuitive Risk taking Ambiguity tolerance	Intuitive heuristic Decision speed	Decision speed (Intuition first)	Intuitive Response speed, Conformity
CAPABILITIES/ POTENTIAL	Problem Solving Style, Awareness	Understanding	Problem Solving Style	Awareness
FEASIBILITY	Mental Model Confidence	Mental Model Relevance	Mental Model Relevance and Richness	Mental Model Confidence

Source: own taxonomy.

Feasibility of decision-making across all four dimensions is influenced by the underlying mental model, particularly through the dimensions of Relevance, Richness, Confidence, and their combinations. Within the capabilities domain, Awareness enhances decision-making

quality in both the World and Me dimensions. The Goal and Me elements are notably impacted within the Problem-Solving Style, while collaboration in the We dimension is primarily shaped by Understanding.

Moreover, several intuitive factors influence the willingness and courage to make decisions under uncertainty. The phenomenological classification presented in this section is based on the author's interpretation of practitioner experiences and is conceptually grounded in the TCI (Theme-Centered Interaction) model. While care has been taken to ensure theoretical consistency and relevance, the classification remains inherently subjective. It represents a synthesis informed by professional practice rather than empirical generalization. Accordingly, this framework should be regarded as a proposed model that requires further empirical validation.

7. Conclusions

This paper explores the central role of intuition in project management decision-making, emphasizing its significance as a crucial cognitive tool for experienced project managers. Theoretical insights drawn from the reviewed literature, as well as the phenomenological classification presented herein, reveal that intuition, particularly when rooted in over-consciousness, plays a vital role in enhancing decision-making efficiency and strategic thinking. These insights are grounded in the understanding that mental models, as a third-order cybernetic loop, integrate internal experiences with external inputs, supporting decision preparation (Ashby, 1956). While part of the mental model is consciously constructed, a substantial portion arises from unconscious perception of external stimuli (Kahneman, 2011), making decision-making itself predominantly unconscious. The Orch-OR theory (Penrose, Hameroff, 2011), though still unproven, offers a conceptual framework that lends credibility to the idea that consciousness involves an interplay of information and energy, explaining the dynamics of intuitive decision-making.

The key recommendations emerging from the models and reflections include:

1. Development of Intuitive Capacity: Project managers should be encouraged to actively develop their intuitive thinking alongside rational decision-making skills. Training programs should incorporate strategies to enhance awareness of intuitive processes and foster the confidence to apply them in practice.
2. Educational Paradigm Shift: Project management education should evolve to include intuition as a core component, ensuring that practitioners understand its role and learn how to integrate intuition and rational analysis in their decision-making processes.

3. Future Research and Empirical Validation: Further empirical studies are needed to explore the specific conditions under which intuition-based decision-making yields the most effective outcomes, as well as to refine the theoretical frameworks presented in this paper. This could lead to the development of concrete tools, training approaches, and methodologies that integrate intuition into standard project management practice.

In summary, this paper presents a conceptual foundation for understanding the role of intuition in project management and offers both theoretical insights and practical recommendations for future development in this area.

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QUANTITATIVE CRITERIA DETERMINING THE SELECTION OF MULTIPLIER METOHODS IN VALUING A SMALL ENTERPRISE BASED ON DENTAL SERVICES

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Purpose: The main purpose of this article was to present the key factors determining the valuation of a small business. As part of the research conducted, quantitative criteria determining the economic value of small businesses were defined and evaluated. The article presents the most commonly used multipliers and their importance from the perspective of determining the value of a small business. The key factors shaping the value of a small business taken into account in determining the weights necessary for the preparation of a valuation are included in the analysis. Small entities are defined as enterprises whose competitive advantage and high profitability is conditioned by the specialised knowledge and education of their owners, who usually practice the so-called liberal profession. The choice of dental services was dictated by the specificity of the business to be valued, the fact that one business can be run by people with similar specialisations.

Design/methodology/approach: In order to answer the research question posed, an analysis of the financial statements for the years 2016-2020, i.e. a period of 5 years, was carried out. Due to the COVID-19 pandemic, the financial situation of enterprises before the pandemic was also taken into account, with the assumption of a period of stabilisation of the financial situation in 2016-2019. The structure of current and non-current assets and its impact on shaping the financial result of the enterprise was assessed. The research was based on the financial data of 15 enterprises operating in the dental services industry located in the capital city of Warsaw.

Findings: Preliminary results of the study showed that the value of a dental practice is most strongly shaped by factors such as the stability of staff employment and investment in facility equipment. The performance of businesses related to the COVID-19 pandemic did not significantly affect dental businesses.

Originality/value: The topic addressed is a new issue from the quantitative side. It combines a very diverse range of issues, taking into account both a quantitative approach focused on financial analysis and a qualitative approach relating to the assessment of the situation by consumers of medical services. The essence of the issue taken up is that it relates to the specifics of the liberal professions, the way of valuation of which differs from other businesses.

Keywords: business valuation, freelance, multipliers, financial performance.

Category of the paper: Scientific paper.

Introduction

In the practice of business valuation to date, the defined, accepted and commonly used methods for determining the value of companies are the income, asset and comparative methods. Guidelines for their application have been adopted in Interpretative Note No. 5 - General Principles of Business Valuation and the RICS International Valuation Standards. The adopted standards have been developed by the professional business valuation community and their purpose is to set out principles of good professional practice in business valuation. These standards do not impose on analysts the need to use selected valuation methods, the appropriate selection of which affects the outcome of the valuation and depends on many factors both tangible and intangible taking into account the nature of the business. The state of knowledge to date indicates that there is little interest in the issue of determining the value of a small company, and many researchers apply the same standards for determining the value of small companies as for large companies, using only simplifications resulting from the lack of obligation to use full financial reporting. Data from the Central Statistical Office shows that the number of non-financial enterprises has been steadily increasing over the last several years. Data from the Central Statistical Office shows that the number of non-financial enterprises has been systematically increasing over the last several years (from 1,727,000 in 2010 to 2,262,000 in 2020), of which the vast majority were SMEs. In 2022, the share of micro-enterprises accounted for 97%, while small companies accounted for 2.2% (Raport PARP, 2022, p. 12).

The increase in the number of companies, the scale of mergers and acquisitions, changes in capital, tax, civil, insurance and compensation proceedings require research to focus more on highly specialised companies providing services to the general public.

The choice of the right method, which in turn depends on a correct assessment of the factors that make up the value of a business, leads to a division in the valuation process between 'traditional businesses' and 'specialised professional practices'. Specialised professional practices are defined as enterprises whose competitive advantage and high profitability are determined by the expertise and training of their owners, who are usually self-employed. At present, both academic output and practice in determining the value of a business have been little directed towards developing appropriate valuation methodologies for small businesses. Nor have the value-creating factors of small enterprises, whose source of competitive advantage lies in the role of endogenous factors, both tangible and intangible, been identified. The available results from studies carried out in other countries indicate that there are no homogeneous factors that shape the value of all small enterprises without taking into account their business profile. The literature points to specific valuation standards for individual activities (Table 1).

Table 1.
General valuation standards in different industries

Type of business	Practical principle applied in valuation
Accounting firms	100-125% of annual revenue
Car sales	0-10% of annual sales + inventories
Bookshops	15% of annual sales + stock
Cafes (exquisite)	40% of annual sales + stock
Day care centres	45-50% of annual sales including stock
Dental practices	60-65% of annual revenue including inventories
Dry cleaners	40-45% of annual revenue
Engineering services	30-35% of annual sales + inventory
Florists	30% of annual sales + inventories
Grocery shops (delicatessens)	15-20% annual sales + stock
Petrol stations (excluding shops)	35% of annual sales including stock
Gift shops	45% of annual sales including inventory
Hardware shops	125-150% of annual revenue
Insurance agencies	45% of annual sales
Landscape companies	90-100% of annual revenue
Law practices	40-45% of annual sales + inventory
Liquor shops	30-35% of annual sales + inventory
Full service restaurants	30-40% annual sales + inventory
Restaurants (limited portions)	25% of annual sales + inventory
Sports equipment shops	40% of annual sales + inventory
Taverns/bars	35-40% of annual commissions
Travel agencies	70% of annual revenue + inventory
Veterinary practices	

Source: Alhabeeb, 2014, p. 307.

Difficulties associated with establishing the value of small businesses whose activities can be recognised as a specialised professional practice include: the lack of diversification of activities due to the high level of specialisation and unique skills of the business owner, the high correlation between the specificity of the services provided and the level of intellectual capital of both the owner and employees, and the high proportion of intangible assets in total assets. Current value standards in business valuation refer to very generally formulated values and concern: fair market value, fair value, investment value and intrinsic value. However, there is a lack of any standards or research results in the area of standards relating to specialist practices. The literature explicitly points out that in the theory and practice of business valuation no standards have so far been developed for the valuation of goodwill (the intangible aspects of a company) (Zarzecki, 2010, pp. 89-98) and the research results presented in the studies refer to the American experience, which is of little use from the perspective of Polish economic realities. The factors shaping the value of specialised practices have not been sufficiently verified on the basis of data and financial results of companies operating in the Polish economic reality. Generally, the factors characterised and quoted in the literature do not include weights and are not classified according to the legal form of the business, the type of services provided or the location of the business. The methods currently used to determine the value of a small enterprise (without distinguishing its specifics) focus on the use of comparative methods, as defined in Interpretative Note No. 5. This is one of the methods that allow the value of intangible assets including goodwill of a company to be determined. Within the comparative

approach, three methods of valuing intangible assets are distinguished: the method of comparable uncontrolled transactions, the method of comparable profit margin, the method of exemptions from fees for the use of intangible assets. However, available studies indicate that these cannot be the only approaches used in practice (Szymański, 2021, p. 303).

Results of research carried out to date

The results of the completed research indicate the high importance of tangible (financial) as well as intangible (reputation) factors in shaping the value of dental practices. The development of appropriate multipliers to be taken into account in the valuation focuses on determining the importance of the individual factors. 'Dental practices are mainly differentiated by the amount and modernity of equipment. In addition, the number of dental practices is greater than practices of other medical specialities. Therefore, special valuation standards are developed for them (Kuczowic, 2012, p. 194).

As indicated in the literature, the value of a dental practice is shaped by the following factors: local economic conditions, age and condition of equipment, location, types of procedures, staff competence and experience, size of the practice, staff specialties and medical procedures used, as well as the terms of the facility lease (Michael, 2022, pp. 1-35).

Valuation of a dental practice taking into account the specifics of the activity requires not only taking into account the appropriate determinants but also requires knowledge of the industry in preparing the valuation, which clearly indicates the lack of possibility of developing uniform standards that could be included in the valuation of small specialist enterprises. Currently, there are two approaches used in the world in the valuation of dental practices. The first is the market approach. The market approach to valuation uses comparable previous sales transactions of similar practices to determine the value. The second commonly accepted valuation method is the profit capitalization approach. The profit capitalization approach uses the concept that a multiple of profits or capitalization of profits is a justified return on investment and therefore a justified value. This method is considered to be too often overused. The method based on the financial results of the practice is called the industry rule of thumb method. The disadvantages of this method include the number of different multiples that are used for the same type of practice (Trugman, 2018).

Important factors such as the possibility of relocating the practice, its size and the numbers of existing and new patients are also pointed out. It should be noted that the valuation methods commonly used and indicated in the literature are not reflected in the Polish reality. 'Some appraisers use the direct market data method in determining the value of a dental practice. This method attempts to determine the value of the practice using market data. This method typically multiplies gross revenues by a multiple derived from one or more

databases that track the price to gross revenue ratio of sold dental practices. The valuator typically attempts to determine whether the practice being valued has more or fewer strengths and weaknesses than a typical or average practice. This assessment is then used to determine whether the multiplier to be used will be more or less than the average multiplier. The choice of multiplier is usually subjective and depends on the valuer (American Dental Association, 2006, p. 48).

In the studies carried out to date, great importance is attributed to location and patient turnover and potential for loss of patients. ‘Location factors include town size, location near shopping centres and patient demographics. The potential loss of patients was analysed from the perspective of the sale of the dental practice and accounted for approximately 10% (Dunning, Lange, 2016, p. 91).

It is important to note that secondary data, that is, data on completed transactions and conducted valuations, is currently used worldwide in valuing a dental practice. For example, the ‘goodwill registry located in Plymouth Meeting, Pennsylvania, has collected data received from appraisers, auditors, business brokers and lawyers who have sent valuation information over many years. The methods used by the analysts identified in the registers were comparable market sales, gross revenue multiples, discounted cash flow, surplus earnings capitalisation and income capitalisation methods (Rawley, Benton, 2009).

However, the key factor for proper valuation of a company is the significance of the multiplier used in the valuation. "In this method, the valuer multiplies the current gross revenues achieved by the dental company by the company value ratio. According to research, the price to revenue ratio (P/R) for general dental practices, maxillofacial surgeons and orthodontists in 2010 was approximately 60% (Brown, 2020, pp. 36-46).

Currently, the largest database is available in Canada and the US. The appraisers' work uses the ’Private Company Pricing Line Addendum (IPCPL), a resource useful for smaller companies with revenues of less than $10m a year. This database uses private (and some public company) resale statistics to develop a discount rate calculator specifically for private companies by regressing the prices actually paid for 500 private companies over the past few years, the equivalent discount rate and revenue (Feder, Rosoff, 2000, p. 13).

According to the results of research available so far, based mainly on experience from the US market, it is currently not possible to implement multipliers used in other economic realities. It should be noted that sale and purchase transactions cannot be the only point of achievement for determining the value of an enterprise, therefore it is important to determine both financial and non-financial factors determining the value of an enterprise in a specific economic reality, taking into account the specifics of a given small enterprise.

Purpose and research methods

The main objective of the article was to define the factors determining the value of small enterprises operating as a capital company by persons representing liberal professions (according to the definition of liberal professions contained in Article 88 of the CCC).

The research was carried out on the basis of basic balance sheet data and financial results of enterprises in the dental services industry, on the example of 15 treatment entities operating in the central districts of Warsaw. Financial data was obtained from the National Court Register. The years 2016-2020 recorded in the balance sheets and profit and loss accounts of the dental services analysed were analysed. The criterion for selecting the sample for the study was the lack of possibility to diversify the business due to the high level of specialisation and unique skills of the business owner. Only homogeneous and diversified dental services were included in the sample selection. Companies whose business consisted of combining dental services with other medical services and chain establishments were excluded from the study.

The focus of the study was to establish the impact of quantitative financial factors on the formation of company value. It should be noted that the available publications also point out that there are no formal rules for company valuation that indicate the differences between small and large entities (Zarzecki, pp. 261-274).

The main value factors were developed on the basis of the links between the DCF (income) approach and the specificity of the value of small businesses. However, the terminology used most often refers to ‘small enterprises’, and in the available studies the authors focus their considerations on an attempt to characterise the factors identifying their value. It should be noted, however, that the term ‘small enterprises’ does not clearly indicate which group of entities is meant. The definition of a small enterprise appears in many legal acts and is very broad. However, no provision clarifies the essence of a small enterprise from the perspective of the factors affecting its value for both customers and stakeholders. In addition, the factors that build the value of a small business often identified as important in the literature are not the same as those that influence the value of specialist practices run by professionals. The aim of the study was to verify whether the factors indicated in the literature as important from the perspective of value creation of a small enterprise are equally important from the perspective of value creation of a dental practice. A key element in the selection of enterprises for the study was not so much professionalism as specialisation. Entities comparable in size and scope of services were accepted for the study. The study examined the relevance of the factors shaping the value of a dental practice, such as:

- the sustainability of employment (measure: % share of salaries in operating costs),
- the level of investment in the equipment of the establishment (measure: % share of fixed assets in the balance sheet total),

- the ownership status of the real estate on which services are provided (measure: % share of the value of buildings in the value of fixed assets),
- demand for services (yardstick: average level of revenue generated in selected years),
- the position of the service provider in the market (measure: how long the service provider has been operating in the market).

The method used in the study was to analyse the data recorded in the financial statements for the years 2016-2020 in order to establish coefficients such as: % share of fixed assets in total assets, % share of equipment in total assets, % share of salaries in operating costs, % share of building value in fixed assets, number of years on the market, level of revenue (cv).

The study also defined ranges for the relevance of the individual attributes allowing specific weighting to be assigned to the selected company operating in the dental services market. The analyses also determined the impact of the COVID-19 pandemic on the financial performance achieved. The study focused exclusively on financial factors. The results obtained were confirmed in the statistical analyses for which the following methods were used: descriptive statistics, Pearson's correlation coefficient and the t-student's statistical significance test.

Results

As can be seen from the analyses carried out, the market for dental services, despite the homogeneity of the services offered, is differentiated in terms of the relevance of the various attributes to both building the value of the business and the financial results achieved. The analysis of the revenue generated from the core business between 2016 and 2020 showed that the COVID pandemic did not significantly affect the level of sales revenue generated. Relative to the 2016 base year, at the end of 2020, dental companies increased their revenues by nearly 40%. No significant correlation was found between the amount of revenue achieved and the number of years an establishment has been in business.

Table 2.
Structure, quartiles and volatility of dental revenues from 2016 to 2020

Years	Mean	Median	Minimum	Maksimum	Lower quartile	Upper quartile	Standard Deviation	(cv)
2016	3 114 322,96 zł	1 446 322,40 zł	0,00 zł	10 762 979,12 zł	811 121,50 zł	5 738 574,89 zł	3 544 569,42 zł	113,8151
2017	3 488 109,29 zł	1 908 461,12 zł	0,00 zł	10 847 485,59 zł	567 939,20 zł	6 676 120,57 zł	3 627 752,93 zł	104,0034
2018	3 491 425,30 zł	1 748 637,52 zł	0,00 zł	10 941 847,00 zł	573 525,05 zł	6 558 876,33 zł	3 865 365,57 zł	110,7102
2019	4 234 737,13 zł	2 574 392,77 zł	0,00 zł	12 313 462,97 zł	529 262,71 zł	8 356 357,68 zł	4 305 236,09 zł	101,6648
2020	4 871 338,23 zł	4 500 126,46 zł	0,00 zł	11 457 332,50 zł	1 121 430,94 zł	7 621 181,41 zł	4 319 934,71 zł	88,6807

Source: own research.

The group of companies surveyed consisted of those operating in the market for between 2 and 20 years. No significant correlations were found between the amount of revenue generated and the number of years the practice had been operating in the market.

In the literature, an important role is attributed to the constancy of employment in shaping the value of a dental practice. As a financial measure, the share of salaries and its variation from year to year in operating costs is taken as a measure (table 2). The analysis carried out showed a large variation in the level of this measure and a lack of correlation between the amount of sales revenue and payroll liabilities. With regard to the importance of real estate ownership in shaping the value of the company, the % share of real estate value in the value of fixed assets varied greatly, and with regard to the sample analysed, only a few companies reported this balance sheet item in their financial statements. The average share was 38%.

With regard to the constancy of the sales revenue generated, examined as demand for services, its variability was not related to the level of employment. According to the studies carried out so far, the average share of fixed assets in the balance sheet total was 60%. However, the analyses carried out concerned dental practices in the US market, whose multipliers were established on the basis of actual acquisitions of medical companies in the US. The averages obtained in the study were compared with the results of the US study using the t-student test. The value of the calculated t-student statistic was -2.73 with a statistical significance level of $p = 0.02$.

The study confirmed that among the commonly cited financial factors shaping the value of dental practices, factors related to the level of fixed assets, such as equipment and facilities, as well as the stability of employment, are important. The results obtained only halfway confirm the correct choice of multipliers used in the valuation of this type of business. According to an analysis of the financial statements of dental facilities, the COVID-19 pandemic also did not significantly affect changes in the level of fixed assets held or the stability of employment. Only the level of fixed assets held by the facility, mainly plant and equipment, and the level of salaries showed a relationship with the level of revenue (table 3).

Table 3.
Average share of key financial drivers of dental practice value in total assets

	Mean	Median	Minimum	Maksimum	Standard deviation	CV
% share of fixed assets in total assets	40,40	34,83	9,71	85,59	25,87	64,05
% share of wages and salaries in operating costs	15,97	12,68	1,47	42,39	12,84	80,37

Source: own sources.

Discussion

According to the research conducted, not all aspects relevant to the valuation of a company can be determined on the basis of an analysis of financial statements, which is why it is important to include intangible aspects in the valuation as well; with regard to fixed assets,

an example is the modernity of the medical equipment and apparatus owned, as assessed by both owners and patients.

Despite the large number of buy-sell transactions carried out in the US market, most of the results obtained on the value of businesses in the dental services market need to be continuously updated in terms of price levels, which will change if only with medical advances. In addition, transaction data cannot be used for companies operating in other economic realities exposed to other risk factors. The pilot study showed that for dental practices operating in large cities located in business and commercial districts that are attractive, the equipment owned by the practice and the stability of the workforce are key to creating value for the service. The analysis of revenues shows that customers attach less importance to the location of the practice, which indicates the importance of specialisation and expertise in the choice of services. The analysis of revenue and revenue structure shows that revenue is not only determined by the number of customers, but also by the segmentation of services offered.

These results allow us to conclude that the development of appropriate multipliers for valuation would require a breakdown into specific areas of dental services, which internally prove to be heterogeneous. The research carried out does not fully confirm the results of the US study in terms of establishing the type of factors that create the value of a dental practice in terms of reporting. The lack of correlation between the number of years of operation of the practice and the amount of revenue generated may suggest both a high demand for dental services and indicate other factors of importance to the customer, such as price, qualifications possessed by employees. For the time being, it is necessary to carry out further more in-depth analyses that also take into account the importance of non-material factors involving both medical staff and patients, as well as taking into account facilities located in smaller towns.

Conclusion

The analysis of the available literature results indicates that there is little interest in conducting research on the application of multiplier methods in relation to Polish realities. Also, the available results of foreign research do not report up-to-date research results in the search for appropriate valuation methods for small enterprises characterised by high specialisation and knowledge of the owner and those providing dental services. At present, in Polish business valuation practice, the results of American experience are often used, which does not take into account the risk factors present on the Polish market. Our own research confirms the importance of only some financial attributes in creating the value of a specialised dental practice. So far, no universally recognised business valuation standards specify the methods that should be used to determine the value of a small business. There is also a lack of defined and research-confirmed multipliers that could be used in valuation processes. The lack

of sufficient scientific research in this area does not correspond to the needs and practical implications of using valuations of small businesses, which play an important role in court cases, compensation processes and purchase-sale transactions. With a view to further analysis, further research is planned, both quantitative and qualitative, to assess which factors most determine the value of a company.

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COMPARABILITY OF ECONOMIC AND FINANCIAL DATA IN THE THEORY AND PRACTICE OF FINANCIAL ANALYSIS

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Purpose: The aim of this article is to provide an overview of the distortions in the comparability of economic and financial data that may occur in the course of economic analyses.
Design/methodology/approach: The theoretical considerations presented in this publication are based on a critical analysis of the financial analysis literature. The problems presented are supported by numerous empirical examples (case studies).
Findings: A properly prepared economic and financial analysis is most often based on a comparative analysis of the financial data under consideration. When conducting such an analysis, however, it should be taken into account that the data used in it may not be comparable. The ability to identify distortions (from different areas) may, nevertheless, allow correct conclusions to be drawn regarding the economic condition of the analysed economic entity.
Originality/value: The originality of this publication results from the multi-faceted approach to the issue of economic analysis. The considerations combine aspects of accounting, finance or legal issues. In addition, both micro- and macroeconomic aspects are included in the course of the argument.
Keywords: comparability of financial data, methodological, financial, organizational and substantive distortions, inflation, valuation, IFRS/IAS.
Category of the paper: Viewpoint, Case study.

1. Introduction

This article presents an important and significant aspect of economic and financial analysis concerning distortions in the comparability of data that are subject to analysis. Four areas of distortion can be distinguished: methodological, financial, organisational and material. The most common problems observed during the analysis are distortions in the first two areas mentioned above, i.e. methodological and financial. Taking the above into consideration, a significant part of the theoretical considerations presented in the article, supported by analysis of case studies taken from the economic environment, concerns methodological and financial distortions.

2. Literature review

In the economics and finance literature, various accounting definitions can be identified. For the purposes of the present paper, accounting can be defined, on the one hand, as an information system (Andrzejewski, 2012, pp. 32-36; Hołda, 2012, pp. 125-140; Walińska, 2014, pp. 509-523), and on the other hand as the voice of business (Turyna, 2014, pp. 8-10; Świderska, Więcław, 2016, pp. 19-20). Accounting as an information system focuses on the assessment of the economic condition of an entity and the outcomes of its business activities. Information about an entity's resources and sources of financing is expressed in the balance sheet, while the effects of its operations are found in the profit and loss statement and in the cash flow statement. Subsequently, accounting as an information system provides stakeholders (both internal and external) with information about the economic and financial condition of the business entity. Thus, accounting as the language of business provides information used by management in making both short and long-term decisions. Information from the accounting system is also used by external stakeholders, for instance, when deciding whether or not to invest capital in a given business entity.

The information generated in the accounting system is reported to external audiences in the form of financial statements. Thus, a financial statement can be defined as a product of accounting (Micherda, 2003, pp. 465-479; Zieniuk, 2020, pp. 15-29) that helps to shape the picture of an economic entity and is, further down the line, communicated to stakeholders. According to Micherda (2003, pp. 465-479), an integral part of accounting is financial analysis, used when reading and interpreting financial statements. Thus, according to the literature, financial analysis performs one of the functions of accounting (Stępień, 2019, pp. 24-36), that is, the analytical function. In order to be able to perform this function efficiently and effectively, the data that are subject to analysis, mainly in the form of financial statements of business entities, need to be comparable. This is due to the fact that in the course of analysis, in order to draw valid conclusions about both the present and the future, multidirectional comparisons are made on many levels. In this respect, we can distinguish comparisons over time, comparisons with the plan (budget) or comparisons across an entire field (that is, with other units or industry averages) (Waśniewski, Skoczylas, 2002, pp. 32-34). The possibility of valid conclusions about the financial condition and the state of the assets of the entity and its financial results is conditioned by the quality and comparability of the analysed data. It should be noted, however, that in economic practice there may be many factors that will interfere with this comparability. As indicated by Waśniewski and Skoczylas (2002, p. 29), distortions can be divided into:

- methodological,
- financial (pricing),
- organizational, and
- substantive.

In addition to these, Nowak (2008, p. 39) points to time-related distortions in comparability, resulting for instance, from the analysis of financial data covering different reporting periods. This may occur, for example, when an entity changes the financial year, affecting such categories as revenues, expenses and the financial results of the entity.

3. Methods of research

The starting point for the considerations presented in this article is a critical analysis of the literature on financial analysis, taking into account the issue of distortions in data comparability. Referring to the aforementioned publications by B. Micherda (2003, pp. 465-479), T. Waśniewski and W. Skoczylas (2002, pp. 29-34), within the identified areas of distortions, examples of problems were identified and analysed in the form of case studies.

The research concerns financial statements of selected economic entities prepared in accordance with different accounting standards (the research referred to selected companies preparing statements in accordance with the Polish Accounting Act, as well as in accordance with IAS/IFRS and USGAAP).

The considerations refer to balance sheets, profit and loss accounts and cash flow statements. Information contained in other elements of the financial statements (i.e. in the additional information) and in the auditors' reports on the financial statements was also analysed.

4. Methodological distortions

In terms of the comparability of economic and financial data, methodological distortions may, for example, result from changes that take place in financial reporting, different accounting standards, or even different definitions of indicators used in the analysis.

Some examples of changes in financial statements that may have caused a problem in data comparability include:

- a requirement for the balance sheet as to the categorization of assets, prepared in accordance with the Accounting Act of 2016, to show: "Owner's equity (shares)" and "Called-up contributions to share capital",
- the introduction in 2016 of an international standardization (with mandatory compliance for reporting periods from January 1, 2019), namely IFRS 16, concerning the recognition and presentation in the financial statements of leases (IFRS 16).

The change that has taken place in Polish regulations for balance sheets regarding the presentation of "Owner's equity (shares)" and "Called-up contributions to share capital" has the effect of artificially inflating the balance sheet's total and the value of equity. Thus, the structure of liabilities has also changed: the share of equity has increased, while the level of debt has decreased, which could imply that the financial condition of the analysed business entity is better than in reality. Of course, this problem will not occur if (which happens quite often) the values of these items in the balance sheet amount to "zero". At the same time, it should be added that such solutions are not commonly used in other accounting systems. For example, IAS 32, paragraph 33 indicates that "if an entity acquires its own equity instruments, these instruments (acquired stakes/own shares) are deducted from equity" (IAS 32, § 33). This factor can result in an overstatement of the value of assets and the value of equity when making comparisons with businesses producing financial statements under different accounting standards.

The second example mentioned concerns the recognition of leases in financial statements prepared in accordance with IFRS/IAS. The introduced standard eliminated the concept of operating leases, and thus the off-balance sheet presentation of assets used under such principles (https://www.inglease.pl/_fileserver/item/1500275). In the case of business entities which, prior to the implementation of above standards, used assets under operating leases, such solutions resulted in, among other things (*MSSF 16 „Leasing". Całkowicie nowa koncepcja…*): an increase in the value and share of payables among liabilities, an increase in the value of fixed assets, an increase in depreciation, and financial expenses (in the form of interest) with a corresponding decrease in the value of third-party services. The above changes resulted in an increase in EBITDA. Adjustments are also visible in the cash flow: the net operating cash flow increases, while net cash flow from financing activities is decreasing.

According to Hońko (2016, pp. 41-51), referring to publications prepared by the IASB, the introduction of the above standard had its greatest impact on the value of liabilities of companies in retail, airlines, hospitality and leisure, and transportation industries. In the case of retail and airlines, as a result of implementation of IFRS 16, an estimated increase of the amount of long-term liabilities has more than doubled.

As indicated earlier, the cause of methodological distortions in the comparability of economic and financial data may also be the dissimilarity of accounting standards applied in the preparation of financial statements. Of course, different standards do not necessarily result in significant differences in the key items presented in the financial statements and the analytical ratios based on them, but on the other hand, the differences between reports prepared using different accounting standards can be significant. This publication will take a closer look at the examples of two business entities where financial data prepared using different accounting standards are made available. These will include:

- Dadelo SA - an entity engaged in the sale (both in-store and online) of bicycles and bicycle accessories, listed on the Warsaw Stock Exchange as of 2020. The comparison will focus on the entity's financial figures as of December 31, 2020, prepared according to the Accounting Act versus International Accounting Standards[1].
- ASML Holding NV - a Dutch company specializing in the production of photolithographic machines used in the manufacture of semiconductors, with shares listed on the Amsterdam and New York stock exchanges. The entity prepares its financial statements based on International Accounting Standards and using US GAAP[2] - the comparison will include data as of December 31, 2023.

Table 1.
Selected financial figures of Dadelo SA as of December 31, 2020, based on the Accounting Act and using IFRS/IAS (in thousands of PLN)

Specifications	Figures as of 31.12.2020 based on the Accounting Act (Financial statement as of 31.12.2020)	Figures as of 31.12.2020 based on IFRS/IAS (Financial statement as of 31.12.2021)
Fixed assets	5,175	11,312
Current assets	20,142	20,142
Total assets	25,317	31,454
Equity	16,836	19,605
Liabilities	8,482	11,850
Sales revenues	64,521	64,521
EBIT	5,746	6,272
Net financial result	4,554	5,061

Source: own compilation based on Dadelo SA Financial Statements as of 31.12.2020 and as of 31.12.2021.

In the case of Dadelo SA, the change in accounting standards can be observed. It has significantly affected the information contained in the entity's financial statements. The most significant change takes place for fixed assets - an increase of 119% in their value can be observed. These differences are mainly attributable to the lack of depreciation in IFRS/IAS of company value (in accordance with IAS 36 Impairment of Assets) and the disclosure (in accordance with IFRS 16 Leases) in the financial statements of the long-term lease agreement. These differences between accounting standards also affected the observed changes in the structure and value of liabilities, as well as the level of financial results (both operating results and net financial results).

The next table presents selected financial data of ASML Holding NV as of 31.12.2023, based on US GAAP and IFRS/IAS. The biggest discrepancies that can be identified relate to the value of fixed assets. The notes to the entity's financial statements indicate that the variation is mainly due to the different recognition of R&D expenses, in statements prepared in accordance with IFRS/IAS.

[1] Example of a comparative analysis (Accounting Act vs. IFRS/IAS) of accounting solutions for financial instruments, see publication: (Rówińska, 2015, pp. 181-188).
[2] The differences between the referred standards (that is, IFRS/IAS and US GAAP) are exemplified in the publication: (Gierusz, 2023, pp. 9-36).

Table 2.
Selected financial figures of ASML Holding NV as of 31.12.2023, based on US GAAP and using IFRS/IAS (in million Euros)

Specifications	Figures as of 31.12.2023 based on US GAAP	Figures as of 31.12.2023 based on IFRS/IAS
Fixed assets	15,564	19,009
Current assets	24,394	24,069
Total assets	39,958	43,079
Equity	13,452	16,210
Liabilities	26,505	26,869
Sales revenues	27,559	27,559
EBIT	9,042	9,512
Net financial result	7,839	8,115

Source: own compilation based on ASML Holding NV Financial Statements as of 31.12.2023.

In the process of financial analysis, another problem of methodological distortions is the commonly divergent definitions of the analytical indicators used. This problem can apply to most indicators, but for the purposes of this paper, two will be examined:

- current liquidity ratio and
- inventory cycle in days.

The first of these indicators bears information about the entity's ability to pay its short-term liabilities on time. It is used in the day-to-day management of the enterprise, but is also a very good tool in predicting any threats to the continuity of the business. The concept of the definition of current liquidity ratio was extensively presented in earlier publications of Maślanka (2013, pp. 255-264; 2019, pp. 31-36). In this respect, the publications of the following authors can also be cited: Krzeczewski, Krzeczewska, Pastusiak (2017, pp. 63-80), and Kuciński (2022, pp. 180-191).

Referring to the terminology taken directly from accounting, this ratio should be defined as current assets divided by short-term liabilities. However, referring to the terminology of management, this ratio should be defined as: short-term assets divided by current liabilities. Most often, current assets are defined in the literature as follows:

Short-term assets = current assets - trade receivables over 12 months

Dudycz (2011, p. 64) defines the indicator in question differently, namely:

Short-term assets = inventories + short-term receivables - trade receivables over 12 months - receivables claimed through court

Other aspects are pointed out by Wędzki (2009, pp. 112-113):

Short-term assets = current assets - trade receivables over 12 months + short-term positive company value + short-term asset component of deferred tax

Similar definitional problems may arise with this indicator’s denominator. Here we find short-term liabilities, or using managerial terminology, current liabilities. In this case, it should be remembered that among current liabilities we may also find trade payables of more than 12 months. Additionally, from the perspective of the entity’s management, it should also be considered that among liabilities one can find economic categories very similar to short-term payables - for example short-term accruals.

The second of these indicators is the inventory cycle, which is used in the day-to-day management of the enterprise, especially in the management of working capital. For this indicator, the definition is as follows:

Inventory cycle in days = (average inventory × number of days in the period) / cost of sales

In this case, each of the three economic categories indicated in the definition can be determined differently. For example, the average inventory is most often determined based on data taken from the opening balance sheet and the closing balance sheet of the business. However, in a situation where we are dealing with an enterprise that is growing dynamically or an entity whose activities are characterized by seasonality, it may be more appropriate to use data from shorter periods, from several consecutive observations or simply from the end of the period.

The second in terms of size or magnitude is the number of days in a period, most often referring to calendar days in a year (we can consider 360 or 365 days). However, in some analyses, you can find information on working days in the referred period (year), which varies significantly from calendar days.

Referring to the denominator of the inventory cycle indicator, here we find information about the cost of sales, that is, the value taken from the income statement in the calculation method. The question remains unanswered whether the costs of goods sold should be increased by the costs of the period, that is, costs of sales and overheads? How should this problem be approached if the entity prepares the income statement only in the comparative version based on costs by type? On the other hand, it should be noted that in some publications dealing with financial analysis, this ratio is estimated using the stream of revenues from the sale of products, commodities and materials (Waśniewski, Skoczylas, 2002, p. 176) the items of which may differ significantly from the incurred costs associated with the operating activities of the business.

A separate problem in methodological comparisons encountered when making comparisons with a plan or budget of an economic entity may be the fact that planned (forecast) financial statements are most often prepared with a greater or lesser degree of simplification (Gryko, 2007, pp. 510-519). They reflect the average values of various economic categories, excluding the so-called one-time (non-recurring) events. However, it should also be remembered that the presented plans or forecasts primarily approximate the effects of the entity's operational activities. Thus, the existing deviations from the plan (budget) may be a result of non-operational activities, that most often will not be repeated.

5. Financial distortions

Another type of distortion in financial analysis is that arising from the financial area. Here we can talk about problems related to inflation, valuation and the system of value recognition.

For a number of years, inflation may have been marginalized in the course of financial analyses, both short-term and those involving longer time periods. However, recent years (average annual inflation in 2022 was 14.4%, in 2023, 11.4%, and in February 2023, December-to-December inflation was 18.4%) (https://stat.gov.pl/...) have shown that the impact of inflation on the analysis can be significant. The inflation we have experienced in recent years has caused a significant problem when comparing data over time, especially when analysing multi-year data (a good analysis should cover a minimum of three consecutive time frames, that is, when analysing annual data it will cover three consecutive years). Interpretation problems will occur, particularly when analysing stream values, that is, revenues, costs or financial results obtained by the entity.

The issue of inflation will be all the more important when analysing the effectiveness of the investment. When forecasting cash flows related to an investment project, a problem will arises: should the forecasts be made in constant prices or current prices? If at current prices, what rate of inflation should be taken into account when adjusting the projected revenues and costs? A separate issue is how to estimate the discount rate in inflationary conditions, and which one to assume: real or nominal?

Another issue that should be recalled in the context of distortions of the analysis of the economic and financial situation of an entity is the issue of the valuation of the assets, liabilities, streams of income, and operating expenses. It should be remembered that in many areas, accounting allows the application of different bookkeeping policies, and valuation is certainly such an area. For example, when analysing assets, it should be recognized that they should be valued at the time of use, at the balance sheet date, as well as at the time of sale or when the asset is used up. Ultimately, the decisions about the type of accounting policy adopted by the entity will probably have the greatest impact on financial results, revealed in the financial statements. This topic was discussed in Maślanka (2007, pp. 520-530), as well as Grabiński (2016), Hernik (2001, pp. 21-32), Luty (2001, pp. 116-121) and Stępień (2019).

When discussing the problem of how different methods of valuation affect the findings of a financial analysis, one can consider the example of valuation of inventory outflows by the Orlen Group (see also: Zarzycka, Klimczak, 2011, pp. 163-178). In its financial statements, prepared in accordance with IFRS/IAS, the company values inventories using a weighted average production cost or cost of purchase method. At the same time, however, the company reports to investors the values of its financial performance using the LIFO approach to inventory valuation, eliminating the impact of changes in oil prices on the Group's performance

(https://www.orlen.pl/...). A comparison of the performance of EBITDA for 2020-2023, as reported in the financial statements, and determined using LIFO inventory valuation, is presented in the table below. As can be seen in the reports for 2022-2023, the differences in EBITDA values oscillated within +/-2%. In the previous period (2020-2021) they were many times higher. Similar discrepancies would appear when comparing the rates of return determined using the EBITDA value, which could distort the conclusions of a profitability analysis of the business under investigation.

To summarize the discussion, we can quote Luty (2001, pp. 116-121): "What does a profit achieved mean? According to the current rules, it means as much as crediting real or hypothetical consumption of resources that can be coextensively offset to income, in compliance with current conventions".

Table 3.
Development of EBITDA and EBITDA with consideration of inventory valuation, according to the LIFO method- Orlen Group for 2020-2023 (financial data in PLN million)

Specification	2023	2022	2021	2020
EBITDA	42,256	56,074	19,211	8,465
EBITDA (correction LIFO)	43,155	54,977	14,965	10,839
Variation (%)	-2.1	2.0	22.1	-28.0

Source: own compilation based on Orlen Group and Orlen SA Board of Directors' Report 2023, p. 365 (https://www.orlen.pl/...).

Another problem that should be noted when referring to methodological distortions is the presentation in financial statements of values. This problem will be presented using the example of different depreciation rates of similar assets that can be applied in different business entities. For example, two business entities from the same industry acquired production machinery for the amount of PLN 1 million. In line with the depreciation policy applied in entity A, the depreciation period of the acquired asset was set at 4 years (a rate of 25% per year), while in entity B it was 5 years (a rate of 20% per year). Both entities generated comparable revenues from the sale of goods (approximately PLN 1.5 million annually). The analyses need to look at the efficiency of fixed assets utilized, as measured by the productivity index. Selected calculations over the first 3 years are presented in table below. In analysing the data, two things should be emphasized: the successive increase in the productivity ratios in both entities and the increasingly favourable level of the considered indicator in entity A compared to entity B. At the same time, it is likely that the obtained rates of return (measured by net or gross financial result) in entity B would be at a more favourable level compared to entity A. Are the conclusions presented really indicative of such changes in the financial condition of the entities? It seems that this question can be left unanswered.

An analogous problem can be observed in the case of small-value fixed assets: business entities have the right to choose that the expense incurred for the acquisition of such assets be fully recognized as current-period expense or in accordance with the expected economic life of the assets to determine their depreciation period.

Table 4.
Evaluation of the productivity of fixed assets in companies A and B

Specification	Year 1	Year 2	Year 3
Net fixed assets (company A) (in PLN)	750,000	500,000	250,000
Net fixed assets (company B) (in PLN)	800,000	600,000	400,000
Sales revenue in the year (in PLN)	1,500,000	1,500,000	1,500,000
Fixed assets productivity ratio (A)	2.00	3.00	6.00
Fixed assets productivity ratio (B)	1.88	2.50	3.75

Source: own compilation

As a comment to the considerations presented here, consider the statement by Brealey and Myers (1999, p. 1086): "The true value of assets may be lower, so a low rate of income from assets does not necessarily mean that a company's assets could be put to better use. Similarly, a high rate of income does not mean that you could acquire the same assets today and get an equally high rate of income from them".

6. Organizational and substantive distortions

Organizational distortions in the comparability of economic and financial data may occur when the organizational structure of the enterprise in question changes, for example, resulting from a merger with another entity, the acquisition of another entity, or the division into several enterprises. Moreover, distortions of this type will most often occur when there is a need to restructure the entity, resulting from the poor financial condition of the entity under consideration.

One example of an entity that has grown dynamically over the past few years is the Orlen Group. In this case, the entity's growth is mainly attributed to external developments involving the acquisition of other entities, both with similar business profiles and those operating in completely different areas. Over the past few years, the Orlen Group has acquired, among others: ENERGA Group (2019), RUCH SA (2020), LOTOS Group (2022) and PGNiG SA (2022). Thus, when analysing all areas of activity of this entity, one needs to bear in mind that a significant part of the changes that have taken place over the past few years are due to this policy of mergers and acquisitions. Omission of this factor when analysing liquidity, debt, profitability or the efficiency of operations may result in incorrect conclusions regarding the effectiveness of this enterprise.

A different situation occurred in Selvita SA, which for organizational and financial reasons, in 2019 split into two capital companies (https://strefainwestorow.pl/...): Ryvu Therapeutics SA and Selvita SA. As a result, the existing entity was divided into two bodies: Ryvu Therapeutics, a company which will continue to develop innovative oncology therapies, and Selvita, rendering research services to other pharmaceutical, chemical or biotechnology companies, providing qualified research teams in the form of outsourcing (https://ryvu.com/wp-content/...).

In this case, due to the organizational changes, it will be impossible to carry out a proper analysis in time.

Substantive distortions (in other words, business related) (Nowak, 2008, p. 40) can occur when the technology of the entity's manufactured products changes. It should be remembered, however, that avoiding such problems in the current turbulent times, with dynamic technological progress is practically impossible, and therefore, especially when conducting an analysis over time, this factor should be kept in mind as one of the causes of such changes.

Going further, substantive disruptions also occur when an entity's business profile changes, not only due to the withdrawal of deteriorating products or the introduction of a new offering, but as a result of change in the entity's business model. For example, this type of fundamental change in business profile took place in 2010 in a company listed on the NewConnect stock exchange since 2008, namely Blu Pre IPO SA (formerly: Carbon Design SA and Carbon Invest SA). This company in the 2009-2010 operating period engaged, among other things, in the production of bicycles, then in the production of chassis for sports and racing cars (https://newconnect.pl/ebi/files/1661-raport.iii.kw.pdf). In 2010, the company withdrew from its existing businesses and completely re-formulated its business model. Since 2010, the company's business focus has been "the acquisition of shares of companies classified as small and medium-sized enterprises, including companies in the early stages of development or just starting up" (https://newconnect.pl/ebi/...). Thus, any analysis of the financial data over time of the described entity covering the years 2009-2011 is impossible, since these figures describe a completely different business profile of the company.

7. Summary

Correctly prepared economic and financial analysis will be largely based on a comparative analysis of the financial data. When making such analysis, however, it should be remembered that the data used in it are characterized by greater or lesser comparability. The ability to identify distortions (of different types) may, nevertheless, allow drawing valid conclusions about the economic condition of the investigated business. On the contrary, in certain situations, looking for example at the problem of different accounting standards or the differences between real and nominal terms, can help to better understand the processes taking place in the economic entity under scrutiny.

In summary, it should be emphasised that a correct in-depth analysis of an entity's financial situation requires a simultaneous overview of the economic entity from different perspectives. Thus, correct conclusions can be drawn by analysing of the problem simultaneously through the prism of the balance sheet, profit and loss account and cash flow statement. Furthermore, correct conclusions should take into account external, i.e. macroeconomic factors.

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ANALYSIS OF THE AUDIT MARKET IN POLAND FROM 2010 TO 2020

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Purpose: The aim of this article is to provide an overview of the concentration issue on the Polish audit market.
Design/methodology/approach: The theoretical considerations presented in this publication are based on a critical analysis of the literature on the subject. The empirical part presents an analysis conducted on the basis of audit reports of financial statements of companies listed on the Warsaw Stock Exchange in the period 2010-2020. A total of 4281 audit reports concerning 506 listed on the Warsaw Stock Exchange entities were analysed.
Findings: Among the conclusions presented, it can be pointed out that the Polish audit market is less concentrated compared to other European countries. It was noted that, during the period under review, the market share of the Big Four entities is decreasing, while the importance of the other large (usually also global) audit entities is increasing.
Originality/value: The original aspect of this publication is the detailed analysis of the audit market structure in Poland. The author of the paper proposed a significantly more detailed division of audit firms compared to other studies in this field. It should be emphasised that the conducted analysis includes all audits of separate financial statements of public companies in the period under consideration.
Keywords: audit market, audit market concentration, Big Four.
Category of the paper: Research paper.

1. Introduction

This article presents the results of research on the structure of the audit market in Poland in 2010-2020. The analysis of the topic of concentration was carried out on the basis of independent auditors' reports of individual financial statements of business entities listed on the Warsaw Stock Exchange. The research included financial data and auditors' reports of 506 companies, a total of 4281 opinions and auditors' reports were analysed. The importance of the problem of market concentration, and its potential impact on the quality of the services provided, is also evidenced by the following data (PANA, 2024): 53 audit firms in 2023 conducted audit of financial statements of public interest entities, whereas in 2015 there were

97 audit firms. In the analysed years, the total number of audit firms decreased correspondingly from 1612 to 1230[1].

The main objective of the publication is to present the changes occurring in the audit market over the period 2010-2020. In addition, the following research problems are formulated:

1. How did the concentration of audit services provided to companies listed on the Warsaw Stock Exchange change between 2010 and 2020?
2. Which entities most often provided the services indicated above?
3. How often did the analysed entities change auditors over the years under review?

The presented results of the analysis are part of a larger study, carried out by the Author of this publication, concerning the audit market in Poland, covering such issues as: the role of the auditor in making the financial statements credible, addressing the issue of the threat of going concern in auditor's report, or the importance of key audit matters (KAM), i.e. matters that, according to the auditor's professional judgment, were most significant during the audit of the financial statements for the audited period.

2. Concentration of the audit market - a review of past studies

Studies of audit market concentration indicate a high (or very high) concentration of the audit market in the analysed countries and the dominance in this market of the "Big Four" entities. It should be emphasized, that the problem of concentration becomes apparent when this aspect is evaluated using the size of the business entities under study (assessed, for example, through sales revenues, balance sheet total or market value of the companies under consideration).

Some of the publications analysed (Francis, Michas, Seavey, 2013) indicate that the high concentration of the audit market influences the higher quality of the audit performed. Selected studies emphasize that higher audit quality in a situation of increasing market concentration should be linked to increasing audit fees (Ting-Chiao, Hsihui, Jeng-Ren, 2016).

On the other hand, there are studies (Boone, Khurana, Raman, 2012) suggesting that the dominance of the Big Four entities may lead to a reduction in the quality of audit services provided. B. Song (2021) indicates that the decline in audit quality associated with increasing market concentration can be mitigated by the high competence of audit committee members (in finance, law or tax aspects) functioning in the audited business entities.

[1] Similar conclusions can be drawn by analyzing the publication (Cwyl, 2018) referring to the situation in the audit services market in Poland in the period 2009-2017. Compare also: (Wielogórska-Leszczyńska, Zakrzewska, 2020).

At the same time, it is possible to identify publications (Willekens, Dekeyser, Bruynseels, Numan, 2023) indicating that concentration in the audit market does not show a relationship (or shows an ambiguous relationship (Makarenko, Plastun, Makarenko, Kozmenko, Kozmenko, 2021) with the quality of audits performed.

A summary of selected studies of this issue with a brief description and conclusions is presented in the table below.

Table 1.
Selected publications on the structure and concentration of the audit market

No.	Author/country	Research sample/years of analysis	Description
1.	J.R. Francis, P.N. Michas, S.E. Seavey (42 countries; US and UK most represented)	Years 1999-2007; 54,734 observations were analysed - data was obtained from the Global Vantage database (including: 18,980 observations from the US and 5277 from the UK)	Studies conducted suggest higher audit quality by both Big Four auditors and other auditors when the audit market is more concentrated.
2.	V. Beattie, A. Goodacre, S. Fearnley (UK)	Year 2002; 2180 traders listed on the London Stock Exchange	Very high concentration of the audit market (the "Big Four") - especially as measured by audit firm compensation.
3.	N. Mansor, E.N. Sutan Maruhun, A.M. Ishak (Malaysia)	Year 2003; 520 entities listed on the Kuala Lumpur Stock Exchange	1. High concentration of the audit market in Malaysia. 2. The analyses conducted showed that there is a lack of specialization among the Big Four auditors.
4.	J.P. Boone, I.K. Khurana, K.K. Raman (USA)	Years 2003-2009; 4779 observations	Among the conclusions, the authors point out that the dominance of the Big Four companies in the audit services market leads to a reduction in the quality of the services provided.
5.	M.Z. Groff, A. Salihovic (Slovenia)	Years 2008-2011; 3038 surveys conducted during the analyzed period (an average of 760 per year)	1. High concentration of audit firms of the "Big Four" for listed entities. At the same time, there is a slight trend indicating a decrease in concentration. 2. For non-public companies, concentration is at a much lower level.
6.	S. Sever Malis, M. Brozovic (Croatia)	Years 2008 and 2013; data of 58 entities were analyzed	The analysis showed a slight decrease in audit market concentration in the years compared. The study found that concentration is least evident referring to the number of entities audited, while based on the total assets of the audited entities or their sales revenue - concentration is at a much higher level.
7.	J. Gad (Poland)	Years 2011-2016; public companies listed on the Warsaw Stock Exchange; 2652 reports	1. The level of concentration in the market for audit services provided to public companies in Poland is lower than the average level of concentration for other EU countries. 2. In the various years under consideration, about one-fifth of public units changed their auditing firm. On the other hand, over 34.8% of the entities did not change their auditing firm at all between 2011 and 2016.
8.	M. Willekens, S. Dekeyser, L. Bruynseels, W. Numan (USA)	Years 2009-2017; data on 25,254 subjects from the Compustad database. After the initial selection, 13,819 observations remained in the study.	The analyses conducted showed a very low correlation between audit market concentration and the quality of audits performed. The result of the research suggests that the quality of the audit is influenced by the market leader's dominance over competitors.

Cont. table 1.

9.	J. Wielogórska-Leszczynska, J.B. Zakrzewska (Poland).	Year 2018; survey conducted among chartered accountants attending mandatory training courses - completed questionnaires were returned by 310 auditors	The research showed a high concentration of the audit services market. A simultaneous survey of the number of auditors practicing in the profession showed a significant decrease in the number of auditors over the 2016-2019 period.
10.	J. Rajabalizadeh (Iran)	Financial statements and audit reports of 1050 entities for 2012-2018	The results indicate a positive relationship between competition in the audit market and the quality of the audit conducted. The research also confirms the positive impact on audit quality caused by the lack of change of audit firm over the years.

Source: own compilation based on: (Beattie, Goodacre, Fearnley, 2003; Boone, Khurana, Raman, 2012; Francis, Michas, Seavey, 2013; Gad, 2018; Groff, Salihovic, 2014; Mansor, Sutan Maruhun, Ishak, 2013; Rajabalizadeh, 2024; Sever Malis, Brozovic, 2015; Wielogórska-Leszczyńska, Zakrzewska, 2020; Willekens, Dekeyser, Bruynseels, Numan, 2023).

Referring to the problem of concentration in the Polish audit market (Gad, 2018), it should be emphasized that it is less pronounced than in many other countries (EU countries, the United Kingdom, the United States).

3. Research sample and methodology of the study

The independent auditor's audit reports and financial statements of the analysed business entities were obtained from the following sources:

- The websites of individual public companies.
- EMIS Intelligence Region database.
- Notoria Online databases.
- Public company announcements from ESPI/EBI systems available to the Economic Service of the Polish Press Agency (www.biznes.pap.pl/pl/reports).
- Warsaw Stock Exchange website.

The analyses carried out were based on the independent auditors' reports on audits of separate financial statements (audit opinions and reports - for audits of financial statements for periods ending before December 31, 2016)[2] and using separate financial statements of

[2] Audits of financial statements prepared for periods ending before December 31, 2016 were conducted in accordance with the requirements of the National Auditing Standards (Krajowe Standardy Rewizji Finansowej, KSRF, adopted by Resolution No. 1608/38/2010 of the National Chamber of Statutory Auditors dated February 16, 2010 on national auditing standards), according to which, on the basis of the audit evidence collected, the auditor prepared an opinion with a report. Audits of the financial statements for periods ending December 31, 2016 and thereafter are conducted in accordance with the National Auditing Standards in the wording of the International Auditing Standards (adopted by Resolution No. 2783/52/2015 of the Polish Chamber of Statutory Auditors dated February 16, 2015 on national auditing standards) and the auditor prepares an independent auditor's report containing the audit opinion.

companies listed on the Warsaw Stock Exchange from 2010 to 2020. The auditors' reports were obtained manually in each case.

As a result of the initial selection, auditors' reports and financial statements of business entities based outside Poland and listed on the Warsaw Stock Exchange were omitted. Such entities were omitted because their financial statements were subject to audit by an auditor in the country where the entity's headquarters are located. For example, the audit did not include the financial statements and audit report of KRKA d.d. Slovenia, based in Novo Mesto, Slovenia, whose financial statements for period ending before December 31, 2020 were audited by Ernst & Young d. o.o., Ljubljana. Another example is AmRest Holdings SE, whose financial data for part of the period under review was included in the audit. However, since 2018, the company's headquarters has been based in Madrid, Spain (thus, the financial statements and audit reports for 2018-2020 were omitted from the study). In addition, it should be pointed out that for several observations during the period under review, auditors' reports (or opinions with report) were not available.

Finally, auditors' reports of 506 entities that were listed on the Warsaw Stock Exchange for at least one year in the mentioned period, i.e. from 2010 to 2020, were analysed. It should be noted that some of the entities were listed on the WSE during the entire analysed period (thus, auditors' reports and financial statements of these entities for 11 years were available)[3], some of the entities only in selected years. A total of 4,281 auditors' reports were analysed.

The table below summarizes the number of auditors' reports analysed in each of the years under review.

Table 2.
Number of auditors' reports of listed companies analysed for 2010-2020

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Number of auditors' reports *	350	373	376	381	398	413	420	408	396	391	375	**4281**

* for audits of financial statements of public interest entities covering periods ending before December 31, 2016 – opinion with report.

Source: own compilation.

4. The results of the research conducted

As mentioned above, a total of 4281 auditors' reports were analysed in the course of the work conducted. These audits were conducted by 144 audit firms between 2010 and 2020. Over the years analysed, audit firms merged among themselves, joined existing groups and also

[3] Among the entities that have been listed on the Warsaw Stock Exchange throughout the period under consideration, i.e. 2010-2020, and thus their financial statements and audit reports (previously opinion and report) are available, for example: Agora SA, Apator SA, CD Projekt SA, Fabryka Mebli Forte SA, Giełda Papierów Wartościowych SA.

changed their names. For example, ECA Seredyński i Wspólnicy joined the UHY International group in 2015 and changed its name to UHY ECA Audyt.

In 2010, the separate financial statements of companies listed on the Warsaw Stock Exchange were audited by 72 auditors, in 2015 (the number of audit firms dropped to 66, while in 2020 such audits were conducted by 51 audit firms. One of the reasons for the decrease in the number of audit firms auditing WSE-listed companies is the high labor intensity and complexity of such audits. The audit of financial statements of entities listed on the WSE, which are public interest entities, is perceived by audit firms as a "higher risk audit"[4]. It should be emphasized that the higher reporting requirements for listed companies and the stricter requirements and regulations for auditing public interest entities are primarily related to the fact, that the reliable financial data and information contained in the financial statements as well as the independent auditor's opinion on the audit of the statements can affect the listing of such an entity and reaches a wide range of users. In addition, the limitation of the number of auditors undertaking audits of entities listed on the WSE is probably also influenced by additional requirements imposed by the Polish Audit Supervision Agency.

In the literature, the most common division of audit firms made is between the "Big Four" and other firms. In this study, the Big Four auditors are presented separately, while the other audit firms are divided into three groups according to their market share, which was determined by the number of obligatory audits of separate financial statements of public companies listed on the Warsaw Stock Exchange for the years 2010-2020. During the period under review, the Big Four audit firms audited between 289 and 435 separate financial statements subject to this analysis. Auditors from the second group audited between 233 and 334 separate financial statements. As for the third group, for the purposes of this study, it included auditors who audited between 62 and 116 separate financial statements during the period under review. As a criterion for inclusion in this group, a minimum of one percent participation in all audits conducted by audit firms in the analysed sample was used. The remaining auditors (129 in number) were included in the fourth group. In most cases, this group includes audit firms that have conducted audits of several separate financial statements of public companies listed on the Warsaw Stock Exchange.

The adopted division of audit firms is presented in the table below.

[4] Compare audit market analysis: https://www.parkiet.com/ranking-audytorow/art36138061-pwc-dzierzy-paleczke-lidera-na-gieldzie, 11.04.2023.

Table 3.
Categories of auditing firms adopted in this research

Audit firm category adopted in the study	Number of audit firms in the category	Audit firm Name	Number of obligatory audits of separate financial statements conducted in the period 2010-2020	Percentage share
"Big Four" (BIG4)[5]	4	PWC Poland Ernst & Young Audit Poland KPMG Audit Deloitte Audit	1 449	33,8%
GROUP II	4	Grant Thornton Poland BDO UHY ECA Audit PKF Consult	1 133	26,5%
GROUP III	7	Mazars Audit Misters Auditor Adviser Moore Poland[6] 4Audit NCPF Dr. Piotr Rojek HLB Group WBS Audit	674	15,7%
GROUP IV	129		1 025	23,9%
TOTAL	**144**		**4 281**	**100%**

Source: own elaboration.

Taking into account the presented breakdown of audit firms, the table below shows the numbers of opinions issued by auditors on separate financial statements over the years analysed.

Table 4.
Number of auditors' reports of WSE- listed companies analysed for the years 2010-2020 issued by audit firms from each group

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
BIG4	104	120	122	132	145	159	166	155	135	116	95	**1 449**
GROUP II	88	98	95	93	95	101	105	106	106	118	128	**1 133**
GROUP III	61	62	72	66	65	59	56	57	58	58	60	**674**
GROUP IV	97	93	87	90	93	94	93	90	97	99	92	**1 025**
Total	**350**	**373**	**376**	**381**	**398**	**413**	**420**	**408**	**396**	**391**	**375**	**4 281**

Source: own elaboration.

Table 5.
Auditors' reports of WSE-listed companies analysed for 2010-2020 issued by audit firms from each group - percentage structure

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
BIG4	29,7	32,2	32,4	34,6	36,4	38,5	39,5	38,0	34,1	29,7	25,3	**33,8**
GROUP II	25,1	26,3	25,3	24,4	23,9	24,5	25,0	26,0	26,8	30,2	34,1	**26,5**
GROUP III	17,4	16,6	19,1	17,3	16,3	14,3	13,3	14,0	14,6	14,8	16,0	**15,7**
GROUP IV	27,7	24,9	23,1	23,6	23,4	22,8	22,1	22,1	24,5	25,3	24,5	**23,9**
Total	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**

Source: own elaboration.

[5] In the article, the name " Big Four" and "BIG4" will be used interchangeably.
[6] In 2021, the merger of the audit firms Moore Finansista and REWIT Accountants and Auditors took place. As a result of the merger, an audit firm named Moore Polska was formed. For the purposes of this analysis, the audits conducted by the aforementioned firms were included as audits conducted by a single auditor.

As can be noticed, during the analysed period there were significant changes in the area of the number of audited separate financial statements by different groups of audit firms. The largest number of audits of separate financial statements of public companies in Poland was carried out by the "Big Four" audit firms. These firms issued 1449 audit opinions over the analysed 11 years, which represents 33.8% of all audits of separate financial statements of entities listed on the Warsaw Stock Exchange. The second distinguished group of audit firms (also represented by four auditors) conducted a total of 1133 audits, representing 26.5% of the total observations. It should be noted that audit firms included in the fourth analysed group have a similar share in the total number of audits of separate financial statements conducted (i.e. 23.9%). It is important to emphasise that 129 audit firms belong to this group, according to the accepted division (which means that, on average, the audit firms in this group carried out less than eight audits in the period analysed, in the vast majority of cases one or two audits).

Attention should also be paid to the concentration of the audit market. In this research, concentration was assessed using the number of audits of separate financial statements conducted. It should be emphasized that the scale of concentration would be higher if other measures (for example: total assets, revenues of the audited entities, market value of the audited entities or auditors' audit fees) were used in its assessment[7]. Nevertheless, such a measurement will not be studied in this paper.

When considering the concentration of the audit market, it should be noted that the largest eight audit firms conducted 60.3% of the considered audits of the separate financial statements of entities listed on the Warsaw Stock Exchange. The remaining 39.7% of the total audits considered were conducted by 136 auditors. It should be noted that the highest level of audit market concentration took place in 2016 and 2017. The number of audits conducted by the eight largest audit firms accounted for 64.5% and 63.9%, respectively. Analysing the entire period under consideration, it should be noted that the total number of audits of separate financial statements of entities listed on the Warsaw Stock Exchange conducted by the "Big Four" and audit firms from the second group accounted for about 60% (the exception was 2010, in which the share was 54.8%).

[7] An example of an analysis of the audit market in Poland taking into account also other criteria for dividing the market is the analysis presented in the 21st Ranking of Auditors in "Rzeczpospolita" for the year 2022 (https://rankingi.rp.pl/rankingaudytorow/2022#ra_full, 11.04.2023). Among the criteria, the authors of the ranking list: revenue from auditing activities forming the basis of the supervision fee for 2021, revenue from the performance of other attestation services not forming the basis of the supervision fee for supervision, revenues from auditing activities in public interest entities in 2021, the number of auditing activities performed in 2021 (both mandatory and optional), the number of auditing activities conducted in 2021 in public interest entities (both mandatory and optional), the average price of auditing activities, the number of auditors with Polish licenses, and the number of people employed in auditing. A separate ranking by Rzeczpospolita concerns Audit Firms auditing companies on the Warsaw Stock Exchange (https://rankingi.rp.pl/rankingaudytorow/2022/audyty_spolek_gpw, 11.04.2023). In addition to the number of audited entities, the ranking criteria include the total value of assets of audited companies and the market value of audited companies. It should be noted that the first eight audit firms in the Rzeczpospolita Auditor's Ranking of audited entities on the WSE are companies included in BIG4 and Group II in this analysis (and appear in the same order). In the next, Group III (distinguished in this study), there are slight shifts from the Rzeczpospolita Auditors' Ranking.

A change occurring in recent years in the audit market in Poland that should be noted is the increase in the number of statutory audits of separate financial statements conducted by audit firms from the second group and the simultaneous decrease in the number of audits conducted by the Big Four firms. In 2016, the Big Four audit firms conducted 166 such audits which accounted for 39.5% of the total cases analysed. In the same year, audit firms from the second group conducted 105 audits which accounted for 25% of the analysed population. In 2020, Big Four audit firms conducted 95 statutory audits of separate financial statements, which accounted for 25.3% of the total, and audit firms from the second group conducted 128 audits, which accounted for 34.1% of the analysed population.

Analysing the above data, it should be taken into account, that the Big Four firms, despite a decline in the number of audits of individual financial statements of companies listed on the Warsaw Stock Exchange, are leaders when it comes to the market value of the audited entities. Thus, for example, the Big Four firms in 2020 audited the largest companies listed on the WSE, among others: PKO BP SA, PGE SA, PKN ORLEN SA, Santander Bank Polska SA, Bank Pekao SA, KGHM Polska Miedź SA, ING Bank Śląski SA, Tauron SA, PZU SA. The exception here is PGNIG SA, which was audited in 2019-2020 by PKF Consult.

It can also be observed a stable share in the number of audits conducted by audit firms from both the third and fourth groups during the period under review. The presented situation in the audit services market in terms of the increasing share of large audit firms (I and II studied group) with a simultaneous market share of between 30% and 40%, of entities performing a small number of audits is explained by J. Cwyl (2018) by two factors, that is: the significant participation of multinational corporations and audit market regulations designed to ensure the independence of auditors.

The previously described changes in the audit market of public company auditors are reflected in its analysis in the sub-periods, that is, from 2010 to 2015 and from 2016 to 2020.

Table 6.
Market share of each group of auditors (based on the number of audits of separate financial statements of companies listed on the Warsaw Stock Exchange) for the years 2010-2015 and 2016-2020 (in%)

	2010-2015	2016-2020	Total
BIG4	34,1	33,5	33,8
GROUP II	24,9	28,3	26,5
GROUP III	16,8	14,5	15,7
GROUP IV	24,2	23,7	23,9
Total	**100,0**	**100,0**	**100,0**

Source: own elaboration.

As can be seen, in recent years the share of auditors included in the second group had been increasing, at the same time all other groups had slightly reduced their market share as measured by the number of statutory audits of separate financial statements conducted.

The last issue presented in this article is the problem of the frequency of auditor changes among the business entities analysed in this research. J. Gad (2016), based on his research conducted in the years 2011-2013, indicates that in the analysed period, the entities that made a change of auditor accounted for 19.1% of the surveyed entities in 2012, while in 2013 - 19.3%. At the same time, the cited author indicates that the most frequent mentioned changes took place among business entities representing: trade, finance and heavy industry.

In these studies covering the period 2010-2020, similar results were obtained. On average, 20.7% of the analysed units changed their auditor in individual years. It should be emphasized, however, that in the studied group of companies there are entities where this change in the entire period under consideration did not take place, as well as entities where such rotation was carried out much more frequently. Examples of companies whose financial statements in the entire period under consideration were audited by the same audit firm include: Agora SA, Firma Oponiarska Dębica SA. On the other hand, there are entities where the exchange of auditor took place much more frequently - for example, in Biomed Lublin the financial statements for 2015-2020 were audited by four different audit firms, in Drewex SA the financial statements for 2010 -2018 were verified by five audit firms, or in Lena Lighting SA the financial statements for the period of 11 analysed years were audited by 6 different audit firms.

5. Conclusions

Among the conclusions of the research, attention should be drawn to the annual decline in the number of audit firms auditing separate financial statements of entities listed on the Warsaw Stock Exchange. The Big Four audit firms, despite the fact that their market share is successively decreasing (measured by the number of audits of separate financial statements), still dominate when it comes to the market value of audited public companies. At the same time, it should be emphasized that over the analysed years the largest increases in the number of audits of separate financial statements were recorded by entities included in the second group of audit firms (large entities such as: Grant Thornton Polska, BDO, UHY ECA Audyt, PKF Consult). Another point to note is that the number of audit entities providing their services only to single public companies is definitely decreasing.

It should also be emphasized that throughout the period under consideration, that is, from 2010 to 2020, on average the replacement of an auditor took place approximately every 5 years.

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GREEN INNOVATION AND FIRM'S INTERNATIONALISATION

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Purpose: Green innovation and internationalization have gained the attention of scholars and practitioners around the world. However, research on the relationship between green innovation and internationalization are still fragmented and scant. Therefore, this study aims to explore the relationship between green innovation and internationalization.
Design/methodology/approach: This is a quantitative study that uses survey data from large and innovative firms in Poland. It uses the cross-tabulation analysis and Kruskal-Wallis test to verify if there are differences in green innovation between domestic, international and global firms.
Findings: The study confirm the mutual interdependence of internationalization and green innovation showing that there are differences between firms with different scope of geographical operations. Our study shows that global companies focus more on green innovation than domestic ones. Unfortunately, the differences between domestic and multinational companies as well as multinational and global companies are not found.
Research limitations/implications: Findings from this study extend knowledge both in the field of international business and innovation showing the positive relationship between green innovation and internationalization of firms, but not in case of all companies. Our study has limitation as it focuses only on large and innovative companies in Poland, and it uses the simple scale of internationalization.
Practical implications: Our study shows that green innovation in not only a necessity for firms around the world, but it might positively impact the internationalization of firms. Simultaneously, internationalization can enhance green innovation as international companies have more opportunities to create collaborating network and source knowledge.
Originality/value: This study builds and extends previous research on the breadth of internationalization and green innovation. It confirms the positive relationship between green innovation and international scope of operation of a firm, but it shows that these differences are only between domestic and global firms.
Keywords: green innovation, internationalization, global firms, international firms, domestic firms.
Category of the paper: research paper.

1. Introduction

Environmental challenges have become central to firms' strategies in the 21st century. Both regulations and market forces have played a role in that. Responsible management seems to have contributed to a competitive advantage as it influences costs and the firms' reputation, and green innovation is perceived as a critical element of corporate and business strategies to gain and sustain a competitive advantage. Additionally, stakeholder pressure, government regulation, and customer needs have grown, and firms must comply with environmental rules. Green innovation related to products and processes mitigates a firm's negative environmental impacts and comes at the forefront of innovation solutions and studies (Barforoush et al., 2021).

Green innovation has been gaining the attention of scholars and practitioners (Zhang et al., 2020). The existing body of knowledge explores green innovation in the context of internal and external drivers (Cao, Chen, 2019; Alnaim et al., 2022) and firm performance (Zhang et al., 2022; Eiadat et al., 2008). There has been much less research on the relationship between green innovation and firm's internationalization (Martínez-Ros, Merino, 2023; Tsai et al., 2021; Šūmakaris et al., 2020). Prior studies on green innovation and internationalization deliver arguments on the positive relationship between green innovation and internationalization. However, they are still fragmented and scant (Anjum et al., 2024; Chiarvesio et al., 2015). The significance of topic in contemporary business environment as well as relatively limited number of research on green innovation and internationalization encourage us to focus on this issue.

This study aims to explore the relationship between green innovation and internationalization. The key question is if there is the significant difference among firms' green innovation activity and their breadth of internationalization. The research results show that internationalized firms focus on green innovation more than those ones which sell only in the national market. Therefore, our findings support those ones which concluded the correlation between green innovation and firm internationalization.

The paper is organized as follows. First, we deliver the literature review and, on this basis, formulate hypotheses. Second, we describe the methodology of empirical research, including sample description and measures. Next, the research results are presented. The final part of the paper is a discussion of the research results followed by concussion, limitations, and direction of further research.

2. Literature review

Green innovation as a topic of firm level research has been evolving. Next to the market driven forces, social factors and international and national regulations are shaping the behavior of the firms and raise novel scientific questions. At first the impetuses to green innovations and then the green innovation and internationalization relationships are discussed by the literature.

2.1. Impetuses to green innovation

In all business consideration customers come first. The increasing ecological awareness of customers is one of the driving factors of changes in companies' behavior. Customers influence companies directly by choosing or not certain products and by pushing governments to set up coercive and incentive policies, thus making companies greener (Cao, Chen, 2019). To respond these challenges, companies introduce more environment-friendly practices in producing, marketing and delivery goods and services (Wang et al., 2020). Those practices refer to energy and water saving, recycling waste, reuse of components, more ecological supply chain management, changes in products at each stage of their life cycle, etc. The new products and processes introduced and/or transformed by companies are described in the literature as green, environmental or eco-innovation. We use green innovation in this paper.

Studies on green innovation emphasize its difference from other types of innovation (Chiarvesio et al., 2015; De Marchi, 2012). Green innovation is more complex than other types of innovation as it includes an additional component: natural environment orientation. Some researchers classify green innovation into three categories: pollution prevention, product management, and the use of clean technology (Hart, 1997). These categories of green innovation are also related to reducing resource consumption, waste recycling, and implementing an appropriate environmental management system (Eiadat et al., 2008; Chen et al., 2006). The aim is to reduce the negative environmental impact of both products and processes by implementing new technologies and ways of operations (García- Sánchez et al., 2020). Green innovators change their business models and improve resource productivity. However, companies apply different approaches to defining themselves as green (Barforoush et al., 2021).

Nowadays, becoming green and implementing environmental innovation are required as it is perceived as a critical element of a competitive advantage. According to Porter and van der Linde (1995), ecology and economy are not mutually exclusive, and adequately designed environmental standards, along with green innovation, make companies more competitive, not less. Prior studies found that green innovation improves production efficiency and the image of a company, which enhances its competitive advantage (Tu, Wu, 2021; Gürlek, Tuna, 2018; Barforoush et al., 2021; Ge et al., 2018). Thus, green innovation is perceived as a strategic choice and response of a company to increasing market dynamics, including government

regulations and stakeholder pressure (Yu et al., 2016). Companies that do not focus on being green can lose opportunities in their markets (Esty, Winston, 2009). Therefore, more and more companies pay attention to internal and external factors of and promote behaviors toward green innovation. Some focus on green products, and some on green upgrading processes.

2.2. Green innovation and internationalization

Prior studies investigate the relationship between green innovation and geographical expansion from the perspective of sustainability and internationalization theories (Aguilera-Caracuel et al., 2012; Anjum et al. (2024). Unfortunately, the research findings do not deliver convincing conclusions on the relationship between green innovation and the geographical scope of activity (Chiarvesio et al., 2015). On the one hand, internationalization should trigger green innovation through flows of knowledge and experience across different markets. On the other hand, a fragmented and geographically dispersed production process is a potential threat to the environment and generates a higher probability of negative environmental consequences because of the cost and regulation arbitrage opportunities. The contradictory findings show positive (Aguilera-Caracuel et al., 2012), nonlinear (Chen, 2022) and no relation (Sterlacchini, 1999) between internationalization and green innovation. However, most of the empirical research outcomes suggest positive relationship between internationalization and green innovation (Ding et al., 2024).

The main argument for the positive relationship between internationalization and green innovation refers to knowledge flows. Geographical expansion enables sourcing knowledge from local partners, which enhances environmental performance. Prior studies indicate that green innovation requires networking, especially with local partners, to acquire knowledge, enabling improved environmental performance. Cainelli et al. (2012) prove the importance of networking in increasing environmental performance and adopting green innovation. However, according to Chen (2022), the positive externalities of internationalization related to green innovation, like staff communication, knowledge flows or cross-regional exchange, are disclosed when internationalization exceeds a certain threshold. Thus, the relationship between internationalization and green innovation is U-shaped.

Internationalization may also induce green innovation as firms must adjust their products or processes to local requirements. The interactive process of selling abroad enables companies to develop a set of best environmental practices that can be transferred across national markets (Bansal, 2005). Even simple exporting may induce firms to implement green innovation to overcome trade barriers related to specific markets. Aguilera-Caracuel et al. (2012) argue that firms, through export activities, acquire and develop knowledge that enables better responses to international demand for green products or processes. Also, Galbreath (2019) found that export intensity is positively associated with green innovation. However, Cainelli et al. (2012) did not find a relationship between export propensity and environmental innovation activities.

Similarly, De Marchi and Grandinetti (2012) found that firms' exporting does not matter in green innovation introduction.

Multinational enterprises (MNEs) are special group of research. Internationalization can also be perceived as a driving force of green innovation implementation (Juniati et al., 2019) as it can generate knowledge spillovers and diffusion of best environmental practices, especially among foreign subsidiaries of MNEs. However, according to Zhang et al. (2024) internationalization breadth (geographic scope) positively, while internationalization depth (intensity) negatively impacts MNE green innovation activity. Kennelly and Lewis (2002) found a positive relation between the degree of internationalization and environmental performance, and they argue that MNEs may be proactive agents of positive environmental performance. MNEs are equipped with capabilities and resources that are out of reach of non-MNE related local firms. They can diffuse adopted environmental standards among subsidiaries through incorporated practices and policies. Thus, participation in the global knowledge flows as a part of a MNE can stimulate the development of green innovation (Chiarvesio et al., 2015; De Marchi,Grandinetti, 2012).

Following the theoretical argumentation and considering that there are contradictory findings about the relationship between a firm's internationalization breadth and green innovation, we aim to investigate whether international firms have a greater focus on green innovation than domestic firms and address the following hypotheses:

H1: There are differences in innovation activity among companies with different internationalization breadth.

H1a: Multinational companies focus more on green innovation than domestic companies.

H1b: Global companies focus more on green innovation than multinational companies.

H1c: Global companies focus more on green innovation than domestic companies.

3. Research method

This is a quantitative study that used a questionnaire to collect data. The online survey was conducted among large (more than 250 employees) and innovative firms in Poland (at least one product or process innovation within the 3-year period (OECD/Eurostat, 2018)). Data from 259 respondents, responsible for and knowledgeable about the firm's green innovation, was collected from 7th to 16th November 2023.

The research sample is dominated by large firms with employment exceeding 500 people (76.4%), while the number of firms with employment between 250 and 500 is smaller (23.6%). Firms studied are manufacturing (41.3%) and service businesses (58.7%) and among them 55.6% have been on the market over 26 years, while 44.4% are younger firms. In the research sample, 46.3% of firms studied sell their product in more than one country but within one

continent (multinational firms), while 37.1% are classified as global businesses and 16.6% as domestic firms (Table 1).

Table 1.
Number of domestic, multinational and global firms in the sample

	Numbers of firms	% of firms
Domestic firms	43	16.6
Multinational firms	120	46.3
Global firms	96	37.1

Source: own elaboration.

This study uses two variables that were drawn from the literature. The first variable is a green innovation measured with the use of the seven-item revised instrument based on Chan (2005) and Zhang et al. (2022). Green innovation is understood as a type of innovation activity that a firm has carried out to implement green (product and process) innovation with the goal of environmental protection (Chan, 2005l Zhang et al., 2022). The scale of green innovation has good reliability (Cronbach's alpha = 0.951; CR = 0.949) and it passed the convergence validity test (AVE = 0.773). We also tested the construct validity with the exploratory factor analysis (EFA) using the principal component extraction with varimax rotation. The pre-test analyses confirm that the data is suitable for the factor analysis. Factor loadings range from 0.849 to 0.907. Therefore, EFA analysis replicates the model of the original construct.

The second variable is the internationalization breadth understood as a scope of international activity of a firm allowing us to identify domestic (selling only domestic market; domestic scope), multinational (selling foreign markets in one continent; multinational scope) and global firms (selling foreign markets in at least two continents; global scope). The internationalization breadth was evaluated by respondents in the questionnaire. Respondents marked whether their company sells only on the domestic market (domestic company), on foreign markets in one continent (multinational company) or on foreign markets in at least two continents (global company). We used the following coding: 0 – domestic firms, 1 – multinational firms and 2 – global firms.

4. Research results

The research aims to investigate the relationship between green innovation and the breadth of internationalization (a firm's scope of international activity). First, we carried out the cross-tabulation analysis (Table 2). It suggests that global firms focus on green innovation more than domestic and multinational firms. Second, we conducted the non-parametric Kruskal-Wallis test, which shows that these differences are statistically significant (Table 3). The value of the test is 6.274, and the p-value is 0.043. Therefore, at a significance level of 0.05, there is sufficient evidence to confirm the difference between groups. It means that green innovation

differs between at least two groups studied (domestic, multinational, and global firms). Third, the pairwise comparison shows the statistically significant differences between domestic and global firms (Table 4) (p-value = 0.019). However, there is no statistically significant difference between domestic and multinational companies, as well as multinational and global companies.

Table 2.
Descriptive statistics

Descriptive statistics	All firms	Domestic firms	Multinational firms	Global firms
Mean	5.43	5.17	5.37	5.64
Max	7.00	7.00	7.00	7.00
Min	1.00	1.86	1.00	1.57

Source: own elaboration.

Table 3.
Results of the Kruskal-Wallis test

Test statistic	Sig.	Recommendation
6.274	0.043	reject the null hypothesis

Source: own elaboration.

Table 4.
Results of the pairwise comparisons

Groups	Test statistic	Std. error	Std. test statistic	Sig
domestic vs multinational firms	-13.663	12.937	-1.056	0.291
domestic vs global firms	-31.327	13.357	-2.345	0.019
multinational vs global firms	-17.665	9.967	-1.772	0.076

Source: own elaboration.

Fourth, we divided the research sample into two subsamples: (1) manufacturing and (2) service firms to check if the relationship between green innovation and breadth of internationalization holds also when different types of firms are considered. We conducted the non-parametric Kruskal-Wallis test, which shows that differences are statistically insignificant in manufacturing and services firms (manufacturing firms: test statistic = 1.594, p-value = 0.451; service firms: test statistic = 3.049, p-value = 0.218). Thus, at a significance level of 0.05, there is no sufficient evidence to confirm the difference between groups. It means that green innovation does not differ between domestic, multinational, and global firms when the type of a firm is considered.

The research conducted shows statistically significant differences between domestic and global firms, but there is no statistically significant difference between domestic and multinational companies, as well as multinational and global companies. It also points out that differences in green innovation focus in domestic, multinational and global firms are not statistically significant when the relationship is analyzed in manufacturing and service firms separately. Therefore, only H1c is supported, while H1a and H1b are rejected. Consequently, H1 is supported partially.

5. Discussion

This study aimed to investigate whether the breadth of internationalization is a significant factor influencing green innovation. Based on previous studies, we hypothesized a difference in green innovation activity among companies with different internationalization breadth. Thus, the findings of this study aim to extend knowledge on green innovation and international behaviors of companies.

First, the study shows a high level of green innovation implementation among firms studied. It could be explained by the sample, which consisted of large innovative firms operating in Poland. These firms are more mature in innovation implementation, including green innovation. Additionally, current government policies (following EU regulations) encourage firms to be more environmentally friendly. ESG ratings and mandatory non-financial reports for large companies push them to invest more in environmental strategies that relate to green innovation. Therefore, policy and regulations (through ESG rating) foster green innovation (Ravasini, 2024). The high level of green innovation among firms studied in this paper may reflect regulations aiming to improve EU's overall ESG performance.

Second, the study advocates for mutual interdependence of internationalization and green innovation, as we observe a higher mean in green innovation measures among multinational and global firms than domestic companies. Following this observation, we argue that multinational and global firms focus more on green innovation. This aligns with current literature indicating that internationalization and green innovation influence each other and create a virtuous circle (Martínez-Ros, Merino, 2023; Juniati et al., 2019). The ability to be a green innovator promotes a broader scope of geographical activity, and green innovative firms are perceived as more successful in international markets (Ratten, 2018). Moreover, the commitment to green innovation generates a premium for companies internationalizing their business activity (Martínez-Ros, Merino (2023). Simultaneously, internationalization is perceived as a trigger of being green (Juniati et al., 2019; Anjum et al., 202), and exposure to different business models existing in international markets stimulates innovations to achieve and sustain a competitive advantage. Our study supports this view by confirming the higher focus on green innovation among global companies than domestic ones.

Next, in this study, we assumed that increasing internationalization breadth would accompany higher green innovation performance as the existing body of knowledge on green innovation points out a positive relation with a firm's internationalization (Chiarvesio et al., 2015; Zhang, Deborah, 2024). Prior studies explained relationship between internationalization and green innovation from a knowledge transfer perspective (Aguilera-Caracuel et al., 2012; Chiarvesio et al., 2015). Companies with higher internationalization breadth can implement new green practices as they acquire knowledge from different markets and spread green practices to other markets (Bansal, 2005; Zhang et al., 2024). Moreover, companies in different

markets are exposed to different environmental policies. Aligning with environmental policy in one country may enhance green innovation spread across subsidiaries in other countries. Thus, international firms are perceived as more innovative (also about green innovation) than those operating only in their domestic market, as they have more significant opportunities to create knowledge networks and cooperations inducing innovation development (Sekliuckiene et al., 2016; Patel et al., 2014; Arvanitis, Bolli, 2013). However, this study only partially confirms this argument. We have observed significant differences only among domestic and global companies. Global companies focus more on green innovation than domestic ones. Unfortunately, the differences between domestic and multinational companies and between multinational and global companies are insignificant. This may indicate that the positive influence of internationalization on green innovation is revealed when the scope of international activity is broader. Positive outcomes of internationalization according to green innovation, like cross-country knowledge flow, are disclosed under higher internationalization breadth, while lower levels of internationalization breadth do not support green innovation. It may also signal a non-linear relationship between green innovation and the international scope of firms. This finding supports the argumentation of Chen (2022), pointing out that positive externalities of internationalization are disclosed when internationalization exceeds a certain threshold.

To sum up, findings of this study show significant differences between domestic and global firms. They point out that green innovation is important in promoting internationalization globally, meaning that a greater focus on green innovation is related to a more global scope of firms.

6. Conclusion

This study contributes both to theory and business practice. The findings from this study extend knowledge in both the field of international business and innovation. The main theoretical contribution is the confirmation of the positive relationship between green innovation and the internationalization of firms. Internationalization is identified as a factor in developing green innovation (Anjum et al., 2024). Our study partially supports previous research findings, which indicate that international firms are more innovative, also in case of environmental innovations (Juniati et al., 2019; Chiarvesio et al., 2015). Our findings suggest some differences between firms by their internationalization into one-continent (multinational) and more-continent (global). The main managerial implication refers to supporting managers' awareness that green innovation is not only a necessity of 21st century firms but also has huge potential to enhance the internationalization of firms. Moreover, we argue that green innovation can be enhanced through internal investments (like R&D investments) and external sourcing.

The promising way to obtain a higher level of green innovation and simultaneously increase internationalization is collaboration with foreign partners.

Our study is not without limitations. First, it covers a sample of large, innovative companies. Those firms are more prone to develop green innovation and implement internationalization strategies. Second, this study was carried out on firms operating in Poland, while the implementation of green innovation is closely related to government regulation and coercive and incentive policy. Third, we measured green innovation without dividing it into product and process innovation. Fourth, the study examined green innovation at a single point in time, which limits to track causality and longtime outcomes. Finally, internationalization was measured with the use of a simple, basic scale.

Considering the limitations of this study, we argue that further research directions should focus on more diverse samples (e.g. two or more countries, as well as large as small and medium enterprises) and more sophisticated and multilevel measures of the degree of internationalization. The implementation of longitudinal analysis would also provide a better insight into the relationship between green innovation and internationalization, especially as those activities are time-consuming. Additionally, it would be interesting to differentiate green innovation into product and process and check its relationship with a firm's internationalization. However, we think that this study can explore interesting insights into a hot and important topic, which is about green innovation and the internationalization of firms.

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MAPPING ESG RISKS IN THE POLISH LOGISTICS: A CAUSAL LAYERED ANALYSIS AND FORESIGHT PERSPECTIVE

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Purpose: This paper examines the barriers, risks, and strategic directions of ESG (Environmental, Social and Governance) implementation in Poland's logistics sector. It aims to identify institutional and cultural constraints, map ESG risks, and develop future scenarios.
Design/methodology/approach: The research is based on a qualitative, exploratory approach combining Causal Layered Analysis (CLA) and strategic foresight. It integrates literature review, secondary data analysis, and scenario development, grounded in institutional theory, risk management, and sustainability transitions.
Findings: ESG implementation is hindered by systemic, regulatory, cultural, and narrative barriers. Often seen as a formal burden, ESG lacks strategic integration. Three scenarios are developed, with "bottom-up leadership" proving the most resilient. A risk map shows ESG-related risks vary by approach.
Research limitations/implications: Reliance on secondary data limits generalizability. Future research should include stakeholder interviews and cross-country comparisons within the EU.
Practical implications: Logistics firms must shift from compliance to strategic ESG integration. Public support should address organizational culture and SME capacity.
Social implications: The paper redefines the social role of logistics in sustainability transitions, creating broader, value-based ESG narratives.
Originality/value: It is the first to apply CLA in analyzing ESG in logistics, giving a multi-perspective view of strategic risks and cultural challenges. It provides pragmatic insights for policymakers, researchers, and practitioners.
Keywords: ESG, logistics sector, Causal Layered Analysis, sustainability transitions.
Category of the paper: Research paper.

1. Introduction

The role and importance of sustainable development activities have grown in recent years. It is visible in EU regulations and the growing social expectations towards companies. The ESG (Environmental, Social and Governance) concept is becoming a key point of business

strategies and a tool for assessing risks related to the economy (Guo et al., 2024). Implementing ESG standards serves companies not only to limit the negative impact on the environment or society but also to build long-term value and competitive priority (Annesi et al., 2025).

The literature on the subject encounters various approaches to ESG. The compliance approach treats ESG as an obligation to meet regulatory requirements - mainly reporting and compliance with standards (Cremers et al., 2021; Christensen et al., 2022). The strategic approach focuses on integrating ESG with the core of the business model, seeing it as a source of innovation, efficiency and value for stakeholders. Based on values and identity, the third approach sees ESG as an element of the company's mission and social responsibility. The clash of these approaches in economic reality and their coexistence in managerial narratives causes tensions and risks requiring deeper analysis (Corsalini, 2023).

The logistics sector plays a core part in the economy and global supply chains and in shaping climate and social goals. The Polish logistics is fragmented and dominated by SMEs, which impedes ESG adoption due to insufficient knowledge, tools, and capital. ESG is generally viewed as an impediment tagged along with large companies (Sun et al., 2022; Zils et al., 2023).

With all the growing scholarly focus, sector-level ESG studies—especially within logistics—continue to be rare and are susceptible to overlooking deeper cultural and narrative dimensions. This article employs causally layered analysis (CLA) and foresight methodology to explore ESG issues and propose three 2030 development scenarios.

The aim of the paper is as follows: (1) to show the barriers limiting the implementation of ESG in logistics, (2) to provide three available future scenarios, and (3) to assess the strategic risks that may come from each of them. The main question is: How can we understand and reduce ESG risks in logistics by examining deep cultural, institutional, and narrative factors?

The text is a proposal for an interdisciplinary approach to the place of sustainable development in sectoral implementation. It combines institutional economics, strategic management, sustainable finance, and cultural analysis.

2. Theoretical framework

ESG is an acronym for three English terms: environmental, social, and governance. They are acronyms for ecological, social, and corporate governance issues. ESG describes how companies quantify and control their externalities on the natural world, social relations and internal governance rules (Adomako, Tran, 2022; Christensen et al., 2022).

Environmental factors include, among others, greenhouse gas emissions, energy consumption and waste management (Friede et al., 2015; Kong et al., 2014). Social aspects include, among others, human rights respect, working conditions and relations with the local community (Eccles et al., 2014; Ali et al., 2020). Conversely, corporate governance issues like

transparency of decisions, board composition and moral conduct (Khan et al., 2016). ESG indicators help stakeholders and investors decide whether or not a firm does business sustainably and responsibly, which affects its financial condition and image.

Theoretically, ESG is determined not only by economic rationality or internal capacity but also by institutional environments. Drawing on institutional theory (DiMaggio, Powell, 1983), ESG uptake can be understood as a response to three types of pressure: coercive (e.g., EU legislative action such as the CSRD), mimetic (imitating industry leaders) and normative (civil society and stakeholder expectations). Coercive powers generally result in shallow or symbolic ESG practices in the disintegrative logistics sector.

Contemporary views of ESG in economic and management theory are increasingly concentrated on its strategic importance for value creation, organizational resilience, and risk management (Kaplan, Mikes, 2012; Leoni, 2025). ESG is an element of regulatory compliance and an element of corporate strategy. Considering ESG goals is particularly worthwhile in industries with substantial adverse impacts on the natural environment and of high value for the socio-economic development of countries (Almnadheh et al., 2025). Institutionally, ESG application can be described in terms of three types of pressure mentioned by DiMaggio and Powell (1983): coercive pressure (legislative demands, i.e. CSRD), mimetic pressure (copying market leaders) and normative pressure (stakeholder pressure).

The logistics sector is vital for socio-economic development and its harmful impact on the natural world. Green and organizational work regulations within this sector in the EU introduce tensions between formal compliance and actual operational change. Particular attention should be paid to the complexity of supply chains and their impact on ESG practice implementation. As Ahi and Searcy (2015) suggest, the lack of standard measurement and measurement instruments complicates the control of sustainable supply chains. For logistics, these are added by market fragmentation, the abundance of SMEs, and reduced operation visibility (Evangelista et al., 2018).

These organizational dynamics reinforce the gap between nominal ESG compliance and meaningful sustainability transformation. Strategic ESG integration is undermined by internal legitimacy deficit and perceived incoherence with business objectives, especially for SMEs.

The literature documents that the size of the logistics industry and the vast percentage of micro and small firms affect the implications of ESG implementation by businesses. Martinsen and Huge-Brodin (2014) illustrated that larger logistics firms are more likely to implement sustainable measures and ESG reporting. SMEs are likely to limit themselves to meeting the bare minimum formal requirements. This means that ESG transformation in the logistics sector is asymmetric and heterogeneous.

Qualitative and multi-faceted approaches help balance the complexity of adaptation conditions to the changing socio-economic climate with environmental protection conditions in mind. While SWOT or PEST primarily focus on surface drivers, Causal Layered Analysis (CLA) offers a richer method for addressing systemic complexity, resistance to change,

and visionary thinking. CLA has been applied successfully in foresight analysis and sustainable policy planning (Slaughter, 2004), gaining insights into buried cultural stories that keep change at bay.

Causal Layered Analysis (CLA) by Inayatullah (1998) allows ESG issues to be examined on four levels: litany (facts and figures), systemic (processes and structures), worldview (values and beliefs), and mythological (cultural metaphors and deep narratives). The approach allows recognition of the current state and provides directions for change by influencing organizational culture and industry identity.

Applying CLA to the analysis of ESG in logistics allows a better comprehension of why implementing sustainable practices is ostensible or superficial despite growing regulations and expectations. The application of CLA combined with foresight analysis enables the determination of obstacles and the proposal of realistic development scenarios, which is essential from the strategic management point of view and policy design in the sector's interests.

By integrating institutional schools, risk management, supply chain research and narrative methodologies, I aim to develop a theory structure that allows for extensive study of how ESG in logistics is both an external-driven response and, in fact, the transformative potential for an entire industry.

The conceptual framework proposed in this study synthesizes three layers of analysis: Institutional Pressures (external ESG drivers shaping organizational response), Strategic Risk Mapping (ESG-related risks arising from shallow vs. deep implementation), Narrative and Cultural Layers (deep-rooted beliefs influencing sectoral transformation).

This coupled framework allows a structured understanding of how external pressures, strategic risks, and embedded cultural stories converge in influencing ESG pathways within logistics (Figure 1).

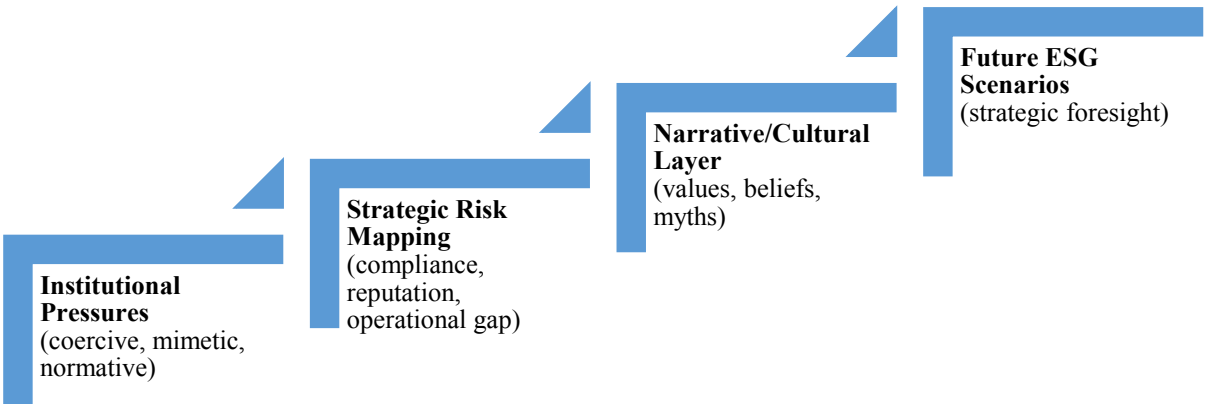

Figure 1. Theoretical framework for ESG integration in the logistics sector using CLA.

Source: own elaboration based on Inayatullah (1998), DiMaggio (1983), Kaplan, Mikes (2012).

3. Methodology and Research Design

This research is qualitative, conceptual and exploratory. It is not aimed at quantitative hypothesis testing but at developing a rich scenario and contextual analysis for the Polish logistics sector.

The research's primary purpose is to perform a multi-level analysis of the conditions and barriers to using ESG strategies in the logistics sector in Poland using the Causal Layered Analysis (CLA) tool and foresight approach. The purpose is also to identify potential ESG development paths up to 2030 and analyze the strategic risks related to each. In particular, the study seeks to:

- Identify key barriers and enablers to ESG implementation in logistics.
- Examine how different levels of analysis (litanic, systemic, ideological, mythological) affect the perception and use of ESG in the sector.
- Develop plausible scenarios of ESG evolution until 2030 and comment on their consequences for the sector's strategy.
- Strategic risk assessment for each scenario for key ESG fields.

Research questions:

- On what grounds and why will ESG implementation continue to be superficial for most logistics players?
- What are the prevailing stories and perceptions among logistics players regarding ESG?
- Which paths will likely be followed by ESG strategy development within logistics based on a 2030 vision?
- What strategic risks are associated with each option for ESG implementation?

The study employed a foresight approach and the Causal Layered Analysis (CLA) methodology, by which it is conceivable to analyze socio-economic problems from the perspective of different cognitive depths: data, structures, worldviews and narratives. CLA allows for examining discernible systemic circumstances (institutions and policies, for example) and less transparent cultural, linguistic, and evaluative aspects.

Sources of data chosen: Secondary analysis of data (desk research) was used, including:

- ESG and sustainable development reports of some of the chosen logistics operators (e.g. InPost, DB Schenker, Raben).
- EU and national institution documents (e.g. SFDR, CSRD, Fit for 55, GOZ strategies).
- Scientific literature on the topic of logistics, ESG, foresight and risk management.
- Expert and industry analyses (including Transport Intelligence, PwC, Deloitte, and E&Y reports).

Phases of the study:

- Identification of the most critical ESG issues in logistics based on the literature and industry research.
- Construction of a four-stage CLA analysis – for ESG challenges and barriers in the industry.
- Development of three alternative scenarios of ESG evolution until 2030: regulated change, bottom-up leadership and surface-level adaptation.
- Comparison of strategic risk maps for each scenario – into reputational, operational, regulatory, supply chain and innovation risk.

The adopted method allows for considering both formal and hidden (cultural, systemic, narrative) determinants that influence the adoption of ESG. Foresight with CLA can capture current obstacles and future avenues of change.

The paper is interdisciplinary – it combines economic, institutional, and foresight approaches, making it possible to comprehend better the problem of sustainable development in the logistics sector.

4. Research results

Table 1 summarizes barriers to ESG implementation in Polish logistics using Causal Layered Analysis (CLA). On the litany level, surface-level media stories and technical problems dominate, such as a lack of ESG reports, considering sustainable activities costly and unprofitable, especially for SMEs, and EU regulatory pressure.

At the system level, institutional deficiencies are evident – no money, ESG professionals and individual training programs. The industry, dominated by SMEs, treats ESG as a challenge and not a possibility.

On the worldview level, there is a deeply ingrained sense that ESG is a means "for the big guys" and that it does not correspond to the national reality. There is a short-term view, and ESG is not integrated with the companies' mission.

At the mythological level, deep cultural narratives play – logistics is only transport and marginally contributing to the environment. Entrepreneurs see themselves as solo "warriors" rather than responsible actors of change, which makes it difficult to identify with the notion of ESG.

Table 1.
CLA of ESG Implementation Challenges in Logistics Sector in Poland

CLA Layer	Analytical Level Description	Key ESG Challenges in Logistics	Interpretation and Deeper Meaning	Transformative Recommendations
1. Litany (Facts, data, dominant media narratives)	The visible level of discourse: facts, statistics, media headlines, public debates.	• Only a minority of logistics companies in Poland publish ESG reports • Lack of coherent ESG benchmarks tailored to the logistics sector • Dominant narratives: "Green technologies are unavailable", "SMEs cannot afford ESG", "More bureaucratic burdens"	These are surface-level symptoms of deeper systemic and cultural barriers. ESG is often perceived in a technical rather than strategic manner.	• Develop public ESG knowledge repositories for the TSL sector • Create sector-specific ESG guidelines (e.g., aligned with ESRS) • Disseminate best practices through industry and national media
2. Systemic (Institutional, regulatory, and market structures)	The institutional and financial environment that shapes firms' operational capacity and decision-making.	• Lack of dedicated support programs for ESG implementation in logistics (e.g., tax incentives, green fleet subsidies) • Insufficient number of ESG professionals (e.g., compliance officers, analysts) • Misalignment of vocational and managerial education with ESG needs • Prevalence of SMEs with limited implementation capacity	The system does not facilitate ESG advancement. ESG is treated as a compliance burden rather than a source of competitive advantage.	• Introduce fiscal incentives and public grants • Establish ESG competence centers (e.g., under logistics chambers) • Launch micro-grant schemes for ESG in SMEs • Embed ESG in logistics education and professional training
3. Worldview (Beliefs, cultural values, business logic)	The values and ideologies that shape strategic choices and management mindsets.	• ESG is perceived as an external imposition rather than a development opportunity • Belief that sustainability is only relevant for large enterprises or public actors • Low trust in institutions and regulatory bodies • Strong orientation toward short-term financial performance	The sector operates according to cost-efficiency logic and reactive compliance. ESG is not integrated into strategic management.	• Reframe ESG as a value-generating opportunity • Promote values-based leadership in logistics firms • Link ESG to KPIs and core business strategies • Educate on long-term risk reduction and stakeholder value
4. Mythic (Deep cultural narratives and identity archetypes)	The deepest level: subconscious narratives, metaphors, and archetypes that shape sectoral identity.	• "Logistics is just transport – it does not affect the environment" • "An entrepreneur is a fighter – success comes from cost-cutting, not sustainability" • "ESG is an EU-imposed agenda – not our priority" • "Poland lacks the conditions to implement ESG effectively"	These narratives foster a sense of disempowerment and disconnect from the sustainability agenda. ESG is not part of the sector's identity.	• Build new narratives: "Logistics as the backbone of the green economy" • Showcase local ESG champions among SMEs • Conduct campaigns to reshape entrepreneurial archetypes • Incorporate ESG into sectoral culture and professional ethics

Source: own elaboration.

CLA use has shown that ESG issues in the logistics sector are not technical or regulatory but deeply ingrained, cultural, ideological and narrative-based. Effective ESG transformation thus requires multi-level action – not just regulatory and cost adjustments, but adjustments of mind, values and social narratives about the contribution of logistics to economic transformation.

Table 2 presents three possible development paths for ESG in Polish logistics by 2030: Regulated transformation, green grassroots leadership, and apparent adaptation. Each one has been examined using the CLA methodology, enabling understanding not only drivers from the outside world but also underlying stories and assumptions shaping the strategy towards ESG.

Scenario 1: Regulated transformation. ESG is introduced mainly due to EU regulations, not out of conviction. Companies are in reaction, often treating ESG as an obligation, not a strategy. The most significant risk is a formative implementation without fundamental changes, threatening greenwashing and exclusion of SMEs. Not only is the law necessary, but it also supports companies in its implementation.

Scenario 2: Green Grassroots Leadership. ESG is becoming part of companies' identity and strategy. Changes are taking place at all levels - from data to values. Companies, including SMEs, treat ESG as a way to build relationships, reputation and innovation. This scenario shows the most significant potential but requires promoting good practices and supporting change leaders.

Scenario 3: Apparent adaptation. ESG is limited to reporting "on paper". There are no fundamental changes, and ESG is perceived as unnecessary bureaucracy. Such a model will result in lost trust and the risk of exclusion from European supply chains. The most important educational activities and improvement of reporting quality are resumed here.

Table 2.
Future ESG Scenarios in the Polish Logistics Sector by 2030 – CLA and Strategic Foresight Approach

Scenario	Description	Connection with CLA Layers	Opportunities / Risks	Strategic Implications
Regulated Transformation	ESG is implemented primarily under pressure from EU and national regulations. Companies comply formally, focusing on legal conformity.	• Litany: increasing number of ESG reports • Systemic: emergence of subsidies, public support, and standards • Worldview: ESG seen as cost and obligation • Mythic: continued narrative of external enforcement	Opportunities: regulatory compliance, standardization Risks: superficial implementation, SME exclusion, greenwashing	Financial and educational support for SMEs is essential. ESG must be reframed as a source of value, not only compliance.

Cont. table 2.

Grassroots Green Leadership	Transformation is driven by proactive SMEs and industry leaders integrating ESG with values and strategy.	• Litany: new ESG indicators, grassroots benchmarks • Systemic: sectoral self-regulation and collaboration • Worldview: ESG as opportunity and innovation • Mythic: redefined entrepreneurial archetype as a change leader	Opportunities: cultural shift, innovation, enhanced reputation Risks: limited scalability without systemic support	Support grassroots ESG leaders and storytelling. Enable networks of good practices and partnerships.
Superficial Adaptation	ESG is formally adopted but lacks real operational changes. Focus is on reporting and penalty avoidance.	• Litany: increased reporting, poor data quality • Systemic: no structural reform • Worldview: ESG as bureaucracy • Mythic: reinforced belief that logistics has no real impact	Opportunities: minimal, primarily reputational Risks: credibility loss, stagnation, marginalization in EU	Monitoring and education are needed. There is a risk of "dead ESG" that undermines transformation.

Source: own elaboration.

Synthetic cross-sectional conclusions:

- Full ESG transformation will not happen without changing deep cultural and narrative layers – even the best regulations will not transform the sector if ESG does not become part of its identity.
- The "green leadership" scenario is the best of possible scenarios, but it involves active support of change leaders, especially SMEs – through mentoring, networks and narrative campaigns.
- The biggest threat is not the lack of ESG implementation but its superficiality – formal actions without depth increase the reputational and operational risk of the sector.
- The integrated CLA + foresight approach provides good insight to public decision-makers, business and academia, allowing for better development intervention planning.

The three foresight scenarios were constructed following a structured Causal Layered Analysis (CLA). The link to CLA layers—litany, systemic, worldview, and mythic—is made explicit in the third column of Table 2. By this, the methodology enables us to examine how visible deeper institutional foundations, management logic, and cultural accounts shape ESG behaviours (e.g., disclosure). For example, in the "Superficial Adaptation" scenario, high-level reporting (litany) accompanies the absence of structural change (systemic), a worldview that ESG is bureaucracy, and firmly rooted myths that logistics does not concern itself with the environment (mythic). The reverse scenario, though, under "Green Grassroots Leadership", illustrates changes in all the CLA levels, suggesting that successful ESG change must address, at least, policy, belief, identity, and values.

The analysis of ESG risks in three foresight scenarios – Regulated transformation, Green leadership from below and Apparent adaptation – shows different risk profiles and potential for the sector's resilience to the challenges of implementing sustainable development (Table 3).

Reputational risk is most evident in the Apparent adaptation scenario, where companies limiting themselves to ESG declarations expose themselves to accusations of greenwashing and loss of trust from partners. The lack of real action may result in exclusion from business relations.

Operational risk is the lowest in the Green leadership scenario, where ESG is integrated with the strategy. In other cases, the lack of coherence and implementation leads to gaps in governance, environmental safety and operational resilience.

The Regulated transformation scenario best mitigates regulatory risk, although it may not meet market expectations. Companies in the Apparent adaptation scenario are most exposed to sanctions and exclusion from regulated markets.

The risk of exclusion from EU supply chains is particularly high in the Apparent adaptation scenario. The requirements for transparency, carbon footprint and risk management no longer apply to leaders but to smaller subcontractors.

Strategic (innovation) risk is limited only by companies operating by the Green Leadership scenario. The rest treat ESG as a cost, losing the opportunity to develop innovative business models and competitive advantage.

Table 3.
A comparative risk analysis for three foresight-based ESG implementation scenarios

Risk Domain	Regulated Transformation	Grassroots Green Leadership	Superficial Adaptation	Strategic Comments
Reputational Risk	Low (compliance-based trust)	Low (values-driven, credible)	High (risk of greenwashing and distrust)	Superficial adaptation leads to loss of stakeholder confidence and brand damage.
Operational Risk	Medium (costly, reactive adaptation)	Low (integrated into operations)	High (inefficient ESG integration)	Only the leadership scenario aligns ESG with core logistics operations.
Regulatory Risk	Low (meets formal standards)	Medium (voluntary standards may lag behind)	High (non-compliance or symbolic compliance)	Scenario 3 exposes firms to legal sanctions or future exclusion.
Supply Chain Exclusion Risk (EU)	Medium (compliance, but no innovation)	Low (preferred partner in green chains)	Very High (lack of trust, poor transparency)	In Scenario 3, firms may be excluded from sustainable EU value chains.
Strategic Innovation Risk	High (focus on minimum standards)	Low (ESG as innovation driver)	High (no real improvement or learning)	Only Scenario 2 treats ESG as a competitive and transformative asset.

Source: own elaboration.

Risk analysis shows that the greatest threats to the sector result from apparent and superficial actions not supported systemically or culturally. On the contrary, the most significant potential for resilience and advantage is gained by those companies that engage in ESG deeply and authentically, regardless of regulatory pressure.

For the logistics sector to effectively implement sustainable development goals and remain competitive, actions are necessary at three levels:

- Institutional - support from the state and industry organizations.
- Cultural - shift in the narrative and values of management.
- Strategic - ESG integration with day-to-day action and innovation.

Figure 2 presents a comparative assessment of five ESG risk domains across three strategic foresight scenarios for the Polish logistics sector.

It reveals that:

- Grassroots Green Leadership consistently shows the lowest risk profile, supporting that authentic, value-driven ESG integration increases resilience and trust.
- Superficial Adaptation carries the highest strategic risks, especially regarding reputation, innovation stagnation, and exclusion from EU green supply chains.
- Regulated Transformation ensures regulatory compliance but offers limited innovation and long-term adaptability.

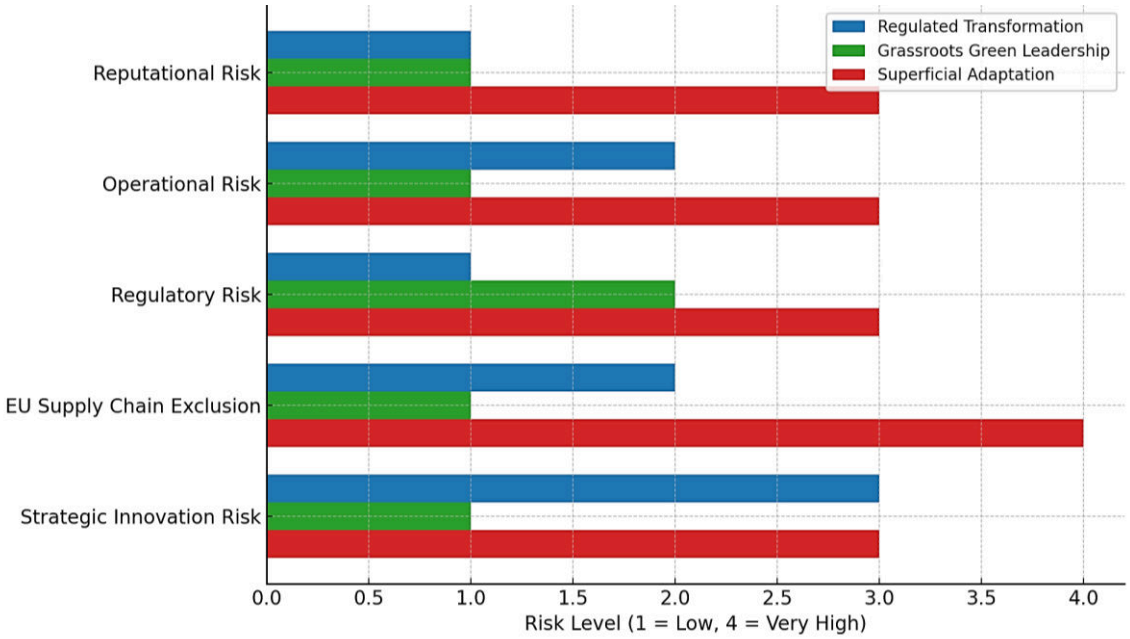

Figure 2. ESG risk domains across three strategic foresight scenarios for the Polish logistics sector.
Source: own elaboration based on Inayatullah (1998), DiMaggio (1983), Kaplan, Mikes (2012).

This visualization highlights the need for profound cultural and strategic shifts beyond formal compliance to minimize systemic ESG risks.

Table 4 provides a comparative evaluation of the three ESG scenarios based on key strategic criteria. The Green Grassroots Leadership scenario is identified as the most desirable and strategically resilient path, although it requires stronger support mechanisms. In contrast, the Superficial Adaptation scenario poses the highest long-term risks, while the Regulated Transformation offers feasibility without profound impact.

Table 4.
Evaluation of ESG Scenarios by Desirability and Feasibility Criteria

Criterion	Scenario 1: Regulated Transformation	Scenario 2: Green Grassroots Leadership	Scenario 3: Superficial Adaptation
Feasibility	High – aligned with current regulatory framework	Moderate – depends on culture shift and SME support	High – minimal effort, maintains status quo
Desirability	Moderate – ensures compliance but lacks innovation	High – fosters long-term resilience and stakeholder trust	Low – risks exclusion and reputational loss
Strategic Resilience	Moderate – compliance-focused, limited adaptability	High – integrated, value-driven ESG	Low – vulnerable to future shocks and market changes
Alignment with EU ESG Goals	Formally high, but implementation shallow	High – deep and genuine engagement	Low – symbolic compliance without substance

Source: own elaboration.

5. Discussion

The analysis confirmed that the main reason for the superficial implementation of ESG in the logistics sector is cultural and systemic factors, including the lack of internal motivation of the organization, as well as limited market pressure and the lack of clear financial incentives for SMEs (Evangelista et al., 2018; Martinsen, Huge-Brodin, 2014).

In the worldview layer, ESG is often perceived as a bureaucratic tool or a requirement of large corporations rather than as an internal strategic drive (DiMaggio, Powell, 1983). The dominant narratives revolve around the "low-margin transport sector" that "does not have the resources" to implement ESG – which is consistent with the remarks of Evangelista et al. (2018) and Martinsen & Huge-Brodin (2014).

However, the CLA study reveals that these are not only barrier measures but also deep-rooted perceptions of the role of logistics as the implementer of service-oriented tasks and not system change leaders (Inayatullah, 1998). The scenarios proposed in the analysis (controlled transformation, bottom-up leadership, apparent adaptation) indicate different paths of possible development, of which only the "green leadership" scenario creates conditions for deep, lasting and strategically integrated ESG change. The apparent adaptation scenario leading to high

reputational and operational risk is also confirmed by the results of other authors (Ahi, Searcy, 2015; Kaplan, Mikes, 2012).

Practical application has the following consequences:

- logistics companies should develop narrative and strategic ESG skills, not based on respecting the law itself (Czarniawska, 2004),
- public institutions should present support instruments (e.g. subsidies, reliefs) based on cultural change, not technological change,
- investors should consider the risk of "greenwashing" when evaluating the logistics sector (Ahi, Searcy, 2015).

Polluting against some of the literature that assumes ESG primarily as an element of compliance, as is so often the case in Anglo-Saxon approaches this time (cf. Eccles et al., 2014), this article illustrates the need for deeper engagement, combining organizational culture and sector narratives. Not only are indicators and reports sufficient, but there is also a change in the language in which logistics and its role in the economic system are discussed (Inayatullah, 1998).

The study's limitations result from its qualitative nature and the use of secondary data. The absence of empirical data (e.g. interviews) limits the possibility of generalization. Additionally, the scenarios are exploratory and require further verification in studies involving sector representatives.

Despite these limitations, the study adds value to the literature by combining CLA and foresight in the analysis of the ESG sector. It also draws attention to the need for a more daring research approach regarding narratives, identity and long-term industry strategies.

Although cultural and institutional factors are central to ESG transformation, digital technologies can be practical enablers, especially for SMEs in fragmented logistics networks. Technologies such as ESG reporting platforms (e.g., SAP Sustainability Control Tower, EcoVadis, Enablon), carbon footprint monitoring, or blockchain supply chain platforms reduce operational effort and enhance transparency. Policy interventions should thus promote compliance and digital infrastructure, training, and access to tailored ESG technologies for the logistics sector.

Future research should also focus on empirically tracking shifts in ESG-related narratives within the logistics sector. Suggested methods include longitudinal discourse analysis of ESG reports, media content and policy documents; interviews with logistics managers to explore changing perceptions; and social media sentiment analysis to monitor grassroots attitudes. This would allow researchers to detect cultural shifts across CLA's worldview and mythic layers and assess the transformation's pace over time.

6. Conclusions

The analysis conducted using the Causal Layered Analysis method and the foresight approach allowed us to identify key conditions hindering the effective implementation of ESG strategies in the logistics sector in Poland. The results indicate that the most significant barriers are the lack of institutional and financial support, deeply rooted beliefs, dominant narratives, and limited ability to perceive ESG as a strategic value.

The identified scenarios - regulated transformation, bottom-up leadership and apparent adaptation - reveal various possible development directions. Only an approach based on internal motivation and an organizational culture supporting ESG can ensure long-term effects and resilience of the sector. The key conclusion is the need to integrate public policy, education and institutional support with actions to change the values and language in which logistics and sustainable development are discussed.

From an economic and financial perspective, ESG in logistics has to be addressed not only as a cost of compliance but also as an investment in long-term stability, risk mitigation, and reputation building. That implies reshaping sector strategy, developing qualitative indicators, and setting predictive and adaptive capabilities for logistics companies.

The article's results provide valuable advice for researchers, decision-makers and practitioners in the logistics industry. At the same time, the study's limitations – including its qualitative nature and reliance on secondary data – indicate the need for continued empirical work, including research with the participation of sector representatives and comparative analysis with other EU countries.

It is recommended that narrative and foresight methods be used further in ESG sector research and to deepen cooperation between science and practice in modelling and implementing sustainable economy solutions.

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ON THE EVOLUTION OF THE CONCEPT OF SUSTAINABLE DEVELOPMENT

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Purpose: The aim of this article is to show the evolution of the concept of sustainable development from the beginning to its current understanding in ongoing scientific debates. The author focuses on the analysis of the meaning of the title concept in its historic development, putting aside its various practical dimensions.
Design/methodology/approach: The article analyzes selected, available literature on the concept of sustainable development. Apart from literature review, the author uses the method of analysis and logical construction.
Findings: The concept of sustainable development is a relatively new one. The concept that we are dealing with today has evolved since about the middle of the 20th century. The idea of sustainable development is defined as a multi- and interdisciplinary issue, encompassing the following aspects: environmental, social, and economic. The emergence of the titular concept was preceded by a long process of development of the concepts of progress, environmental ethics and sustainability in both secular and religious traditions. It seems to be the best possible way to organize the modern world, giving a chance for sustainable and equitable development of human society both on a global and local scale.
Research limitations/implications: The article refers to a limited number of studies. Sustainable development is a multidimensional issue. This concept is defined in different ways depending on the theoretical adopted perspective.
Originality/value: The article refers to selected literature in the field sustainable development. The value of the article is mainly expressed in the approach to the issue of sustainable development in the aspect of the evolution of this concept from its beginning to the present day.
Keywords: Sustainable development, progress, environmental ethics, sustainability.
Category of the paper: Conceptual paper.

1. Introduction

There are many studies analyzing the concept of sustainable development in its different dimensions. Historically, the concept of sustainable development has its source in the 17th and 18th centuries ideas regarding sustainable forest management. Already in 1662, John Evelyn, in his essay entitled *Sylva*, emphasized the need for sustainable forest management (Caradonna, 2017; McKusick, 2013). In 1713, the German mining administrator Hans Carl von Carlowitz published a work on forestry entitled *Sylvicultura economic*. In this work, he developed the ideas of Evelyn and the French minister Jean-Baptiste Colbert, creating a theory of forest management aimed at obtaining sustainable yields. Von Carlowitz's concept influenced other theorists in various countries. In the 1960s, under the influence of various publications (Carson, 1962; Boulding, 2013; Hardin, 1968)) the developing environmental movement drew attention to the relationship between economic growth and environmental degradation.

The origins of the concept of sustainable development in its modern understanding date back to the early 1970s. An important role was played by the report commissioned by the Club of Rome, prepared by a group of MIT scientists led by Dennis and Donella Meadows, entitled *Limits to Growth* (Meadows et al., 2013). In the following years other works were published in which the idea of sustainable development appeared (Woodell, 1972; World Wildlife Fund, 1980). The concept of sustainable development has become in the twentieth century, due to the emerging threats of environmental degradation, on the one hand, a way of understanding the world, and, on the other, a way to save it (Sachs, 2015).

The breakthrough moment in the development of the discussed concept was *the Brudtland Report*. The Report states: "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brudtland Report, 3.27). The importance of *the Report* is mainly expressed in the fact that it placed environmental protection problems on the political agenda and treated economic development as inseparably connected with the environment (Andersson, Hatakka, 2023).

Important documents also include *The Earth Charter* published by the United Nations World Commission on Environment and Development in 1992. It was a declaration of construction of the fundamental principles of a just, balanced and peaceful society of the 21st century. In *The Earth Charter* we read the following words setting the goals of the Conference: "The choice is ours: form a global partnership to care for Earth and one another or risk the destruction of ourselves and the diversity of life. Fundamental changes are needed in our values, institutions, and ways of living" (Initiative, 2000). This project was an attempt to make a comprehensive approach to the sustainable development in its all manifestations.

It is worth remembering, however, that the notions of "sustainability" and "development" that make up the title concept have their antecedents and have undergone a long evolution. Thousands of years of human development have led to the emergence of many different positions regarding the relationship between humans and nature. The dominant trend in antiquity was that which granted man a distinguished position in nature and gave him the right to subordinate it. In particular, however, the Ancient Greeks were the ones who decidedly gave humans a leading role in the natural world. This position was later strengthened by Judeo-Christian tradition. It is important to remember that the world of ideas is not a static one. This also applies to the title concept. The discussion on ecology, its understanding and methods of implementation is still ongoing and is an important element of contemporary scientific, philosophical and also theological discourse.

The philosophical reflection essential for the analysis of the title concept is very rich. The considerations of this article are of an overview nature. This is mainly due to the volume of the text. The notions that constitute the antecedents of the concept of sustainable development appear already in ancient Greece and are present in almost all great thinkers of all eras. The purpose of the considerations carried out in this article was to outline this long path of development.

The originality of this article lies in the applied research approach to the analysis of the progress of the concept of sustainable development. The method of literature review and logical text analysis was used to examine the development of notions that are antecedents of the title conception. The aim was to trace the evolution of the sustainable development concept in both Western philosophical thought and the related Judeo-Christian religious tradition.

2. Methods

The article uses a research technique such as literature review to collect, analyze, and synthesize relevant information from a wide range of sources. A literature review is a fully-fledged research method. A well-conducted literature review allows you to get acquainted with the current state of knowledge in a given field and provide reliable answers to research questions (Snyder, 2019). This is an excellent method for analyzing interdisciplinary research. It also allows for the synthesis of research results and the discovery of areas where further research is necessary. The literature review was conducted on the Google Scholar and Science Direct platforms. The databases were searched based on the following keywords: sustainable development, progress, environmental ethics, sustainability.

The table 1 below summarizes the different types of literature review.

Table 1.
Types of Literature Review

Type	Systematic	Semi-systematic	Integrative
Typical purpose	Synthesize and compare evidence	Overview research area and track development over time	Critique and synthesize
Search strategy	Systematic	May or may not be systematic	Usually not systematic
Research questions	Specific	Broad	Narrow or broad
Analysis and evaluation	Quantitative	Qualitative/quantitative	Qualitative
Sample characteristics	Quantitative articles	Research articles	Research articles, books, and other published texts
Examples of contribution	Evidence of effect Inform policy and practice	State of knowledge Themes in literature Historical overview Research agenda Theoretical model	Taxonomy or classification Theoretical model or framework

Source: own elaboration based on: Snyder, 2019.

The considerations presented in the article also use the method of logical analysis. The essence of this method is the use of logical tools to distinguish correct arguments, i.e. those that are consistent with the laws of logic, from those that violate the rules. Logic and its methods allow us to discover the most general structural aspects of our thinking and actions (Peregrin, Svoboda, 2017). The application of the tools of logical analysis to propositions expressed in natural language is justified by the fact that the rules of such a language are also subject to the laws of logic.

Logical analysis is helpful in research conducted in social and management sciences. It enables better understanding of their theoretical and conceptual framework (Ngulube et al., 2015). Management sciences, like any other scientific discipline, have their own research methods and are characterized by interdisciplinarity. For this reason, some kind of methodological eclecticism can be attributed to these sciences. It allows to combine methods from various disciplines, paradigms and approaches, ensuring their cognitive and pragmatic efficiency. These are both quantitative and qualitative methods. The research process in management sciences is often accompanied by various types of models, including: theoretical and conceptual, research or statistical. The model, in general, means a hypothetical thought structure, i.e. the arrangement of assumptions, concepts and relationships between them, allowing you to describe some aspect of reality. The role of logic in research is crucial because it allows to draw correct conclusions and avoid errors in reasoning.

Logic is a formal science. Both formal and informal principles of logic can be applied to the analysis of a text in natural language (Ngalande, 2011). The author of this article does not use formalisms. The goal is not to strictly reproduce the conceptual structure of the analyzed field but to capture the most central problems of the concept of sustainable development in the aspect of its evolution. The term "logic" that appears here should not be identified with a priori science. It is rather a specific method of research used in the social sciences (Mahoney, 2021).

3. Evolution of the idea of progress

A proper understanding of the concept of sustainable development requires an analysis of its component concepts: development, environmental ethics, and sustainability. This, however, presupposes the study of the concept of progress, which is the antecedent of the concept of development.

R. Nisbet writes: "The essence of the Western idea of progress can be simply stated: mankind has advanced in the past, is now advancing, and may be expected to continue advancing in the future" (Nisbet, 2017, p. 7). This definition, although at first glance consistent with the common understanding of the concept of progress, requires explanation and leads to further questions. First of all, the question of what does "advance" mean? One can also ask what kind of progress is meant: scientific, technological, moral, demographic or some other kind? There is also the question of the measure of this progress.

The concept of progress has a long history. The first ideas about progress were formulated in the classical Greco-Roman period (Burkert, 1997; Du Pisani, 2006). We are dealing here with a certain paradox, because, as M. Asper notes, technical progress in antiquity was, from a modern perspective, quite slow (Asper, 2013). In this article, however, we are interested in the idea of progress as such, not in its specific forms as it appears in reality. It turns out that the Greeks had many ideas about progress, especially when it comes to knowledge (Dodds, 1985; Edelstein, 2019). To sum up, Greek philosophers introduced to the idea of progress the pioneering concept of the natural growth of knowledge over time.

Christian philosophers basically continued the views of Greek thinkers. Like classical philosophers, they emphasized the role of knowledge, art, and science as essential factors of progress. This was the case both in the era of the Church Fathers and in the Middle Ages. The idea of the progress of knowledge and culture in general gained its greatest development thanks to the philosophers of the twelfth and thirteenth centuries. Some researchers note that the idea of progress was shaped by the gradual replacement of the medieval belief in providence (Löwith, 1949) or at least point out the importance of the religious concept for the idea of progress (Cantor, 2012). In its most general aspect, the Judeo-Christian tradition brings three essential points to the idea of progress: (1) the concept of the world created by God; (2) the linear concept of time; (3) belief in the value of work (Marchetti, 1977). The three mentioned motives are the link between the religious concept and the modern idea of progress.

The Reformation, which on the one hand was a criticism of the church, on the other hand revived critical thinking and thus contributed also to reflection on the idea of progress. It is worth noting that M. Luther's doctrine of equality favored the democratization of the church or even of power as such (Cavanaugh, Scott, 2019). From about the middle of the eighteenth century to the beginning of the twentieth century, the idea of progress reached its apogee among Western intellectuals, both in popular and scientific circles. In the West, it became a dominant

idea. Even if one takes into account the growing importance of other ideas raised by the French Revolution, such as freedom, equality, and social justice. As is well known, belief in unlimited progress was one of the characteristics of the Enlightenment (Wagner, 2016). The ultimate goal of progress was seen as an ever-increasing degree of individual freedom. This vision was supported by numerous scientific and technical achievements in the eighteenth and nineteenth centuries. These, in turn, were made possible by the increasing freedom of scientists and philosophers. Interestingly, at the same time when personal freedom was seen as the goal of progress, power was seen as both a necessary means to achieve progress and its goal (Nisbet, 2017).

Many modern philosophers have addressed the issue of progress. An important contribution to the construction of the idea of progress was Kant's *Idea for a Universal History* (Lloyd, 2009). Kant postulates striving to achieve the "cosmopolitan goal", i.e. a world order in which the relations between nations achieve something analogous to the order characterizing a set of individuals that transforms them into an ordered state. More radical versions of progress were postulated by other modern philosophers such as Hegel in his *Phenomenology* and *Lectures on the Philosophy of History* or by K. Marx and F. Engels (Hegel et al., 1977; Hegel, 1861; Sayers, 2020). The idea of historical progress found in Hegel's philosophy, which is relatively independent of nature, enables research on the constantly changing relationships between human and non-human developing forms. Also, the vision of history presented by A. Comte with his concept "the law of three necessary stages" of human development was based on the concepts of order and progress (Comte, Bridges, 2015). Some researchers place the sources of the contemporary concept of progress in the earlier era. F. Fukuyama, for example, sees the appearance of a modern concept of progress in Machiavelli's thought, in his separation of politics and morality (Fukuyama, 1992).

Nowadays, one can meet the view that the idea of progress died with Herbert Spencer’s evolutionism, definitely ended with the nineteenth century. Spencer was a nineteenth-century thinker who devoted a lot of attention to the idea of progress. He made a category of progress one of the most important of his whole philosophy (Spencer, 1891). In the twentieth century, faith in the existence and power of progress was shaken by the tragic historical events of two World Wars and all the horrors that accompanied them. It seemed at that time that the faith in progress expressed in previous centuries was only an illusion. Has anything changed in this regard? R. Morgan notes that in the current era of globalization, the idea of progress has been replaced by the idea of sustainable development. Reflecting on the possibility of its implementation, he states: “Is this just a ridiculous utopian dream that has no material referent, no chance of realization, or is it an imperative of human evolution? It all comes down to a matter of choice. If we say we have no dream, then we have no choice—and without choice, who are we? Devoid of choice, humanity has no meaning and no future. We must choose the dream– a vision of the future of humanity– and then we must choose to make it real” (Morgan, 2015, p. 118). Let these words be the answer to the question asked above.

Another question arises about the future of the idea of progress in the West. It seems that the real and most comprehensive answer to this question is, so far, the concept of sustainable development. This is for several reasons:

- It is an idea based on interdisciplinary scientific research showing that "that any progress through learning could never be only contemplative in nature" (Mouzakitis, 2017, p. 4). The idea of sustainable development is no longer a purely theoretical concept discussed in academic circles but has become part of political, economic and social activities.
- As a concept, on the one hand, that is the result of a centuries-old philosophical, ethical, scientific but also theological tradition, on the other hand, as based on the practices of people living in changing realities of social, economic, geographical and cultural life meets the requirement of a universal concept exceeding cultural barriers. As such, it has become just a pan-human concept.
- The concept of sustainable development can be understood as the transfer of the idea of progress in the field of philosophical reflection to the field of policy shaping the real environment of human life.
- There is also another reason that can be described as methodological in nature. A more effective and complementary conception of human development has not yet been developed.

Of course there are also critics of the concept of sustainable development (Daly, 1995; Blühdorn, Welsh, 2013). This criticism comes from various sources. Part of it stems from a simple lack of understanding of the concept (Shi et al., 2019). Factors of various kinds should be involved in explaining the idea of sustainable development and promoting it: organizational, cultural, religious at various levels, both government and local government. A completely separate issue, but also the future, especially when it comes to implementing the concept of sustainable development, is the use of AI tools.

4. Evolution of the concepts of environmental ethics and sustainability

The concept of sustainability appears for the first time in the 17th and 18th centuries in the context of forest resources management (Wilderer, 2007). It seems that there have always been two opposing views on the relationship between man and nature and the resources he uses. One of them emphasized the need for harmonious coexistence with nature, the other postulated its conquest and considered man as the lord and master of nature. All Western ancient civilizations were agrarian (Attfield, 2021). Describing the contemporary understanding of Sustainability F. Weder states: "Sustainability is not only a principle of action. Sustainability is a norm of regenerative practices and resource restoration, manifested in and supported by the United Nations in their 17 Sustainability Development Goals" (Weder, 2023, p. 228).

Sustainability is a multidimensional concept. The idea of sustainable development as a universally recognized model of human development did not appear until 1987 with the publication of "Our Common Future" released by the World Commission on Environment and Development (WCED) (Hajian, Kashani, 2021). This document applies to the tension that arises between the economic development of humanity and limited resources of nature (Kuhlman, Farrington, 2010). There are some similarities between the concepts of sustainability or sustainable development and business ethics. Both combine elements of humanistic culture and economics (Orbik, 2016).

The issue of the ancient Greeks' attitude towards the environment and ecology is not clear. Some scholars trace the origins of ecological thought to Aristotle and his student and successor Theophrastus (Coates, 2013). However, already Plato in the dialogue *Timaeus* proposes a holistic view of the world as a living creature (Ti. 30c). It is worth noting that the term "ecology" comes from the Greek *oikos* and means household. Both of the aforementioned thinkers tried to understand reality and the relationships between its components. R. Post, characterizing the Greeks' interest in the problem of the relationship between humans and nature, rightly notes the following: "The origins of interest in the relationship between humans and the environment in the ancient Greek world can be traced back to diverse 19th- and 20th-century intellectual movements, such as Romanticism in the German-speaking countries, human geography in the English-speaking world and the Annales School in France. The study of the environment in the ancient world only assumed a form recognizable today, however, with the rise of the environmentalist movement in the 1960s" (Post, 2022, p. 318). It is therefore difficult to speak of an ecological movement in the strict sense in antiquity. However, just as Greek thought created the foundations for scientific reflection about the world, the Greeks played a similar role in the case of ecological awareness. However, both individual and social awareness awakens slowly. The one that interests us here fully developed only in the twentieth century.

It is worth noting that the relationship between people and nature is based on an ontological assumption concerning the distinction between two orders: culture and nature. The Greeks were the first to distinguish these orders. The concept of nature itself was also subject to evolution in Greek philosophy (Habash, 2016). Greek discussions of nature began as attempts to answer the question: should nature or customs determine the way of human life? More generally, this issue can be framed as a question about the nature of just law regulating social life. Various answers have been given to this question. Importantly, there is a reflection in Greek thought on the organization of community life. It is a matter of debate to what extent the reflections of ancient philosophers took into account issues concerning the relationship of people to the environment.

S. Erck, for example, proposes an ecological interpretation of Plato's *Republic*. She writes: "The *Republic's* political discussion begins with the construction of two contrasting cities: a 'healthy' city and a 'city with a fever'; one defined by environmentally sustainable substance practices and the other by 'luxurious' over consumption that exceeds the carrying capacity of its

land" (Erck, 2022, p. 213). M. Chemhuru, in turn, tries to justify the thesis about the existence of environmental ethical thinking in Greek philosophy (Chemhuru, 2017). The said author states: "The question concerning the ethical relationship that ought to exist between human beings and other non-human beings and their surrounding remains at the core of Western environmental ethics and African environmental ethics as well" (Chemhuru, 2017). Greek ethics was mainly anthropocentric. This is an issue that exceeds the framework of this article, however, it is worth noting that the non-anthropocentric thinkers can also be found among Greek philosophers (Coman, 2006). Traces of such thinking can be found, among others, in Thales, Plato or Aristotle.

A clear distinction between humans, animals and plants appears in Aristotle. We read: "In like manner we may infer that, after the birth of animals, plants exist for their sake, and that the other animals exist for the sake of man, the tame for use and food, the wild, if not all, at least the greater part of them, for food, and for the provision of clothing and various instruments. Now, if nature makes nothing incomplete, and nothing in vain, the inference must be that she has made all animals for the sake of man" (Aristotle, 2001, 1256b, 15-22). Aristotle was obviously not an ecological thinker in today's understanding. In his time there was also no crisis in terms of environmental state. He was, like all Presocratics, a philosopher with anthropocentric attitude. However, in his writings you can see motives that are attractive to modern ecological thought (Cooper, 2001).

The next step in ancient Greece towards an ecological way of understanding the world was taken by the Stoics. Stoicism was a philosophical school of the Hellenistic period founded by Zeno of Citium around 300 BCE. Zeno's teachings were influenced by the philosophy of the Cynics, Socrates and Plato. Prominent Stoics of the Roman period included Seneca, Epictetus, and Marcus Aurelius. The Stoics taught that a happy life consisted in living in harmony with nature. The Stoics identified life understood in this way with the "virtuous" life. The revolutionary nature of their views was expressed in the belief that the ability to act virtuously was independent of social status, level of education, gender, or material wellbeing. The Stoics taught that all people are equal according to the laws of the eternal *Logos* permeating nature. The Stoic student is called to "follow nature" or study physics. This resulted from the belief that human life is a part of nature.

In subsequent centuries of philosophy, ecological issues gained more and more interest among philosophers. The role of philosophy boiled down to providing a comprehensive understanding of nature and place of man in it (Gare, 2018). C. Glacken in his published in 1967 but still important book points out that ecological ideas appearing in European philosophy since ancient times mainly concerned three issues: the idea of a designed earth, the idea of environmental influence, and the idea of man as a geographic agent (Glacken, 1967). The ideas developed by philosophers of different eras concerned, in the most general sense, the relationship of culture to the environment. Getting rid of the anthropocentric way of thinking was not easy even for the brilliant minds like Descartes or Leibniz. This leads to the thesis that

the decisive factor here was not so much the genius of a given individual but the spirit of the era. In short, the development of ecological thought was rather evolutionary than revolutionary.

Modern science, which emerged from philosophy during the Renaissance, and the direction of technological development that modern societies underwent was done with the specific goal of conquering nature. At that time, the anthropocentrism of classical Greek humanism, whose main representatives were Plato and Aristotle, had already been absorbed by Christian doctrine. However, technological development caused people to start paying attention to the impact they had on the surrounding environment. Ecological awareness was born, on the one hand, under the influence of certain evolving philosophical and theological views, and on the other hand, it was the result of scientific and technological progress.

Table 2.
Philosophical perspectives of wellbeing and their insights into sustainable development

School/ Perspective	Type of Wellbeing	Wellbeing Obtained Through	Contribution to the concept of sustainable development
Aristotle	Eudaimonic	Virtue is a necessary but not sufficient element of a happy life (eudaimonia). In addition to virtue, material goods, health, and education are also necessary.	Virtue is the most important element to achieve balanced ideals. It is acquired through knowledge. Everyone is obligated to build a social order based on virtue.
Stoicism	Eudaimonic	Virtue is the only necessary and sufficient means by which one can experience eudaimonia. Everyone has the capacity to achieve virtue. Material goods are good or bad depending on how they are used. Virtue is an end in itself.	Zeno's Republic of Sages, as an ideal Stoic city represents a collective vision of eudaimonia. It had "Communistic" elements, derived from his philosophical view of belonging to the community as a whole and the moral obligation one has within it to behave virtuously.
Epicurean	Hedonic	The basic principle is the rational maximization of pleasure and minimization of pain. The way to achieve this is social isolation, austerity, and avoidance of public life.	A happy life is a life of rationally experiencing pleasure. This involves social isolation and a focus on simple pleasures, which is consistent with the principles of sustainable development.
Cyrenaic	Hedonic	Pleasures of the past, present and future. Pain is to be avoided. One should strive to achieve the greatest possible pleasure. The Cyrenaics reject the dominant Greek concept of eudaimonia, which is the ultimate goal of life.	The Cyrenaic view is the antithesis of sustainable development. If every individual were to seek to maximize their own well-being through the unfettered accumulation of material goods without concern for what truly constitutes well-being, humanity could not survive.
Platonic/ Neoplatonic	Ascetic	Union with Divine Consciousness, eudaimonia identified with deification.	The Platonic and Neoplatonic traditions see the path to true happiness in a philosophical life and an arduous effort at moral improvement. The call to an ascetic lifestyle assumes, among other things, limiting material needs and a consumerist lifestyle.
Materialistic	Material	The acquisition of money, possessions, and status.	Strong focus on materialistic aims, quality of life and self-actualization.

Source: own elaboration based on: Whiting et al., 2018.

The views of the main trends in European philosophy presented in the table above show that elements of reflection that can be called ecological occur in various philosophical traditions since ancient times. Although environmental destruction is a relatively new problem facing humanity, it turns out that many centuries earlier one can observe manifestations of rational reflection on possible threats (Pereira, Funtowicz, 2015). To some extent one can say that theoretical reflection has outpaced the real effects of human activity related to environmental exploitation. Ecological motives were manifested in philosophical reflection, especially in ethical systems.

5. Ecological movement in Christianity

The issue of the influence of Christianity on the ecological movement is the subject of many analyses (Hampton, Hedley, 2022; Lea, 1994; Poungpet, 2023; Purwanto, Silalahi, 2024; Tabalaka, 2023). Christian beliefs and practices in the discussed topic are based on the concept of stewardship. This concept includes responsibility for the natural environment and sustainable use of its resources. This results from the biblical teaching about the creation of the world by God, who entrusted man with the role of steward: "The Lord God took the man and put him in the Garden of Eden to work it and take care of it" (Genesis, 2:15). Ecological themes appear throughout the Bible. In the Old Testament, we can point to Psalm 104, where we find a description of the natural world created by God, or Prov. 12:10, where we read: "'A righteous man regards the life of his beast". There are, of course, more similar passages in the Old Testament. In the New Testament, we can point to some of Jesus' statements in which He points to the beauty of nature or the superior role of man (Mt. 6:26-29). The Apostle Paul, perhaps under the influence of Stoic anthropocentrism, includes the whole of creation in God's plan of salvation (Rom. 8.21-23).

B. Poungpet notes that stewardship is an important concept in Christianity, especially in relation to the environment (Poungpet, 2023). In Christian theology, stewardship refers to the responsibility God has given humans to care for the natural world and all its living things, and has its roots in the Bible's creation story. Stewardship means managing and conserving natural resources, promoting biodiversity, and protecting the environment from pollution and other forms of degradation" (Poungpet, 2023, pp. 76-77). Some point to the Church Fathers as the forerunners of ecological thinking. In Irenaeus, for example, there is the idea of the entire cosmos as renewed at the end of time. Ecological threads can be found, among others, in the writings of Basil the Great, Chrysostom, Ambrose, or Theodoret (Stander, 2000). The themes outlined above have been developed throughout the long history of Christianity. The problem of the relationship of man as a steward to the natural environment is also a theological issue. However, it is a separate problem for many reasons and cannot be analyzed in this text.

In the Middle Ages, just as in the first centuries, Christian ecological views were based on the belief that nature, as created by God, is good and that humans have a duty to steward and care for it (Carl, 2020). This view, typical for Christian thought, reflects an understanding of stewardship as a divine command. There is no consensus among scholars as to the contribution of the most outstanding medieval Christian philosopher Thomas Aquinas to the development of ecological thought. Some accuse Aquinas of extreme anthropocentrism (Singer, 2004; Linzey, 2016). They claim that Thomas did not grant animals any rights and people no moral responsibility towards them. There are also defenders of Aquinas' ecological sensitivity (French, 1993). Leaving aside the detailed discussions, the essence of Thomas's thought is the view that animals are not moral subjects because they do not possess a rational soul and are therefore incapable of achieving the happiness that Aquinas identifies with the contemplation of God. It seems that Thomas Aquinas's position is accurately summarized by R. McLaughlin who states: "In short, for Aquinas, moral concern must be directed to human welfare, which is ultimately directed toward God. Any attempt either to ascribe direct moral concern to nonhuman animals or unhinge what is ultimately an eco-theological ethics of anthropocentric conservation would render central claims of Aquinas' theological framework incoherent. Ultimately, Aquinas provides a powerful resource to expand our concern for the welfare of the nonhuman creation within the borders of an anthropocentric conservation in which indirect moral concern grounds this expansion. If one seeks to move beyond these borders, however, one will have to move beyond Aquinas to other voices in the Christian tradition" (McLaughlin, 2012, p. 97).

In modern times, the attitude of Christianity towards ecological issues has become much more complicated. This was influenced by the fact that, especially after the rise of Protestantism, various trends appeared in Christian theology and ethics, but also by significant changes caused by the ongoing development of science and technology. The problem with an unambiguous assessment of the attitude of Protestantism towards ecology stems from the fact that it is not a monolithic movement (Cobb, 2003). In general, it should be recognized that Protestantism, like all Western Christianity, is anthropocentric. As in Christianity as a whole, an evolution of views on environmental ethics and attitudes towards sustainable development can also be observed within Protestant churches. Research conducted by twentieth-century Protestant theologians, historians and ethicists emphasizes that the notion of grace and the models of gifting implied by it play an important role in the shaping of the idea of ecology. Grace gives rise to a sense of gratitude towards all those creatures to whom we owe something (Keller, 2016).

Ecological motives play an important role in the teaching of recent popes. John Paul II wrote: "In our day, there is a growing awareness that world peace is threatened not only by the arms race, regional conflicts and continued injustices among peoples and nations, but also by a lack of due respect for nature, by the plundering of natural resources and by a progressive decline in the quality of life (…) Faced with the widespread destruction of the environment,

people everywhere are coming to understand that we cannot continue to use the goods of the earth as we have in the past" (Pope John Paul II, p. 230). Currently, Christianity even calls for spiritual, anthropological and ecological conversion. An important step towards environmental ethics was the encyclical entitled *Laudatio Si*, published by Pope Francis in 2015. We read in the encyclical: "The urgent challenge to protect our common home includes a concern to bring the hole human family together to seek a sustainable and integral development, for we know that things can change" (Francis, 2015, no. 13). Due to the influence of the Pope's teaching on Christians around the world, this document should be considered an important contribution to the development of the concept of sustainable development and ecological awareness (Francis, 2022).

It can be stated that now Christianity is part of the ecological current dominating in the West. Evidence of the ecological commitment of contemporary Christianity can also be found in new concepts such as eco-theology or animal-theology (Bauman, 2011). M. Eaton points out that the trend called eco-theology has its source in the writings of Christian Neoplatonists such as Nicholas of Cusa and Giordano Bruno (Eaton, 2024). It is worth remembering that much of the development of Christian philosophy, ethics and theology overlaps in scope with the philosophical tradition of the West as such. In other words, it is its integral part.

6. Results and Discussion

After tracing the concept of sustainable development in its historical evolution, the question arises: do we now fully realize the true meaning of this concept and its implications? Historical research can also provide answers to another important question: what caused the emergence of this concept. There are various ways of presenting the history of humanity. One of them is the description of the relations between humans and the environment in which they live. The origins of this approach can be found in the history of the West already in Greek thought. Of course, Greek thinking about nature was completely different from modern one, especially when it comes to understanding the mechanisms of nature (Gregory, 2020). Ecological thinking and reflection on the relationship of humans to the environment in which they live has changed in much the same way as scientific views on the nature of the world have changed.

One of the concepts preceding the ecological movement that saw the need or even necessity for sustainable development was the concept of progress. The idea of progress is multidimensional and raises many questions. From the point of view of the subject considered in this article, the most important seems to be scientific progress. Its most common version is the cumulative conception of progress according to which, as scientific research is conducted, the amount of knowledge increases. The cumulative concept of progress found its critics in the twentieth century. One of them was T. Kuhn, according to whom scientific progress is made

not through evolution but through a change of paradigm (Kuhn, 1997). This concept is today more of a history of science than a seriously discussed idea. However, it has played an important role as one of the attempts to understand the nature and mechanisms of scientific progress (Ogundele, Ogunyomi, 2020). In the twentieth century there were also other concepts trying to explain the essence and development of science formulated by K. Popper, I. Lakatos or P. Feyerabend (Popper, 2005; Lakatos, Feyerabend, 2019). Scientific progress is, of course, accompanied by technological one. Both of these factors affect people's lives. A prerequisite for everyone to benefit from the development of scientific knowledge, however, is access to technological achievements.

The analysis of the development of the idea of progress entitles you to state that the difference between the idea of progress or at least the vision of history between the ancient and the modern people is that they placed their "golden age" in the past, while our thinking is focused on the future (Inge, 2023). Since the 1970s, the idea of progress has found its exemplification in the concept of sustainable development. The contemporary concept of sustainable development is therefore an embodiment of the idea of progress understood as such a relationship between man and various elements of the natural environment that realizes or even enables development in various areas of human activity.

Philosophy is, as we know, one of the pillars of European culture. Many concepts in the field of science, art, economics, and politics have their source in philosophical reflection. The same applies to the concept of sustainable development. Although this was not the purpose of the considerations contained in this article, it is worth noting that the title concept is based on some philosophical assumptions. One of them, for example, is the assumption of the ethical importance of the entire biosphere. An attempt to understand the roots of the title concept forces us to trace its philosophical antecedents. On the other hand, the concept of sustainable development itself can be treated as a kind of "holistic philosophy" (Molotokienė, 2024). The latter term should be understood in both a historical and systematic aspect. It is therefore about examining, on the one hand, the history of philosophical concepts that create the idea of sustainable development and, on the other, the metaphysical or axiological assumptions that constitute it.

The concept of sustainable development is multidimensional. In this article, we have focused on its evolution, omitting other important threads such as the principles of this development or the political, economic and social challenges associated with its implementation. In light of the conducted literature review, it turns out that the contemporary understanding of this concept was shaped in a long process of creation of concepts, both in secular and religious grounds. As Hariram et al. (2023) write: "The world’s ancient cultures combine worship and religious convictions with environmental preservation, which calls on people to take care of the planet and keep it in good condition” (p. 1).

An important aspect of the development of ecological issues is also the issue of human rights. The concept of human rights is essentially a product of European culture and especially democracy (Orbik, 2019). The relationship between human rights and development has long been the subject of discussion (Arts, 2017). However, there is even no need to justify the thesis that it is difficult to talk about sustainable development in the case when basic human rights are violated. The issue of human rights itself can be treated as an important indicator of civilizational progress.

Reflections on environmental ethics can also be found in Christianity from its beginnings. In general, it should be stated, however, that the attitude of Christianity or, more broadly, the Judeo-Christian tradition towards ecological issues is complicated. In the sense that, despite the clearly outlined biblical anthropocentrism, we also find many passages in the Bible that can be considered groundbreaking in relation to the contemporary perspective of environmental ethics. It is worth mentioning that there are also views criticizing Christianity for supporting the massive exploitation of natural resources (Abdi, Pardamean, 2019; White, 1967; Rodd, 2001). An area particularly susceptible to ecological issues is Christian ethics. The problem of the relationship of man as a steward to the natural environment also concerns theology. However, this is a separate issue concerning doctrinal matters.

The contribution of Christianity to ecological thought is aptly summed up by Purwanto and Silalahi who write: "Historical perspectives on Christianity and ecology reveal a complex and evolving relationship that is both controversial and collaborative. Historically, Christianity has often been accused of contributing to ecological degradation, as seen in the debate sparked by Lynn White Jr.'s 1967 article, which criticized Western Christianity for its role in the modern ecological crisis (Abdi, Pardamean, 2019). However, this view is challenged by the recognition that within the Christian tradition, there are rich resources for ecological thought and practice" (Purwanto, Silalahi, 2024, p. 163). Taking into account the Judeo-Christian tradition in all its historically rich development, it should be stated that it constitutes a valuable contribution to the development of the concept, the culmination of which is the idea of sustainable development and which sees man as a responsible steward. Of course, an accurate reconstruction of the development of ecological ideas in the Judeo-Christian tradition requires further research.

In the most general terms, it should be noted that ecological thinking and reflection on the relationship of man to the environment in which he lives have changed in a similar way to the changes in scientific views on the nature of the world. The ecological movement should not be treated as some isolated set of views. It is rather an integral part of the rational attitude of humanity towards the world and human place in it. C. Harper, discussing the relationship between religion, science and ecology, notes:" The relationship between religion and environmentalism surely emerged as a subset of the relationship between religion and science" (Harper, 2008, p. 6). One should remember that all these areas are a product of humans and reflect human awareness of both themselves and the environment in which they live.

7. Summary

The concept of sustainable development is a complex construct that has undergone some evolution. The idea of sustainable development as we understand it today arose in the nineteenth century and was fully developed in the twentieth century. The beginning of ecological thinking underlying this concept can be traced back in Western tradition to ancient Greek philosophy.

Judaism and Christianity also played an important role in shaping the relationship between man and nature. Although the considerations contained in this text are limited to Western culture, it is worth mentioning that ecological motives also appear in many Eastern religions such as Buddhism, Hinduism and Islam. In general, the great religions raise the issue of the relationship between man and nature.

The attempt to take a historical look at the evolution of the concept of sustainable development also results from the fact that concepts and notions are subject to an evolution analogous to that which concerns material objects. The term "sustainable development" appeared for the very first time in the seventeenth century. This concept was developed in the following centuries. However, it was only in the 1970s that it gained a global dimension.

The antecedents of the title concept are the notions of progress and environmental ethics. These concepts have source in philosophical reflection but also in theological disputes. They are also present, as mentioned above, in all world religions. In Western culture, ecological consciousness on the one hand, under the influence of certain evolving philosophical and theological views, and on the other, it was the result of scientific and technological progress.

The formation of the idea of sustainable development occurred, as stated above, as a result of centuries of evolution. The emergence and development of science and the accompanying technological progress aimed at conquering nature and making it subservient to man which have led over time to the degradation of the biosphere. In modern times, the concept of sustainable development has replaced the idea of progress that has been developed over the centuries in various understandings. The concept of sustainable development is not only the result of theoretical reflection on the development of humanity, but has also become a necessity and a condition for any further progress of humanity.

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INSIGHTS FROM RESEARCH ON DYNAMIC CAPABILITIES IN POLISH ENTERPRISES

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Purpose: The primary aim of this paper is to analyze the differences in dynamic capabilities across high-growth enterprises (HGE) and those from IT sector. The conducted research will provide insights into how these enterprises integrate, transform, and manage their resources to foster growth and achieve market success.
Design/methodology/approach: The theoretical considerations in this study focus on the microfoundations of dynamic capabilities, specifically sensing, seizing, and reconfiguring. The theoretical assumptions were verified using quantitative methods. Empirical research was conducted on a sample of 502 enterprises from the HGE and IT sectors. To analyze differences between variables across enterprises, linear modeling (ANOVA) and Tukey's post hoc test were applied.
Findings: The empirical findings expand existing knowledge and highlight differences in the exploration of dynamic capabilities between HGE and IT enterprises. Notably, in each of the examined constructs (SEN, SEI, REF), enterprises in the HGE group consistently achieved higher average scores. However, despite these observed differences favoring HGE, the results are not sufficiently heterogeneous to suggest significant disparities in how HGE and IT enterprises respond to dynamic market challenges.
Research limitations/implications: The quantitative study focused on enterprises that operate in dynamic environments and are characterized by high innovation, flexibility, and agility. Future research should consider low-growth enterprises or SMEs to gain insights into their approach to dynamic capabilities.
Practical implications: The findings provide practical implications and recommendations for business leaders. For HGE and IT enterprises, these recommendations address identified gaps and shortcomings, while for other businesses, they offer valuable guidance for adapting to dynamic environments.
Originality/value: A key novelty of this study is its focus on dynamic capabilities at the microfoundational level. The results enhance our understanding of how enterprises act and react to maintain a competitive advantage in rapidly changing markets. They highlight both similarities and, more importantly, differences in how enterprises approach sensing, seizing, and reconfiguring their dynamic capabilities.
Keywords: sensing, seizing, reconfiguring, HGE, IT sector.
Category of the paper: Research paper.

1. Introduction

The concept of dynamic capabilities (DCs), rooted in the resource-based view, considers environmental changes and integrates organizational learning theory, emphasizing a firm's adaptive abilities. The literature highlights that the concept of dynamic capabilities supports competitive advantage (Wang, Ahmed, 2007), but this is not a sufficient condition (Eisenhardt, Martin, 2000). Both strategic renewal and dynamic capabilities play a key role in enabling enterprises to adapt to a rapidly changing, resource-rich environment (Fainshmidt et al., 2019). It is recognized that the concept of dynamic capabilities refers, on one hand, to the outcomes achieved, which translate into competitive advantage (also in the long term), and on the other hand, consists of many factors, with routines and managerial actions playing a key role (Stańczyk-Hugiet et al., 2016). Previous research confirms the existence of a relationship between dynamic capabilities, competitive advantage, business performance, and value (Dyduch et al., 2021; Fainshmidt et al., 2019; Girod, Whittington, 2017; Prester, 2023; Wilden et al., 2013). However, dynamic capabilities should also be viewed from the perspective of microfoundations, which allows for their identification as well as the relationships both between themselves and with the environment. These capabilities are based on microfoundations, representing distinct skills, processes, procedures, organizational structures, decision rules, and disciplines.

This article focuses on the microfoundations of dynamic capabilities according to the typology proposed by Teece (2007), highlighting their significance in two groups of enterprises: high-growth enterprises (HGE) and those in the IT sector. Both groups belong to enterprisess focused on growth in a dynamic environment and are characterized by high innovativeness, flexibility, and agility. Despite many similarities, there are differences between them, such as in their approach to responding to technological changes and strategic actions. It is worth emphasizing that the priority for HGEs is market expansion, while IT enterprises focus more on the development of their products or services' technologies. Frešer (2022) adds that rapidly growing firms—usually younger, innovative, and willing to take risks—can be more strategically agile and better able to respond to global changes. The most considered factors driving high growth in enterprises are human capital, human resource management, strategy, organizational capabilities, and innovation (Demir et al., 2017; Grabowska, Otola, 2022). According to a report prepared by McKinsey & Company (2022), HGEs invest 2.6 times more in intangible assets, which translates into a 6.7% higher revenue growth compared to low-growth firms. The growth imperative is driven by intangible assets such as: brand, innovation, organizational capabilities, ecosystems and partnerships, as well as digital technologies and analytics. The compilation of intangible resources is one of their success factors. IT enterprises are aware of the demand for ready-made technological services in various sectors of the economy. This leads them to focus on the development of their technologies and products,

which are mainly related to the skills and competencies of their employees. IT enterprises often seek technological niches, which also requires highly qualified yet narrowly specialized workers (Perspektywy rozwoju rynku IT w Polsce do 2030 roku).

The main objective of the article is to analyze the differences between the categories of dynamic capabilities in enterprises from the HGE group and the IT sector. The conducted research will evaluate how enterprises from the HGE group and the IT sector integrate, transform, and manage the resources they possess, contributing to their development and market success.

2. Theoretical background

The concept of dynamic capabilities was introduced to the literature in the second half of the 1990s. Initial research focused on definitional aspects, as well as the frameworks and conceptual models of DCs. Currently, empirical studies increasingly appear in the literature indicating the links between dynamic capabilities, value, business performance, and competitive advantage. However, it is important to agree with the view that although there is a consensus on the definition and the role that DCs play within a company (Kump et al., 2018), as a complex and somewhat abstract concept, they are difficult to identify. In this article, Table 1 presents the most frequently cited definitions of dynamic capabilities proposed by researchers who have popularized this topic.

Table 1.
Most frequently cited definitions of dynamic capabilities

Authors & Year	Definition
D.J. Teece, G. Pisano, A. Shuen, 1997	"The firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments"
K.M. Eisenhardt, J.A. Martin, 2000	"The firm's processes that use resources—specifically the processes to integrate, reconfigure, gain, and release resources—to match and even create market change. Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die"
S.A. Zahra, H.J. Sapienza, P. Davidsson, 2006	"The abilities to reconfigure a firm's resources and routines in the manner envisioned and deemed appropriate by its principal decision-maker(s)"
D.J. Teece, 2007	"DCs consist of valuable and difficult-to-replicate organizational routines required to address a changing environment though sensing opportunities and threats, and reconfiguring resources to seize opportunities"
C.E. Helfat, S. Finkelstein, W. Mitchell, M.A. Peteraf, H. Singh, D.J. Teece, S.G. Winter, 2007	'The capacity of an organization to purposefully create, extend, or modify its resource base"

Cont. table 1.

I. Barreto, 2010	"A DC is the firm's potential to systematically solve problems, formed by its propensity to sense opportunities and threats, to make timely and market-oriented decisions and to change its resource base"
R. Wilden, T.M. Devinney, G.R. Dowling, 2016	"Processes relating to sensing, seizing opportunities and reconfiguring the firm's resource bases to achieve organizational survival and growth"

Source: based on Teece et al., 1997; Eisenhardt, Martin, 2000; Zahra et al., 2006; Teece, 2007; Helfat et al., 2007; Barreto, 2010; Wilden et al., 2016.

The presented definitions suggest that DCs play a crucial role in a dynamically changing environment, enabling enterprises to adapt and modify a broad range of resources, competencies, and skills to survive in the market and foster growth. Kay (2010) emphasizes the key role of DCs in strategic management, highlighting the difficulties in predicting future market conditions where time and technological changes are significant. In contrast, Wang & Ahmed (2007) stress that dynamic capabilities are embedded in processes. The cited authors identify three main components of dynamic capabilities: adaptive capabilities, absorptive constructs and the factors influencing them. He proposed three categories within DCs: (1) sensing, (2) seizing, and (3) reconfiguring. Sixteen years later, Teece (2023) underscores that these are key actions that management should take to determine in which direction markets and technology are heading, and based on that, make decisions about the company's further development.

The first category, sensing, is related to the "understanding" of the organization's environment and identifying emerging opportunities. Thus, sensing involves two smaller components: to explore and to identify, which complement each other. To explore the environment of the organization means the process of scanning the external environment, gathering market information, and analyzing their trends (Dias, Lages, 2021; Kowalski et al., 2024). In turn, identify aims to explore the previously conducted scan. Monitoring the environment, including markets, industries, technologies, customers, suppliers, competitors, etc., should allow for detecting weak signals, which in turn shape the organization's development (Otola et al., 2024). In this context, it is essential to understand future technological and digital opportunities, the desires and needs of customers, and the actions of competitors (Dias et al., 2022; Furnival et al., 2019). Implementing 'explore and identify' allows for effectively detecting emerging market opportunities, as well as avoiding potential threats.

The second highlighted category, seizing, is associated with assessing the resources and capabilities the company possesses, as well as acquiring them (Fainshmidt et al., 2019; Wilden et al., 2013). According to Teece (2007, 2019), seizing means the ability to quickly respond to changing conditions by mobilizing resources, implementing innovations, and developing business models that will effectively transform an opportunity into real market value. This is similarly interpreted by Khan et al. (2020), who state that seizing involves mobilizing internal and external resources and capabilities to implement actions recommended by the identified opportunities that favor competitive advantage. The importance of flexibility and adaptive capabilities is emphasized, with a focus on the learning process.

The third category, reconfiguring, involves transforming and integrating resources and processes in a way that allows for maintaining a competitive advantage in the long term. According to Teece's view, resource reconfiguration is required for creating and capturing value. Researchers point out that reconfiguration involves greater complexity and may sometimes require a complete redesign of the business model (Breznik et al., 2019; Teece, 2007). The ability to reconfigure allows a company to continuously renew, adapt, and reorganize its resources and skills to effectively respond to dynamic changes in the business environment (Dias et al., 2022).

The complementarity of these three DCs categories enables the creation of value for the company and the maintenance of competitive advantage. The literature clearly emphasizes that the processes discussed above must be developed and applied simultaneously, as only their combined action can be a source of competitive advantage (Teece, 2019; Fainshmidt et al., 2019; Wilden et al., 2013). If a company identifies a market opportunity but fails to provide the necessary resources or take transformative actions in terms of its strategy or business model, it will only operate within the first category (sensing), which will not generate value. Conversely, developing resources and capabilities (seizing) without prior market verification may not lead to acquiring the proper resources necessary for further development.

3. Methodology

Empirical research on dynamic capabilities was conducted on a sample of 502 enterprises from two different groups in the years 2023-2024. The sample selection was purposive. The first group consisted of 252 high-growth enterprises (HGE), meeting the criteria of annual revenue or employment growth of over 20% on average over the past 3 years. The second group consisted of 250 enterprises from the IT sector. The sample included 76 small, 282 medium-sized, and 144 large enterprises. The survey questionnaire included 16 questions and addressed 3 constructs of dynamic capabilities: sensing (SEN), seizing (SEI), and reconfiguring (REF). All questions were based on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The sensing category included five questions, which focused on identifying and exploiting new market opportunities through analyzing customer needs and studying market trends. Additionally, the questions addressed research and development activities aimed at both generating new knowledge and technologies to support products or processes development. In contrasts, the seizing category (six questions) focused on searching for and securing appropriate resources—both tangible and intangible, such as knowledge and skills—necessary for effectively implementing the previously identified opportunities. The role of strategic partners in these activities was also considered. The last category, reconfiguring, included five questions that examined the degree of modifications in technologies, processes,

and management methods, as well as building valuable business relationships and developing employee competencies.

To examine the differences between the variables in the high- growth enterprises and those from the IT sector, a linear modeling method—ANOVA—was applied. Using the ANOVA test, the mean values of the dynamic capabilities' variables were compared for the entire group of dynamic capabilities and for each construct, i.e., SEN, SEI, and REF. In the next step, a post-hoc Tukey's test was conducted. Comparable samples were independent. For research purposes, the following main hypothesis was formulated:

H0: There is no statistically significant difference in the mean dynamic capabilities between enterprises in the HGE group and enterprises in the IT sector.

Additionally, due to the identification of three constructs of dynamic capabilities—SEN, SEI, and REF—the existence of relationships between these constructs in both groups of enterprises were examined.

H0a: There is no statistically significant difference in the mean SEN between enterprises in the HGE group and enterprises in the IT sector.

H0b: There is no statistically significant difference in the mean SEI between enterprises in the HGE group and enterprises in the IT sector.

H0c: There is no statistically significant difference in the mean REF between enterprises in the HGE group and enterprises in the IT sector.

4. Results and Fundings

The study examined whether there are statistically significant differences between the variable groups SEN, SEI, and REF depending on whether a company belongs to the HGE or IT sector. The research results are presented in tables and graphs.

Table 2.
Results of ANOVA Analysis

Construct	Wilks' Lambda	F-test	Effect df	Error df	p
SEN	0.927535	7.750	5	496	0.000000
SEI	0.923977	6.788	6	495	0.000001
REF	0.911587	9.621	5	496	0.000000
Total (SEN, SEI, REF)	0.881986	4.0560	16	485	0.000000

Note: p – p-value.

Source: own elaboration.

The fundings indicate that the null hypotheses should be rejected in favor of the alternative hypotheses. The conducted analyses demonstrate statistically significant differences in dynamic capabilities based on the constructs SEN, SEI, and REF, depending on whether an enterprise belongs to the HGE or IT sector. This is confirmed by the values of Wilks' Lambda, the F-test,

and significance levels ($p < 0.001$). However, given that Wilks' Lambda values fall within the 0-1 range, where lower values indicate greater group differences, the results suggest that while the samples are not homogeneous, the degree of variation is not large. The overall analysis of the three constructs indicates a moderate level of variation between the two groups, while individual variance analyses for each construct suggest relatively small differences between the groups.

Since the ANOVA F-values were statistically significant, a post-hoc test was conducted. Post-hoc Tukey's test was used to compare the individual variables within each of the three constructs. The results revealed significant differences in 15 out of 16 examined variables. Detailed results are presented in Table 3.

Table 3.
Results of post-hoc Tukey's Test

Variable	p	Error: MS between groups	Variable	p	Error: MS between groups	Variable	p	Error: MS between groups
SEN1	**0.128173**	1.0593	SEI1	0.001239	1.1544	REF1	0.000014	1.0903
SEN2	0.000228	0.94167	SEI2	0.003152	1.1642	REF2	0.000009	1.0022
SEN3	0.000758	1.0179	SEI3	0.000143	1.1488	REF3	0.000023	1.1215
SEN4	0.000009	1.2038	SEI4	0.000009	1.0986	REF4	0.000009	1.0236
SEN5	0.000009	1.113	SEI5	0.000009	1.0994	REF5	0.000012	1.0955
			SEI6	0.003220	1.3155			

Note: p – p-value.

Source: Own elaboration.

The only variable where no statistically significant difference was observed was SEN1 ($p = 0.128173$), meaning that there are no significant discrepancies in identifying customer needs between enterprises in the HGE and IT groups. Therefore, variable SEN1 will not be discussed in further research. For all other variables, the differences are statistically significant, indicating differentiation between enterprises in the HGE group and the IT sector. The graphs illustrate differences in mean scores across the SEN, SEI, and REF constructs based on enterprise group affiliation.

The conducted empirical research allows for the following conclusions:

- There are statistically significant differences in dynamic capabilities between high-growth enterprises (HGE) and enterprises in the IT sector.
- There are statistically significant differences in the ability to detect market trends and changes, as well as in research and development activities, between enterprises in the HGE group and those in the IT sector.
- There are statistically significant differences in the ability to modify strategies and acquire resources between enterprises in the HGE group and those in the IT sector.
- There are statistically significant differences in the ability to modify technologies, processes, and management methods, as well as in the development of employees' competencies, between enterprises in the HGE group and those in the IT sector.

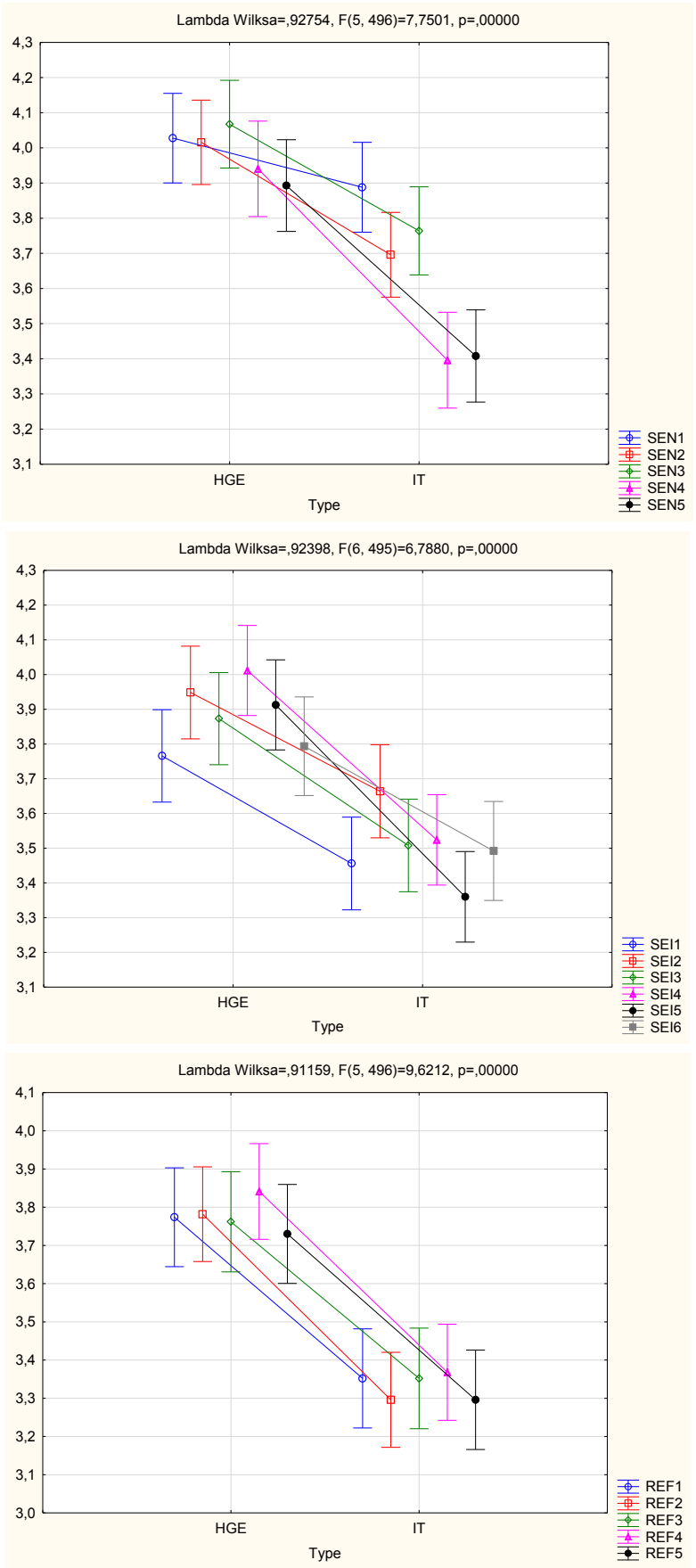

Figure 1. Mean scores across the SEN, SEI, and REF for HGE and IT enterprises.

Source: own elaboration.

Enterprises belonging to the HGE group demonstrate greater capabilities in detecting changes (SEN), seizing market opportunities (SEI), and reorganizing resources (REF) compared to enterprises in the IT sector. For each examined variable, the HGE group has a higher mean score. When analyzing the SEN construct, the largest differences among the examined variables appear in SEN4 (M = 3.94 for HGE and M = 3.39 for IT) and SEN5 (M = 3.89 for HGE and M = 3.40 for IT). Both factors are related to research and development activities aimed at generating new knowledge and testing new ideas. The analysis of the SEI construct indicates that the most significant disparities in mean values are observed for SEI5 (M = 3.91 for HGE and M = 3.36 for IT) and SEI4 (M = 4.01 for HGE and M = 3.52 for IT). The SEI5 variable is associated with acquiring human resources necessary for implementing newly identified opportunities, while the SEI4 variable is related to obtaining knowledge or skills for the same purpose. In the final construct, REF, the largest differences in mean values are observed for REF2 (M = 3.78 for HGE and M = 3.29 for IT) and REF4 (M = 3.84 for HGE and M = 3.36 for IT). REF2 corresponds to the introduction of new solutions or significant modifications to existing technologies/processes to implement newly identified opportunities. Meanwhile, REF4 pertains to changes in management methods within the company.

5. Limitations and Future Research

The conducted research is not without limitations. Although High-Growth Enterprises operate under similar guidelines worldwide, the data analyzed in this study—relating to both HGEs and companies from the IT sector—comes from a single country. Additionally, potential biases related to respondent self-reporting must be acknowledged, as they may affect the objectivity and reliability of the collected data.

An interesting direction for future research could involve comparative studies between HGEs and companies from less dominant industries, helping to identify which components of dynamic capabilities are the least developed. It would also be valuable to extend the research to economies at different stages of development (both emerging and highly developed) in order to better highlight existing disparities and identify research gaps. Longitudinal studies would certainly be justified, as they could track how individual components of dynamic capabilities evolve over time. Such studies could also offer valuable insights in the context of the increasing digitalization of enterprises, which significantly affects internal business processes.

6. Conclusions

Dynamic capabilities indicate a firm's ability to adapt and grow in an evolving market environment. Analyzing DCs provides insights into how well enterprises navigate situations requiring flexibility and rapid responses to change. The empirical findings expand our understanding and highlight differences in how HGE and IT enterprises leverage dynamic capabilities.

In each of the examined constructs (SEN, SEI, REF), higher mean scores were observed among enterprises in the HGE group. However, despite the observed differences favoring HGE, it is important to note that the results are not heterogeneous enough to suggest significant discrepancies in how HGE and IT enterprises handle dynamic market challenges. Overall, these differences can be classified as moderate, with both groups demonstrating similar approaches to leveraging opportunities and adapting to changing conditions.

In conclusion, the study results suggest that HGE enterprises are more advanced in utilizing dynamic capabilities, which may be attributed to their greater emphasis on innovation, research and development, and management flexibility. While IT enterprises also demonstrate adaptability, they focus more on incremental technological modifications and internal knowledge development rather than radical changes. Instead of large-scale transformations, they tend to make smaller adjustments to existing technologies and rely on internal human capital by enhancing their employees' competencies and knowledge.

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ANTICIPATING ESG TRANSITIONS IN POLISH LOGISTICS: A SPECULATIVE AND DESIGN FUTURES-BASED SCENARIO STUDY

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Purpose: The paper will analyze possible directions of ESG changes in the Polish logistics industry in the next decade. We use Design Futures methods and typological speculative thinking. The article seeks to project other ways of fixed evolution paths that can promote the sector's sustainable development.
Design/methodology/approach: The study uses a qualitative foresight approach combining Design Futures and speculative scenario writing techniques. The analysis consists of a literature review, secondary data and an analysis of ESG trends in logistics. Based on the above, three scenarios of the future of the Polish logistics sector were developed.
Results: Based on the analysis, three scenarios of ESG development in the Polish logistics sector were presented: "Compliance" scenario - ESG as a requirement forced by formality, minimal integration; "Transformation" scenario - full integration of ESG in the strategy of logistics companies; Scenario "Innovation" - ESG as a source of innovation and competitive advantage. All the scenarios assess the sector's potential economic, social and environmental implications.
Research limitations/implications: The research is based on assessing secondary data and qualitative evaluation of trends, which may involve limiting the competence of generalizing the results. We based our findings on secondary data analysis and qualitative assessment of trends, which may include determining the potential of generalizing the findings. Further research can be based on empirical quantitative data or training of logistics stakeholders in the industry.
Practical implications: The research results can help managers and decision-makers plan logistics ESG strategy. Scenarios are a method of exploring possible development trajectories. We identify opportunities and challenges in ESG implementation in logistics in Poland.
Social implications: ESG integration in logistics can assist in raising corporate social responsibility, improving working conditions and reducing negative environmental impact. The scenarios provide insight into how different ESG approaches can impact Poland's society and environment.
Originality/value: This article is the first to apply a design futures and speculative approach to ESG in logistics. It offers a new future for researchers, managers, and decision-makers interested in long-term sustainability planning in the logistics sector.

Keywords: ESG, logistics sector, design futures, speculative scenarios, sustainability development.
Category of the paper: research paper.

1. Introduction

The modern economy requires companies to conduct their business responsibly and sustainably. The ESG (Environmental, Social and Governance) concept is becoming the basis for non-financial reporting (Kimbrough et al., 2022; Chopra et al., 2024). Its implementation is essential for risk management and building trust among investors. It is imperative in sectors with high emissions and energy intensity. From this point of view, the logistics sector is at the centre of interest for decision-makers, investors, and public opinion in the context of ESG transformation (Friedman et al., 2021).

At the EU level, regulations such as the Corporate Sustainability Reporting Directive (CSRD), the EU Taxonomy, and Fit for 55 have significantly increased pressure on companies to embed ESG principles in strategic and operational planning. Globally, ESG is evolving from a voluntary reporting tool into a core requirement for access to capital and public legitimacy.

In recent years, ecological initiatives such as the implementation of low-emission fleets, the construction of environmental warehouses or non-financial reporting have been visible in the logistics sector in Poland. In the meantime, most companies, especially SMES, see ESG as a costly and vague administrative burden. These paradoxes indicate more profound contradictions between different visions of the future of logistics. Some entrepreneurs see ESG as part of the business model; others only try to obey the law and regulations (Wang et al., 2021).

Previous research on ESG in logistics in Poland has focused mainly on identifying implementation barriers, analysing compliance with standards, assessing risks, and conducting descriptive analyses of ESG implementation cases (Witkowski, Pisarek, 2017; Zhou et al., 2023). Less attention has been paid to what ESG development scenarios are possible and desirable in the long term. Analysing what value models and financial strategies can promote or impede environmental investments is also important.

In addition, there are few future studies on integrating ESG with strategic foresight and design methods. These can dig up risks, limitations, utopian futures, and systemic paths.

Therefore, this article aims to (1) anticipate possible ESG transformation trajectories in the Polish logistics sector using the Design Futures approach and speculative scenario writing tools, (2) identify key systemic enablers and barriers to ESG implementation, and (3) explore the methodological value of futures thinking in sustainability planning.

The study used desk research (analysis of strategic documents, industry and ESG reports), trend analysis and methods for designing narrative future scenarios. The paper presents three contrasting scenarios of ESG in logistics: (1) deep sustainable transformation, (2) ESG as superficial regulatory compliance, and (3) stagnation resulting from systemic crises.

The paper is an original contribution to sustainable finance, logistics, and strategic foresight literature. It proposes an interdisciplinary approach that combines economics, management, design, and future science. It also points to practical implications for logistics companies. In the face of growing environmental tensions, regulatory pressure, and social expectations, thinking about the future of ESG in logistics is becoming useful and necessary.

This article is the first to apply Design Futures and speculative scenario methods to explore ESG transitions in the Polish logistics sector, offering an original interdisciplinary approach that integrates foresight, sustainability strategy, and economic transformation. The research aims to (1) anticipate possible ESG transformation trajectories by 2040, (2) identify key systemic drivers and barriers to ESG implementation, and (3) assess the methodological contribution of design- and futures-based approaches to long-term sustainability planning.

The paper is structured as follows: Section 2 offers a Literature Review of futures thinking and ESG. Section 3 outlines the methods, conceptual foundations, and the research process for scenario creation—section 4 details the Results, outlining three possible ESG scenarios. Section 5 offers a Discussion of findings against systemic circumstances and strategic considerations. Finally, Section 6 offers the Conclusions, including policy, practice, and recommendations for future research.

2. Literature review

The ESG concept is a tool for assessing the activities of companies in the context of their environmental, social and governance responsibility. Considering ESG in investment analysis can lead to better long-term financial and social performance (UN Global Compact, 2004).

According to OECD (2020), ESG refers to "standards for disclosing non-financial information by companies that reflect their impact on the environment, society and the way the organization is managed and assess the risks and opportunities associated with the long-term value of the company". Similarly, Schoenmaker and Schramade (2018) define ESG as "a set of non-financial factors that affect the value of a company by influencing its regulatory, reputational and investment environment".

In turn, Eccles and Krzus (2018) indicate that ESG is not only a set of metrics but also a way of thinking strategically. The long-term success of an organization depends on its relationships with key stakeholders and responsible management.

In practice, ESG elements include, among others (MSCI, 2023):

- environmental: greenhouse gas emissions, energy efficiency, waste management,
- social: working conditions, diversity and inclusion, human rights, relations with local communities,
- governance: management structure, transparency of operations, business ethics, anti-corruption.

The implementation of ESG principles is increasingly becoming an institutional requirement (e.g. EU taxonomy, CSRD directive) and an expression of a new norm of corporate responsibility. In the context of the logistics sector, ESG can contribute to increased operational efficiency, improved reputation, access to financing and reduction of regulatory and environmental risks (Lazar et al., 2021; Kolasińska-Morawska, Ziółko, 2023).

Traditional approaches to economic research are based on exploring historical data, econometric models and predictions based on the past. In complex environmental, social and technological crises, transformational and foresight approaches are gaining increasing importance, allowing us to imagine alternative futures and analyze their consequences (Slaughter, Hines, 2020; Raworth, 2017).

In the foresight literature, two main approaches are distinguished: strategic foresight, a benevolent identification of potential trajectories of system development (Young, 2008), and narrative scenario writing, which creates qualitative stories about the future based on data from various actors and values (van der Heijden, 2004).

Design Futures is a research and practice approach that combines design with foresight and systemic analysis. Its goal is not to predict the future but to create it through speculation, imagination and constructive doubt (Candy, Dunagan, 2017). The opposite of extrapolative forecasts is speculative design, which allows for the design of alternative worlds, future artefacts and scenarios that force the viewer to reflect on the present (Dunne, Raby, 2013).

In the context of ESG in logistics, Design Futures allows for the exploration of questions such as:

- What if ESG became a prerequisite for economic activity?
- What could ESG financing and reporting models look like in 2040?
- What values and narratives would support sustainable logistics of the future?

Although design approaches are used even less frequently in economics, they are gradually being recognized as a flattening of classical analyses, especially in research on social innovation, sustainable development and sectoral transformations (Manzini, 2015; Facer, 2016).

This study integrates three perspectives:

- The ESG concept as a strategic paradigm of sustainable management.
- The foresight perspective as a tool for exploring alternative development paths.
- Moreover, designing the future is a method for designing valuable visions.

On this basis, a set of ESG scenarios in the Polish logistics sector was constructed, considering institutional, economic and cultural variables.

3. Methods

This research uses a qualitative, exploratory, and forward-looking research methodology. We based on strategic foresight and Design Futures. The study explores possible long-term trajectories of ESG development in the Polish logistics sector. We want to construct alternative futures that outline how ESG might develop under different institutional, financial, cultural, and regulatory forces. The research is grounded on three theoretical foundations:

- the ESG model as a paradigm of sustainable business management,
- foresight as a method of anticipating changes in the system,
- speculative design as a tool for constructing conjectural, value-charged futures.

The research began with desk research, including analyzing secondary data, sector reports, ESG disclosures of logistics firms, EU regulatory documents and relevant academic literature. This phase aimed to identify current ESG trends, constraints, and enabling factors in the logistics sector in Poland.

Based on this review, the author identified a set of key variables influencing ESG transitions, such as the availability of sustainable finance, regulatory pressure, organizational culture, technological innovation, and stakeholder expectations.

The next stage involved the development of three contrasting narrative scenarios for ESG in logistics by the year 2040. The scenario construction method follows foresight literature (van der Heijden, 2004; Facer, 2016), emphasizing narrative plausibility over statistical probability.

Each scenario presents a different trajectory of ESG transition: a deep and systemic transformation, a stagnated or superficial adaptation, and a regressive or blocked pathway. The scenarios include governance models, ESG reporting frameworks, investment strategies, and public policy context.

Moreover, imagined experiences of actors within the logistics ecosystem. The narratives are not intended as forecasts but as thought experiments, enabling critical reflection on the present and exploration of what kinds of futures are desirable or avoidable.

In order to enrich the imaginative component of the study, the speculative design approach was adopted. This involved the creation of an artefact of the future: a hypothetical piece of an ESG report of a logistics company in Poland in 2040. The artefact is a complex object, representing one of the possible materializations of ESG logic in future corporate existence.

The use of speculative design is aligned with the goal of Design Futures: to provoke debate, widen the range of possibilities under consideration, and examine deep cultural, institutional, and value-based assumptions about the future.

4. Research results

Table 1 presents a comparative overview of three narrative scenarios of ESG evolution in the Polish logistics industry until 2040. Each scenario foresees a different path of ESG evolution based on different institutional, economic, and organizational drivers.

Scenario 1: Compliance is a low-ambition pathway in which ESG practices are implemented primarily due to external regulatory pressure. Integration is shallow and reactive, and there are SME difficulties in meeting formal requirements. The social and environmental impact of ESG activities under this scenario is modest.

Scenario 2: Transformation illustrates a deep and strategic integration of ESG principles into logistics operations. ESG becomes a guiding vision for long-term value creation and system change. SMEs are actively supported through policy and financing tools. This scenario achieves the most favourable outcomes in both social and environmental dimensions.

Scenario 3: Innovation depicts ESG as a means of experimentation and competitive advantage. Under this scenario, ESG catalyses innovation in logistics services, technology, and business models. It is a dynamic and opportunity-led strategy with a patchy impact: profound in some sectors but scattered in general. SMEs become niche innovators or face marginalization.

Table 1.
Comparison of ESG Scenarios in Polish Logistics (2040)

Dimension	Scenario 1: Compliance	Scenario 2: Transformation	Scenario 3: Innovation
ESG Motivation	Regulatory pressure	Strategic vision	Competitive advantage
Integration level	Superficial, reactive	Deep, cross-functional	Selective, agile
Investment logic	Minimum required	Long-term value creation	Opportunity-driven
Role of SMEs	Struggling with compliance	Fully supported by policy & finance	Niche innovators or excluded
Social impact	Low	High	Mixed (opportunities + risks)
Environmental outcome	Marginal	Substantial	Differentiated, tech-focused

Source: own elaboration based on Eurostat database.

Figure 1 presents a relative schematic visualization of ESG development pathways in the Polish logistics market until 2040. Relative ambition in each scenario and the relative coherence along six strategic dimensions are emphasized.

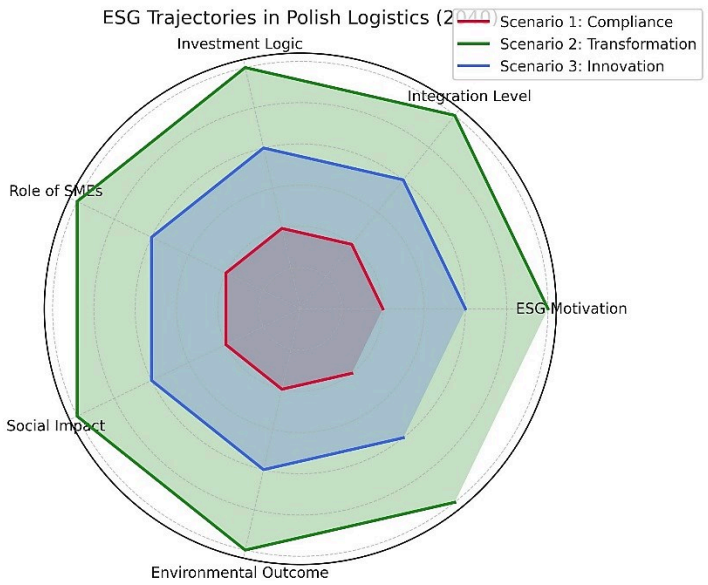

Figure 1. ESG Trajectories in Polish Logistics (2040).

Source: own elaboration.

The rounded and expansive shape of the Transformation scenario indicates a holistic, balanced and systemic approach, with consistent high engagement in ESG integration, investment logic, and social and environmental impact. In contrast, the compact and constrained shape of the Compliance scenario suggests minimal engagement, fragmented effort, and low transformative capacity. The innovation scenario appears asymmetric, pointing to selective prioritization — strong in competitiveness and experimentation but less comprehensive in social and SME inclusiveness.

This visual format enables a quick grasp of how different ESG logics manifest in strategy, revealing not just content but pattern and distribution of focus — essential in understanding future policy and managerial choices.

Table 2 presents the key enablers and barriers to implementing ESG in the Polish logistics sector. It is divided into four categories: regulatory, financial, cultural and technological. Each presents both positive impulses for change and constraints encountered in practice.

Table 2.
Key Drivers and Barriers of ESG Implementation in Polish Logistics

Category	Key Drivers	Key Barriers
Regulatory	EU Taxonomy, CSRD, Fit for 55 policies	Complexity of ESG reporting and legal compliance
Financial	Access to green bonds and ESG investment funds	Limited financial capacity and access for SMEs
Cultural	Growing awareness of sustainability in society	ESG fatigue and resistance to change in management culture
Technological	Adoption of AI and IoT in logistics monitoring	High cost and uncertainty of adopting green innovations

Source: own elaboration based on Eurostat database.

The regulatory landscape at the EU level (e.g., CSRD, Fit for 55) is a primary driver of ESG expectations but also creates complexity in compliance. Financially, the emergence of green investment products contrasts with most SMEs' limited capacity to access such funds. Culturally, organizational inertia and ESG fatigue generally oppose growing sustainability awareness. Technologically, new instruments such as IoT and AI enable ESG monitoring but require investment and risk tolerance.

This matrix highlights the systemic interplay of forces that can accelerate or decelerate ESG transformation and serves as a foundation for interpreting plausibility and challenges in the scenarios developed.

Table 3 presents the key actions that need to be taken to achieve the most ambitious scenario – Transformation – in a four-step timeline (2025, 2030, 2035, 2040). These actions include:

- 2025: Political and financial foundations (e.g. ESG roadmap, green public procurement, ESG credits),
- 2030: ESG integration with sector metrics and mandatory training for managers,
- 2035: ESG mainstreaming in SMEs, AI monitoring, ESG innovation clusters,
- 2040: Universal climate neutrality, ESG as a reputational and market asset.

The table serves as a backcasting plan to define what needs to happen today and in the coming years to reach the desired state in 2040.

Table 3.
Backcasting Pathway to ESG Transformation in Polish Logistics by 2040

Time Horizon	Strategic Milestones / Interventions
By 2025	– National ESG roadmap for the logistics sector introduced. – Green public procurement pilot in transport and warehousing. – Establishment of ESG competency centers for SMEs. – Preferential financing mechanisms launched (green credits, ESG bonds).
By 2030	– Mandatory ESG training for logistics managers and board members. – Integration of ESG metrics into national logistics performance indicators. – Tax reliefs for investments in low-emission fleets and circular logistics. – Transparent ESG ratings become standard for B2B contracts.
By 2035	– 60% of logistics SMEs with ESG-aligned business strategies. – Real-time ESG monitoring via AI and blockchain adopted in large firms. – Cross-sectoral ESG innovation clusters (e.g., transport–energy–ICT).
By 2040	– Majority of logistics operators operate carbon-neutral or net-zero supply chains. – ESG becomes a reputational asset and market differentiator. – ESG-linked wages and bonuses introduced across the sector.

Source: own elaboration based on Eurostat database.

Table 4 shows Appendix A, which is an official and forward-looking ESG performance snapshot of LogiTrans Polska S.A. within the "Transformation" scenario by 2040. The table categorizes the company's achievement on the three ESG pillars—Environmental, Social, and Governance—and cross-cutting and forward-looking. It presents a synthetic yet integrated picture of how ESG values can be infused into business strategy, operations, and stakeholder engagement within the Polish logistics sector.

The ESG performance indicators presented in the LogiTrans S.A. artefact were selected based on their relevance to EU regulatory frameworks (e.g., CSRD, EU Taxonomy), commonly used ESG rating methodologies (e.g., MSCI, GRI), and strategic importance for the logistics sector. Criteria included regulatory alignment, operational relevance, and the ability to capture measurable, long-term impact across environmental, social, and governance dimensions.

Table 4.
ESG Report Snapshot – LogiTrans Polska S.A. (2040)

ESG Dimension	Category	Key Achievements / Initiatives
Environmental	CO_2 Emissions	73% reduction since 2020
	Fleet Transition	100% zero-emission fleet
	Circular Logistics	System implemented in 8 regional hubs
Governance	Organizational Structure	ESG Committee evolved into Strategic Governance Board
	Financial Integration	ESG-linked executive compensation model (since 2032)
	Contractual Standards	92% of contracts aligned with National ESG Standard
Social	Leadership	Gender-balanced management board
	Workplace Culture	Mental health support and inclusive workplace certification
	Employee Engagement	17% increase in retention since 2030
Cross-Cutting	Training	2,500 employees trained via Green Leadership Academy
	Partnerships	Active role in EU Climate-Smart Transport Coalition
Outlook	Future Vision	Roadmap to ESG 3.0 and autonomous clean delivery systems by 2045

Source: own elaboration based on Eurostat database.

In an environmental review, LogiTrans has reduced its carbon footprint by 73% since 2020, introduced a fleet of zero-emission vehicles and installed circular logistics systems in eight regional hubs. These efforts have proven a strong commitment to climate neutrality and resource efficiency.

Governance: The company has advanced its ESG Committee to a Strategic Governance Board, integrating ESG monitoring into the core of strategic planning. The fact that there is ESG-related executive remuneration and high contractual ESG alignment (92%) speaks volumes of the strong governance culture in which sustainability performance drives decision-making and interactions with the external environment.

The social is also massively impacted. LogiTrans confirms a balanced-gendered board of directors, a certified workplace for inclusion, and employee retention 17% higher than in 2030. These achievements confirm that the company is focused on staff wellbeing, inclusivity, and long-term interest.

Cross-cutting initiatives include upskilling 2,500 employees via the Green Leadership Academy and actively participating in the EU Climate-Smart Transport Coalition to indicate sector leadership and alignment with international sustainability goals. The final section explains the company's strategic vision, which includes scaling autonomous clean delivery systems and adopting ESG 3.0 frameworks by 2045.

Table 4 illustrates how aspirational ESG goals can be deconstructed into concrete and measurable metrics, giving a roadmap for logistics transformation at a system level. It illustrates that genuine ESG integration is not compliance—it reimagines governance, investment values, and operating ethos.

Notably, ESG has moved from a risk management strategy to a strategic resource and competitive advantage driver, influencing everything from procurement contracts to leadership incentives. The change scenario also supports the idea that organizational culture and human capital are at the core of ESG success. Investments in employee engagement, diversity, and training directly impact performance and resilience.

Finally, the way forward for the company is the future of ESG 3.0, a next-generation sustainability framework that integrates digitalization, automation, and systems thinking. Under this vision for the future, ESG is placed alongside environmental or regulatory requirements. In this vision for the future, ESG is aligned with environmental or regulatory requirements and innovation, value creation, and social purpose.

Figure 2 offers a full-colour visualization integration of the study findings, merging four core analytical components: scenario analysis, systemic drivers and impediments, a backcasting transformation timeline, and a future-oriented company case (LogiTrans S.A.).

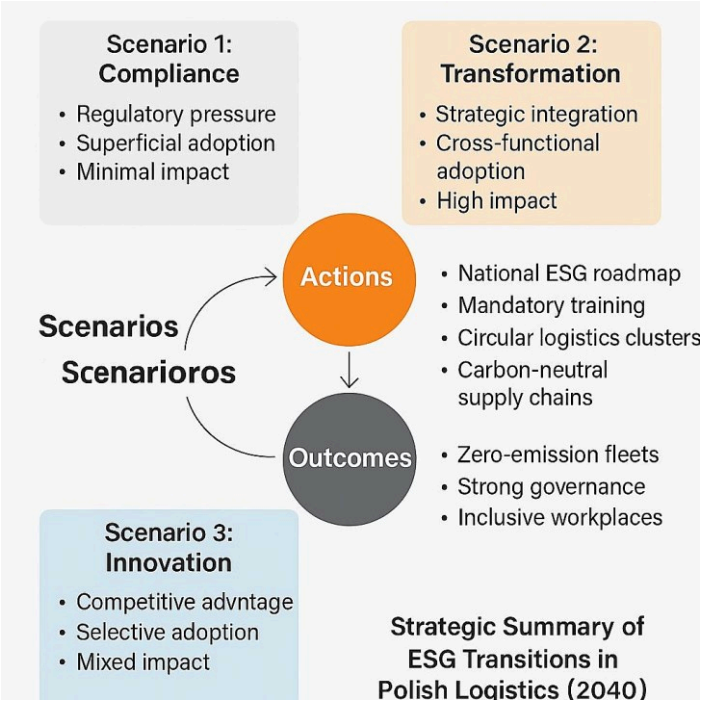

Figure 2. Strategic Summary of ESG Transitions in Polish Logistics (2040).

Source: own elaboration based on scenario methodology and speculative foresight.

Three narrative scenarios—Compliance, Transformation, and Innovation—are at the image centre and symbolize varied ESG transition paths for the Polish logistics sector by 2040. All the scenarios are supported by alternative institutional, strategic, and cultural logic, from regulatory compliance minimalism to systemic ESG embedding and innovation-led evolution.

Around the scenario framework, the infographic highlights the key enablers and barriers that influence ESG implementation. These are grouped into four essential dimensions: regulatory, financial, cultural, and technological. This model captures the results of Table 2 and highlights that ESG development is not a one-size-fits-all solution—it depends on the dynamic interplay between internal capabilities and external pressures. The trajectory a firm or industry follows is shaped by how these forces intersect, facilitate, or constrain change.

The infographic also adds a backcasting roadmap (2025-2040), with such significant milestones as national ESG roadmaps, compulsory training, financing mechanisms, innovation clusters, and net-zero supply chains. These align with Table 3 and show how deliberate, sequenced actions can create the conditions for the Transformation scenario.

The bottom represents a hypothetical snapshot of LogiTrans Polska S.A.'s ESG in 2040, drawing from Table 4. What the future should hold is displayed in this illustration, with such success in curbing carbon emissions, governance reform, employee activism, and planning (e.g., ESG 3.0 and self-driving transportation systems).

ESG change should be strategic, multidimensional, and co-created by institutions, firms, technologies, and cultures. It explains how foresight techniques can support ESG deployment by offering systemic, realistic, and actionable futures. It also reiterates the most important finding of the study: that integrated well, ESG is not a bottleneck but an instrument of innovation, competitiveness, and public value.

5. Discussion

Our research aimed to explore how ESG practices might evolve in the Polish logistics sector by 2040 and what factors influence the natural transformation. We developed three future pathways and assessed the systemic forces that may enable or constrain them.

The first research question concerned the plausible development pathways of ESG in the Polish logistics sector. The three constructed scenarios offer distinct visions of the future: the Compliance scenario represents minimal regulatory-driven engagement; Innovation reflects agile, opportunity-led experimentation; and Transformation depicts full strategic integration of ESG into logistics operations. Only the Transformation scenario aligns comprehensively with long-term sustainability goals, suggesting that significant institutional, financial, and cultural adaptation is required to achieve such an outcome.

The second question focused on the key systemic drivers and barriers to ESG implementation. As shown in Table 2, regulatory mandates (e.g., CSRD, EU Taxonomy), green financing, and digital infrastructure can catalyze change. However, ESG fatigue, cultural resistance, and limited SME capacity remain critical obstacles. The interplay between these

enablers and constraints confirms that ESG transitions are path-dependent and require coherent cross-sectoral coordination.

The third research question was about the value of design-based and speculative methods in ESG planning. The research shows that narrative futures and speculative artefacts are valuable tools in uncertain and complex situations. They allow organizations and policymakers to conceptualize long-term trajectories, test dominant assumptions, and evaluate various development logic in a structured way.

The most desirable transformation scenario delivers broad environmental and social benefits. It supports views from sustainability scholarship (Schoenmaker, Schramade, 2018) that ESG can become a source of innovation, strategic alignment, and stakeholder value when fully embedded into business models. Its operationalization—outlined through the backcasting timeline (Table 3)—depends on institutional support, financial incentives, and managerial capacity building.

The compliance scenario reinforces the criticism that ESG, when driven solely by regulation, risks becoming a superficial or symbolic exercise (Forliano et al., 2025). Due to complex reporting requirements and limited access to ESG financing, SMEs are particularly vulnerable in this pathway. Without supportive structures, ESG compliance may not lead to real sustainability outcomes.

The innovation scenario offers an agile, entrepreneurial path that treats ESG as a source of experimentation and advantage. While this logic aligns with emerging ESG-business case models (Porter, Kramer, 2011), it also reveals disparities. Without coordinated public policy, firms with lower innovation capacity or ESG maturity may fall behind—widening inequalities in the sector.

The barrier-driver matrix confirms that ESG adoption is not a purely rational or linear process. Cultural readiness—leadership mindsets, openness to change, and organizational learning—is as important as technical tools or regulatory pressures. ESG transitions require a shift in how logistics firms define value, risk, and responsibility. This aligns with recent research highlighting sustainability transformation's social and cognitive dimensions (Fougère, Solitander, 2020).

The ESG snapshot of LogiTrans Polska S.A. (Table 4) demonstrates how aspirational ESG objectives can be operationalized into measurable actions. The artefact incorporates circular logistics, inclusive governance, ESG-linked compensation, and training programs—offering a vision of ESG maturity. Although speculative, this scenario helps firms and policymakers imagine the institutional architecture needed to support fundamental Transformation.

This study is qualitative, exploratory, and speculative. It does not claim generalizability but aims to provoke structured reflection on plausible futures. Using secondary data and narrative construction means the results require further empirical validation—such as interviews with logistics firms, surveys, or foresight workshops. A second important limitation is the absence

of direct stakeholder perspectives. While the scenario building was grounded in robust secondary data and regulatory documents, incorporating SMES', policymakers', and logistics practitioners' perspectives would bring contextual richness and experiential knowledge to the analysis. Future research needs to include participatory foresight workshops or Delphi panels to complement the desk research. Future research should consider participatory foresight workshops or Delphi panels to complement the desk research.

Furthermore, the situations in this paper can be extended by adding geopolitical and macroeconomic shocks such as energy crises, inflationary shocks, or global supply chain realignments. Such externalities can reshape ESG agendas, accelerate changes, or slow developments, particularly in poor logistics subsectors. Stress-testing situations against such shocks would make them more resilient and policy-relevant.

Theoretically, this research contributes to bridging future studies with ESG scholarship, proposing a new lens for analyzing complex, long-term sustainability transitions. It challenges linear planning models and invites interdisciplinary dialogue between design, strategy, and economics.

The results offer scenario-based materials to companies, regulators, and investors. The results can inform long-term ESG master plans, training plans, funding mechanisms, and stakeholder engagement processes. Importantly, differentiated ESG support policies are needed to reflect firm size and capacity. Large logistics players require regulatory certainty, investment incentives, and innovation hubs. SMES, on the other hand, face challenges such as limited capital, lack of ESG competencies, and compliance expenses. Public support must incorporate simple reporting facilities, subsidised training, digital ESG platforms, and green financing programs available at an affordable cost for small businesses. Organisations can increase their adaptive capacity and resilience in preparation for the possible future development of ESG and act accordingly.

These findings serve as a basis for ESG strategic planning and capacity-building programmes, especially in sectors undergoing regulatory and technological transition.

6. Conclusions

This paper explored possible ESG transition pathways in the Polish logistics sector by 2040 using Design Futures and scenario methods. The three scenarios—Compliance, Transformation, and Innovation—reflect different levels of ambition and system change. Only the Transformation scenario leads to deep integration of ESG into business strategy and operations, with the most sustainable and inclusive outcomes.

The research illustrates that ESG development depends on the interaction of regulatory, financial, cultural, and technological drivers. Without institutional support, ESG has the potential to be shallow or unevenly applied, particularly in SMEs.

The backcasting roadmap and LogiTrans S.A. snapshot illustrate how ESG transformation can be achieved through strategic direction, policy support, and investment in people and innovation. Future thinking adds value by allowing organizations and policymakers to anticipate challenges and prepare long-term solutions.

Logistics businesses must treat ESG as a strategic opportunity, not a compliance exercise. Policymakers must provide decisive ESG policy guidance, financial incentives, and capacity-building support, especially for SMEs.

The study contributes to future ESG literature by illustrating how scenario methods can inform strategic sustainability planning. Future research is invited to test the scenarios empirically and examine their relevance to other industries and countries. By combining foresight, ESG analysis, and design thinking, this paper contributes to a deeper understanding of systemic sustainability transitions.

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APPLICATION OF THE STRUCTURAL-GEOGRAPHIC SHIFT-SHARE ANALYSIS TO ASSESS CHANGES IN TANGIBLE CURRENT ASSETS IN THE PUBLIC AND PRIVATE SECTORS

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Purpose: The aim of this research is to apply the structural-geographic shift-share analysis to assess changes in tangible current assets in both public and private sectors, providing insights into the factors influencing these changes across different regions.
Design/methodology/approach: The research employs the shift-share analysis method, which decomposes changes in tangible current assets into national growth, industrial mix, and regional shift effects. The study uses empirical data from various voivodeships in Poland over the period 2018-2023.
Findings: The findings indicate significant regional and sectoral variations in tangible current asset management. In the public sector, certain regions, such as Lubelskie and Śląskie, showed inefficiencies with increasing asset levels, while regions like Pomorskie and Małopolskie demonstrated improved management. The private sector exhibited more effective resource management in several regions, with Kujawsko-Pomorskie and Świętokrzyskie experiencing declines in current assets.
Research limitations/implications: The results suggest the need for region-specific policies to enhance resource management efficiency, especially in the public sector. Future research should explore integrating additional economic indicators to refine the analysis further.
Originality/value: This study is one of the few to apply structural-geographic shift-share analysis to the assessment of tangible current assets, providing a comprehensive understanding of the factors driving changes in asset levels in different regions and sectors.
Keywords: Shift-share analysis, tangible current assets, public and private sectors, regional analysis.
Category of the paper: Research paper.

1. Introduction

The analysis of tangible current assets is a key element in resource management for both the public and private sectors. Tangible current assets, which include inventories, materials, and work-in-progress products, constitute a significant portion of the assets of enterprises and institutions, impacting their financial liquidity and ability to carry out ongoing economic

operations. Understanding the changes in the structure of these assets enables more effective planning and resource allocation. In the context of the dynamic economic transformations observed over recent decades, there is an increasing need for precise and complex analyses that facilitate a deeper understanding of the mechanisms driving changes in current assets. In particular, in an era of economic globalization and regionalization, it becomes essential to consider both geographical and structural factors when analysing these changes. Previous studies have mainly focused on one of these perspectives, which does not provide a complete picture of the situation. There is a lack of analytical tools that integrate structural and geographical aspects, thereby allowing for a more accurate assessment of changes in current assets. Given the above, there is a need to apply the structural-geographical shift-share method, which enables a comprehensive analysis of tangible current assets in both the private and public ownership sectors. The purpose of this article is to present and apply the shift-share method for assessing changes in tangible current assets within the public and private sectors. This method, which combines structural and geographical approaches, provides useful insights that can be applied in both academic research and practical resource management for enterprises. The article will discuss the theoretical foundations of the method, the process of its implementation, and the results of an empirical analysis conducted on data from selected regions.

2. Role of Tangible Current Assets in the Public and Private Ownership Sectors

Tangible current assets are a key component of a company's balance sheet, encompassing material resources expected to be converted into cash, sold, or consumed within one operating cycle, typically lasting a year. The primary elements of tangible current assets include inventories, raw materials, and work-in-progress products. Effective management of these assets is an essential aspect of organizational operations in both the public and private sectors. The Accounting Act defines assets as resources controlled by an entity that have a reliably determined value, arising from past events, and expected to generate economic benefits for the entity in the future, as stated in Article 3(1)(12). Assets are classified into fixed assets and current assets, with their definitions also provided in Article 3(1)(18) of the Accounting Act.

Current assets include:

- tangible assets,
- financial assets,
- receivables and short-term investments,
- prepaid expenses.

Tangible current assets of an entity primarily include:

- Inventories– materials acquired for internal use, which include items purchased from other enterprises for consumption within the company. Examples of such materials are cleaning supplies, office materials, and any related stock.
- Finished goods or services– products or services manufactured or processed by the entity that are ready for sale.
- Work-in-progress – products and services being manufactured or produced by the entity that are incomplete as of a given date, i.e., still in the production process.
- Semi-finished products – items that have undergone specific stages of production and are intended for use in subsequent production phases.
- Goods purchased for resale in their unaltered state – items acquired from other enterprises for resale, which may be repackaged, portioned, etc., before sale.

Tangible current assets play a crucial role in corporate financial management, directly impacting a company's ability to meet its current liabilities and maintain operational liquidity. Effective management of current assets is essential to achieving a balance between liquidity and profitability. Companies must strive to optimize inventory levels and the collection of receivables to ensure sufficient resources are available to cover current obligations and finance operational activities. In the public sector, managing tangible current assets presents unique challenges due to budgetary constraints, legal regulations, and the need to maintain transparency and accountability. Efficient management of these assets is vital for delivering public services and ensuring operational effectiveness.

Changes in tangible current assets in the public and private sectors have been the focus of numerous studies, shedding light on various aspects of management and the efficiency of resource utilization. Notably, as early as 2019, the European Commission highlighted a correlation between investments in intangible assets in the private sector and co-investments in the public sector, which may influence changes in the structure of tangible assets (Lampel, Edler, Gadepalli, 2020). Similarly, Lim, Macias, and Moeller (2020) analysed the impact of intangible assets on capital structure, comparing bank debt, private debt, and public debt, with implications for managing tangible assets. The UK government, in studies conducted in 2018, examined how investments in intangible assets in the public sector generate value streams comparable to tangible assets (HM Treasury, 2018). Netsuite's 2022 research outlined various asset types, including tangible and intangible assets, and their importance in corporate accounting (Beaver, 2022). Furthermore, in analysing changes in tangible assets in the public sector, Demirkan and Platt (2009) explored accounting principles for intangible assets in the public sector, impacting the management of tangible assets. Bartel and Harrison (2005) addressed inefficiency sources in the public sector, critical for understanding tangible asset management. Private-sector studies have also extensively investigated changes in tangible assets, emphasizing the role of information technology, managerial ownership, and economic growth in optimizing operating assets. Brynjolfsson and Hitt (2000) analysed the influence of

information technology on organizational transformation and business performance. Himmelberg, Hubbard, and Palia (1999) explored the determinants of managerial ownership and its relationship with performance, shedding light on the role of tangible assets. Raghuram and Zingales (1996) examined the link between financial dependence and economic growth, relevant for managing tangible assets in the private sector. Kaplan and Norton (2004) discussed measuring the strategic readiness of intangible assets and their indirect importance to tangible assets, while Bharadwaj (2000) investigated firms' informational capabilities and their impact on outcomes, critical for managing tangible assets. Black and Lynch (2001) emphasized the influence of workplace practices and technology on productivity, which can translate into the efficient management of tangible current assets.

In summary, the significance and role of tangible current assets in both public and private sectors underline that effective management involves optimizing inventory levels. Maintaining appropriate inventory levels is crucial to avoiding costs associated with excess storage while ensuring that enterprises do not experience shortages that could disrupt production.

3. Shift-Share Method: Introduction, Assumptions, and Adopted Research Methodology

The shift-share method is an analytical technique primarily used in regional economics to decompose changes in employment, production, or other economic indicators at the regional level. It enables an understanding of the extent to which these changes result from general national trends, industry-specific trends, and unique regional competitive factors. This approach helps identify the sources of growth or decline in a given region and the factors influencing regional development. The literature includes studies highlighting the utility of the shift-share method in analysing changes in capital structure (Crouzet, Eberly, 2023), examining regional competitive advantage and its impact on the labour market (Haynes, 2023), analyzing economic behaviour at the regional level with a decomposition of changes in employment or production (Prats, Armrnta, 2013), and decomposing growth in Metropolitan Statistical Areas (MSAs) into three components: national, industrial, and competitive growth (Ferri et al., 2022). However, it is worth noting the lack of studies exploring the application of the shift-share method in the analysis of corporate current assets.

The shift-share analysis calculates absolute changes by measuring sectoral changes in the analysed region and at the national level between the beginning and the end of a given period. These changes are divided into three components: the National Growth Effect (NGE), the Industrial Mix Effect (IME), and the Regional Shift Effect (RSE).

The National Growth Effect (NGE) represents the portion of change attributed to the general growth or decline trends in the national economy:

$$\mathrm{NGE_{ri}} = \mathrm{E_{ri,0}} \times \frac{\mathrm{E_{n,t}}}{\mathrm{E_{n,0}}}$$

where:

$E_{ri,0}$ – initial production value in sector i within region r),

$E_{n,t}$ – total national production value at the end of the period,

$E_{n,0}$ – total national production value at the beginning of the period,

$\frac{E_{n,t}}{E_{n,0}}$ – national growth rate of production value.

The Industrial Mix Effect (IME) represents the portion of change resulting from the difference in the sectoral composition of the region compared to the national sectoral structure:

$$\mathrm{IME}_{ri} = E_{ri,0} \times \left(\frac{E_{i,t}}{E_{i,0}} - \frac{E_{n,t}}{E_{n,0}}\right)$$

where:

$E_{i,t}$ – production value in sector i at the national level at the end of the period,

$E_{i,0}$ – production value in sector i at the national level at the beginning of the period,

$\frac{E_{i,t}}{E_{i,0}}$ – growth rate of production in sector i at the national level,

$\left(\frac{E_{i,t}}{E_{i,0}} - \frac{E_{n,t}}{E_{n,0}}\right)$ – difference between the growth rate of sector i and the overall national growth rate.

The Regional Shift Effect (RSE) represents the portion of change attributed to local factors specific to the given region.

$$\mathrm{RSE}_{ri} = E_{ri,0} \times \left(\frac{E_{ri,t}}{E_{ri,0}} - \frac{E_{i,t}}{E_{i,0}}\right);$$

where $E_{ri,t}$ – the production value in sector i within region r at the end of the period.

Analysing each component (i.e., NGE, IME, RSE) helps determine whether changes are driven by overall national trends, structural differences between the region and the country, or unique local factors. Based on the results, conclusions can be drawn regarding strategies for regional economic development, employment policies, or other intervention measures.

4. Identifying the Potential of Tangible Current Assets in Individual Voivodeships – Results of the Applied Shift-Share Analysis

The identification of potential in the area of tangible current assets within the voivodeships was first conducted on a nationwide scale, and then differentiated by the public and private sectors. For the purposes of this study, current assets were defined as inventories, specifically materials, semi-finished and work-in-progress products, finished goods, and merchandise. Given that higher levels of tangible current assets reduce operational flexibility, the values obtained in the research were classified as destimulants. Consequently, in interpreting the results, lower values indicate a more positive impact on a company's operations.

Data for the study was obtained from the databases of the Central Statistical Office. Data was obtained for 16 voivodeships. The data is expressed in value in thousand PLN. Data was collected for individual enterprises by province for two periods, i.e. for 2018 and 2023.

1.1. Poland: An Overview

In Poland, over the studied period from 2018 to 2023, all identified areas exhibited a positive rate of change. Overall, the growth of current assets amounted to 70.7%, while in the public and private sectors, the growth rates were 47.0% and 72.6%, respectively. Table 1 presents the growth rates of tangible current assets broken down into materials, semi-finished and work-in-progress products, finished products, and goods. The most favourable situation in the public sector can be observed in the categories of materials (a growth of 27.5%) and semi-finished and work-in-progress products (a growth of 431.8%). It is important to emphasize once again that, for interpretative purposes, the lowest values in the table indicate a favourable outcome. To identify the components contributing to national growth, Table 2 shows the average rates of change for each voivodeship. In the public sector, three negative values — considered desirable — can be observed. The Pomeranian Voivodeship recorded a decrease of 22% in current assets, while the Małopolskie and Wielkopolskie Voivodeships reported declines of 2% and 1%, respectively. The highest growth in current assets in the public sector was recorded in the Śląskie Voivodeship. Table 3 summarizes the analysis results for Poland as a whole. This table shows the structural growth rate, i.e., the rate of change balanced by the average growth in Poland. From the results in Table 3, a favourable trend can be seen in the public sector for materials (-19.5%) and semi-finished and work-in-progress products (15.2%). In the private sector, improvements in current asset indicators were observed for finished products (-1.5%) and goods (-10.2%).

Table 1.
Growth Rate in Poland from 2018 to 2023 – Ownership Sector: Overall, Public, Private

Tangible Current Assets – Inventories	National Growth Rate from 2018 to 2023		
	Overall	Public	Private
Materials	79.8%	27.5%	87.2%
Semi-finished and Work-in-Progress Products	70.4%	31.8%	72.7%
Finished Products	71.4%	79.8%	71.1%
Goods	63.2%	89.7%	62.4%

Table 2.
Average Rate of Change in Individual Voivodeships in the Analysed Areas

Voivodeship	Overall	Public	Private
Dolnośląskie	8.2%	2.3%	8.6%
Kujawsko-pomorskie	1.7%	3.3%	1.6%
Lubelskie	1.9%	7.3%	1.5%
Lubuskie	1.6%	0.0%	1.8%
Łódzkie	3.0%	0.4%	3.2%
Małopolskie	4.0%	-2.0%	4.4%
Mazowieckie	21.8%	16.6%	22.2%
Opolskie	1.1%	0.5%	1.1%
Podkarpackie	2.3%	2.8%	2.3%
Podlaskie	1.3%	0.6%	1.4%
Pomorskie	2.8%	-22.4%	4.1%
Śląskie	8.7%	28.8%	7.9%
Świętokrzyskie	1.4%	9.3%	0.7%
Warmińsko-mazurskie	1.0%	0.2%	1.0%
Wielkopolskie	8.4%	-1.0%	9.2%
Zachodniopomorskie	1.6%	0.1%	1.7%

Table 3.
Structural (Sectoral) Growth Rate in Poland from 2018 to 2023 – Ownership Sector: Overall, Public, Private

Tangible Current Assets – Inventories	Average Growth Rate (2018-2023)		
	Overall	Public	Private
Materials	9.1%	-19.5%	14.6%
Semi-finished and Work-in-Progress Products	-0.4%	-15.2%	0.1%
Finished Products	0.7%	32.8%	-1.5%
Goods	-7.6%	42.7%	-10.2%

1.2. Sector: An Overview

Table 4 presents the results of the Shift-Share Analysis, detailing changes in terms of sectoral competitiveness (structural effect) and the development of potential at the regional level. It should be noted that the overall change in a voivodeship's potential, whether an increase or decrease, is influenced by the growth or decline in sectoral competitiveness (structural effect) and the growth or decline in potential relative to other voivodeships (geographic effect). Kujawsko-pomorskie and Pomorskie Voivodeships demonstrated the most favourable changes, with total effect values of -37.14% and -32.73%, respectively. A negative total effect indicates a decline in current assets, which benefits businesses by suggesting that companies in these regions have improved resource management, leading to greater operational

efficiency. The local geographic effect is the primary driver of the decline in current assets. This may result from favourable local conditions, such as supportive regional policies, good market conditions, or other factors enabling firms to manage their resources more effectively. In contrast, the Lubuskie Voivodeship shows the least favourable outcome, with a total effect of 32.51%. The significant increase in current assets indicates a negative impact on businesses. Companies in this region may struggle with efficient resource management or face other factors that inflate their current assets, potentially straining their financial liquidity.

Table 4.
Shift-Share Analysis in the Sector: Overall

Voivodeship	Total	Structural	Geographic
Dolnośląskie	31.94%	0.10%	31.83%
Kujawsko-pomorskie	-37.14%	-0.40%	-36.74%
Lubelskie	24.91%	0.04%	24.87%
Lubuskie	32.51%	2.59%	29.91%
Łódzkie	-13.25%	0.43%	-13.68%
Małopolskie	-8.41%	-0.10%	-8.32%
Mazowieckie	10.36%	-0.80%	11.16%
Opolskie	-8.75%	1.06%	-9.81%
Podkarpackie	-5.46%	0.61%	-6.07%
Podlaskie	12.27%	0.14%	12.13%
Pomorskie	-32.73%	0.21%	-32.94%
Śląskie	-3,8.%	0.98%	-4.85%
Świętokrzyskie	1.54%	0.83%	0.71%
Warmińsko-mazurskie	-13.39%	1.00%	-14.38%
Wielkopolskie	1.38%	-0.83%	2.22%
Zachodniopomorskie	-5.79%	2.01%	-7.80%

1.3. Sector: Public

Table 5 presents the detailed results of the Shift-Share Analysis for enterprises operating in the public sector. The voivodeships with the highest total effect values (Lubelskie and Śląskie) experienced a significant increase in current assets, which is unfavourable and indicates a deterioration in inventory management during the analysed period. In both cases, the primary factor driving this increase is local geographic conditions. In contrast, the voivodeships with the lowest total effect values (Pomorskie and Małopolskie) recorded a significant decrease in current assets, which is favourable and suggests improved resource management. In both instances, local geographic conditions play a crucial role in facilitating this reduction.

Table 5.
Shift-Share Analysis in the Sector: Public

Voivodeship	Total	Structural	Geographic
Dolnośląskie	93.76%	-5.88%	99.64%
Kujawsko-pomorskie	14.35%	14.72%	-0.37%
Lubelskie	260.28%	4.50%	255.78%
Lubuskie	-37.58%	3.68%	-41.26%
Łódzkie	3.56%	-14.71%	18.27%
Małopolskie	-87.08%	11.07%	-98.15%
Mazowieckie	2.07%	-8.05%	10.12%

Cont. table 5.

Opolskie	118.75%	-8.06%	126.82%
Podkarpackie	168.35%	-13.26%	181.61%
Podlaskie	52.97%	-1.96%	54.93%
Pomorskie	-135.86%	0.69%	-136.56%
Śląskie	181.13%	7.43%	173.70%
Świętokrzyskie	127.70%	2.66%	125.04%
Warmińsko-mazurskie	7.12%	-1.49%	8.60%
Wielkopolskie	-69.84%	12.81%	-82.66%
Zachodniopomorskie	-26.45%	-14.90%	-11.55%

1.4. Sector: Private

In the shift-share analysis for the private sector, significant differences in the values of the total, structural, and geographic effects across voivodeships are noticeable, indicating diverse regional conditions that influence how enterprises manage their current assets (see Table 6). The Lubuskie and Dolnośląskie Voivodeships show the highest total effect values, at 32,63% and 29,51%, respectively. This result suggests a significant increase in current assets, which is unfavourable for companies as it may point to challenges in efficient resource management, leading to excessive accumulation. In Lubuskie, a moderately positive industry mix effect (3,94%) indicates that certain economic sectors may contribute to the accumulation of current assets, though the primary driver of this increase remains local geographic conditions (28,69%). Similarly, in Dolnośląskie, the industry mix effect has a minor impact (0,46%), while local geographic factors play a crucial role (29,05%). In contrast, the Kujawsko-Pomorskie and Świętokrzyskie Voivodeships display the lowest total effect values, at -41,61% and -28,26%, respectively. The decline in current assets in these regions benefits the private sector, suggesting improved operational efficiency and better resource management by companies. In Kujawsko-Pomorskie, a minimal negative industry mix effect (-0,34%) shows that the region's economic structure is not the primary factor driving the decrease in assets, while local geographic conditions play a decisive role (-41,28%). In Świętokrzyskie, there is a slight positive industry mix effect (0,75%), whereas local geographic conditions are the main factor supporting the reduction of current assets (-29,01%).

In summary, the shift-share analysis reveals that in regions with the highest total effect values, local geographic conditions are the main factor driving the increase in current assets, suggesting a need for better resource management in these voivodeships. Conversely, in regions with the lowest total effect values, local conditions facilitate the reduction of assets, positively impacting firms' operational efficiency.

Table 6.
Shift-Share Analysis in the Sector: Private

Voivodeship	Total	Structural	Geographic
Dolnośląskie	29.51%	0.46%	29.05%
Kujawsko-pomorskie	-41.61%	-0.34%	-41.28%
Lubelskie	2.25%	0.05%	2.19%
Lubuskie	32.63%	3.94%	28.69%
Łódzkie	-15.05%	0.86%	-15.91%
Małopolskie	-4.88%	0.21%	-5.09%
Mazowieckie	11.51%	-1.62%	13.13%
Opolskie	-11.89%	1.96%	-13.85%
Podkarpackie	-10.70%	1.06%	-11.76%
Podlaskie	10.72%	0.22%	10.50%
Pomorskie	-3.40%	-1.07%	-2.34%
Śląskie	-11.93%	1.79%	-13.72%
Świętokrzyskie	-28.26%	0.75%	-29.01%
Warmińsko-mazurskie	-14.92%	1.63%	-16.55%
Wielkopolskie	2.09%	-0.76%	2.85%
Zachodniopomorskie	-6.73%	3.06%	-9.78%

2. Discussion and Conclusions

The conducted shift-share analysis for the public, private, and total sectors across various voivodeships provides valuable insights into the variability of data and its impact on the economy and business conditions in specific regions. The analysis considered the total, structural, and geographical effects, which help identify the main factors shaping the level of current assets. The results of the total effect analysis revealed significant variability across sectors and regions. In the public sector, substantial increases in current assets were observed, potentially indicating inefficiencies in resource management. In contrast, the private sector exhibited both increases and decreases in current assets, suggesting that enterprises in some regions manage their resources more effectively than others. Voivodeships such as Lubelskie and Śląskie recorded the highest total effect values in the public sector, implying excessive asset accumulation, while Kujawsko-Pomorskie and Świętokrzyskie showed the lowest values, indicating improved resource management efficiency. It is also worth noting that the structural effect, which reflects the influence of the sectoral composition on changes in current asset levels, had a relatively minor impact on the outcomes. In most cases, the structural effect was low, suggesting that a region's economic structure (e.g., dominant industries) is not the main factor driving changes in current assets. The third calculated component — the geographical effect — pertains to the influence of region-specific local conditions and plays a key role in shaping current asset levels. In many voivodeships, especially those with high total effect values, the primary drivers of current asset growth were local conditions such as regional policies, infrastructure, or market access.

The study also highlighted sectoral differences. The public sector tends to accumulate larger volumes of current assets, which may result from the lack of effective management mechanisms or other public administration-related factors. Conversely, the private sector in some regions demonstrates a greater capacity for efficient resource management, though there are also areas where the opposite is true.

Diverging results across voivodeships may stem from several key institutional, socio-economic, and historical factors. Regions with high total and geographical effect values, such as Lubelskie and Śląskie, often feature a strongly developed public administration, a high share of budgetary units, and a traditional approach to resource management. This may lead to conservative fund accumulation and lower flexibility in adapting to changing market conditions. In the case of Śląsk, an additional factor may be the historical structure of the economy based on heavy industry and large public entities.

In contrast, regions with low total effect values, such as Kujawsko-Pomorskie or Świętokrzyskie, may benefit from a more dynamic development of the private sector, better cooperation with academia and local governments, and more effective resource management strategies. This could be the result of active local policies supporting entrepreneurship, investments in human capital, and the digitalization of public administration. A relatively smaller number of large public institutions may also contribute to a more flexible, market-oriented asset management approach.

It is also important to note that regions attracting foreign investments or having a strong position in modern technology industries often exhibit higher efficiency in the private sector — a result of stronger competition, pressure for efficiency, and better access to knowledge and capital. On the other hand, voivodeships with higher unemployment rates, lower labor mobility, or limited infrastructure availability may show reduced capacity for efficient asset management, regardless of the sector.

The findings highlight the need for a differentiated approach to regional economic policy. In regions with high geographical effect values, particularly in the public sector, interventions may be necessary to improve resource management efficiency — for example, through administrative process modernization, implementation of performance assessment mechanisms, and increased transparency of public finances. Meanwhile, regions with low total effect values can serve as benchmarks, offering best practices in resource management and acting as natural partners for knowledge and experience transfer.

The shift-share analysis reveals significant differences in the efficiency of current asset management between sectors and regions, which directly affect the economic situation and business climate in Poland. Understanding these differences and their territorial determinants is crucial for making informed economic and policy decisions. Effective regional economic policy should be based on a thorough diagnosis of local resources, barriers, and development potential.

It is also important to acknowledge certain limitations related to the quality and availability of regional data, which may affect the accuracy and interpretation of the results. In some voivodeships, data on current assets, particularly in the public sector, may be incomplete, aggregated in a way that limits comparability, or reported with delays. Furthermore, differences in reporting methodologies between public and private sector entities may compromise the consistency of input data. Therefore, the results should be treated as indicative and supportive for diagnosis rather than a definitive picture of the situation. Further in-depth research and the standardization of reporting practices at the regional level could enhance the precision and informational value of future analyses of this kind.

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CENTRIC FORMS IN ARCHITECTURE AND URBAN PLANNING IN ANALOGUES TO PRIMARY BIOLOGICAL STRUCTURES

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Purpose: The article is part of the current issues of human ecology, and particularly the biophilia trend, which focuses on the relationships between humans and nature and their adaptation to the environment, which enables them to survive and function freely in it. The aim of the research is to compare the structures of primary microorganisms from the algae group (diatoms and green algae) and architectural forms produced by humans in terms of the occurrence of radial symmetry as well as centric forms, which humans have used to consciously shape the nearest space since the beginning of their existence.
Design/methodology/approach: The article analyses the spatial structures of algae organisms from the diatom and green algae classes, as well as spatial structures produced by humans in the period from the 2nd millennium BCE to the 19th century CE. The comparison was made by examining individual elements of the composition responsible for harmony, maturity and beauty, which are: compositional axes, rhythms (produced by single and repeatable structural elements) and the central point, which are always derived from the occurrence of radial symmetry in nature.
Findings: The results revealed the occurrence of similar spatial structures in both algae forms and human structures. Basically, two types of forms were distinguished:
Type no. 1: the structure of the organism based on a star-shaped plan; elongated and slender arms with constant proportions are the basic elements of a two-dimensional composition; radial symmetry consists of several axes and does not exceed eight-radius symmetry; the central point at the base of the composition is built on a circular plan and is small in size.
Type no. 2: the structure of the organism based on a circular plan. Algae are characterized by a compact and concentrated form created from many identical cells, which in space constitute elementary particles, permanent modules responsible for the cohesion and balance of the composition; the number of axes of radial symmetry that can be distinguished in individual species is much greater than in representatives of the first type and ranges from a dozen to several dozen axes of symmetry; structures of the system built on the radii of several circles, the central point of which is the center of the composition; individual spatial points spaced at the same distance from each other create a fixed module based on the same proportions, which, processed in fixed rhythms and in various spatial arrangements, creates the structure of the organism.
Research limitations/implications: Only two of the six groups of algae were accepted for the study, which constitute only one of the five kingdoms occurring in nature. It is probable that they represent only a narrow fragment of reality. Considering the fact that the natural world is

based on radial symmetry in many aspects, the study of the structure of individual primary groups of organisms should be extended to other kingdoms and groups.
Social implications: Man subconsciously strives to imitate the structures of nature and create usable forms, among others, based on radial symmetry. The method of shaping space based on the composition of primitive algae presented in the article can be used, among others, in urban planning to create city plans and shape functional and harmonious spaces. Compositions based on star symmetry are always legible, determine spatial dominants and increase the comfort of life of its inhabitants. Radial symmetry can also be helpful in creating contemporary architectural objects, which will be based on repeatable rhythms and a central point, which will allow for a clear and logical layout of space.
Radial symmetry not only organizes space, but also creates a universal pattern that is naturally understandable and comfortable for humans. The repeatability and proportions typical of radial symmetry resemble systems found in nature, which has a positive effect on the psyche of users. All this means that radial symmetry can become a tool for designing universal, repeatable and scalable architectural solutions. It can be used both on a small scale, from detail to large-scale urban layouts.
Originality/value: The article presents an attempt to analyze and systematize the structural features of the original group of organisms with centric forms, such as algae, in terms of compositional features based on radial symmetry and relating these results to spatial structures created by humans. This type of research can influence a better understanding and dissemination of the idea of radial symmetry in design, where we will always find tools responsible for the sense of beauty such as: composition, rhythm and proportions. The article is addressed primarily to architects and planners who are responsible for maintaining spatial order in the urbanized environment, creating a space that is harmonious with nature.
Keywords: radial symmetry, biophilia, organic forms, algae.
Category of the paper: research paper.

1. Introduction

Since the second half of the 20th century, a dominant, geometric and regular arrangement of forming the closest human space has become widespread. Even at the beginning of the 20th century, building elevations were in most cases shaped by architectural details that directly referred to organic shapes and centric forms. This is particularly visible in ornaments, shapes of window and door openings or rosettes always present in sacral architecture. The first settlements and defensive strongholds in which urban life was confined were based on a spherical or elliptical form, which is reflected in nature. In the later period, many planning assumptions were also based on the form of a circle with communication routes spreading out centrally.

Nature has created a uniform code for forming spatial structures, widespread in the world of living organisms, which is based on a rounded line and circular, centric forms and radial symmetry with repeating systems of rhythms and proportions, which are also used by humans. Aristotle believed that beauty is associated with a strict creative pattern encoded in nature - beauty is otherwise known as proportions found in nature. Representatives of many species of

algae, whose structure is based on a centric form, have a very diverse and, at the same time, coherent form, which is often repeated in nature. These are microscopic plant organisms living in water with a size of several to several hundred micrometers. Examining their structure under a microscope, one can see that they consist of uniform, repeatable single cells that arrange themselves into repeatable centric forms. A characteristic feature here is the occurrence of radial symmetry, which generates the formation of constantly repeating rhythmically elements that arrange themselves into a mature composition. Of particular interest in terms of the diversity of forms is the structure of groups of diatoms and green algae, whose natural forms based on systems of rhythms and proportions have often been used for centuries in the urbanization of living space and human art.

This article attempts to answer the question of how repetitive forms based on radial symmetry, found in primitive animals, are reflected in the structures and architectural details created by humans in different eras.

2. The concept of beauty

A man shapes their immediate surroundings according to specific canons of beauty, which include: rhythms, proportions and symmetry. The human psyche has the ability to remember perceived spatial arrangements and to isolate individual forms from the environment through simplification and geometrization (Wejhert, 1984). The forms that are best remembered are those that are characterized by balance, symmetry and regularity, and are isolated from a broader context through contrast with the environment (Szymski, Dawidowski, 2006). Forms that are easily noticeable and at the same time beautiful are characterized by order and proportion that the human brain perceives subconsciously. When designing, as the ancient architect Leone Battista Alberti claims, the principle should be applied: "(...) so that one member agrees with the other, creating and consolidating together the glory of the whole work, and this is so that one does not seize all the beauty, leaving the rest ugly (...) and they must be similar to each other in such a ratio that they look rather like an inseparable and completely finished body than separate and scattered members. Then, when giving shape to these members, one must imitate the modesty of nature, because in this as in other things we will praise moderation and condemn excessive passion for building" (Alberti, 1960a, p. 33).

Another ancient architect, Vitruvius, had similar views on beauty and proportions. In his work he wrote: "Proportion is the application of a fixed module in each work of art to both the building's elements and its entirety, from which the law of symmetry results. No building can have a proper layout without symmetry and good proportions, which should be based strictly on the proportions of the body of a well-built human being. […] Similarly,

the elements of temples should have the most appropriate proportions both between their individual parts and in relation to the entire building" (Witruwiusz, 1999, p. 30).

This method of shaping space is constantly present in the world of living nature, which is characterized by logical rhythmicity manifested, among others, by the rhythmicity of the construction of microstructures and symmetry (Satkiewicz-Parczewska, 2001). Man, being a part of nature himself, governed by permanent rules regarding matter and life, is subject to the physical and biological rules governing the universe (Caillois, 1967).

Despite the subconscious tendency to build harmony and beauty, especially since the 20th century, there has been a decline in the quality of standards and a break with tradition, which consisted in ceasing to apply specific canons and orders developed in evolution by artists. Currently, we often deal with chaotic arrangement of space and deliberate or accidental use of disharmony, manifested by the lack of basic elements of beauty: composition, symmetry and harmony in contemporary works of architecture (Maciejko, 2017).

2.1. Symmetry

The basic element of beauty that builds coherence and a sense of beauty is symmetry. As Aristotle said: "What else but a certain kind of uniformity and equally measured intervals? What is the beauty of iambic, trochaic and tribrach... if not that the smaller part of the foot can divide the larger into two equal parts" (Tatarkiewicz, 1962, p. 61).

The idea of symmetry has probably accompanied man since the beginning of his existence: "thanks to which he tried to create order around himself during the process of evolution and later to perceive beauty and perfection" (Weyl, 1997, p. 11).

According to the mathematical definition, symmetry is a system of identical elements, evenly distributed from the axis. Elements located on one side of the axis are a mirror image of those on the other side. Symmetry gives finiteness to a given set of elements and emphasizes static, calm and monumentality (Żórawski, 1973).

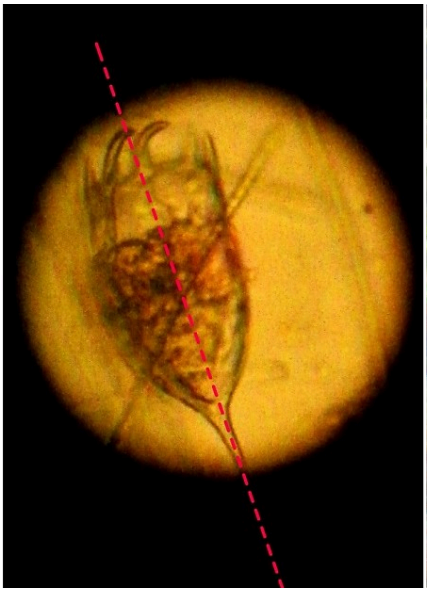
Idea symetrii towarzyszyła człowiekowi prawdopodobnie od początku jego istnienia: „dzięki której starał się podczas procesu ewolucji tworzyć porządek wokół siebie a w późniejszym czasie dostrzec piękno i doskonałość” (Weyl, 1997,p. 11).

2.2. Symmetry in the animal world

In nature, symmetry is present from the very beginning of the life-forming process and is a basic feature of the structure of an organism, which determines the arrangement of its parts in relation to a hypothetical axis. In the world of nature, we distinguish two basic types of symmetry:

Bilateral symmetry. The symmetry of a body made of two similar halves, each of which is a mirror image of the other (figures 1 and 2). It is determined by a plane running along the main axis. Bilateral symmetry occurs in many representatives of almost all groups of plants and

animals. Most animals, including humans, have only one axis of symmetry (Kowalska, 2005) (figures 3 and 4).



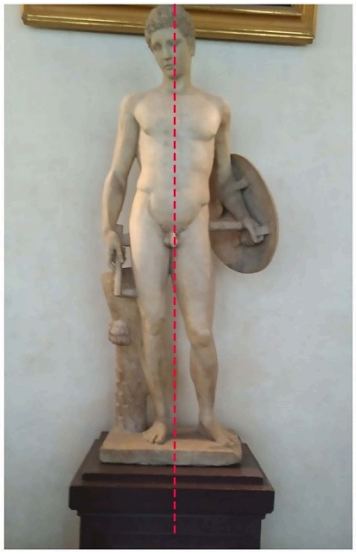
(Figure 1)

(Figure 2)

Figure 1. Bilateral symmetry in a representative of plankton (Rotatoria). Source: own elaboration.

Figure 2. Bilateral symmetry in amphibians (toad). Source: own elaboration.

(Figure 3)



(Figure 4)

Figure 3. Bilateral symmetry of the human face. Source: own elaboration.

Figure 4. Symmetry of the human body. Source: own elaboration.

Radial symmetry. The symmetry of a body whose appearance does not change after rotation around the axis by a part of the rotation determined by the type of symmetry. A characteristic feature is a large number of planes of symmetry running through the body of the organism along the main axis. The nomenclature is based on the number of rays that can be determined in a given case, e.g.: biradiate symmetry (two rays, two planes of symmetry), triradiate symmetry (three rays, three planes of symmetry) (Larousse, 1990). Bilateral symmetry is characteristic of

most animals and higher organisms and has developed in connection with active movement. Radial symmetry is most common in primitive animals and is most widespread in forms of algae representatives - microscopic organisms inhabiting the sea.

3. Algae. General characteristics

Algae are plant and animal organisms with small body sizes that float freely in water (5 um to 10 mm in diameter). They do not have the ability to move and their specific gravity is as close as possible to the weight of water. In many species of algae, the process of settling is significantly delayed by their microscopic size and the presence of various outgrowths that significantly increase the surface area. They are the primary producers of organic matter and oxygen produced in the process of photosynthesis (Pliński, 1992).

The most complex and representative shapes are those of algae from the diatom and green algae classes. Their form is spherical in many cases. Studies have shown that the richness of species decreases exponentially with the elongation of cells and the departure from the circular form (Stanca et al., 2013).

Chlorophyta are a group of algae most closely related to terrestrial organisms, which in evolution constitute one of the three developmental lines of plants. These are unicellular and multicellular organisms that have the ability to form extensive colonies. To date, 9000 species have been identified (Radziejewska et al., 2002).

In turn, diatoms (Bacillariophyceae) are unicellular algae that occur singly or can form colonies of various forms. The shape of the cell variety in individual species is a variety of one of two basic types: centric (round) in diatoms from the centrales group or elongated in the pennales group. The actual diatom cell is enclosed in a two-part, box-like (with a "lid" and a "bottom") siliceous shell saturated with pectin (Żmudziński, 1997).

3.1. Coenobium

Algae, as one of the few groups of phytoplankton, have the ability to create complex colonies from individual cells (Campbell, 2018) into extensive structures - coenobium. Coenobium is a common unit that brings together from several to several hundred individual algal cells using a common gelatinous shell that is a binder of the entire structure (Strasburger, 1967). The name coenobium itself derives its origin from one of the forms of monastic life in the monastic community - coenobitism. Coenobium in different species of algae are arranged in various shapes, but we can observe a certain property that many coenobium take on a centric form in the form of star symmetry based on a circle. The construction of the central system begins with fragmentation and the construction of the system from one repeating element (cell). A given element in the form of repeating rhythms spreads from the central point and arranges

itself into a centric structure based on star symmetry. Each individual cell can give rise to a new coenobium.

4. Methodology

In terms of research, the focus was on a detailed analysis of the centric forms of selected representatives of algae species from the diatom and chlorophyta, which were compared with centric forms produced by humans. The detailed analysis primarily concerns the following elements responsible for the construction of the studied structures: radial symmetry, central point and repeatable modules appropriately arranged in relation to the composition axis. Two types of centric systems were distinguished, based on a star-shaped plan and a circular form.

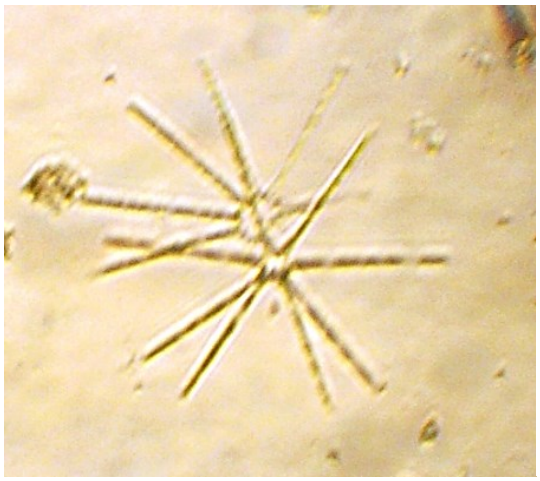
Representatives of some of the oldest and most primitive organisms on Earth, which appeared around 700-750 million years ago, were selected for analysis. These organisms are unicellular and have the ability to form colonies that form centric forms and in their assumptions refer to the canons of beauty.

In the case of buildings and architectural assumptions, those examples (from different eras and on different scales) were selected for analysis that show the characteristic way of shaping compositional systems that is present in primitive algae.

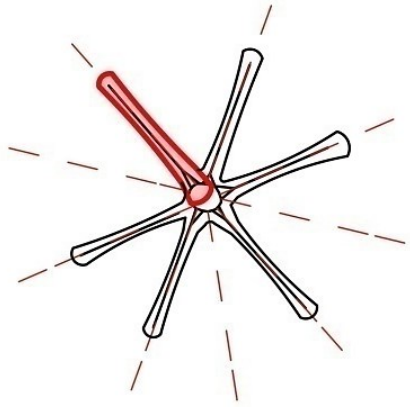
4.1. Type No. 1. Star symmetry

4.1.1. Centric structures of algae based on star symmetry

The structure of the species Asterionella sp. (figures 5 and 6), a freshwater representative of the diatom class of algae, is based on star symmetry. In this case, the coenobium most often occurs in the form of six individual cells that create a star structure. The coenobium of Asterionella sp. may fall apart or change the number of modules under the influence of environmental changes, but in its essence it will always strive to create six-axis symmetry. Similar features are presented by another species of diatoms - Staurastrum gracile, in which we can distinguish a constant three-axis symmetry (figure 7).



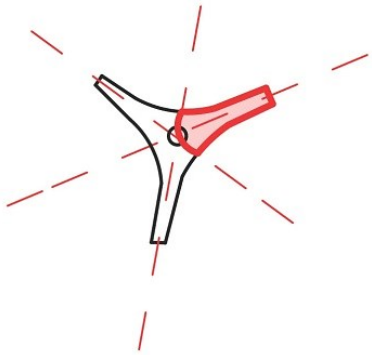
(Figure 5)



(Figure 6)

Figure 5. Asterionella sp. Enlarged photo. Source: own elaboration.

Figure 6. Asterionella sp. The cell forming the cenobium structure is marked in red. Source: own elaboration.



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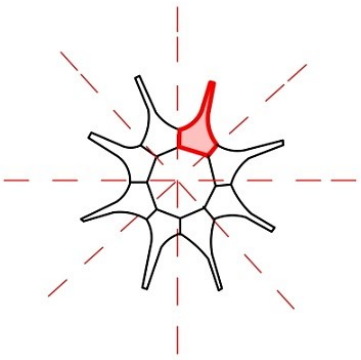


(Figure 8)

Figure 7. Scheme of Asterionella sp. Source: own elaboration.

Figure 8. Scheme of Pediastrum simplex. Source: own elaboration.

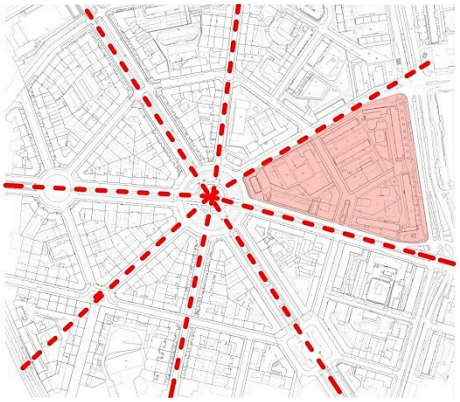
Following the further developmental evolution of subsequent representatives of diatoms, we can state that the radial ends of the arms begin to change their proportions and the central point of negligible size grows. These features are present in another representative of diatoms - Pediastrum Simplex, where we can observe the process of slowly approaching a circle (figure 8). The central part of the system begins to grow significantly and the arms slowly disappear. The simplex pedastrium heralds the beginning of the transition to the next form, the system of which is based on a circle.

As shown in figures no. 5-8, individual cells (marked in red) in the form of elongated rays connected in cenobia create a star-shaped structure.

4.1.2. Architectural structures based on star symmetry

In human architecture, star-shaped forms are characteristic of the spatial arrangements of larger urban agglomerations, an example of which is Grunwaldzki Square in Szczecin. The square was modelled on the concepts of Georges Haussmann, responsible for the

reconstruction of 19th-century Paris. The focal point of the composition is a square in the shape of a circle from which a network of eight communication routes underpinned by greenery radiates (figure 9 and 10). Between the streets, tenement houses were built, similar in shape to an equilateral triangle, which, repeated in different arrangements, constitute the basic module of the square's composition (Kozińska, 2015).



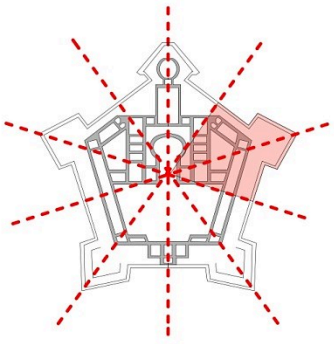
(Figure 9)

(Figure 10)

Figure 9. Scheme of Grunwald Square in Szczecin. Source: own elaboration.

Figure 10. A bird's eye view of Grunwald Square. Source: own elaboration.

However, it should be remembered that the very idea of star symmetry and ideal proportions existed already in the antiquity. The first plan of an ideal city was presented by the architect Vitruvius. According to his concept, the ideal city is to be planned on the plan of a regular polygon, the corners of which can be connected by a circle. All sides of such a figure should have the same length and the angles should have the same inclination. The plan of the ideal city was based on the symmetry of streets and shapes as well as the appropriate proportions of individual elements such as: the proportions of internal squares in relation to the width of communication frontages and the height of tenement houses (Szpakowska, 2012).



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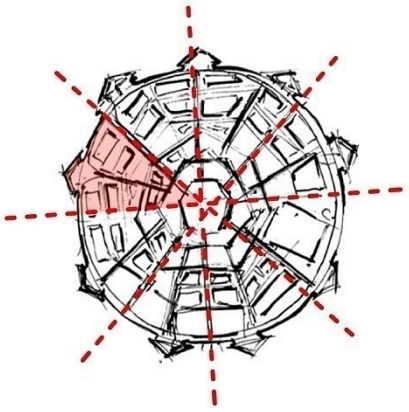


(Figure 12)

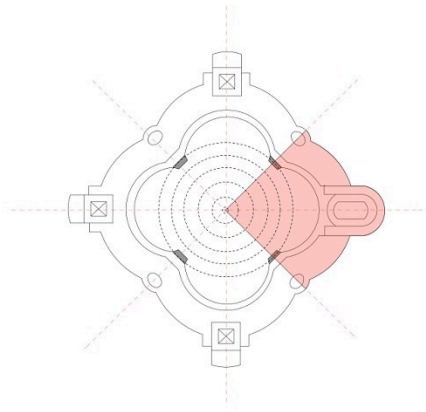
Figure 11. Scheme of the castle in Krzyżtopór. Source: own elaboration.

Figure 12. Plan of the ideal city – Palma Nuova. Source: own elaboration.

An excellent example of an ideal city is "Palma Nova", which was designed in the 16th century by the Venetians. In the city center there is a hexagonal regular public square in the shape of a regular polygon, the extreme points of which are inscribed in the line of a circle (figure 12). From the central point of the square, six streets radiate in a star shape with the same dimensions: width and length, which lead to the entrance gates.

In later times, up to the 20th century, defensive fortresses were built on star symmetry and the principles of the ideal city, an example of which is the Krzywotopór castle in Ujazdów (figure 11) from the 17th century. Krzyżtopór was built on a pentagonal plan with bastions in the shape of rhombs on the edges of the figure. The axial symmetry and geometricization of the palace were determined by the towers of the palace and gates growing from the corners of the figure. The city was surrounded by walls that in their form constitute a polygonal star, with its shape referring to the petals of the stitch.

The composition of the People's Hall in Wrocław, which was built at the beginning of the 20th century, also refers to the principles of the ideal city and radial symmetry.



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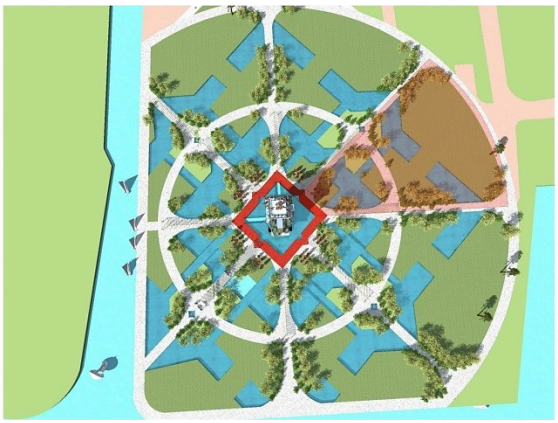


(Figure 14)

Figure 13. Scheme of Centennial Hall in Wrocław. Source: own elaboration.

Figure 14. Contemporary Concept of land development of the Area Around the Coal Tower in Szczecin based on Star Symmetry. Source: own elaboration.

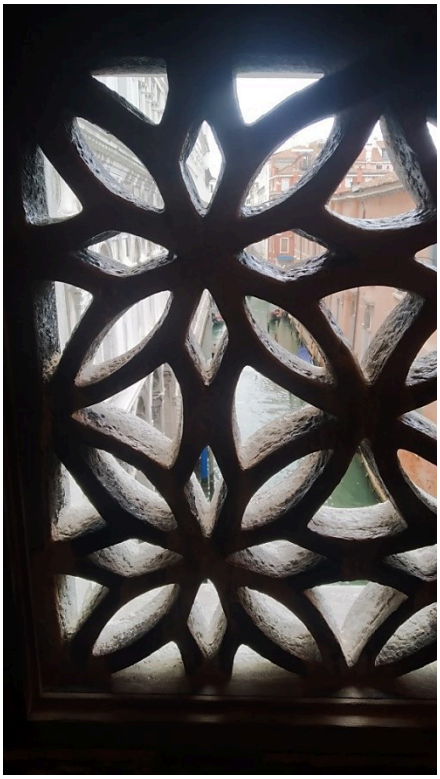
The object based on three-axis symmetry is topped with four protruding arms (figure 13). The central point in the form of a stage based on a circle is covered by a reinforced concrete dome consisting of 32 ribs ending with a central ring. The people's hall is a transitional form, which is already tending to close the plan of the body in a circle. The central part of the layout begins to grow significantly and the process of slow disappearance of the arms begins.

(Figure 15)

(Figure 16)

Figure 15. Floor of the church in Ravenna. Source: own elaboration.

Figure 16. The rose window of the Gothic church in Valencia. Source: own elaboration.



(Figure 17)

(Figure 18)

Figure 17. Detail of a window from the Italian Renaissance. Source: own elaboration.

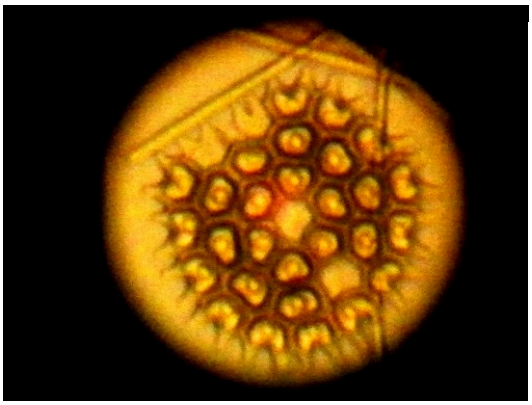
Figure 18. The star vault of the Prague church of a window. Source: own elaboration.

The star shape is a common motif that is repeated in small architecture or details in the form of elements illuminating objects, vaults or floor patterns (figures 15-18).

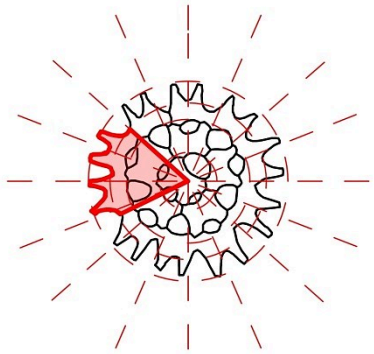
4.2. Type No. 2. Centric structures based on a circle

4.2.1. Centric structures of algae based on a circle

In the process of evolution, due to the growth of the central point and the disappearance of radial arms, coenobium in subsequent representatives of phytoplankton approached the ideal form – a circle. Characteristic of organisms representing type 2 is that from the central point radiate several circles that at regular intervals connect the entire composition. Individual cells arrange themselves in a circle around the central point, simultaneously creating a repeating module identical for the entire composition.



(Figure 19)

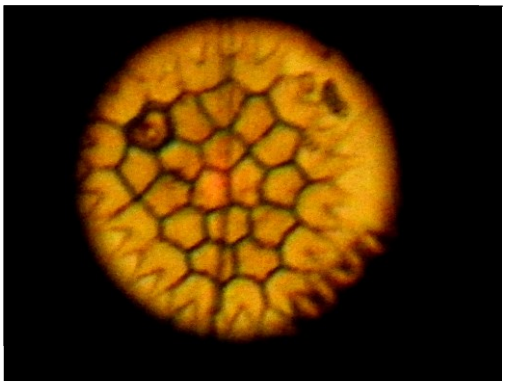


(Figure 20)

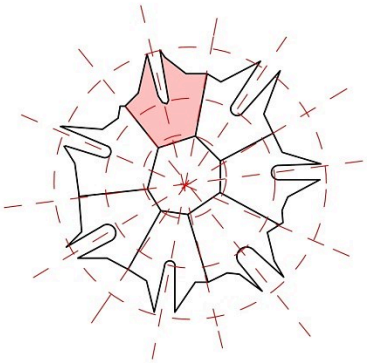
Figure 19. Pediastrum duplex. Enlarged photo. Source: own elaboration.

Figure 20. Pediastrum duplex. The cell forming the cenobium structure is marked in red. Source: own elaboration.

In Pediastrum duplex, a representative of the green algae group, the cells are gathered in flat colonies differentiated by edges and internally elongated processes (figures 19 and 20). Cenobia usually consist of 4-64 cells, although they can reach up to 128. The cells in the colony can be tightly adjacent to each other or touch each other at the ends, leaving free spaces. In the structure itself, we can clearly distinguish several circles around which the entire colony is built. Similar properties can be observed in Pedastrium tetras (figures 21 and 22).



(Figure 21)

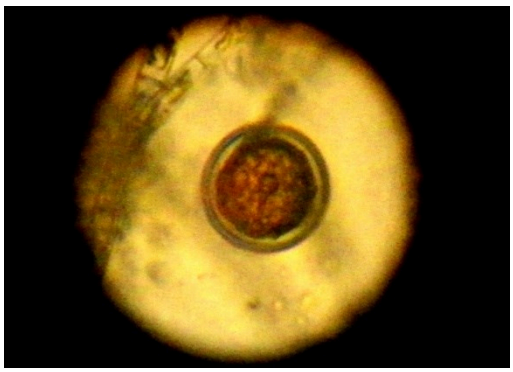


(Figure 22)

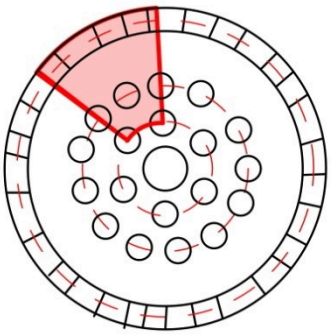
Figure 21. Pedastrium tetras. Enlarged photo. Source: own elaboration.

Figure 22. Pedastrium tetras. The cell forming the cenobium structure is marked in red. Source: own elaboration.

Another almost ideal form, similar to a circle, is a cyst (endospore). This is a resting form that allows organisms to survive unfavorable conditions (low temperature, drought) and produces spores stored inside the cell. A cyst is characterized by a significant degree of dehydration of the cytoplasm as well as thick and multi-layered covers.



(Figure 23)



(Figure 24)

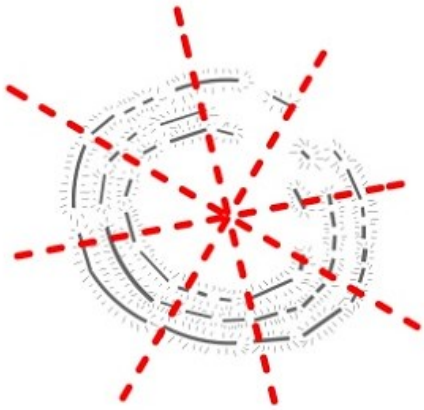
Figure 23. Cyst. Enlarged photo. Source: own elaboration.

Figure 24. Cyst. The cell forming the cenobium structure is marked in red. Source: own elaboration.

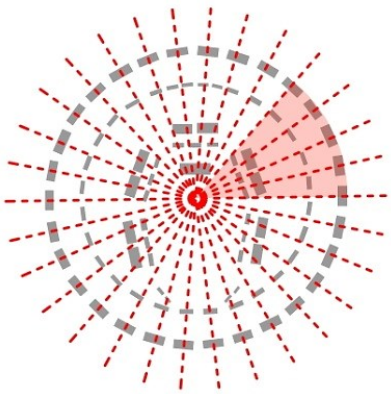
The protective layers of the endospore, similarly to the previously mentioned species of green algae, are arranged in central circles radiating from the central point of the composition (figures 23 and 24).

4.2.2. Centric structures based on the form of a circle produced by human

The first structures shaped by man were based on a circular form, also characterized by a radial structure. The original stronghold structure shown in figure no. 25 has a form close to a circle and is characterized by a four-radius symmetry. Individual defensive ramparts were shaped on three circles with the central point of the entire composition. It is also worth paying attention to the repeating rhythms. The entire composition consists of two types of earth mounds, a longer one and a shorter one, which is often built on a 1:2 ratio (especially within the first rampart).



(Figure 25)



(Figure 26)

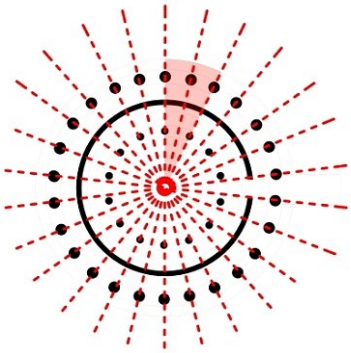
Figure 25. The original stronghold from the turn of the 6th and 7th centuries BC in Opole Lubelskie. Source: own elaboration.

Figure 26. Stonehenge. 2095-1600 BC. Source: own elaboration.

However, forms based on a circle were characteristic primarily of public and sacred. The oldest ideal forms derive from the tholos – a building of a temple character, consisting of a naos (rotunda) surrounded by a colonnade (figure 28). figures no. 26 and 27 show two representative forms of the tholos located in Epidaurus (4th century BC) and the oldest of them presenting a sacred object in Stonchage (2nd millennium BC). By comparing these forms, one can find clear similarities. Both temple complexes exhibit features of radial symmetry and are based on three circles that define rhythmically repeating colonnades. Individual columns (or stone blocks) occur in relation to each other in constant rhythms and proportions, which is why they constitute the basic module for the entire composition.

The features of the tholos are also exhibited by the form of the Greek theater (figures 29 and 30). The focal point here is the stage. The composition of the system consists of several circles that spread out from the central point.

In turn, in the Pantheon, a rotunda with a diameter of 43.6 m, the central Roman temple dedicated to planetary deities, the lines of symmetry are determined by niches (figures 31 and 32). In this case, we are dealing with eight-radius symmetry. The central part of the composition, based on a circular plan, has been significantly expanded and is separated by rhythmically repeating columns that support the dome.

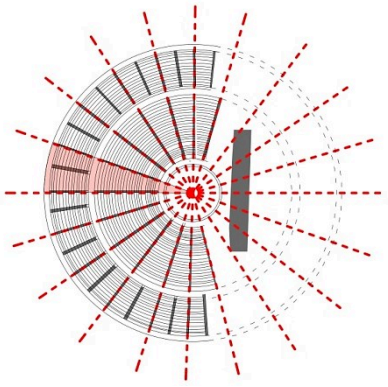


(Figure 27)

(Figure 28)

Figure 27. Scheme of the tholos at Epidaurus. 370 BC. Source: own elaboration.

Figure 28. Decorative form of a tholos from the 19th century. Source: own elaboration.

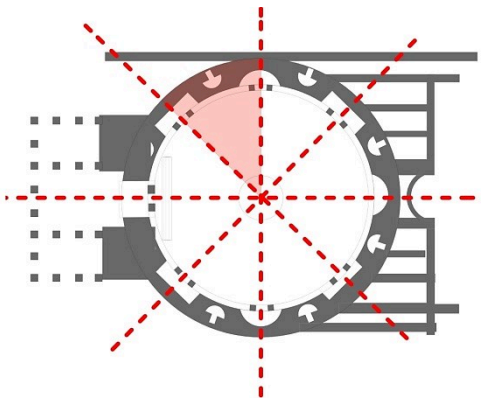


(Figure 29)

(Figure 30)

Figure 29. Scheme of the amphitheater, Epidaurus. 330 BC. Source: own elaboration.

Figure 30. Odeon of Herodotus in Athens. 161 CE. Source: own elaboration.



(Figure 31)

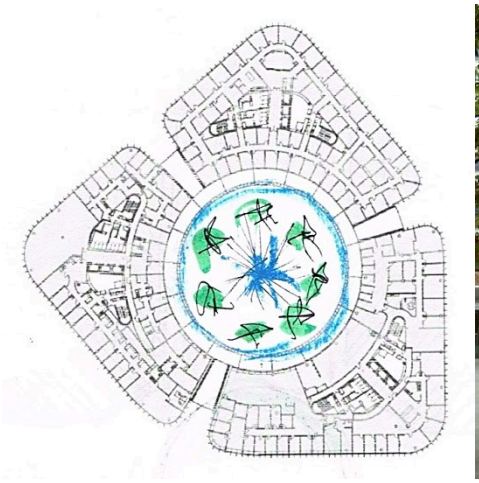
(Figure 32)

Figure 31. Scheme of the Pantheon. Rome, 125 AD. Source: own elaboration.

Figure 32. The colonnade in the Pantheon supporting the dome. Source: own elaboration.

Nowadays, public spaces are also designed based on a centric plan, an example of which is the inner courtyard of the Metropolitan building in Warsaw designed by Norman Foster (figures 33 and 34). Greenery in the form of dwarf ornamental trees was used as compositional elements here, which, like colonnades in ancient temples, situated on a circle at equal intervals,

emphasize the cohesion of the composition (figures 35 and 36). A characteristic element of the layout is also a fountain that marks the boundaries of the internal water reservoir, which is the central point of the composition.



(Figure 33)

(Figure 34)

Figure 33. Scheme of the inner square of the Metropolitan. Warsaw. Source: own elaboration.

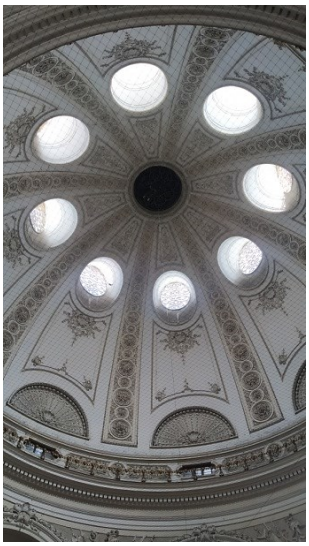
Figure 33. View of the square. Source: own elaboration.

(Figure 35)

(Figure 36)

Figure 35, 36. Natural elements in the form of trees and water constituting elements of the composition.

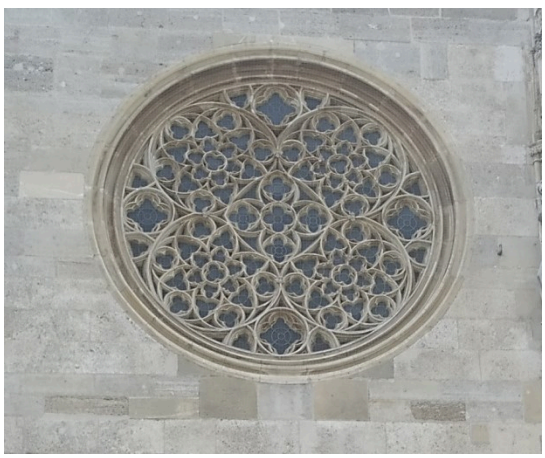
The procedure associated with the use of a dome became particularly popular in the Baroque era.



(Figure 37) (Figure 38)

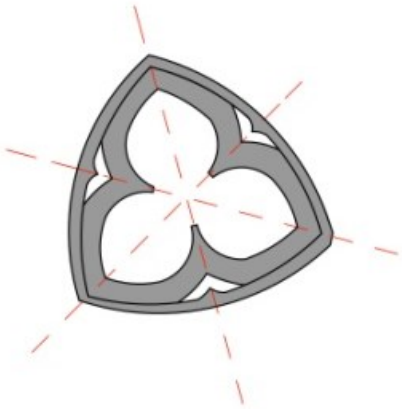
Figure 37, 38. Examples of domes enriched with illusion painting or architectural elements. Source: own elaboration.

Domes were enriched with additional elements in the form of illusory paintings (figure 37) or openings illuminating the object (figure 38), which always emphasized the symmetry of the composition.

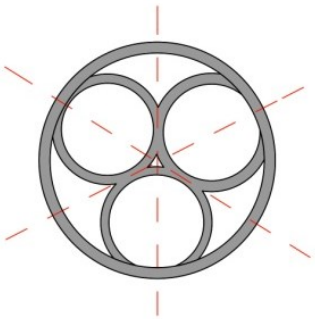


(Figure 39) (Figure 40)

Figure 39, 40. Examples of wall rosettes of gothic. Source: own elaboration.



(Figure 41)



(Figure 42)

Figure 41, 42. Frequent organic motifs found in window openings in the Gothic period. Source: own elaboration.

In detail, circular forms were represented by, among others, church rosettes, which were characterized by ideal proportions (figures 39-42).

5. Findings

The analysis carried out showed that the centric forms of larger spatial layouts designed by humans are based on two types of structures that occur in primitive organisms and their basic feature is the occurrence of radial symmetry.

Representatives of the first type of algae species (based on star symmetry) are less complex and have the following features:

- the structure of the organism is based on a star plan,
- elongated and slender arms with constant proportions are the basic elements of a two-dimensional composition,
- radial symmetry consists of several axes and does not exceed eight-radius symmetry,
- the centric point at the base of the composition is built on a circular plan and is small in size.

Type no. 1 is characteristic of larger urban layouts and is particularly characteristic of the plans of 19th and 20th century city centers (e.g. Paris, Szczecin), defensive fortresses and cities based on the idea of the "ideal city" (created during the Renaissance and the idea of which dates back to antiquity). Radial symmetry is characterized by a central point in the form of a public, open square from which axes of symmetry radiate out, defining harmonious rhythms and proportions for the entire layout. The above features can also be found in larger cubature objects that imitate the structure of the ideal city.

The structure of type no. 2 is much more developed and the following features can be distinguished in it:

- they are characterized by a compact and concentrated form created from many identical cells that in space constitute elementary particles - permanent modules responsible for the cohesion and balance of the composition,
- the number of radial symmetry axes that can be distinguished is much greater than in type no. 1 and ranges from a dozen to several dozen axes of symmetry,
- the structures of the system are built on the radii of several circles whose central point is the center of the composition,
- Individual spatial points spaced at the same distance from each other create a permanent module based on the same proportions, which, processed in constant rhythms and in various spatial arrangements, creates the structure of the organism.

Spatial structures of type no. 2 are characteristic primarily of larger public buildings and temples that originate from the original form of the tholos, where its mature form appeared in ancient Greece. The center of gravity of the repeatable modules of the composition is based on several circles radiating from the central point of the composition. Basic spatial units are built from single points, e.g. in the form of columns, which occur in fixed distances and proportions to each other, and thanks to radial symmetry and its arrangement, they create constantly repeating rhythms.

The examples presented are limited to the European cultural sphere. However, it should be remembered that space was shaped differently outside Europe. Research on architectural assumptions from other cultural circles in relation to centric forms requires deeper and further research.

6. Discussion

For centuries, attempts have been made to find uniform principles in nature that shape beauty. Many different theories have been created on this subject, based on, among others: the golden ratio, Fibonacci sequences or fractal structures. According to them, every day we encounter geometric objects that are self-similar and can be infinitely complex, by which we mean that their smallest particles resemble the entirety of the created structure. This property is often found in nature, e.g. in trees that resemble a structural whole (Bociek, Wytrki, 2021). At the end of the 20th century, the biophilia hypothesis gained popularity, which examines the relationships of highly developed species with nature and their adaptation to the environment enabling them to survive. In addition to the natural environmental conditions in which we live every day (chemical and physical conditions such as light, wind, temperature), humans also create feedback with the spatial order of nature, manifested through appropriately occurring rhythms, divisions and systems of proportions that, when perceived by humans, affect their way of thinking and aesthetics and, as a result, determine the canons of beauty (Celadyn, 2023).

The research presented in this article is consistent with this hypothesis. Humans subconsciously use radial symmetry and a system of spatial structures to shape their immediate surroundings, which have been present in nature since the beginning of life and whose traces can be found in some of the most primitive organisms - algae (from the diatom and green algae classes), the first fossils of which appeared about 750 million years ago. Since, as it was shown in the article, man subconsciously strives for a sense of order, stability and beauty, a thorough examination of the structures of primitive organisms, especially in the aspect of radial symmetry, will help us better understand the needs and way of thinking and spatial orientation in the field of the species Homo sapiens.

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UTILIZATION OF ARTIFICIAL INTELLIGENCE IN ORGANIZATIONAL SUSTAINABLE DEVELOPMENT: BIBLIOMETRIC ANALYSIS AND FUTURE RESEARCH DIRECTIONS

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Purpose: The paper aims to conduct a bibliometric analysis to investigate the utilization of artificial intelligence in organizational sustainable development.
Design/methodology/approach: This study uses bibliometric analysis to evaluate literature on artificial intelligence in organizational sustainable development. By applying quantitative and qualitative methods, it identifies key trends, influential works, and research gaps. Data were collected from the Scopus database using keywords like "artificial intelligence", "sustainability", and "organization" resulting in a dataset of 217 relevant journal articles and conference papers published up to March 11, 2025.
Findings: The study highlights increasing scholarly interest in artificial intelligence's role in organizational sustainable development, with a significant rise in publications over the last decade. Geographical analysis shows the United States, China, and Germany as leading contributors. Keyword co-occurrence reveals prominent themes like AI-driven decision-making and predictive analytics, but also points to a lack of empirical studies on AI's long-term impacts. A conceptual model linking AI adoption factors to sustainability outcomes is proposed to guide future research.
Research limitations/implications: This study exclusively utilizes the Scopus database, which, despite its comprehensiveness, excludes other significant sources such as Web of Science, Google Scholar, and specialized databases focused on sustainability and technology. This limitation may result in the omission of pertinent research. Furthermore, the search strategy's reliance on the specific keywords "artificial intelligence", "sustainability", and "organization" could have inadvertently excluded relevant studies addressing AI's role in sustainability that do not explicitly use these terms.
Practical implications: The findings highlight the need for organizations to develop strategic approaches for integrating AI into sustainability initiatives, ensuring that technological advancements align with environmental, social, and economic goals.
Social implications: AI-driven sustainability initiatives have the potential to enhance social well-being by promoting ethical labor practices, improving resource distribution, and fostering inclusive economic growth. However, the uneven adoption of AI across industries and regions may deepen existing inequalities, particularly for small businesses and developing economies with limited access to advanced technologies.

Originality/value: This study provides a comprehensive bibliometric analysis of AI's role in organizational sustainable development, offering a structured overview of key research trends, influential studies, and emerging thematic areas.
Keywords: bibliometric analysis, artificial intelligence, sustainability, organization.
Category of the paper: Literature review.

1. Introduction

The increasing acknowledgment of sustainability as a fundamental element for organizational success has prompted businesses across diverse industries to adopt sustainable practices within their operations (Mariani et al., 2022). At the same time, the rapid development of artificial intelligence (AI) technologies has introduced new possibilities for advancing sustainability efforts (Al-Raeei, 2024). With its capacity to analyze large datasets, enhance decision-making processes, and foster innovation, AI presents a powerful tool for driving sustainable development. Despite the growing interest in how AI intersects with sustainability (e.g. Khakurel et al., 2018; Nishant et al., 2020, Goralski, Tan, 2020; Bracarense et al., 2022) there is still a limited understanding of its full potential in supporting organizational sustainability initiatives. Especially, research in this field has been conducted to a limited extent by Polish researchers. Among the few studies, the following can be indicated: Siuta-Tokarska, 2021; Makowski, 2023; Czemiel-Grzybowska, 2024.

The research problem addressed by the author is: What is the current state of knowledge regarding the use of AI in facilitating sustainable development in organizations? That is why, the primary objective of this paper is to perform a bibliometric analysis (BA) examining the role of AI in facilitating sustainable development in organizations. Moreover, the author aims to: (1) analyze the distribution of publications by year regarding the role of AI in organizational sustainable development; (2) identify the most cited papers in this area; (3) determine which countries have made the most significant contributions to the field through their research outputs; (4) highlight the keyword co-occurrence in publications on the use of AI in organizational sustainable development; (5) suggest potential future research directions in this domain. It is crucial to emphasize that the research tasks involved will encompass both quantitative and qualitative approaches (what is consistent with the methodology of BA).

This study offers two key contributions. First, it delivers a clear overview of the current state of knowledge regarding the utilization of AI in organizational sustainable development. While numerous publications exist on this topic, there is a noticeable gap in comprehensive analyses. In response to this, the study provides a comprehensive and current BA of 217 journal and conference papers from the Scopus database. The author anticipates that this research will be a valuable resource for a range of audiences. Researchers and academics studying AI applications, sustainability, and organizational development can benefit from the BA and

identified research gaps. Business leaders and managers looking to integrate AI into sustainability strategies can gain insights into trends and best practices. Policy makers and government officials shaping regulations on AI and sustainability may find the findings useful in developing informed policies and supporting innovation.

This study adopts the IMRAD (Introduction, Methods, Results, and Discussion) structure, ensuring a clear and organized presentation of the research findings. This format allows for a seamless progression from the formulation of research questions and objectives to a thorough explanation of the chosen methodology, the presentation of results, and their analysis in relation to the existing body of literature.

2. Methods

A literature review can be approached through different methodologies. But in recent years, BA has gained significant traction in business research (Donthu et al., 2021). This growing interest can be attributed to two key factors. Firstly, advancements in technology and improved accessibility to bibliometric tools such as VOSviewer have facilitated its application. Secondly, the increased availability of extensive research databases like Scopus has enabled scholars to explore large datasets efficiently. BA allows researchers to visualize the evolution of a research domain, assess influential publications, trace author collaborations, and uncover structural patterns within a given academic discipline (Verma, Gustafsson, 2020).

BA techniques can be broadly classified into two main categories: (1) performance evaluation and (2) scientific mapping. Performance evaluation is concerned with assessing the impact and contributions of various research elements, such as authors, institutions, and journals, within a specific field (Cobo et al., 2011). On the other hand, scientific mapping aims to explore and visualize the connections and interrelationships among different research components, offering insights into the structural patterns and intellectual landscape of a given domain (Baker et al., 2021).

BA was used across a wide range of research areas. Examples of some prominent areas where BA is commonly utilized include: computer sciences (e.g. Cancino et al., 2017; Shukla et al., 2019), social sciences (e.g. Wang, Yang, 2019; Ye et al., 2021), environmental sciences (e.g. Zhang et al., 2017; Mao et al., 2018), as well as business sciences (Albort-Morant, Ribeiro-Soriano, 2016; Tandon et al., 2021).

As an initial step, the author conducted a search in the Scopus database to determine whether any studies had employed BA to examine the utilization of AI in organizational sustainable development. To achieve this, the author utilized the following search query: (TITLE-ABS-KEY (“sustainability”) AND TITLE-ABS-KEY (“artificial intelligence”) AND TITLE-ABS-KEY (“organization”) AND TITLE (“bibliometric analysis”)).

This search yielded seven articles that met the specified criteria (Qaiser et al., 2017; Alrawashdeh et al., 2022; Kuang et al., 2023; Gorski, Dumitraşcu, 2023; Campoverde et al., 2024; Kumar et al., 2024; Solaz et al., 2025). Nevertheless, none of the analyses provided a comprehensive overview of the body of literature concerning the application of AI tools in the implementation of the sustainable development concept within organizations. While some studies may have touched upon related topics, there is a lack of a detailed BA that systematically explores the role of AI technologies in shaping sustainability strategies in organizations. This represents a significant research gap, highlighting the need for further studies in this area to better understand the impact of AI on achieving sustainable development goals in an organizational context.

Before conducting the BA, the author formulated four research questions:

RQ1. In which publications (journals/conference papers) does information on the use of AI in organizational sustainable development appear?

RQ2. Which articles on the use of AI in organizational sustainable development are most frequently cited?

RQ3. Which countries have contributed the most to the development of AI applications in organizational sustainable development through publication activities?

RQ4. What is the keyword co-occurrence in publications on the use of AI in organizational sustainable development?

The data retrieval process was conducted on March 11, 2025, with Scopus serving as the primary data source. This database was chosen to ensure both scientific credibility and thorough coverage of the research field. The selection was primarily influenced by Scopus's accessibility and its reputation as a leading repository of high-impact academic publications. Furthermore, Scopus's robust indexing system and comprehensive abstract database provided a solid foundation for conducting a rigorous bibliometric examination of the selected research area. Other researchers have also chosen Scopus for BAs, recognizing its reliability and inclusiveness (e.g. Mirek et al., 2016; Glińska, Siemieniako, 2018; Balkan Akan, 2025).

The author began the research by defining inclusion criteria, which involved identifying publications that contained the terms "sustainability", "artificial intelligence", and "organization" within their titles, abstracts, or keywords. This was executed using the search query: (TITLE-ABS-KEY ("sustainability") AND TITLE-ABS-KEY ("artificial intelligence") AND TITLE-ABS-KEY ("organization")). To ensure the relevance of the results, the author selected the "topic" category rather than the broader "text" category.

Similar to other studies employing BA (e.g. Di Vaio et al., 2021), the search for relevant articles was conducted without any specific time constraints. However, it was strictly limited to journal and conference papers. To ensure transparency and the ability to assess research methodologies, all selected publications had to be openly accessible and officially published. Additionally, the alignment between each publication's title and its actual content was a key selection criterion. To avoid potential misinterpretations, only papers written entirely in English

were considered. Consequently, the final search formula used to identify publications for analysis was structured as follows: (TITLE-ABS-KEY (“sustainability”) AND TITLE-ABS-KEY (“artificial intelligence”) AND TITLE-ABS-KEY (“organization”)) AND (LIMIT-TO (DOCTYPE , “ar”) OR LIMIT-TO (DOCTYPE , “cp”)) AND (LIMIT-TO (PUBSTAGE , “final”)) AND (LIMIT-TO (LANGUAGE , “English”)) AND (LIMIT-TO (OA , “all”)).

As a result of the exclusion process, a total of 217 journal and conference papers were identified and selected from the Scopus database. These publications served as the primary dataset for the author's analysis, providing the basis for addressing the four research questions (RQ1, RQ2, RQ3, RQ4) previously established in the study.

3. Results

3.1. Distribution of publications by year

The Figure 1. illustrates the number of journal articles and conference papers published between 2012 and 2025, focusing on the application of AI in implementing sustainable initiatives within organizations. The overall trend shows minimal research activity from 2012 to 2018, followed by a significant increase starting in 2019. The highest number of publications is recorded in 2024, with 71 journal articles and 1 conference paper. The decline in 2025 is likely due to incomplete data rather than a decrease in research interest.

Journal articles, represented by black bars, dominate the publication trend. A noticeable rise in AI-driven sustainability research begins in 2019, with a significant increase in 2020 and continued growth through 2024. Conference papers, depicted in gray bars, are published intermittently, with peaks in 2020, 2022, and 2023, though their numbers remain considerably lower than journal articles.

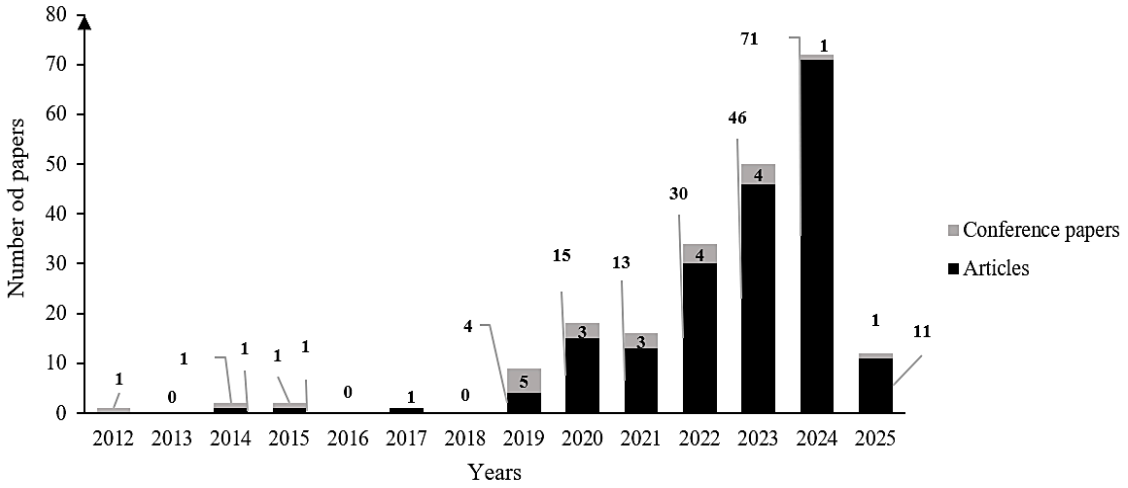

Figure 1. Distribution of conference papers and articles by year.

Source: Own elaboration based on Scopus.

The early years from 2012 to 2018 indicate limited attention to this research area, suggesting that AI-driven sustainability initiatives were not yet a major focus. A turning point occurs in 2019 and 2020, likely due to the increasing recognition of AI's potential in optimizing sustainability efforts within organizations. The period between 2022 and 2024 marks the highest research activity, indicating a strong and growing academic interest in this field. The apparent decline in 2025 may be attributed to incomplete data rather than a decrease in research output.

The surge in publications could be driven by several factors, including the growing urgency for organizations to adopt sustainable practices, advancements in AI technologies, increased funding for sustainability research, and the expansion of open-access publication platforms. The preference for journal articles over conference papers suggests that researchers in this field prioritize peer-reviewed, in-depth studies for disseminating their findings.

3.2. Most frequently cited publications

The most frequently cited papers are given in Table 1. Overall, the most cited paper (328 citations) was a study by Feroz et al. entitled "Digital transformation and environmental sustainability: A review and research agenda" (2021). That paper was printed in the Sustainability (Switzerland). This study examined the impact of digital transformation on environmental sustainability by conducting a systematic review of the existing literature. The findings introduced a comprehensive framework that categorized the transformative effects into four main domains: pollution control, waste management, sustainable production, and urban sustainability. Each of these domains was further broken down into specific subcategories, providing a detailed analysis of the changes that occurred within them.

Table 1.
Most frequently cited publications

Citation count	Publication year	Authors	"Document title"	"Source" (volume, pages)
328	2021	Feroz et al.	"Digital transformation and environmental sustainability: A review and research agenda"	"Sustainability (Switzerland)" (13(3), 1-120)
267	2020	Kamble et al.	"A performance measurement system for industry 4.0 enabled smart manufacturing system in SMMEs - A review and empirical investigation"	"International Journal of Production Economics" (229, 107853)
252	2020	Bednar, Welch	"Socio-Technical Perspectives on Smart Working: Creating Meaningful and Sustainable Systems"	"Information Systems Frontiers" (22(2), 281-298)
202	2021	Wang, Huang	"The impact of COVID-19 pandemic on sustainable development goals - A survey"	"Environmental Research" (202, 111637)
163	2020	Strohm et al.	"Implementation of artificial intelligence (AI) applications in radiology: hindering and facilitating factors"	"European Radiology" (30(10), 5525-5532)

Cont. table 1.

163	2019	Allaoui et al.	"Decision support for collaboration planning in sustainable supply chains"	"Journal of Cleaner Production" (229, 761-774)
128	2022	Dora et al.	"Critical success factors influencing artificial intelligence adoption in food supply chains"	"International Journal of Production Research" (60(14), 4621-4640)
118	2022	Hughes et al.	"Perspectives on the future of manufacturing within the Industry 4.0 era"	"Production Planning and Control" (33(2-3), 138-158)
115	2020	Alami et al.	"Artificial intelligence in health care: Laying the Foundation for Responsible, sustainable, and inclusive innovation in low - and middle-income countries"	"Globalization and Health" (16(1), 52)
114	2014	Shin et al.	"Predictive analytics model for power consumption in manufacturing"	"Procedia CIRP" (15, 153-158)
113	2021	Ogbeibu et al.	"Leveraging STARA competencies and green creativity to boost green organisational innovative evidence: A praxis for sustainable development"	"Business Strategy and the Environment" (30(5), 2421-2440)
111	2023	Song, Song	"Enhancing academic writing skills and motivation: assessing the efficacy of ChatGPT in AI-assisted language learning for EFL students"	"Frontiers in Psychology" (14, 1260843)

Note. The table includes publications with a total citation count of 100 or more.

Source: Own elaboration based on Scopus.

Another highly cited publication is the work of Kamble et al. (2020). This study examined the adoption of Smart Manufacturing Systems (SMS) in Small, Medium, and Micro Enterprises (SMMEs) within India's auto-component manufacturing sector. While SMS provided significant advantages over traditional manufacturing systems by integrating technologies such as automation, cyber-physical systems, AI, and the Internet of Things, their implementation was complex and costly. Given the resource constraints of SMMEs, businesses sought tangible benefits before committing to SMS investments.

Using a combination of exploratory and empirical research, the study identified and validated key performance measures for evaluating SMS investments. The findings revealed that Industry 4.0-enabled SMS offered superior competitiveness compared to traditional systems. Investment evaluation was structured around ten performance dimensions: cost, quality, flexibility, time, integration, optimized productivity, real-time diagnosis and prognosis, computing, social sustainability, and ecological sustainability.

The paper ranked as the third most frequently cited is authored by Bednar & Welch and titled "Socio-Technical Perspectives on Smart Working: Creating Meaningful and Sustainable Systems". It was published in 2020 in Information Systems Frontiers. This paper examined the impact of technological advancements on industrial and commercial applications, particularly in AI, virtual reality, and integrated manufacturing systems. These developments enabled remote business operations through information and communication technologies, leading researchers to identify a phenomenon known as "smart" working.

Focusing on unique perspectives of work roles and sustainability, the paper raised critical questions: Who defined "smart" systems? Did they contribute to sustainable organizations? How should their design be approached? The study argued that contemporary socio-technical systems approaches provided the most effective framework for analyzing and integrating smart technologies within organizations to maximize their benefits.

The absence of extensively cited publications focusing on the role of AI in organizational sustainable development suggests that this research area remains underexplored and lacks a strong foundational framework. This gap indicates that while AI has gained significant traction in various fields, including automation, decision-making, and process optimization, its direct application in sustainability-related organizational transformations has not yet been comprehensively analyzed or widely acknowledged within academic discourse.

A closer examination of the existing body of work reveals that most of the highly cited studies emphasize empirical findings, often detailing specific AI applications within organizations without addressing the broader implications for long-term sustainability. These works primarily focus on AI's role in enhancing efficiency, reducing costs, or improving workflow automation. While these aspects indirectly contribute to sustainability, they do not explicitly frame AI as a transformative force for achieving sustainable organizational development.

Furthermore, only a limited number of publications engage in a critical discussion regarding the potential benefits and risks associated with AI-driven sustainability initiatives. The lack of theoretical discourse and conceptual models leaves several fundamental questions unanswered. For instance, how can AI-driven solutions be effectively aligned with sustainability goals? What ethical and operational challenges arise when implementing AI in sustainability strategies? How can organizations ensure that AI applications do not inadvertently lead to negative environmental or social consequences, such as increased energy consumption or biased decision-making?

3.3. Contributing countries

The Figure 2. illustrates the global distribution of authors contributing to research on the use of AI to support sustainable initiatives within organizations. Countries are shaded in varying intensities of gray, with darker shades representing a higher number of contributing authors.

The United States (the leading research centers are: Brigham Young University, Pennsylvania State University), China (the leading research centers are: Central South University, Hohai University), and India (the leading research centers are: JIS College of Engineering, O.P. Jindal Global University) appear to have the highest number of authors, as indicated by their dark shading, with the maximum recorded being 41. These countries are recognized as major hubs for AI and sustainability research, reflecting their strong technological advancements and industrial focus.

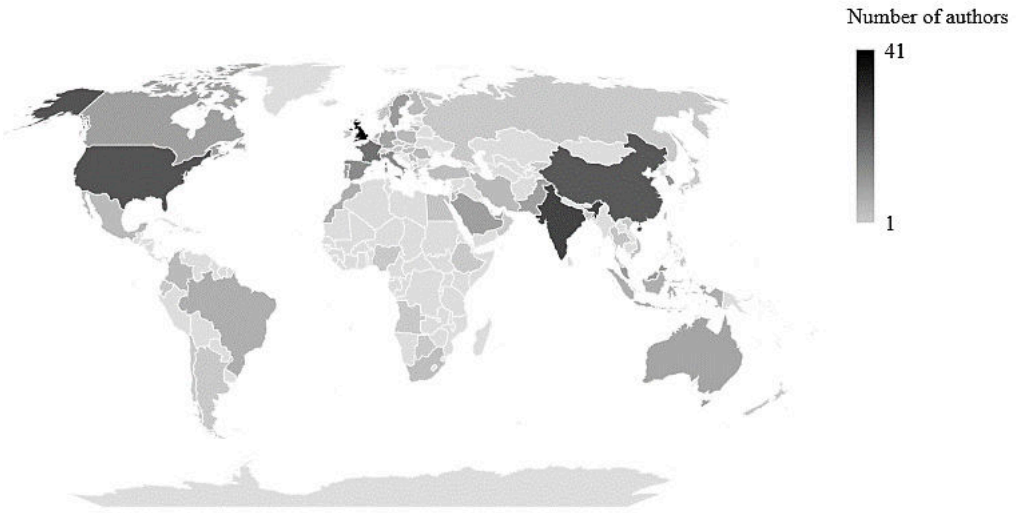

Figure 2. Publishing activity by country.

Source: Own elaboration based on Scopus.

European countries, such as the United Kingdom and Germany, also demonstrate significant contributions, though to a lesser extent than the leading nations. Latin America, Africa, and some parts of Southeast Asia show lighter shades, suggesting a lower number of authors contributing to this research field. Australia also appears to have a moderate number of contributions.

The overall distribution suggests that AI-driven sustainability research is primarily concentrated in technologically advanced and industrialized nations, while developing regions have a comparatively lower presence in this domain.

3.4. Keyword co-occurrence

Analysis of keyword co-occurrence using the full counting method with minimum number of 8 occurrences of a keyword at the level of 3 identified 6 clusters (Figure 3).

A significant theme within the network is decision-making and strategy, represented by a blue cluster. Keywords such as “decision”, “strategy”, “quality”, “manufacturing”, and “machine learning” indicate a focus on how AI is leveraged to enhance decision-making processes in industrial and corporate environments. This cluster signifies an intersection between technology and human-centered decision-making, where AI tools contribute to optimizing complex processes.

Another dominant cluster, shown in red, revolves around relationships, tools, and economic applications. Words such as “relationship”, “tool”, “insight”, “agriculture”, and “economy” suggest that AI is increasingly being integrated into agricultural and economic processes. The connection between “researcher” and “literature” implies that this cluster is heavily influenced by academic research investigating AI’s role in industry-specific challenges.

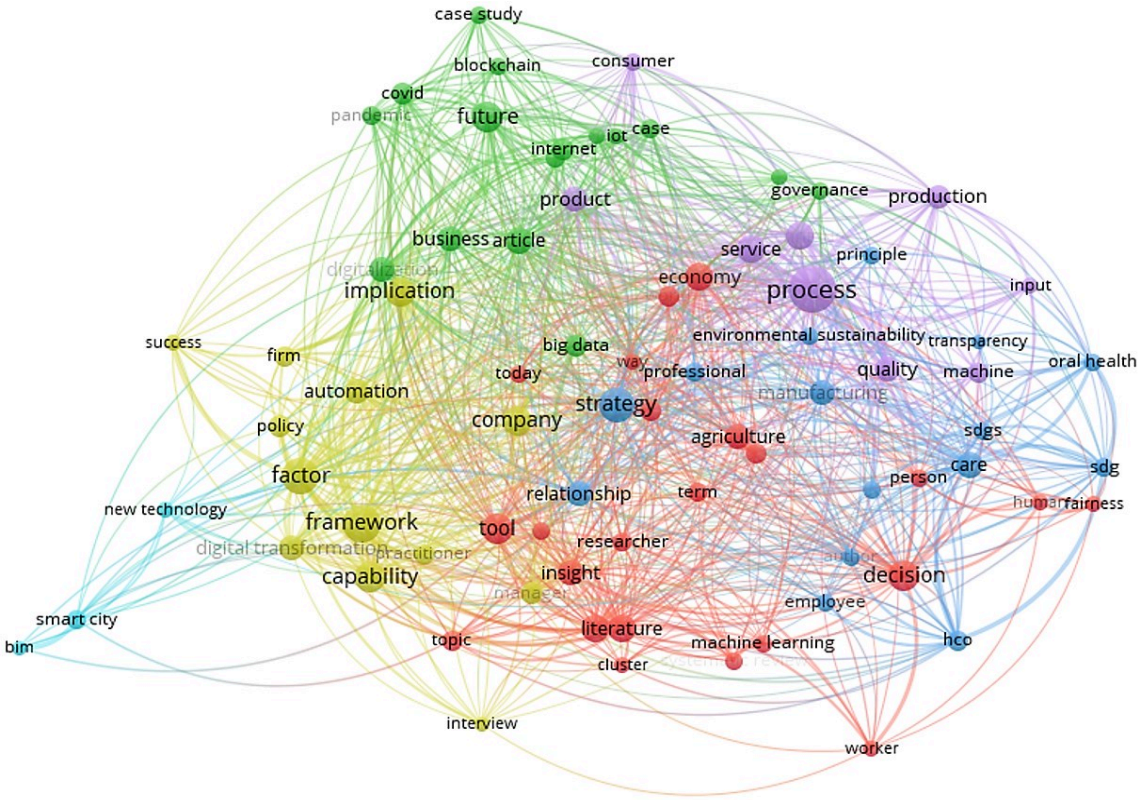

Figure 3. Keyword co-occurrence.

Source: Own elaboration based on Scopus.

The green cluster highlights the implications of AI in digital transformation and business applications. Terms like "future", "implication", "consumer", "blockchain", and "internet" reflect an emphasis on emerging AI-driven trends that influence both corporate strategies and consumer behavior. Blockchain, as a keyword, suggests ongoing discussions about how AI can be integrated with decentralized systems to improve transparency and efficiency. The presence of "pandemic" in this cluster hints at research exploring how AI has been utilized to manage crises and adapt business operations to disruptions.

Automation and organizational capabilities emerge as another focal point within the network, represented by a yellow cluster. The terms "framework", "capability", "automation", "factor", and "policy" indicate a research direction focused on AI-driven organizational transformations. The interconnection with "firm" and "success" suggests that AI's impact on business performance is a critical area of investigation. Discussions in this cluster likely explore how organizations can adopt AI frameworks, the policies needed for smooth integration, and the factors influencing AI adoption in corporate settings.

Governance, production, and sustainability form the foundation of the purple cluster, which includes keywords such as "process", "governance", "production", "service", and "environmental sustainability". This cluster suggests a research focus on the regulatory and ethical aspects of AI, particularly in the context of sustainable production. The emphasis on

"principle" and "transparency" implies an ongoing discussion about AI's role in ethical governance and responsible innovation.

Lastly, the light blue cluster centers on smart technologies and urban applications. Words like "smart city", "new technology", "BIM", and "digital transformation" indicate research on AI's role in reshaping urban environments and technological advancements. The inclusion of "BIM" (Building Information Modeling) suggests that AI is being utilized in smart infrastructure planning, sustainable construction, and urban management. This cluster underscores the transformative impact of AI on city planning and public services.

The keyword co-occurrence network reveals that while AI is widely studied in various domains, only a small portion of publications explicitly focus on its role in supporting organizational sustainable development. The dominant clusters center around decision-making, automation, digital transformation, and industrial applications, with significant emphasis on efficiency, productivity, and technological integration. While sustainability-related terms such as "environmental sustainability" and "SDG" appear in the network, they are not the central focus of the most densely connected clusters. Instead, they are linked more peripherally, suggesting that AI's contribution to sustainable organizational practices is still an emerging or secondary research area. This highlights a gap in the literature, indicating the need for further exploration of AI-driven strategies specifically aimed at enhancing long-term sustainability within organizations.

4. Discussion

4.1. Contributions

This study bridged a critical gap across several key areas. By conducting a BA, multiple research objectives were achieved: first, it mapped the yearly distribution of scholarly articles and conference proceedings addressing the role of AI in fostering organizational sustainable development. Second, it identified the most frequently cited works in this domain. Third, it determined the countries that have made the most substantial research contributions to AI-driven sustainability initiatives within organizations. Fourth, it examined the primary subject areas most frequently associated with AI's application in sustainability efforts.

Additionally, this paper serves as a methodological reference for conducting BA. It presents a structured, step-by-step approach, beginning with the formulation of research objectives and the development of a systematic review plan, followed by an exhaustive literature search based on predefined selection criteria.

4.2. Limitations

A primary constraint lies in the exclusive reliance on the Scopus database, which, while comprehensive, excludes other valuable sources such as the Web of Science (Institute for Scientific Information), Google Scholar, and specialized databases focused on sustainability and technology.

Another limitation stems from the specific search terms used, namely "artificial intelligence", "sustainability", and "organization". These terms directly influenced the selection of publications, meaning that studies discussing AI's efficiency, economic impact, or indirect contributions to sustainability may have been excluded if they did not explicitly include these keywords in their titles, abstracts, or keywords. Consequently, this review overlooked publications that explored AI applications in sustainable business practices, such as its role in optimizing resource efficiency and supporting environmentally responsible strategies (e.g. Vinuesa et al., 2020; Ramos et al., 2024). While these studies could provide valuable insights, they did not meet the methodological inclusion criteria set for this analysis.

4.3. Research gaps and future research directions

Based on the identified limitations and the assessment of selected articles, the author was able to identify several research gaps. One significant gap is the absence of comprehensive frameworks that integrate AI applications across all dimensions of sustainability, including environmental, social, and economic aspects (Research gap 1). Existing studies tend to focus on specific AI applications, such as energy efficiency or waste management, rather than presenting a holistic perspective on how AI can drive sustainability across various organizational functions (Research gap 2). Additionally, while many studies explore the theoretical potential of AI in sustainable business practices, there is a lack of empirical evidence demonstrating AI's long-term impact (Research gap 3). Short-term case studies provide valuable insights, but they fail to capture the broader consequences, challenges, and unintended effects of AI-driven sustainability initiatives over extended periods. Finally, small and medium-sized enterprises (SMEs) encounter significant challenges in adopting artificial intelligence for sustainability efforts. In contrast to large corporations, which possess substantial financial resources and advanced technological capabilities to seamlessly integrate AI into their sustainability frameworks, SMEs frequently grapple with financial constraints, a shortage of specialized expertise, and insufficient infrastructure to support AI implementation. The high costs associated with acquiring and maintaining AI-driven technologies further exacerbate these difficulties, making it challenging for smaller organizations to leverage AI effectively. SMEs often lack the internal knowledge and skilled workforce necessary to manage AI applications, leading to further disparities in technological adoption between large and small enterprises. Given these obstacles, there is a pressing need for further research aimed at designing AI solutions that are not only scalable but also financially and technically accessible to SMEs (Research gap 4). By developing AI-driven sustainability models tailored to the unique

needs and constraints of smaller organizations, researchers can help bridge the gap and ensure that AI-driven sustainability practices are not exclusively confined to large corporations but are also accessible to SMEs, thereby fostering broader, more inclusive progress in sustainable development.

To address these gaps, a research model can be proposed that examines the relationship between AI adoption and sustainable organizational outcomes (Figure 4). It was prepared based on previous studies such as: Kurup, Gupta, 2022; Parasad Agrawal, 2023; Li, Jin, 2024; Chen et al., 2024. The left side of the model (Figure 4) identifies key enablers of AI adoption, which include: (1) change capability, (2) leadership, (4) AI readiness, and (5) AI adoption by trading partners.

Change capability reflects an organization's ability to adapt to technological transformations, while leadership signifies the role of decision-makers in facilitating AI-driven innovations. AI readiness encompasses the preparedness of an entity in terms of infrastructure, human resources, and technical capabilities, whereas AI adoption by trading partners indicates the influence of external business networks in encouraging AI integration.

The right side of the model represents the broader sustainability outcomes associated with AI adoption, which are categorized into economic, social, and environmental sustainability. Economic sustainability denotes the potential for AI to enhance productivity, efficiency, and long-term financial viability. Social sustainability encompasses the societal implications of AI, including workforce transformation, equity, and ethical considerations. Environmental sustainability addresses the role of AI in optimizing resource use, reducing waste, and mitigating negative ecological impacts. The model suggests a causal relationship where AI adoption is contingent upon a set of organizational and external factors, ultimately shaping sustainability outcomes across multiple dimensions.

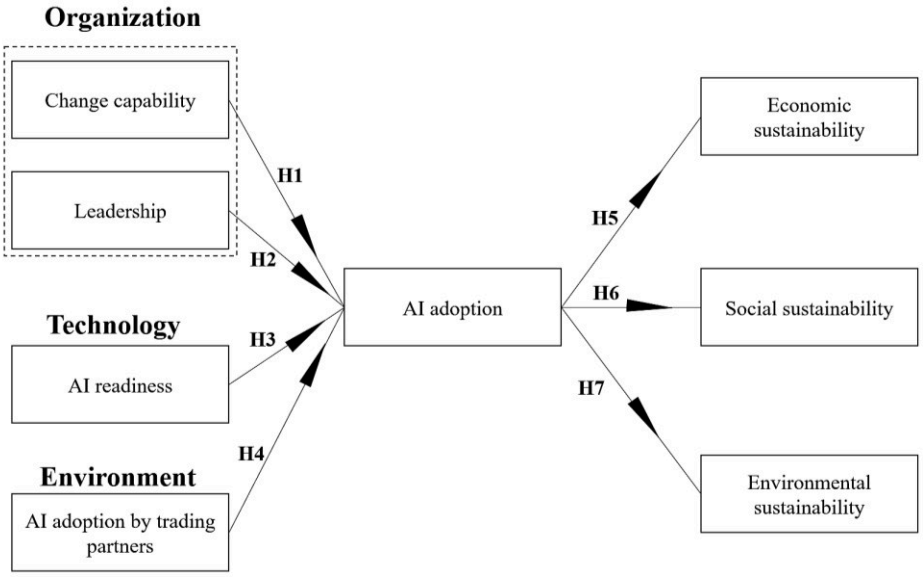

Figure 4. Research model.

Source: Own elaboration.

As a result, the author proposes that future research should explore and empirically validate the following hypotheses:

H1: Change capability has a positive influence on AI adoption.

H2: Leadership has a positive influence on AI adoption.

H3: AI readiness has a positive influence on AI adoption.

H4: AI adoption by trading partners has a positive influence on AI adoption.

H5: AI adoption has a positive influence on economic sustainability.

H6: AI adoption has a positive influence on social sustainability.

H7: AI adoption has a positive influence on environmental sustainability.

These hypotheses suggest that organizational, technological, and environmental factors drive AI adoption, which in turn contributes to various dimensions of sustainability.

5. Conclusions

This study provides a comprehensive BA of the utilization of AI in organizational sustainable development. By examining the distribution of scholarly publications, identifying the most frequently cited works, and analyzing contributions from different countries, the research offers a structured overview of existing knowledge in this field. Additionally, the study highlights key thematic areas associated with AI-driven sustainability initiatives, contributing to a clearer understanding of how AI supports environmental, social, and economic sustainability efforts within organizations.

A key contribution of this research lies in its methodological approach, which establishes a structured and reproducible framework for conducting bibliometric analyses in related fields. Through a systematic examination of existing literature, the study not only highlights prevailing research trends but also uncovers critical gaps in knowledge. One of the most urgent gaps is the lack of comprehensive frameworks that encompass AI applications across various aspects of sustainability. Additionally, although numerous studies discuss the theoretical possibilities of AI, there remains a significant shortage of empirical investigations that assess its sustained impact on organizational sustainable development over time. That is why, the author suggests validating the conceptual model outlined in this paper. This approach will enable them to address questions such as: (1) Does change capability positively influence AI adoption?; (2) Does leadership have a positive impact on AI adoption?; (3) Does AI readiness contribute positively to AI adoption?; (4) Does AI adoption by trading partners positively affect AI adoption?; (5) Does AI adoption enhance economic sustainability?; (6) Does AI adoption positively influence social sustainability?; (7) Does AI adoption contribute to environmental sustainability?

In response to the need for more actionable guidance, it is recommended that future research emphasizes the development of interdisciplinary teams integrating expertise from AI, sustainability science, organizational studies, and strategic management. Additionally, incorporating sustainability-specific key performance indicators (KPIs) into AI implementation strategies is essential for both assessing the effectiveness of AI initiatives and ensuring their alignment with long-term sustainability goals. These directions aim to bridge the gap between theoretical insights and practical applications, thereby enhancing the strategic integration of AI within sustainable development efforts.

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APPLICATION OF THE SYNTHETIC MEASURE OF TMR IN ASSESSING THE FINANCIAL HEALTH OF INDUSTRIES IN POLAND

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Purpose: The purpose of the study was to classify sectors of the Polish economy based on their financial condition, focusing on key indicators such as profitability, liquidity, debt, and operational efficiency. The aim was to identify sectors with stable performance and those facing financial challenges.
Design/methodology/approach: The analysis used financial ratio data from 2019 and 2022 for various sectors, applying the TMR (synthetic measure of development) method to evaluate and rank industries. Data were derived from the sectoral financial indicators compiled by the Commission of Economic Reporting and Analysis of the Scientific Council of the Accountants Association in Poland and InfoCredit.
Findings: The study revealed differences in financial performance across sectors. Certain industries demonstrated strong financial standing, while others showed weaknesses in key areas. The rankings helped highlight patterns of efficiency and risk.
Research limitations/implications: Limitations include the availability and quality of sector-level data and the use of a synthetic index that may overlook specific financial nuances. Future studies should integrate more macroeconomic variables and consider alternative comparative methods for deeper insight.
Practical implications: The findings can guide investors, entrepreneurs, and policymakers in identifying stable and at-risk sectors. Banks and financial institutions may use the results for credit assessments, while researchers may benefit from the classification in further sector-based analyses.
Social implications: Identifying financially vulnerable sectors may support targeted policy interventions, job market planning, and allocation of public support where needed most.
Originality/value: Unlike typical studies focusing on single indicators, this research offers a synthetic sectoral classification based on multiple financial metrics, providing a more comprehensive perspective.
Keywords: financial analysis, sectoral efficiency, sectoral competitiveness, TMR.
Category of the paper: Research paper.

1. Introduction

In a rapidly evolving economic environment, assessing the financial health of companies and entire sectors has become a crucial component of strategic decision-making. Financial indicators provide valuable insights into the stability, profitability, and value-generating capacity of entities. However, their interpretation can be complex, particularly when analyzing multiple entities simultaneously. Consequently, there is growing interest in methods that aggregate data and offer a synthetic overview of sectoral financial conditions.

The importance of developing robust tools for sector-level financial assessment has been highlighted in numerous international studies. Researchers emphasize that multidimensional frameworks are essential for identifying structural weaknesses, managing financial risk, and supporting long-term investment strategies (Zhao et al., 2022; Albulescu, 2020). Moreover, sector-specific diagnostics help public authorities design targeted policies, especially during periods of economic disruption (Hyršlová et al., 2019; Ahmad, Malik, 2009). According to Tarawneh et al. (2024), integrating aggregated financial data into sectoral analysis increases transparency and comparability—critical for both private investors and regulators.

One promising approach is the synthetic TMR measure, which enables a multidimensional assessment of financial indicators and a comparative evaluation of industries. This method facilitates the creation of rankings that identify the strongest and weakest sectors in terms of financial condition. It supports decision-making not only at the enterprise level but also within institutions responsible for economic policy.

The use of a synthetic indicator like TMR stems from the need to increase transparency and reduce subjectivity in financial analysis. Traditional assessments based on individual indicators may lead to conflicting conclusions, especially when different metrics signal divergent trends. TMR addresses this challenge by providing a comprehensive and unified perspective on sectoral financial performance, allowing investors, analysts, and policymakers to make better-informed decisions regarding investments, restructuring, or policy direction.

In addition to identifying overall sectoral health, the synthetic TMR metric highlights key drivers of financial performance, such as resilience to macroeconomic shifts, capital accumulation capacity, and operational efficiency. This allows the identification of sectors characterized by financial robustness, as well as those that may be vulnerable to market risks.

The analysis in this study is based on average values of key financial indicators for each sector, covering profitability, liquidity, indebtedness, and management efficiency. This enabled an objective and comprehensive comparison of financial conditions across industries.

The purpose of this article is to apply the synthetic TMR measure to assess sectors operating in the Polish economy based on financial indicators. The analysis aims not only to evaluate the current financial health of these sectors but also to identify the factors influencing their stability and to highlight potential risks and development opportunities in a dynamically changing

environment. The findings may serve as a valuable tool for forecasting economic trends and developing adaptive strategies for market participants.

2. Literature review

2.1. Review of domestic literature

In the literature, one can find a number of publications that use financial analysis tools in their research. Many of these publications use classical ratio analysis for comparative purposes. However, these comparisons are most often used to analyze the financial situation of a specific company in relation to the industry in which it operates. Here we can mention, for example, the research of A. Kopinski, who, using measures of profitability, evaluated and classified selected banks in Poland (Kopinski, 2016). M. Wilczynska conducted a study in which she used classical ratio analysis to assess the financial situation of the company under study, which was a limited liability company (Wilczynska, 2018). P. Bórawski assessed the financial liquidity ratios of individual farms. The research sample consisted of farms from the FADN region of Mazovia and Podlasie (Bórawski, 2008). K. Drabik et al. conducted an enterprise assessment using profitability indicators. The study was conducted on financial data from the Dino S.A. enterprise (Drabik et al., 2023). Enterprises in the construction, transportation and medical treatment industries were studied by E. Rabiej et al. The authors assessed the financial situation of enterprises in these three sectors using, among other things, ratio analysis (Rabiej, Lichota, Pitera, 2024). E.M. Kraska used indicator analysis to assess the impact of the COVID-19 pandemic on the financial situation of Polish enterprises (Kraska, 2022). K. Wiatrzyk, using ratio analysis, conducted a comprehensive assessment of the financial condition of Poland's largest fuel company, PKN ORLEN. In his research, in addition to the assessment itself, the author also made a number of comparisons of individual metrics and their dependencies (Wiatrzyk, 2018). Other studies worth mentioning include the analyses of the financial condition of a food company by M. Sankowska with Z. Koloszko-Chomentowska (Sankowska, Koloszko-Chomentowska, 2022), the evaluation of chemical and fuel industry enterprises by A. Majek and K. Osiesa (Majek, Ociesa, 2022), and the classical ratio-based analysis by M. Lesiak (Lesiak, 2022).

Another fairly common procedure in the literature is an attempt to evaluate a particular industry through the prism of the results that this type of business achieves. An example of such research is a study by M. Ganc and M. Wasilewski, who assessed the financial condition of dairy cooperatives (Ganc, Wasilewski, 2018). A. Zalewska and M. Sokol conducted a comprehensive analysis of construction industry enterprises using financial indicators across four dimensions: liquidity, profitability, debt and efficiency (Zalewska, Sokol, 2022). P. Figura

analyzed the values of indicators not for a specific industry, but in terms of enterprise size. The research sample consisted of companies classified as SMEs (Figura, 2015). M. Majewska and W. Pacuła conducted an assessment of the banking sector using profitability indicators (Majewska, Pacuła, 2016). Z. Golas made a multidimensional assessment of the food production sector, comparing enterprises from Poland and Germany across different size classes based on ECB data (Golas, 2016).

Studies to date have primarily focused on analyzing the financial condition of individual companies or sectors. However, there is a lack of comprehensive studies that simultaneously compare multiple sectors to classify them based on financial indicators. This research gap also includes the use of synthetic approaches, such as the TMR (Taxonomic Measure of Development), which facilitate the aggregation and comparison of multidimensional financial data.

The literature on sectoral financial analysis in Poland includes numerous studies that provide valuable context for understanding the diversity of economic performance across industries and support the use of synthetic measures such as the TMR index. Agnieszka Grzybowska (n.d.) emphasizes the role of human capital in driving sectoral development and competitiveness, highlighting non-financial determinants such as education and innovation capacity. Jegorow (2014) presents a long-term, non-structural analysis of economic entities by ownership sectors, providing useful insights for public sector assessment. Jędrzejczyk (2010) analyzes the financial condition of the tourism sector, pointing to macroeconomic and sector-specific factors that shape its performance.

Reports from the Polish Chamber of Commerce (2025) offer current financial overviews of various industries, complementing statistical sectoral assessments. Kosińska (n.d.) focuses on the cultural sector's financial structure and funding sources, while Zysińska (2019) addresses methodological issues in evaluating TSL companies, stressing the value of synthetic approaches. Owczarczyk (2010) examines the economic importance of SMEs, whose diversity must be reflected in cross-sector analyses.

The report by the Polish Economic Institute (2020) identifies strategic sectors in the EU and their role in long-term growth, which aligns with efforts to assess sectoral competitiveness. Additional insight is provided by the University of Gdańsk (2014), which analyzes the transport sector's financial constraints and regulatory risks. Famielec and Kożuch (2018) explore restructuring processes and financial strategies aimed at improving sectoral resilience. Szczukocka (2013) offers a comprehensive statistical overview of the services sector, which supports its inclusion in sectoral comparison studies. Finally, Florczak et al. (2018) provide a macroeconomic perspective on sectoral performance using econometric models.

2.2. Review of foreign literature

Foreign literature on the financial analysis of economic sectors, including both the sectoral approach and the analysis of enterprises within them, provides valuable conclusions contained in numerous key scientific publications. Among many such studies, it is worth mentioning the most important ones.

Sectoral analysis in the context of finance, performance, and capital structure plays a significant role in both domestic and international research. In recent years, studies have increasingly focused on the detailed examination of the financial sector's impact on the economy, corporate productivity, capital structure, and financial efficiency.

Tarawneh et al. (2024) conducted a systematic literature review on financial technology (fintech) and the profitability of the banking sector. The authors emphasized the growing importance of fintech as a driver of efficiency and profitability in financial institutions, highlighting its transformative role in the financial sector.

The importance of the financial sector for economic growth was also discussed by Bakar and Sulong (2018), who demonstrated a strong link between financial institution development and GDP growth. Similar conclusions were drawn by Ahmad and Malik (2009), who confirmed the positive impact of financial development on the economies of developing countries, although they noted that this effect depends on the quality of institutional environments.

Industry-specific analyses, such as the study by Hyršlová et al. (2019), demonstrated the use of financial analysis methods in the transportation and storage sector. The authors showed that traditional financial ratios may be insufficient for evaluating the condition of sectors under dynamic changes, suggesting the need for the use of multidimensional methods.

From the perspective of financial risk analysis, Zhao et al. (2022) presented a comprehensive overview of tools and methods for risk assessment using big data. This study emphasizes the growing relevance of modern analytical methods and artificial intelligence in assessing companies' financial conditions.

Albulescu (2020) examined the relationship between investment strategies and financial performance in the wine industry. He indicated that the impact of investment on performance depends on firm structure, size, and the surrounding market environment.

Capital structure has been the subject of numerous empirical studies. Szemán (2017) investigated the applicability of classic capital structure theories in the service sector, revealing differences in their relevance depending on the type of activity. Weill (2008), on the other hand, explored how the institutional environment influences the relationship between leverage and financial performance, showing that country-specific institutional conditions significantly affect the effectiveness of financial models.

Ziegler et al. (2010) proposed tools for the visual analysis of financial time series data, enabling better understanding of trends within specific sectors and facilitating inter-industry comparisons.

In the public sector, Kara (2012) discussed differences in financial analysis methods across the EU, Greece, and Turkey. He noted that variations in public sector accounting systems significantly hinder international comparability.

Joshi et al. (2013) examined the impact of intellectual capital (such as employee knowledge and customer relationships) on the financial performance of Australian financial institutions. They found a positive relationship between intangible resources and profitability.

Regarding strategic decisions in the banking sector, Sermpinis, Tsoukas, and Zhang (2019) analyzed factors influencing a bank's decision to go public. The study showed that such decisions are primarily driven by the bank's size, credit risk, and macroeconomic conditions.

Shalini and Biswas (2019) identified the determinants of capital structure for firms listed in the S&P BSE 500 index. Their research revealed that firm size, profitability, and growth opportunities are key factors shaping corporate financial strategies.

Chatzoudes, Chatzoglou, and Diamantidis (2022) studied the impact of internal and external factors on firm survival during economic crises. They emphasized that success depends on the interplay between internal competencies and external market or regulatory conditions.

Kanto and Martikainen (1992) provided a classic perspective on financial profiling of firms, demonstrating that selected financial indicators can predict a company's future performance using operational research methods.

In conclusion, the reviewed literature highlights the growing complexity of financial and sectoral analysis, which increasingly integrates traditional financial ratios with advanced tools such as big data analytics, visualization techniques, and non-financial indicators (e.g., intellectual capital). Moreover, it underlines the importance of contextual factors—such as institutional frameworks, market dynamics, and crisis resilience—which influence the effectiveness of financial strategies. This suggests a growing need for composite measures that synthesize multiple dimensions of financial condition, making synthetic indicators such as the TMR (Total Measure of Risk or Performance) particularly relevant in contemporary sector-level financial assessments.

These contributions collectively underscore the complexity of assessing sectoral financial condition and validate the use of synthetic measures, such as the TMR index, which allow for a multi-dimensional, comparative view of sectoral dynamics in a changing economic environment.

Future research in this area could include dynamic analysis of the financial health of industries over a longer time horizon, which would allow identification of trends and changes in the stability of economic sectors. In addition, it is worth considering the integration of indicator analysis methods with other approaches, such as predictive models based on artificial intelligence or analysis of macroeconomic factors affecting the financial health of various industries. In this way, it will be possible to understand even more fully the mechanisms shaping the economic situation of companies in different sectors of the economy.

Accordingly, the article attempts to classify the sectors of the Polish economy. The results of the study will fill the research gap in this aspect.

3. Research Methodology and Description of the Research Sample

The article uses data of financial indicators relating to the average values achieved by companies operating in Poland, broken down by economic sectors (divisions). The estimated values were taken from the Study of the Committee for Economic Reporting and Analysis of the Scientific Council of the Accountants Association in Poland, developed in cooperation with InfoCredit. The analysis covers two periods: 2019 (before the COVID-19 pandemic) and 2022 (the most current data available after the pandemic). Adopting this approach was intended to identify changes in the financial health of specific industries as a result of the economic turmoil caused by the pandemic.

The study established two research hypotheses:

- H1. There are significant differences in the financial health of individual sectors in Poland, as reflected in the value of the synthetic measure of TMR calculated on the basis of financial indicators.
- H2. Sectors with higher profitability and better liquidity obtain higher values of the synthetic measure of TMR, which indicates their more stable financial condition compared to sectors with higher debt levels and lower efficiency.

In order to verify the hypotheses, a synthetic measure of TMR was used, which allows a comprehensive assessment of the financial condition of the analyzed industries. The indicators included in the analysis covered all the key aspects of assessing the financial condition of enterprises, i.e. profitability, liquidity, debt and management efficiency. Thanks to the application of the TMR method, it was possible not only to compare the financial condition of various sectors, but also to assess the changes that occurred in the industry structure of the Polish economy during the analyzed period.

Considering the large number of available indicators, thanks to which it is possible to assess the financial condition of a company from various industries, the use of the TMR method is justified, as it allows the creation of a synthetic indicator, which will allow for a more comprehensive observation of this reality. The creation of a taxonomic measure of development (TMR) will allow the construction of a ranking of individual sectors, which will indicate which sectors present the best financial condition and whether significant changes have occurred in this respect. It is also important to indicate which of the indicators influence the improvement of the financial condition and can be assigned to stimulants, so with their increase the condition improves, and which ones destimulate the financial condition, which means that with their increase the condition decreases. Then, during the standardization process, the collected data

were transformed. This allowed determining how much a given indicator deviates from the average (Zeliaś, 2000):

$$zij = \frac{x_{ij} - \bar{x}j}{Sj}$$

where:
i – numbering of objects;
j = 1, 2, …, m;
m – numbering of adopted indicators.

The standardization performed allows obtaining a matrix of standardized values. On this basis, a taxonomic pattern was established (Zeliaś, 2000).

$$z_0 = [z_{01}, z_{02}, \dots, z_{0m}],$$

assuming:

$$z_{0j} = \begin{cases} \max\limits_i \{z_{ij}\} \text{ for stimulants}, \\ \min\limits_i \{z_{ij}\} \text{ for deterrents} \end{cases} \quad \mathbf{j = 1, 2, \dots, m}$$

where:
i – numbering of objects,
m – numbering of adopted indicators.

Next, the similarity of objects to the abstract best object was examined by calculating the distance of each object from the developmental pattern (Hellwig, 1968):

$$d_{i0} = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_{0j})^2};$$

where: d_{i0}- value of the taxonomic development measure for the i-th object.

The obtained taxonomic measures of the development of the studied objects were normalized in the [0,1] interval using the transformation (Hellwig, 1968):

$$TMR_i = 1 - \frac{d_{i0}}{d_0},$$

accepting:

$$d_0 = \bar{d}_0 + 2S_0$$

$$\bar{d}_0 = n^{-1} \sum_{i=1}^{n} d_{i0}$$

$$S_0 = \sqrt{n^{-1} \sum_{i=1}^{n} (d_{i0} - \bar{d}_0)^2};$$

where:
$\bar{d}_0$ – mean value of non-standardized taxonomic measures of development,
S_0 – standard deviation of unstandardized taxonomic measures of development.

The method was developed by Zdzisław Hellwig and is based on a constructed abstract object called a pattern (Szylar, Cegielska, Kudas, 2017). Creating a Taxonomic Pattern of Development is based on several key principles. At the beginning, partial indicators should be selected, which should (Nowak, 1990):

- represent the studied phenomenon as precisely as possible,
- have a relatively small amount of data,
- require the elimination of similar features or those providing similar information.

To assess the sectors of the Polish economy, the TMR indicator (pol. Taksonomiczna Miara Rozwoju) was selected, as it represents an advanced and comprehensive measure of resource utilization efficiency in the economy. Among the advantages of the TMR indicator, the following should be highlighted:

1. Possibility of cross-sectoral and international comparisons.

Thanks to its uniform methodology, TMR allows for the comparison of the efficiency of different sectors within a single economy, as well as in relation to the economies of other countries. This makes it a useful analytical tool in economic policy.

2. Avoiding erroneous conclusions.

Simple productivity indicators may suggest improved efficiency in a sector when, in reality, it results solely from increased inputs (e.g., more employees). TMR helps to avoid such oversimplifications by analyzing the actual contribution of efficiency to sectoral development.

3. Complementarity with other methods.

TMR does not replace other statistics (e.g., GVA, employment, investment inputs) but rather complements them, providing a more complete picture of a sector's condition. Its application in multifactor analysis increases the credibility and accuracy of the conclusions.

The choice of the TMR indicator for assessing the sectors of the Polish economy is justified by its comprehensive nature, its ability to capture systemic efficiency, and the possibility of cross-sectoral and international comparisons. Compared to other statistical methods, TMR provides deeper insight into the real sources of economic growth, making it a valuable tool for economic analysis and policy planning.

The next step is to divide the data into stimulants and destimulants. Indicators considered to be stimulants should have the highest possible value, because they have a positive impact on the studied phenomenon. In turn, destimulant indicators, the higher their values, the more negatively they affect the model (Bąk, 2018). In the context of the 14 sector indicators, they can be classified according to the above criteria. For example, profitability indicators will be stimulants, debt indicators – destimulants, and liquidity indicators – nominatives or stimulants – depending on the approach adopted. In the literature, one can find both positions that financial liquidity indicators are stimulants and nominants. For the purposes of calculating the TMR indicator, the position that they are stimulants was adopted.

The following indicators were used in the study:

- Operating return on assets,
- Return on equity,
- Net sales return,
- Sales return,
- Economic sales return,
- Financial liquidity ratio I,
- Financial liquidity ratio II,
- Financial liquidity ratio III,
- Receivables collection period,
- Liabilities repayment period,
- Inventory turnover,
- Fixed assets coverage ratio with equity and long-term reserves,
- Financing structure sustainability ratio,
- Total debt ratio.

Average values of indicators were adopted for both sectors and subsectors as well as individual industries. Justifying the selection of given indicators, it should be indicated that operating return on assets measures the operating efficiency of asset utilization. It shows how much profit from operating activities is generated from assets. The indicator is important in assessing the company's ability to generate profits without taking into account financial and tax costs. Another indicator is the return on equity (ROE) indicator, which indicates the degree of return for owners from the capital employed. It is crucial for investors and the assessment of the profitability of own financing. Next, the net sales return indicator should be indicated, which informs what part of sales revenues remains as net profit. It allows for the assessment of the cost and management efficiency of the company. Net sales return on sales indicates the profitability of sales before taking into account the net financial result, so it focuses on the core business of the company. Remaining in the area of profitability, an important indicator is the economic sales return indicator, which provides a broader perspective on sales efficiency. Taking into account financial liquidity, the liquidity ratio I, II and III was taken into account. Including them in the analysis allows for an assessment of whether companies are able to cover liabilities on different dates. The next two indicators concern liabilities in terms of collection and repayment, they indicate whether companies have problems with collecting liabilities from contractors and whether they are able to settle them on time. In the perspective of financial condition, the speed of inventory turnover is also important, it illustrates the efficiency of management and the risk of capital freezing. In the study, the area of analysis also included the ratio of coverage of fixed assets with equity and long-term reserves, which allows for checking how stable capital is financed with assets. The use of the financing structure sustainability indicator measures the share of fixed capital in asset financing, the indicator is important for

long-term stability and solvency. The last indicator included in the area of analysis is the total debt ratio, which informs about the general level of debt. In the study, it was assumed that this indicator is a destimulant.

The adopted indicators allow for a comprehensive analysis of the financial condition of the enterprise. Creating a model allows for observing enterprises through the prism of these 14 lenses without the need for a detailed analysis of each indicator separately.

The division of the economy into sectors and subsectors is presented in Table 1. Each sector is composed of several subsectors, to which industries of the economy are assigned.

Table 1.
Division into sectors and sub-sectors

Sector	Subsector
Sector 1: Agriculture, Forestry, Fisheries, and Mining	Agriculture, Forestry, and Fisheries
	Mining and Quarrying
Sector 2: Industry and Manufacturing	Food and Light Industry
	Wood, Paper, and Printing Industry
	Heavy, Chemical, Metallurgical, and Electronic Industry
	Automotive, Furniture, and Transport Equipment
Sector 3: Energy, Water Management, and Waste Management	Energy, Water Management, and Waste Management
Sector 4: Construction	Construction
Sector 5: Trade, Transport, and Logistics	Trade
	Transport and Storage
Sector 6: Media, Telecommunications, and Information Technologies	Media, Telecommunications, and Information Technologies
Sector 7: Financial, Business, and Professional Services	Financial, Business, and Professional Services
Sector 8: Consumer, Social, Cultural, and Recreational Services	Personal, Administrative, and Support Services
	Public and Social Services
	Gastronomy, Tourism, and Culture

Source: Own work.

The indicators adopted for individual industries are presented in Table 2 for 2019 and in Table 3 for 2022. The standard deviation, mean, coefficient of variation were also calculated and the maximum and minimum values were indicated. These results are also necessary to make calculations that will allow the creation of a taxonomic measure of development, which are indicated above.

Table 2 presents the values of indicators for 2019. In addition to the average values obtained by individual sectors, information on minimum and maximum values, standard deviation and coefficient of variation is provided. Individual variables are presented for 8 sectors: agriculture, industry, energy, construction, trade, media, financial services and consumer services.

Table 2.
Average values of indicators in 2019

	Operational Return on Assets	Return on Equity (ROE)	Net Profit Margin	Sales Profitability Ratio	Economic Sales Profitability Ratio	Current Ratio (First-Degree Financial Liquidity Ratio)	Quick Ratio (Second-Degree Financial Liquidity Ratio)	Cash Ratio (Third-Degree Financial Liquidity Ratio)	Accounts Receivable Collection Period	Accounts Payable Payment Period	Inventory Turnover Rate	Fixed Assets Coverage Ratio (Equity and Long-Term Reserves)	Financial Structure Stability Ratio	Total Debt Ratio
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Standard deviation	2,4	5,0	2,3	2,2	2,1	1,0	1,0	0,7	11,7	6,6	22,4	1,8	0,0	3,2
Average	9,0	16,6	7,7	7,0	12,2	3,6	3,1	1,5	57,1	33,9	40,7	4,5	0,7	38,9
Max	12,3	24,1	11,9	10,4	14,7	5,3	4,9	2,7	73,6	43,0	83,3	7,0	0,8	44,7
Min	4,6	9,5	4,8	4,6	8,9	2,2	1,9	0,8	36,9	22,1	13,6	1,9	0,6	34,7
Coefficient of variation	26,3	29,9	29,5	31,7	17,5	27,6	32,6	42,8	20,5	19,3	55,0	39,9	5,8	8,1
Industries	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Sector 1: Agriculture, Forestry, Fisheries, and Mining	6,67	9,49	9,06	4,70	14,64	4,31	3,61	1,50	73,56	42,46	59,47	2,53	0,72	37,20
Sector 2: Industry and Manufacturing	8,39	14,68	5,51	5,89	8,92	2,76	1,92	0,75	51,21	37,31	54,24	2,77	0,67	41,26
Sector 3: Energy, Water Management, and Waste Management	4,56	9,63	4,81	4,94	14,74	2,22	1,99	1,03	43,36	29,98	13,57	1,86	0,77	38,89
Sector 4: Construction	12,34	24,08	9,82	10,12	13,02	3,24	2,60	1,12	63,39	42,97	83,28	5,63	0,65	41,11
Sector 5: Trade, Transport, and Logistics	11,53	21,74	7,38	7,32	10,19	2,57	2,22	0,95	57,83	34,67	28,01	4,75	0,63	44,70
Sector 6: Media, Telecommunications, and Information Technologies	9,17	16,18	7,51	7,95	12,19	4,20	3,61	1,84	62,25	32,26	34,57	6,49	0,70	35,04
Sector 7: Financial, Business, and Professional Services	9,06	17,02	11,92	10,44	13,86	5,31	4,92	2,66	68,10	29,51	38,75	6,99	0,72	34,73
Sector 8: Consumer, Social, Cultural, and Recreational Services	10,35	20,15	5,68	4,58	9,80	4,20	3,90	2,38	36,86	22,10	13,74	4,74	0,70	38,13

Source: Own work.

Table 3 contains the values of the indicators for 2022. Similarly to Table 2, in addition to the average values, the minimum, maximum, standard deviation and coefficient of variation are also presented. Similarly to 2019, the values concern 8 sectors.

Table 3.
Average values of indicators in 2022

	Operational Return on Assets	Return on Equity (ROE)	Net Profit Margin	Sales Profitability Ratio	Economic Sales Profitability Ratio	Current Ratio (First-Degree Financial Liquidity Ratio)	Quick Ratio (Second-Degree Financial Liquidity Ratio)	Cash Ratio (Third-Degree Financial Liquidity Ratio)	Accounts Receivable Collection Period	Accounts Payable Payment Period	Inventory Turnover Rate	Fixed Assets Coverage Ratio (Equity and Long-Term Reserves)	Financial Structure Stability Ratio	Total Debt Ratio
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Standard deviation	1,8	4,8	1,6	1,3	2,2	0,4	0,4	0,3	7,5	4,5	12,5	1,0	0,0	3,2
Average	13,8	24,6	8,1	8,3	12,5	3,4	2,7	1,4	47,8	29,5	37,0	4,1	0,7	40,3
Max	16,8	34,3	11,1	10,4	16,2	3,9	3,3	1,7	58,2	36,8	58,3	5,0	0,7	45,8
Min	10,0	17,0	6,4	6,8	9,6	2,7	2,1	1,0	34,4	20,8	19,0	2,1	0,6	35,5
Coefficient of variation	13,3	19,4	19,4	15,9	17,6	11,7	15,8	19,7	15,7	15,1	33,8	23,9	6,4	8,0
Industries	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Sector 1: Agriculture, Forestry, Fisheries, and Mining	13,97	23,07	11,12	10,10	16,16	3,50	2,82	1,38	58,25	31,20	48,49	3,18	0,70	38,35
Sector 2: Industry and Manufacturing	13,10	21,90	6,93	7,54	10,44	3,12	2,13	0,98	46,32	33,33	58,29	3,62	0,65	42,59
Sector 3: Energy, Water Management, and Waste Management	10,04	17,03	6,37	7,34	15,40	2,70	2,29	1,18	41,93	28,16	19,00	2,11	0,75	41,08
Sector 4: Construction	14,50	27,06	8,42	9,37	11,71	3,28	2,60	1,19	56,27	36,78	45,00	5,01	0,63	43,11
Sector 5: Trade, Transport, and Logistics	16,80	34,29	6,37	7,13	9,57	2,93	2,37	1,09	42,50	30,55	32,23	4,96	0,60	45,81
Sector 6: Media, Telecommunications, and Information Technologies	13,12	21,64	7,80	7,90	11,75	3,86	3,33	1,72	51,35	28,65	35,13	4,90	0,69	35,54
Sector 7: Financial, Business, and Professional Services	13,77	24,75	9,75	10,38	13,83	3,83	3,32	1,64	51,39	26,37	36,90	4,65	0,70	36,83
Sector 8: Consumer, Social, Cultural, and Recreational Services	15,41	27,39	7,69	6,77	11,30	3,60	3,05	1,64	34,43	20,81	21,07	4,09	0,69	39,49

Source: Own work.

The presented values of the indicators constitute the basis for further comparative analysis of the financial condition of the industries. Their interpretation will allow to determine the key differences and relationships between the sectors of the economy. The next part of the article interprets the results, indicating the most important conclusions resulting from the synthetic TMR measure used.

4. Research results

By constructing a taxonomic measure of development from the presented indicators, a synthetic indicator was obtained, which allows for the creation of a ranking of sectors in terms of the financial condition of enterprises. Table x presents the ranking for 2019. It can be seen that the Financial, business and professional services sector was ranked first. Construction came next, followed by media, telecommunications and information technologies. The lack of difference in the TMR result between positions 2 and 3 is due to rounding to 3 decimal places. It is worth noting that the energy, water and waste management sector is in last place with a TMR result of 0.070, which significantly differs from the penultimate position of industry and production. Table 4 presents the ranking of sectors based on the financial condition of enterprises in 2019.

Table 4.
Ranking of sectors in terms of the financial condition of enterprises in 2019

Sector	Position in ranking	TMR Score
Sector 7: Financial, Business, and Professional Services	1	0,629
Sector 4: Construction	2	0,491
Sector 6: Media, Telecommunications, and Information Technologies	3	0,491
Sector 1: Agriculture, Forestry, Fisheries, and Mining	4	0,394
Sector 5: Trade, Transport, and Logistics	5	0,266
Sector 8: Consumer, Social, Cultural, and Recreational Services	6	0,250
Sector 2: Industry and Manufacturing	7	0,187
Sector 3: Energy, Water Management, and Waste Management	8	0,070

Source: Own work.

In 2022, the situation changed. Companies from the agriculture, forestry, fishing and mining sectors came first with a TMR score of 0.562. Financial, business and professional services came second with a score of 0.555. There is a difference in TMR between construction and media in 2022, but it is still very small. Considering the sectors that close the ranking, it is necessary to indicate energy, water and waste management with a worse result than previously. The ranking of sectors according to the financial condition of enterprises in 2022 is presented in Table 5.

Table 5.
Ranking of sectors in terms of the financial condition of enterprises in 2022

Sector	Position in ranking	TMR Score
Sector 1: Agriculture, Forestry, Fisheries, and Mining	1	0,562
Sector 7: Financial, Business, and Professional Services	2	0,555
Sector 4: Construction	3	0,455
Sector 6: Media, Telecommunications, and Information Technologies	4	0,423
Sector 8: Consumer, Social, Cultural, and Recreational Services	5	0,250
Sector 2: Industry and Manufacturing	6	0,227
Sector 5: Trade, Transport, and Logistics	7	0,203
Sector 3: Energy, Water Management, and Waste Management	8	0,060

Source: Own work.

It can be seen that TMR results are more balanced in 2022 than in 2019. This is particularly visible in the top four. In 2019, the difference between 1 and 4 results was 0.235 and in 2022 0.139. The results of the TMR sector study confirm the first hypothesis, which stated that there are significant differences in the financial condition of individual sectors in Poland, which is reflected in the value of the synthetic TMR measure calculated on the basis of financial indicators. Large differences are observable in individual sectors. Detailed results also indicate discrepancies in the scope of individual industries that make up the sectors given in the study. Also in terms of the second hypothesis, which was that sectors characterized by higher profitability and better financial liquidity obtain higher values of the synthetic TMR measure, which indicates their more stable financial situation compared to sectors with a higher level of debt and lower management efficiency. there are visible relationships that may confirm it. Industries with high profitability and liquidity such as Sector 7: Financial, Business and Professional Services or Sector 4: Construction achieve a higher TMR measure than those with low or moderate profitability and liquidity but higher debt.

5. Conclusions

The study The study was conducted to assess the financial condition of various sectors of the economy in Poland using the synthetic TMR measure, which takes into account key economic indicators such as profitability, financial liquidity, debt level, and management efficiency. Data for 2019 and 2022 were analyzed, allowing not only the evaluation of the situation in a given period but also the observation of changes over time.

The results clearly confirm the first hypothesis (H1), indicating significant differences in financial condition across sectors. In both years, substantial variations in TMR values were observed. Particularly high stability was recorded in the financial, business, and professional services sector, consistently ranking at the top. Conversely, the energy, water, and waste management sector remained at the bottom, signaling a relatively weaker financial standing.

Notably, in 2022, agriculture, forestry, fishing, and mining emerged as the top-ranked sector. This shift may reflect improved efficiency and financial performance, potentially due to subsidies, regulatory changes, or favorable economic conditions. Such developments demonstrate that sectoral financial health is dynamic and influenced by macroeconomic and structural factors.

The persistently low position of the energy, water, and waste management sector may point to systemic challenges, including underinvestment, regulatory constraints, and limited adaptability. Given the ongoing energy transition and growing environmental expectations, this sector warrants special policy and investment attention.

Regarding the second hypothesis (H2), the analysis supports a positive relationship between profitability and liquidity levels and the synthetic TMR value. The study confirms that cash-flow-based indicators provide a more accurate reflection of financial stability than accrual-based metrics. This finding justifies the inclusion of a liquidity ratio in the TMR model (Seretidou, Billios, Stavropoulos, 2025). Sectors with low debt and high profitability recorded higher TMR scores, suggesting that the measure effectively reflects actual financial health and is a valuable tool in comparative sector analysis.

Importantly, the 2022 distribution of TMR values was more even, particularly among top-performing sectors. This may signal greater resilience to external shocks and more effective financial management practices post-pandemic. It could also reflect the increasing professionalism in corporate financial governance and broader adoption of analytical tools. Ultimately, the financial health of a sector is shaped by the performance of individual firms, which operate in diverse environments and under varying constraints (Nagy, Valaskova, 2023). As illustrated by research on the Tehran Stock Exchange, financial indicators remain essential in assessing the financial standing of listed companies, further supporting the relevance of synthetic approaches like TMR (Alyasari et al., 2024).

The findings of this study may have wide-ranging practical applications—from supporting investment decisions and public support allocation to enhancing risk assessment in financial institutions. The use of a single, synthetic measure fosters a more holistic understanding of sectoral financial performance and facilitates strategic decision-making.

5.1. Limitations of the study and directions for further analysis

The main limitation of this study lies in its reliance on aggregated sector-level data, which may obscure intra-sectoral disparities. Additionally, while TMR is useful for comparative evaluation, it does not identify root causes of financial outcomes—only their effects. The study is also limited to two years of analysis, suggesting the need for longitudinal research to capture trends and cyclical changes.

Future research should consider applying TMR at the firm level within individual sectors to uncover deeper insights. Moreover, integrating TMR with predictive models—such as credit scoring or bankruptcy prediction—could enhance tools for assessing financial stability. Another promising avenue is the development of sector-specific dashboards that visualize TMR results in real time, offering policymakers and analysts a dynamic view of industry performance. Embedding TMR into public policy frameworks could improve the precision of fiscal interventions, while its application in credit risk modelling could strengthen financial oversight and risk management across sectors.

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WOMEN AND RISK: A LITERATURE REVIEW ON BANK BOARDS

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Purpose: Board gender diversity has attracted growing research interest, especially regarding women's roles on statutory bodies in financial and non-financial companies, with a focus on banks. Exploring the link between gender diversity and banks' risk-taking is vital due to the threat of credit risk. This article aims to review the literature on female directors and bank risk, summarising studies on women's participation and its link to bank risk, including psychological and regulatory aspects of risk aversion.
Design/methodology/approach: To achieve the objective of this paper, relevant literature has been analysed, and verbal description methods have been applied. The review primarily encompasses empirical studies from high-quality journals, introduced by an overview of the theoretical framework, with particular emphasis on the psychological and regulatory aspects.
Findings: The literature review highlights the psychological underpinnings of gender differences in risk aversion. It also outlines the regulatory frameworks influencing women's participation on statutory bodies. Empirical research findings on board gender diversity and bank risk-taking remain inconclusive, leaving the relationship between the gender composition of statutory body members and banks' risk-taking unclear.
Originality/value: This paper provides a comprehensive overview of gender differences in risk preferences and, consequently, board gender diversity in banks. It organises key findings regarding the relationship between women's participation and banks' propensity to take risk. Therefore, it serves as a valuable reference for bank executives, particularly credit risk committees, as well as policymakers and regulators involved in risk management processes.
Keywords: bank boards, credit risk, gender diversity.
Category of the paper: Literature review.

1. Introduction

The relationship between the gender of members serving on bank statutory bodies and the quality of loan portfolios has attracted growing interest among scholars in recent years. The theoretical basis for exploring the link between demographic characteristics - particularly gender - of board members in both financial and non-financial institutions and the level of risk can be traced to the Upper Echelons Theory (Marchewka, 2020, p. 7). Originally formulated by

Hambrick and Mason (1984), this theory posits that organisational outcomes are partially predicted by the characteristics of top executives. According to the theory, strategic decisions made by top management teams are shaped by the personal attributes of their members, including experiences, values, and personalities (Marchewka, 2020, p. 7). These individual-level traits influence how executives perceive and interpret complex situations, thereby playing a crucial role in shaping organisational behaviour and performance (Hambrick, 2007).

The Upper Echelons Theory posits that the individual characteristics and personal preferences of executive members are reflected in the business strategies, financial policies, and overall performance of companies (Palvia et al., 2020). In addition, particular attention should be given to the Upper Echelons Theory's emphasis on the superiority of teams over individuals as the primary decision-makers (Marchewka, 2020, p. 7). This emphasis is justified by its potential to provide more accurate explanations of decision-making processes and their impact on the company's situation. However, the theory does not mandate an exclusive focus on top management teams (TMTs); instead, it allows for the analysis of executive bodies, including CEOs or other individual members of senior leadership (Hambrick, 2007).

However, Hambrick and Mason (1984) emphasize the need to deepen and ground the Upper Echelons Theory by incorporating findings from related areas of research, particularly from the area of psychology. Therefore, this study refers not only to the Upper Echelons Theory - which highlights the significance of demographic characteristics of executive members - but also to research on gender-related risk propensity, as developed in the psychological literature and the field of behavioural finance.

Credit risk remains one of the most critical challenges in the banking sector, directly impacting the sound functioning and stability of the entire financial system (Anastasiou et al., 2016; European Commission, 2019; European Banking Authority, 2021; Ghosh, 2015). Understanding the factors that may influence risk-taking behaviours is essential for developing effective governance and regulatory frameworks. Board gender diversity may constitute one such factor and, consequently, have a significant association with risk management practices.

Psychological research has extensively examined gender differences in risk-taking behaviours. Evidence suggests that men generally exhibit lower risk aversion compared to women, who tend to make more cautious decisions (Byrnes et al., 1999; Croson, Gneezy, 2009). In this vein, women's representation on corporate boards may influence risk management practices, potentially leading to lower risk profiles for companies. The link between board gender diversity and risk-taking has been widely studied in non-financial institutions (Adams, Ferreira, 2009; Bennouri et al., 2018; Huang, Kisgen, 2013; Mohsni et al., 2021; Nguyen et al., 2020; Sila et al., 2016). Given the importance of this topic, a research question arises in the field of women’s presence on bank boards and its relationship with risk-taking behaviour. Addressing this question can provide valuable insights for policymakers, regulators, and banking institutions aiming to enhance corporate governance practices and ensure financial stability.

2. Psychological aspects of gender differences in risk preferences

The psychological literature offers extensive research on differences in risk preferences between men and women (Booth, Nolen, 2012; Byrnes et al., 1999; Eagly, 1995). Scholars have also focused on explaining the biological foundations of gender-based differences in risk aversion (Apicella et al., 2008; Sapienza et al., 2009). Prior to the emergence of studies examining female representation on corporate boards and its relationship with bank risk, researchers explored the connection between gender and:

- Risk-taking in investment decisions (Barber, Odean, 2001; Eckel, Grossman, 2002).
- General tendencies to take risks in the field of finance (Croson, Gneezy, 2009; Jianakoplos, Bernasek, 1998; Powell, Ansic, 1997).
- Risk-related behavior in various activity areas of non-financial firms (Adams, Ferreira, 2009; Bennouri et al., 2018; Huang, Kisgen, 2013; Mohsni et al., 2021; Nguyen et al., 2020; Sila et al., 2016).

The gender-related propensity to take risk has been the subject of substantial research in psychological literature. Studies provide evidence that lower risk aversion is typically associated with men, while women are generally perceived as making decisions more cautiously (Byrnes et al., 1999; Croson, Gneezy, 2009). The role of stereotypes in shaping gender-based differences in risk acceptance is examined by Booth and Nolen (2012). Their findings of an environmental experiment reveal that girls attending single-sex schools exhibit similar levels of risk aversion as boys, while girls from coeducational schools demonstrate higher risk aversion. This may suggest that gender differences in risk propensity arise from social learning and adaptation to societal norms, rather than from biologically determined traits attributed to each gender. Furthermore, Byrnes et al. (1999) investigate age-related differences in risk-taking behaviour, identifying variations in risk acceptance across different age groups.

Understanding the factors influencing gender-based risk-taking is crucial for analyses in this field (Eagly, 1995). Croson and Gneezy (2009) focus on social preferences and competitiveness when identifying the origins of divergent risk aversion between men and women. The authors pay particular attention to theories explaining gender differences in risk preferences, highlighting mechanisms such as emotions, overconfidence, and social role expectations. When considering social preferences, the authors emphasise the greater sensitivity of women to social behaviours. In their analysis of competitiveness, Croson and Gneezy (2009) refer to both innate and acquired tendencies and abilities that influence gender differences in the willingness to compete. Some researchers suggest that the roots of gender-based differences in risk aversion may lie in biological factors. One such factor is the level of testosterone, which is considered to influence the propensity to engage in risky behaviour (Apicella et al., 2008; Sapienza et al., 2009). Apicella et al. (2008) demonstrate a positive

relationship between testosterone levels in men and risk-taking behaviour, as observed in investment games. Sapienza et al. (2009) confirm a similar pattern among women, showing that higher testosterone levels are associated with lower financial risk aversion. However, this relationship is not observed in men. Furthermore, Sapienza et al. (2009) note that individuals with higher testosterone levels and lower risk aversion are more likely to pursue careers in high-risk fields such as finance.

The propensity to take risks depending on gender is an important subject of a vast number of psychological studies. However, this topic also lies at the centre of interest for many authors examining the drivers of investment and financial decisions.

3. Behavioral aspects of gender differences in risk preferences

Special attention should be paid to the works of Barber and Odean (2001) as well as Eckel and Grossman (2002), which identify gender differences in risk-taking related to investment decisions. Barber and Odean (2001) highlight men's overconfidence, which is particularly evident in the financial domain. This overconfidence manifests as a greater willingness to invest, often resulting in poorer investment outcomes compared to the more cautious approach typically observed in women. According to the authors, this pattern stems from overestimating the accuracy of information by highly active investors, which in turn leads to unrealistic expectations of predictable returns. Barber and Odean (2001) emphasize that these differences are most pronounced among unmarried men and women.

Another study addressing acceptable levels of risk as influenced by gender is that of Eckel and Grossman (2002). The authors concentrate on situations involving potential losses, demonstrating that, on average, women exhibit higher risk aversion toward gambling compared to men. Their findings indicate that women are more likely than men to choose risk-free gambling options. Additionally, one-third of women opt for the lowest-risk gambling decisions. Eckel and Grossman (2002) also evaluate how risk aversion is perceived by each gender: they assess women's risk aversion as perceived by men, and men's risk aversion as perceived by women. This analysis shows that men and women tend to overestimate each other's willingness to take risks. However, this overestimation is significantly greater in the case of women evaluating men than vice versa. This suggests the presence of a stereotypical perception of women as having a lower tolerance for risk.

The level of financial risk taken by gender is a key topic in some research (Jianakoplos, Bernasek, 1998; Powell, Ansic, 1997). Women are perceived as holding less risky portfolio assets in their households compared to male-headed households (Jianakoplos, Bernasek, 1998). Unmarried women exhibit higher risk aversion in the field of finance than unmarried men, which is evident in the lower growth of risky assets in households headed by women compared

to those headed by men. A study focusing on gender differences in risk tendencies related to financial decisions is that of Powell and Ansic (1997). The researchers highlight the different motivations between genders as a source of their decision-making. On the one hand, women, being more cautious, concentrate on strategies aimed at avoiding risky situations while ensuring safety. On the other hand, men, who are generally more willing to take risk, choose strategies characterised by the potential for higher returns, albeit accompanied by higher risk. Women with the same level of experience and education as men tend to attribute potential gains to luck and also display lower self-confidence.

Gender remains a significant area of research concerning the level of risk-taking in investments and financial decisions. Overall, the results of these analyses show that women tend to display higher risk aversion than men.

4. Tokenism and critical mass

The assessment of the proportion of women on statutory bodies is sometimes discussed in the context of tokenism. One woman on a board is often seen as a symbol, two as a presence, and three as a voice (Kristie, 2011). In her seminal sociological work on tokenism, Kanter (1977) identifies three key aspects of how this phenomenon is perceived. First is visibility - individuals who differ from the majority group are more noticeable, which can result in increased pressure on their performance. Second is polarization, referring to the heightened visibility and reinforcement of group boundaries. Third is assimilation, whereby individuals who differ from the group are pressured to conform, often altering their characteristics to align with the majority. Kanter (1977) also highlights the distorted perception of a woman in a high-ranking managerial role, who is often viewed through the lens of gendered traits rather than managerial competence. Due to gender stereotypes and the symbolic perception of women by stakeholders, the influence of female members on decisions made by statutory bodies is limited (Liu et al., 2014). As a result, women's roles in management and supervisory boards can be reduced to symbolic participation, lacking real decision-making power (Birindelli et al., 2020). Thus, the issue of tokenism frequently arises in studies examining women's participation in statutory bodies, both in non-financial firms (Liu et al., 2014; Torchia et al., 2011) and in banks (Birindelli et al., 2020; De Cabo et al., 2012; Fiador, Sarpong-Kumankoma, 2021).

One way to counteract tokenism is by achieving a certain number of women in statutory bodies - referred to as the critical mass - that enables them to have real decision-making power (Fiador, Sarpong-Kumankoma, 2021; Liu et al., 2014). Kramer et al. (2006) highlight the importance of increasing the number of women, noting the negative consequences of having only one woman in statutory bodies, such as exclusion from social integration and key discussions. In contrast, they emphasize several benefits associated with having two or more

women on such bodies: the ability to adopt a shared strategy, increased willingness to raise controversial issues, more active participation through questioning, and most importantly, genuine co-creation of the board's work. The concept of critical mass is gaining prominence, as seen in studies identifying the factors that influence its formation. For example, Charles et al. (2015) found that companies with a critical mass - defined as at least three women in director positions - tend to be larger, have more members on their statutory bodies, are more likely to be led by a female CEO, and have a higher percentage of non-Caucasian directors. Notably, company profitability and the proportion of independent board members were not significant determinants of achieving a critical mass of women.

5. Gender quotas

One way to support a certain level of women's representation in management or supervisory positions is through legislative measures, such as the introduction of gender quotas, aimed at ensuring equal access for women to top executive roles. Gender quotas have already been implemented in several European countries. The first was Norway, which enacted a law in 2003 that mandated a 40% gender share in director positions; this law came into effect in 2008. France followed, introducing a legal requirement for gender representation in company statutory bodies - starting at 20% in 2014, based on the 2011 legislation, and increasing to 40% in 2017. In 2012, the European Commission proposed an initiative requiring a 40% gender share in non-executive positions in large listed European companies, or 33% across all director positions. This proposal underwent nearly a decade of public debate before it was formally adopted on June 7, 2022. Member States were given until 2024 to transpose the Gender Balance on Corporate Boards Directive into national law, and companies must meet the targets by June 30, 2026. In 2016, Germany introduced a 30% gender quota on supervisory boards for its 100 largest listed companies. Many other European countries, such as Austria, Belgium, Spain, the Netherlands, and Italy, have also established legal gender quotas for statutory bodies. Meanwhile, some countries continue to rely on "soft law" mechanisms - such as corporate governance codes - that recommend appropriate levels of gender representation in management and supervisory structures (e.g., Luxembourg, Sweden, and the United Kingdom) (Ginglinger, Raskopf, 2021).

The topic of gender quotas is reflected in empirical studies across both the business and banking sectors (Bertrand et al., 2019; Bøhren, Staubo, 2014; Ginglinger, Raskopf, 2021; Greene et al., 2020; Liao et al., 2019; Mazzotta, Ferraro, 2020). Researchers explore various relationships involving the representation of women in top management positions. For instance, Bertrand et al. (2019) examine the impact of gender quotas on women's position in the labour market and wage inequality. Bøhren and Staubo (2014) investigate how companies may change

their organizational form to circumvent gender parity regulations. Ginglinger and Raskopf (2021) analyse the environmental and social performance of firms, while Greene et al. (2020) assess the effect of gender quotas on company value. In the banking sector, Liao et al. (2019) study the relationship between gender parity and risk in international banks, and Mazzotta and Ferraro (2020) explore the connection between gender parity and profitability in Italian banks.

Gender quotas are a regulatory tool that play an important role in addressing the glass ceiling phenomenon - a term used to describe the invisible barriers that often prevent women from advancing to higher-level positions. Adams and Kirchmaier (2015) focus on the structural barriers limiting women's access to statutory body membership, shifting attention away from women's individual characteristics as explanations for their underrepresentation in leadership roles. They highlight the significant influence of economic and cultural factors in creating these barriers, while also noting that women's lower inclination to work full-time may contribute to the issue. Meanwhile, Adams and Funk (2012) challenge the notion that there are inherent gender differences in risk appetite among those who have broken through the glass ceiling. They argue that, in order to reach top positions, women often need to display traits similar to those of men or adapt to a male-dominated environment, which may neutralize any natural differences in risk preferences.

Gender quotas, along with the accompanying legal and ethical pressures, are sometimes criticized as mechanisms that may lead to the appointment of underqualified women who lack the necessary skills or theoretical background. In such cases, an increasing share of women in directorship positions may be linked to heightened risk-taking by banks (Birindelli et al., 2020). Similarly, Fiador and Sarpong-Kumankoma (2021) highlight a decline in credit quality following the appointment of women to the statutory bodies of banks, attributing this to regulatory and societal pressure. According to these researchers, the push to appoint women to leadership roles can result in the selection of candidates with insufficient professional experience or reduced capacity for effective oversight.

The gender composition of statutory bodies encompasses a wide range of issues from tokenism and critical mass to gender parity and the glass ceiling phenomenon. These topics are the focus of ongoing debate not only in public discourse but also within academic circles and among regulators, as reflected in legislative efforts aimed at combating gender discrimination.

6. Women on boards: areas of empirical research and measurement

The presence of women in the statutory bodies of non-financial companies and its link to their activities is a topic widely explored by researchers. The area of empirical analysis covers the relationships between women serving on boards and various corporate activities, including mergers and acquisitions (Levi et al., 2014), cross-listing (Shoham et al., 2020), the value of

the IPO (Rau et al., 2021), dividend payments (Ye et al., 2019; Saeed, Sameer, 2017), the cost of financing with debt capital (Mascia, Rossi, 2017), and the quality of financial statements (García Lara et al., 2017). Links between gender and profitability (Adams, Ferreira, 2009; Bennouri et al., 2018; Flabbi et al., 2019; Nguyen et al., 2020) or risk (Huang, Kisgen, 2013; Khaw et al., 2016; Mohsni et al., 2021; Sila et al., 2016) are also frequently analysed.

Gender diversity on boards is also studied in the context of Polish companies (Bohdanowicz, 2015; Szarzec et al., 2022). Additionally, researchers analyse the presence of women on supervisory boards (Aluchna et al., 2017; Dobija et al., 2021) and the gender of CEOs (Byrka-Kita et al., 2018).

Beyond the topic of women managing non-financial companies, growing attention is being paid to board gender diversity in banks. The presence of women on the statutory bodies of banks is measured using various indices.

The authors analysing gender diversity use several indicators to reflect the extent of women's representation in banks' statutory bodies. These indicators include the presence of women as CEOs (Cardillo et al., 2021; Palvia et al., 2020; Skała, Weill, 2018), women as chairpersons of supervisory boards (Andrieș et al., 2020; Arnaboldi et al., 2021; Palvia et al., 2015), or the number of women on boards. Among the indices often employed in empirical analyses are the percentage share of women in statutory bodies (Birindelli et al., 2020; Farag, Mallin, 2017; Mavrakana, Psillaki, 2019; Fiador, Sarpong-Kumankoma, 2021; Talavera et al., 2018), and a dummy variable indicating the presence of at least one woman on the board (Del Prete, Stefani, 2021; Ghosh, 2017; Gulamhussen, Santa, 2015; Lu, Boateng, 2018). Some authors use a variable indicating the presence of at least three women in a given statutory body (Birindelli et al., 2020; Díez-Esteban et al., 2022; Sghaier, Hamza, 2018). Moreover, Karavitis et al. (2021) and Stefanovic and Barjaktarovic (2020) analyse the number of women in both executive and non-executive bodies, as well as the number of women serving as members of boards of directors. Less frequently, researchers consider indices such as the Blau index (Andrieș et al., 2020; Owen, Temesvary, 2018) or the Shannon index (Andrieș et al., 2020; Proença et al., 2020).

Studies on women's share in statutory bodies are conducted across various areas of bank activity, such as profitability (García-Meca et al., 2015; Phatan, Faff, 2013; Setiyono, Tarazi, 2014; Stefanovic, Barjaktarovic, 2020), political connections (Proença et al., 2020), market reactions to mergers (Hagendorff, Keasey, 2012), the bank's functioning under competitive pressure in the sector (Amore, Garofalo, 2016), cost of borrowing (Karavitis et al., 2021), bank misconduct (Arnaboldi et al., 2021), or remuneration of management members (Fan et al., 2019).

7. Board gender diversity and bank risk-taking

An important body of research is devoted to defining the relationship between the gender of board members and the level of risk-taking by banks. Some authors, when measuring bank risk, use portfolio risk indicators such as the ratio of risk-weighted assets to total assets or the Herfindahl-Hirschman Index (HHI) to quantify the degree of credit portfolio concentration (Berger et al., 2014). Other researchers employ systemic risk indicators (Díez-Esteban et al., 2022; Sghaier, Hamza, 2018), focus on the probability of default assessed using the Z-score (Baselga-Pascual, Vähämaa, 2021; Ghosh, 2017; Gulamhussen, Santa, 2015; Setiyono, Tarazi, 2014), or determine the bank's capital position by the equity to total assets ratio (Baselga-Pascual, Vähämaa, 2021; De Cabo et al., 2012).

A separate area of research concerns the assessment of credit risk, which is carried out using indicators such as loan loss provisions (Gulamhussen, Santa, 2015), loan loss write-offs (Gulamhussen, Santa, 2015; Harkin et al., 2020), or the share of non-performing loans in the portfolio (Dong et al., 2014; Farag, Mallin, 2017; Fiador, Sarpong-Kumankoma, 2021).

Results on relationship between share of women on boards and bank risk are ambiguous. More gender-diverse boards are associated with higher portfolio risk (Berger et al., 2014). Regarding systemic risk, the presence of women on boards matters, but only for small banks (Díez-Esteban et al., 2022). A higher number of women is linked to increased systemic risk.

Links between board gender diversity and risk are also observed in acquiring banks (Sghaier, Hamza, 2018). An increasing share of women in statutory bodies is associated with lower bank risk. Moreover, having a woman serve as CEO, CFO, or chair of the board of directors reduces the level of risk taken by the bank. Similarly, there is a statistically significant and negative relationship between bank risk and a binary variable equal to one when at least three women are present on the board.

Another area of empirical analysis explores the relationship between female board members and the probability of bank default. Some authors find that the bank's default risk increases as the share of women on the supervisory board or board of directors rises (Baselga-Pascual, Vähämaa, 2021; Gulamhussen, Santa, 2015).

However, some studies show that women in top executive positions reduce bank risk (Setiyono, Tarazi, 2014). Additionally, there is research indicating no relationship between greater gender diversity in statutory bodies and measures such as the Z-score, return on assets, or Tobin's Q. Ghosh (2017) observes a lower probability of bank default when a woman holds a director-level position.

Bank risk is sometimes measured by considering its capital position. It has been shown that an increasing share of women on boards is associated with a lower level of equity relative to total assets (Baselga-Pascual, Vähämaa, 2021). Conversely, De Cabo et al. (2012) find that more gender-diverse boards are present in banks characterised by reduced financial leverage,

as measured by the standard deviation of return on assets and the equity to total assets ratio. The authors attribute this phenomenon to the higher risk aversion typically exhibited by women, along with their growing caution in the decision-making process.

Several studies have examined the relationship between female representation on bank statutory bodies and the level of non-performing loans (Adams, Raghunathan, 2017; Dong et al., 2014; Farag, Mallin, 2017; Fiador, Sarpong-Kumankoma, 2021). The findings in this area are mixed. On the one hand, some authors find that a higher share of women on boards is associated with better loan quality (Andrieș et al., 2020; Dong et al., 2014; Farag, Mallin, 2017; Zigraiova, 2016), suggesting that banks with greater female representation in statutory bodies are less risky compared to those with less gender-diverse boards. On the other hand, there are studies indicating that banks with more women in top positions may be more risky (Fiador, Sarpong-Kumankoma, 2021; Mavrakana, Psillaki, 2019). Furthermore, some empirical analyses report no statistically significant relationship between the proportion of women in statutory bodies and the quality of the credit portfolio (Adams, Raghunathan, 2017; Birindelli et al., 2020; De Vita, Luo, 2018; Talavera et al., 2018). This suggests that the presence of women on boards does not necessarily influence the level of non-performing loans. In other words, more gender-diverse banks do not exhibit significantly different levels of credit risk compared to those with lower female representation.

8. Female CEOs and bank risk-taking

In banking, empirical studies focusing on the gender of the CEO are far less common than those examining board gender diversity. Existing research explores the relationship between CEO gender and bank performance (Stefanovic and Barjaktarovic, 2020) as well as bank misconduct (Arnaboldi et al., 2021). The findings suggest that a female CEO strengthens the positive relationship between the share of women on the management board and the bank's net income. Similarly, the presence of women as managing directors positively influences the net income of banks led by a female CEO (Stefanovic, Barjaktarovic, 2020). Arnaboldi et al. (2021), however, find no significant relationship between a female CEO and the number of fines received by a bank due to misconduct.

The next area of analysis addresses the relationship between CEO gender and bank risk (Farag, Dickinson, 2020; Palvia et al., 2015; Palvia et al., 2020; Sghaier, Hamza, 2018). Overall, the literature finds that banks led by female CEOs are generally less risky than those managed by male CEOs. This relationship is supported in the context of credit risk, as measured by charge-offs and non-accrual loans (Palvia et al., 2020). Additionally, banks with female CEOs tend to display stronger capital adequacy ratios and a lower probability of default during financial crises compared to banks with male CEOs during such turbulent periods (Palvia et al.,

2015). Furthermore, having a woman serve as CEO, CFO, or chair of the board of directors is associated with a lower level of risk in acquiring banks. This suggests that women exhibit higher risk aversion and act more cautiously during mergers and acquisitions in the banking sector (Sghaier, Hamza, 2018). However, Farag and Dickinson (2020) find that banks with politically, regulatorily, or state-connected female CEOs are more risky than those led by similarly connected male CEOs.

Research on the relationship between CEO gender and the level of non-performing loans is scarce. Some authors report better loan quality in banks led by female CEOs compared to those led by male CEOs, as measured by loan loss provisions (Andrieș et al., 2020). However, other studies do not find a statistically significant association between CEO gender and the level of non-performing loans (Cardillo et al., 2021; Skała, Weill, 2018). However, banks with female CEOs tend to exhibit higher capital adequacy ratios and equity to assets ratios (Skała, Weill, 2018). These findings have been observed in Central European banks between 2005 and 2012 (Andrieș et al., 2020), European listed banks from 2005 to 2017 (Cardillo et al., 2021), and Polish cooperative banks from 2008 to 2012 (Skała, Weill, 2018).

The authors analyse the association between the presence of women in statutory bodies and bank profitability or stability during financial crises. Andrieș et al. (2020) find that banks with a higher proportion of female members, or those with a female CEO, are characterised by higher returns on assets and equity, as well as a lower probability of default, as measured by the Z-score, compared to their peers. The researchers also examine the relationship between board gender diversity and the likelihood of receiving State aid. They show that banks with greater female representation in statutory bodies are less likely to receive such aid and, when they do, the amount received is lower than that for male-dominated banks. Higher gender diversity is associated with better bank performance, as measured by return on assets, Tobin's Q, and the dividend payout ratio. These findings align with evidence suggesting that women display stronger monitoring skills than men (Cardillo et al., 2021).

9. Conclusions

To sum up, the analysis of the relationship between CEO gender and bank risk-taking is based on two key pillars. Firstly, the assumptions regarding the significant role that the gender of individuals in statutory bodies plays in credit risk management relate to Upper Echelons Theory (Hambrick, Mason, 1984). Secondly, relevant in this area are findings from psychological studies showing differences in risk-taking tendencies between genders (Booth, Nolen, 2012; Byrnes et al., 1999; Eagly, 1995), as well as analyses explaining discrepancies in risk aversion between women and men due to biological factors (Apicella et al., 2008; Sapienza et al., 2009). According to the main conclusion drawn from these studies, women exhibit higher

risk aversion than men, which may influence the level of acceptable credit risk taken by female CEOs in banks.

However, the relationship between the gender of statutory body members and the risk-taking by banks remains unclear. Some studies report a negative link between the increasing percentage of women in management or supervisory boards and the acceptable level of risk (De Cabo et al., 2012; Setiyono, Tarazi, 2014; Sghaier, Hamza, 2018). In contrast, other studies find that bank risk increases with greater female participation (Baselga-Pascual, Vähämaa, 2021; Berger et al., 2014; Díez-Esteban et al., 2022; Gulamhussen, Santa, 2015), while some show no statistically significant relationship between board gender diversity and bank risk (Ghosh, 2017). Research on loan quality and CEO gender suggests that banks led by female CEOs have a lower share of non-performing loans compared to those led by male CEOs (Andrieș et al., 2020). However, other authors find no significant differences in credit risk based on the CEO's gender (Cardillo et al., 2021; Skała, Weill, 2018).

Research examining the relationship between board gender diversity and bank risk-taking reveals several limitations. Firstly, empirical findings are inconclusive. The discrepancies may stem from different methodologies, sample selections, and contextual factors. Secondly, geographical and cultural constraints also limit the generalizability of these studies. Many focus on specific countries or regions making it challenging to apply findings universally. Additionally, most research frequently examine the direct relationship between gender diversity and risk-taking without considering mediating factors like corporate environmental responsibility or the presence of sustainability committees, which could influence risk-related decisions.

To overcome the limitations identified in current research, future studies should adopt an approach that encompasses various areas of expertise. This would provide a more comprehensive understanding of how gender diversity influences risk-taking by banks. Moreover, an in-depth examination is necessary to explore the underlying mechanisms through which diversity impacts risk-taking. Investigating additional factors can offer deeper insights into how diverse boards contribute to banking practices. Finally, integrating qualitative methods like interviews or case studies can enrich the understanding of how gender dynamics affect decision-making processes within banks. Such approaches allow for an including the experiences and perspectives of board members, shedding light on the factors that quantitative methods might overlook.

Recognising the link between board gender diversity and bank risk-taking, this paper underscores its significance regarding practical implications. In terms of bank governance context, the presence of women on bank boards and, at the same time, incorporating diverse perspectives can enhance decision-making processes may lead to improved risk management processes. In addition, regulators might consider promoting gender diversity within bank boards as a strategic measure to mitigate systemic risk within the banking sector.

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SECURITY MANAGEMENT OF MASS EVENTS ON THE EXAMPLE OF UEFA EURO 2012

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Purpose: The aim of this article is to analyze the solutions adopted by the Polish Police regarding safety management during mass events, using the UEFA EURO 2012 Final Tournament as a case study.
Design/methodology/approach: The article is of a cross-sectional nature. The achievement of the objective is based on a critical analysis of the literature.
Findings: The conducted analysis indicates that the actions taken by the Polish Police, based on the prepared operational philosophy, ensured the uninterrupted progress of the event that was the UEFA EURO 2012 Final Tournament. This also serves as an excellent example of the Polish Police's ability to manage the safety of mass events.
Practical implications: The solutions applied in organizing police actions to ensure safety and public order during the UEFA EURO 2012 Final Tournament can be implemented in measures ensuring the safety of lower-level mass sporting events.
Social implications: Proper preparation for organizing mass events by entities responsible for ensuring safety, including the Police, influences the increase in the sense of security among participants of such events.
Originality/value: The relevance of the topic in light of the rise of aggressive behavior during football matches and its significance for the development of theory in this area, as well as practical solutions applied in this field.
Keywords: safety management, Police, football match.
Category of article: literature review.

1. Introduction

In Poland, for several decades, ensuring safety at mass events, particularly football matches, has posed a challenge that has yet to find a satisfactory resolution. The level of safety during such events has fluctuated. This was dictated by various factors, notably the underestimation of the magnitude of the issue and even denying the existence of the problem. This was the case in the 1970s and 1980s when the phenomenon of stadium hooliganism was hidden from society (Socha, 2011).

The tragic events that occurred in Poland in the 1990s prompted an urgent enactment of the Act on the Safety of Mass Events (Journal of Laws 1997, No. 108, item 909). This was the first legal act that comprehensively regulated issues related to the safe conduct of so-called mass events. The evolution of the nature of threats during these events, as well as the new challenges posed to Poland due to the organization of the UEFA EURO 2012 Final Tournament, led the Polish Parliament to adopt a new law on the safety of mass events on March 20, 2009 (Journal of Laws 2009, No. 62, item 5004).

The UEFA EURO 2012 Final Tournament was the fourteenth tournament of the Men's European Football Championship, organized for the first time in history by two Central and Eastern European countries—Poland and Ukraine. The tournament took place from June 8 to July 1, 2012, in eight cities and eight stadiums—four in each country. Sixteen of the best national teams in Europe, selected through qualifiers, participated in the competition, with the host nations automatically included. Key organizational tasks included, among others, ensuring the safety of the mass event.

2. Safety Management in Theoretical Perspective

The presentation of the definition of safety management must begin with an explanation of the concepts of management and safety. As a result of a literature analysis aimed at clarifying the meanings of these terms, it is essential to note that finding universal definitions for both concepts is impossible, as many varied interpretations exist. A.K. Koźmiński defines management as a set of "actions or processes aimed at coordinating and integrating the use of resources to achieve organizational goals through people using techniques and information within organized structures" (Dictionary of National Security Terms, 2002). A similar stance is presented by R. Rutka, who believes that the essence of management, "like any other form of directing, is action aimed at achieving goals through people and with people" (Rutka, 1984). According to H. Koontz and C. O'Donnell, management is an art involving "the achievement of goals through people and with people in the form of organized groups and shaping an environment in which individuals can operate as units and simultaneously cooperate in achieving collective goals" (Koontz, O'Donnell, 1969). R. Griffin, on the other hand, perceives management as "an ongoing process of creating rules of order in a given system in the form of norms, plans, instructions, and other documents, along with a set of actions that include planning, decision-making, organizing, leading (i.e., directing people), and controlling, directed at the organization's resources (human, financial, material, and informational) and performed with the intent of achieving the organization's goals efficiently and effectively" (Griffin, 1997). In the context of these reflections, the definitions provided by T. Pszczołowski and J.A.F. Stoner, R.F. Freeman, and D.R. Gilbert deserve attention. According to T. Pszczołowski,

management is "the act of managing resources and tools according to the goals of the manager." He further defines the tasks of management as formulating action goals, planning, organizing structures (acquiring and deploying necessary human and material resources), and controlling the realization of established goals (Pszczołowski, 1978). Meanwhile, J.A.F. Stoner, R.F. Freeman, and D.R. Gilbert treat management as a process of "planning, organizing, leading, and controlling the work of organizational members and using all available resources of the organization to achieve its objectives" (Stoner et al., 1999). Thus, management is a process focused on efficiently and effectively achieving the organization's goals using all its resources, and it comprises four fundamental functions: planning, organizing, leading, and controlling, which constitute the canon of the management process.

The etymology of the term "safety" (from the French sécurité, Latin securitas, or Anglo-Saxon security) expresses "the primal feeling of threat in relation to the feeling of certainty of one's protection ("without care", meaning without adequate protection, and similarly "sine secura"). Considering the principles of the Polish language, "safety" is understood as a state of being unthreatened, calm, and certain (Socha, 2014).

Safety, as a highly valued good, currently touches all spheres of life: "starting from random physico-chemical factors (including climatic, tectonic, and fire hazards) through biological-existential threats that are essential for survival in the world of living organisms (ensuring food, technical energy, health), ending with factors arising from the mutual invasiveness of people in social life" (Raczkowski, 2012). Hence, various typologies of safety are employed in academia. Additionally, when indicating the area of safety, it is specified using terms such as national, international, regional, local, public, universal, as well as mass events or football matches. Safety refers to the objective state of being free from threats (Socha, 2011) or protection against threats, and it is used to describe the subjective state of freedom from anxiety resulting from threats. In everyday understanding, safety is viewed purely objectively, meaning as a state of being unthreatened, or purely subjectively, meaning as a sense of lack of fear or anxiety. However, safety combines subjective elements with objective ones, as there can be no safety without the feeling of lack of anxiety or fear, but it is also non-existent when that feeling is unjustified.

The concept of "security management" in literature also has many definitions and is understood as, for example, "the minimization or elimination of threats through intentional, regulatory human actions, organized according to a management cycle that includes identifying problems, planning, organizing resources, motivating, and controlling future-oriented activities" (Korzeniowski, 2012). In the public sector, it refers to "organized action utilizing human, financial, technical, and informational resources to reduce potential threats, ensure the uninterrupted flow of social life, and protect health, life, property, and the environment" (Sienkiewicz-Małyjurek, 2010). Thus, security management constitutes a complex, interdisciplinary concept that describes actions aimed at minimizing or eliminating threats through conscious and intentional human activities. It is perceived both as a state, i.e., a sense

of certainty and the absence of threats, as well as a process, i.e., a series of future-oriented activities aimed at anticipating changes. The key features of security management, from a scientific perspective, can be reduced to its process-oriented nature, the minimization or elimination of risks, future orientation and proactivity, as well as systematization and comprehensiveness.

3. Mass Events – Concept, Essence, Types

Addressing the issue of security management during mass events, it should be noted that current legal regulations do not clarify the meaning of the term "event". However, the Act of 2009 on the Safety of Mass Events categorizes mass events while simultaneously defining what should be understood by these terms.

According to the provisions of the law, a mass event is defined as an artistic and entertainment mass event or a mass sports event, including a football match, with the exception of certain types of events such as those organized in theaters, operas, operettas, Philharmonics, cinemas, museums, libraries, cultural centers, and art galleries or in other similar facilities (Journal of Laws of 2023, item 616). The law contains legal definitions of types of mass events such as artistic and entertainment mass events, mass sports events, high-risk mass events, and football matches.

It is important to note that each of the mentioned types of mass events was related to UEFA EURO 2012. For the purposes of achieving the goal of this article, it is necessary to explain the meaning of the term "football match", which should be understood as a mass sports event aimed at competition in the discipline of football, organized in a stadium or other sports facility where the number of places made available by the organizer for individuals, determined in accordance with building law and fire protection regulations, is no less than 1000 (Journal of Laws of 2023, item 616).

4. Security Management Based on the So-Called Philosophy of Police Operations

In preparation for the UEFA EURO 2012 final tournament, the police sought proven solutions to ensure safety. The achievement of this goal was based on three pillars encompassing the philosophy of police operations, referred to as the "three elements of integrated security," which stemmed from the recommendations of the UEFA (Union of European Football Associations) and collaboration with fans.

The police philosophy, referred to as "3xT", consisted of: Care, Tolerance, and Suppression. Care was understood as the supportive role of police officers towards fans, essentially involving "looking after the fans". Tolerance was interpreted as the officers' understanding of often loud and non-standard behaviors, as well as the ways fans express their emotions. Suppression, which was considered a last resort, involved quick and professional actions by police tactical units in cases of collective disturbances of public order (Socha et al., 2010), within the framework of the Police Preparation Concept for the European Championship, 2010. This introduced philosophy referenced the Austrian philosophy of actions during the UEFA EURO 2008 Final Tournament, termed "3xD": Dialogue, De-escalation, and Determination (UEFA EURO 2008 – Final Report, 2009).

The police's preparation for action during UEFA EURO 2012, which was carried out under the operational codename HAT TRICK 2012, also included three elements of integrated security: event security, service, and safety.

Event security consisted of actions that ensured the safety of both participants and local community residents. Service involved actions aimed at creating conditions for the efficient conduct of the event. Safety was understood as the feeling of an uninterrupted atmosphere of celebration and the assurance of peace and the elimination of incidents that threatened the tournament and its participants.

The third pillar of the Polish police operations philosophy was based on the so-called "spotter" institution, and the actions undertaken by them were crucial for the safe conduct of the event in terms of identifying and immediately eliminating threats posed by fans. In a broad sense, a "spotter" refers to a police officer involved in matters related to the football fan environment, who is responsible for communication with fans and cooperation with club authorities. In the Polish police, following the English model, the term "spotters" informally appeared in 2005 to designate officers who typically operated covertly while performing duties during the security of international football matches. Since the UEFA European Football Championship finals in 2008, Polish spotters began to operate openly (Socha, 2011).

5. Coordination of Police Actions

The main center responsible for coordinating police activities during UEFA EURO 2012 was the Police Command Center located at the Police Training Center in Legionowo. The Police Command Center operated 24/7 with 95 officers, supported by 23 liaison officers who exchanged information with Polish police officers. The Command Center was responsible for coordinating police actions within the framework of the police operation. In this regard, it cooperated with the Capital Police Headquarters and the provincial police headquarters. The commander of the police operation, holding the rank of deputy chief of police,

was responsible for managing safety in the context of police operations (Socha, 2011). His duties included, in particular:

- Coordinating and overseeing the implementation of the action plan of the police operation commander and the action plans of the sub-operation commanders in Gdańsk, Kraków, Lublin, Poznań, Rzeszów, Warsaw, and Wrocław.
- Overseeing the information circulation system.
- Cooperating with all entities participating in the operations.
- Making the decision to terminate the police operation.

The Police Command Center consisted of the Operation Command Center and the Information Exchange Center. Among the main tasks of the Operation Command Center are:

- Managing actions within the nationwide police operation.
- Processing information regarding planned and ongoing actions.
- Determining the forces and resources necessary to eliminate emerging threats.
- Communicating decisions from the operation commander to subordinate forces.
- Supervising the execution of tasks by subordinate forces.
- Ensuring full readiness of subordinate forces for action.
- Exchanging information with other services and entities responsible for security during the tournament.
- Collecting documentation from the conducted activities, informational reports, and other planning documentation.

The tasks of the Information Exchange Center include, among others:

- Monitoring and identifying potential threats that could disrupt the course of the tournament.
- Ongoing cooperation with the operation and sub-operation command, including sharing information about identified threats.
- Cooperation and information exchange with the operation command, sub-operation commands, provincial police headquarters (Capital Police), organizational units of the Chief Police Headquarters, and law enforcement agencies from other countries regarding incidents that may disrupt the course of the tournament.
- Collecting and processing information about events that may disrupt the tournament.
- Cooperating with other services, entities, and other non-police institutions.

International information exchange.

6. Participation of Police Forces in Ensuring Safety and Public Order

In order to ensure safety and public order during the UEFA EURO 2012 Final Tournament, officers from all provincial police headquarters were engaged. On average, about 6000 police officers were on duty each day in the host cities. However, in connection with the matches between the national teams of Poland and Russia and between Russia and Greece, the number of forces deployed in Warsaw increased to 14,000 and 16,000 officers, respectively.

The police also provided escorts for both football teams, referees, UEFA delegates, and observers. A total of 3376 officers were involved in this task, conducting 771 escorts and covering almost 40,000 kilometers. The police also had access to aircraft, including 17 helicopters and a CASA transport plane, which conducted 223 flights.

The activities of the Polish police were supported by officers from other countries as well. In total, 174 foreign officers were deployed to assist the Polish police. It is worth emphasizing that the involvement of police officers from other countries during significant sporting events serves as an excellent example of international police cooperation. The exchange of information, as well as the visible presence of officers, contributes to building trust between citizens and the national police on one hand, and between foreign fans and "their" police on the other (www: http://www.finanse.wp.pl/kat, 2012).

During the championships, due to public order disturbances, 652 individuals were arrested, including 473 Poles and 179 foreigners. Among the foreigners, Russian fans (100), Croatian fans (21), and Irish fans (19) were the most represented. The most common reasons for arrests were acts of hooliganism. The majority of individuals faced charges related to participation in an unlawful assembly, violating provisions of the mass event safety law, and assaulting police officers.

Assessing the level of safety in Poland during the tournament, compared to the same period in 2011, the number of thefts during the championships decreased from 3597 to 2946, and burglaries dropped from 1288 to 852. At the same time, there was a 22% reduction in robberies and approximately a 27% decrease in bodily injuries. Furthermore, despite the increase in road traffic participants, the number of traffic incidents decreased by 870 accidents, resulting in 125 fewer fatalities and 1,020 fewer injuries compared to the same period in 2011 (www: http://www.finanse.wp.pl/kat, 2012).

7. Summary

Organizing mass events requires the organizer to meet many requirements specified in applicable legal acts, primarily the Act of March 20, 2009, on the Safety of Mass Events. One of the key responsibilities for ensuring the safety of mass events lies with the organizer, and as specified in the aforementioned act and other regulations, it also falls on (Socha, 2013): the village mayor, town mayor, city president, voivode, police, State Fire Service, and other organizational units of fire protection, services responsible for safety and public order in railway areas, healthcare services, and, if necessary, also other relevant services and authorities (Journal of Laws of 2023, item 616). In this context, the police play a crucial role in the mass event security system as an armed and uniformed formation dedicated to serving the community and ensuring the safety of people, as well as maintaining security and public order (Journal of Laws of 2025, item 636). Detailed principles of organizing police actions during the security of mass events are regulated by internal regulations of the police force.

In conclusion, the actions taken by the Polish police, based on the presented operational philosophy, ensured the uninterrupted course of the event which was the UEFA EURO 2012 Final Tournament. This also serves as an excellent example of the Polish police's ability to manage the safety of mass events. Additionally, the police fulfilled their mission, which stated: "The highest standards of service and security will guarantee the safety of the tournament and its participants" (https://srem.policja.gov.pl/, 2025).

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ORGANIZATIONAL CULTURE AND THE LEVEL OF HEALTHCARE QUALITY AND PATIENT SAFETY IN LIGHT OF INTERNATIONAL EXPERIENCES

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Purpose: The aim of this study is to analyze the state of research on the relationship between organizational culture and the level of healthcare quality and patient safety in light of international experiences.
Design/methodology/approach: The article is a non-systematic literature review. Searches for studies on organizational culture and healthcare quality were conducted in databases such as Google Scholar, Web of Science, PubMed, and Scopus. The search queries included the following descriptors: "organizational culture", "organizational culture and hospital", "organizational culture and health care system", "patient safety", and "quality of health care". Original primary articles focusing on organizational culture and healthcare quality, available in full text in English online, were included in the study. The search identified 70 studies, of which 26 were excluded due to factors such as inappropriate study design, lack of relevance to the research objective, or outdated data. Ultimately, 44 studies met the inclusion criteria and were included in the analysis. The selected articles underwent detailed analysis, and significant data were extracted and organized by the author. The collected data were divided into specific sections, such as organizational culture, safety culture, the impact of management on healthcare quality, organizational culture change, and quality in healthcare. To ensure a coherent presentation of the results, a narrative approach to data synthesis was applied, involving the integration of information from the studies to provide a comprehensive review of the findings.
Findings: The final conclusion is the need to treat organizational culture as an integral component of quality management in healthcare. The pursuit of improving quality and patient safety cannot be limited to formal procedures and tools but should be rooted in values and attitudes supporting shared responsibility, continuous improvement, and mutual respect. Only in such an environment is it possible to achieve sustainable improvement in both clinical outcomes and the experiences of patients and staff. At the same time, it should be emphasized that there is a research gap in analyzing the impact of organizational culture on healthcare quality and patient safety. This area requires in-depth research that will allow for a better understanding of the cultural mechanisms determining quality in healthcare systems.
Originality/value: This paper offers a non-systematic literature review of 44 selected studies that explores the relationship between organizational culture, healthcare quality and patient safety. Value of the paper is synthesis of current knowledge, practical recommendations,

multidimensional analysis, cross-cultural comparative approach, integration of staff and patient perspectives. This paper appears to be addressed to key groups: healthcare administration and managers, clinical leaders, healthcare quality specialists, healthcare policy makers, healthcare educators.
Keywords: organizational culture, patient safety, healthcare quality, leadership, just culture, healthcare management.
Category of the paper: literature review.

1. Introduction

Organizational culture in healthcare is a fundamental element determining the quality of care, patient safety, and the efficiency of medical facilities. In an era of dynamic changes in healthcare systems, rising patient expectations, and increasing economic pressures, understanding and appropriately shaping organizational culture has gained particular importance. As research indicates (Schein, 2017; Braithwaite et al., 2017), shared values, norms, and practices among organizational members directly influence not only staff behavior but also clinical outcomes, patient satisfaction, and the institution's ability to implement innovations and adapt to changing conditions. This article focuses on analyzing the multidimensional relationships between organizational culture and the quality of healthcare services, with particular emphasis on the concept of safety culture (Just Culture) and the role of leadership in shaping an environment conducive to continuous improvement. As Florence Nightingale noted as early as 1863, the primary requirement of a hospital is to "do no harm to the sick" (Kaufman, McCaughan, 2013). However, the modern understanding of patient safety goes far beyond avoiding errors, encompassing the proactive building of high-reliability systems (Weick, Sutcliffe, 2007). Based on the current state of knowledge and an analysis of empirical studies, the article presents organizational culture models relevant to the healthcare sector, including Hofstede's model, the Organizational Culture Assessment Instrument (OCAI), and the concept of Just Culture. Special attention is paid to the challenges of implementing desired cultural patterns in environments with strong hierarchical traditions and the importance of open communication and emotion management in crisis situations. Furthermore, the article explores the links between organizational culture and transformational and authentic leadership, which, according to recent research (Vehvilainen et al., 2024; Tate et al., 2023), are key determinants of staff engagement and care quality. A comprehensive understanding of the mechanisms shaping organizational culture in healthcare institutions has significant implications for both management theory and clinical practice. The synthesis of knowledge from management, organizational psychology, and medical sciences enables the development of a holistic approach to improving care quality, which considers both the technical and social aspects of medical institutions' functioning. In light of the growing challenges facing healthcare

systems worldwide, investing in building a positive organizational culture has become a priority of fundamental importance for the future of this sector.

2. Organizational Culture in Healthcare Institutions

Organizational culture plays a key role in the functioning of healthcare institutions, influencing patient safety, the well-being of medical staff, and the efficiency of services provided. The literature review reveals multidimensional links between organizational culture and various aspects of medical organizations' operations. Silva et al. (2021), in a systematic review of studies from 2014-2020, demonstrated that a positive safety environment in hospitals fosters the development of a safety culture, encourages the reporting of adverse events, and contributes to improved healthcare quality. However, the authors note that the literature inadequately describes the interactions between safety culture and organizational culture, emphasizing the need to strengthen safety culture through education and inter-team collaboration (Silva, Caldas, Fassarella, Souza, 2021). Hsiung et al. (2020) identified 27 tools for measuring organizational culture and climate in primary care, highlighting the diversity of available instruments and the limited availability of data on their psychometric properties. The researchers recommend several tools, including the Culture Questionnaire adapted for healthcare settings and the Nurse Practitioner Primary Care Organizational Climate Questionnaire, while also stressing the need for further validation studies (Hsiung, Colclitz, McGuier, Switzer, VonVille, Folo, Kalko, 2020). Hibbert et al. (2023) focused on the perspectives of international patient safety experts, identifying four key factors influencing healthcare quality improvement: safety culture in healthcare organizations, policies and procedures for investigating and implementing safety initiatives, support for medical staff, and patient engagement. Based on these findings, the authors proposed a patient safety management model that can serve as a tool for policymakers and researchers (Hibbert, Stewart, Wiles, Braithwaite, Runciman, Thomas, 2023).

D'Silva et al. (2024) analyzed the impact of organizational culture on employee behavior and well-being in an emergency medicine department in India. Using the Organizational Culture Assessment Instrument (OCAI), they identified a clan culture as dominant (73.17%), characterized by collaboration and adaptability. Employees operating in this culture reported higher job satisfaction (96.66%) and lower stress levels (48.33%) compared to other types of organizational cultures (market, adhocracy, hierarchical). Nevertheless, symptoms of burnout, including emotional exhaustion (53.66%), were common. The study underscores the importance of organizational culture for department efficiency and employee well-being (D'Silva, Balakrishnan, Bari, Verma, Kamath, 2024). Kim and Jung (2022) analyzed the impact of organizational culture and employee competencies on perceived workplace stress.

Their results indicate that aligning the type of organizational culture with employee competencies can effectively reduce stress levels. Specifically, clan culture proved more effective in reducing stress among employees with adaptive competencies, while market culture better supported customer-oriented employees. The authors emphasize that a mismatch between organizational culture and employee competencies can lead to increased stress and decreased performance (Kim, Jung, 2022). Mutonyi et al. (2022) examined the impact of an internal market-oriented culture and autonomy-supportive leadership climate on organizational attractiveness and innovative employee behavior in Norwegian hospitals. The results showed that an internal market-oriented culture positively influences autonomy-supportive leadership and organizational attractiveness, while the autonomy-supportive leadership climate further enhances organizational attractiveness and innovative employee behavior. The study highlights the importance of investing in organizational culture and autonomy support for improving innovation and workplace attractiveness (Mutonyi, Slåtten, Lien, González-Piñero, 2022).

In summary, the literature analysis indicates the significant role of organizational culture in shaping the work environment in healthcare institutions. A well-matched organizational culture can contribute to improved patient safety, reduced stress and burnout among medical staff, and increased innovation and organizational attractiveness. Further research in this area should focus on practical implications and interventions aimed at shaping optimal organizational culture in healthcare facilities (Silva et al., 2021; Hsiung et al., 2020; Hibbert et al., 2023; D'Silva et al., 2024; Kim, Jung, 2022; Mutonyi et al., 2022).

3. Safety Culture as the Foundation of High-Quality Healthcare and Patient Safety

Patient safety is the cornerstone of modern healthcare. As early as 1863, Florence Nightingale emphasized that the primary requirement of a hospital is to "do no harm to the sick" (Kaufman, McCaughan, 2013). Despite significant advancements in medicine and technology, challenges related to patient safety remain critical for healthcare systems worldwide. These challenges require a systematic approach encompassing not only procedures but also a fundamental cultural shift in medical organizations (Culture of Safety. PSNet [internet], 2019).

Safety culture, derived from research on high-reliability organizations (HROs), is characterized by risk acknowledgment, a blame-free environment, interdisciplinary collaboration, and organizational commitment to problem-solving (Weick, Sutcliffe, 2007). The concept of "just culture" balances a "no-blame" approach with appropriate accountability, distinguishing between human error, risky behavior, and reckless behavior (Dekker, 2012; Marx, 2001). Studies show that a low perceived safety culture is associated with a higher rate

of medical errors (Mardon, Khanna, Sorra et al., 2010). Examples of failures at Bristol Royal Infirmary and Mid Staffordshire NHS Foundation Trust demonstrate how the lack of an appropriate organizational culture can lead to serious consequences for patients (Kaufman, McCaughan, 2013). This chapter analyzes how effective leadership, transparency, and teamwork shape an organizational culture conducive to patient safety, as well as the challenges and assessment methods associated with this process.

Implementing a just culture in healthcare organizations involves numerous challenges. Research by Van Baarle et al. indicates that key elements include open communication, consideration of emotions, and management engagement (Van Baarle, Hartman et al., 2022). Open communication is essential for creating a just culture. Employees should feel safe reporting errors and sharing their experiences. However, finding a balance between openness and individual accountability is challenging. Additionally, emotions related to incidents can hinder objective fact analysis, posing another challenge for organizations (Van Baarle, Hartman et al., 2022). Management engagement is crucial for the success of a just culture. Leaders should exemplify desired behaviors and support employees in learning from mistakes. However, management must also maintain an appropriate distance to objectively assess situations and make informed decisions (Van Baarle, Hartman et al., 2022). Safety culture is fundamentally a local issue, as significant variations in safety culture perceptions can exist within a single organization. Safety culture perceptions may be high in one hospital unit and low in another, or high among management and low among frontline staff (Pronovost, Weast, Holzmueller et al., 2003). Studies also show that individual employee burnout negatively impacts safety culture perceptions (Hall, Johnson, Watt et al., 2016). Many determinants of safety culture depend on interprofessional relationships and other local circumstances, meaning that safety culture change occurs at the microsystem level. Consequently, improving safety culture often requires an emphasis on gradual changes in daily employee behaviors (Mohr, Batalden, 2002). Recent research highlights strong links between patient safety culture and workplace safety culture. A study by Hesgrove et al. found that 69 of 110 examined relationships between these two aspects of safety culture were statistically significant (Hesgrove, Zebrak, Yount, Sorra, Ginsberg, 2024). The strongest correlations with patient safety culture were observed in three aspects of workplace safety culture: overall hospital management support for workplace safety, the ability to report safety concerns without fear of negative consequences, and general workplace safety ratings. Stress and burnout are serious issues among healthcare workers that can negatively impact safety culture. Studies have shown that higher stress and burnout levels were associated with lower patient safety culture ratings (Hesgrove, Zebrak, Yount, Sorra, Ginsberg, 2024). Both the National Quality Forum's Safe Practices for Healthcare and the Leapfrog Group mandate safety culture assessments. The Agency for Healthcare Research and Quality (AHRQ) also recommends annual safety culture measurement as one of its "10 Patient Safety Tips for Hospitals" (Agency for Healthcare Research and Quality, 2018). Additionally,

research indicates growing interest in managing organizational culture as a lever for healthcare improvement (Mannion, Konteh, Davies, 2009).

Achieving a safety culture in healthcare is essential for preventing or reducing errors and improving overall care quality. This requires a systematic approach, management engagement, and changes to fundamental organizational norms and values. Research confirms that high-reliability organizations place significant emphasis on safety culture and organizational factors contributing to a safe work environment (Clark, 2002). Transitioning from a traditional blame culture to a safety culture that encourages error reporting and root cause analysis is necessary for meaningful improvements in patient safety and healthcare quality. Only by creating an environment where patient safety is a priority can we effectively reduce adverse events and improve patient outcomes.

Patient safety culture is a key element of healthcare quality, influencing both treatment outcomes and the well-being of medical staff. In recent decades, there has been growing interest in examining the factors shaping this culture and its impact on medical institutions' functioning. Researchers highlight the need for coherent theoretical frameworks and effective measurement tools to enable comprehensive analysis of this phenomenon (Bisbey et al., 2019). Existing studies show that safety culture is multidimensional and shaped by numerous organizational, team, and individual factors. Among these, staff attitudes, leadership, communication, organizational learning capacity, and human and material resources are particularly significant (Azyabi et al., 2021). Bisbey et al. (2019) note the fragmentation and inconsistency of existing safety culture theories, which hinder the development of practices and research in this area. Based on a review of 50 models, the authors proposed an integrated theoretical framework grounded in organizational culture theory, social identity theory, and social learning theory (Bisbey et al., 2019). This model presents safety culture as a dynamic social structure operating at three levels: artifacts and behavioral norms (most visible), values (intermediate level), and basic assumptions (deepest level). The researchers identified seven key factors enabling the adoption of a safety culture, including leadership, available resources, and group cohesion, as well as four types of behaviors realizing this culture, such as communication and collaboration (Bisbey et al., 2019). A systematic literature review by Azyabi et al. (2021) identified five main tools for assessing patient safety culture in hospital settings: the Hospital Survey on Patient Safety Culture (HSPSC), the Safety Attitudes Questionnaire (SAQ), the Patient Safety Climate in Healthcare Organizations (PSCHO), the Modified Stanford Instrument (MSI-2006), and the Scottish Hospital Safety Questionnaire (SHSQ). Each of these tools focuses on slightly different aspects of safety culture, enabling a multidimensional analysis of this phenomenon (Azyabi et al., 2021).

One of the most commonly used tools, the Safety Attitudes Questionnaire (SAQ), was employed in a study by AL-Mugheed et al. (2022) in two private hospitals in Northern Cyprus. This study assessed attitudes toward patient safety among doctors and nurses and examined the relationships between workload, adverse events, professional experience,

and these attitudes (AL-Mugheed et al., 2022). The study, involving 73 doctors and 246 nurses, found that overall attitudes toward patient safety among medical staff were negative (below the positive threshold of 75%). The highest positive rating was for working conditions (64.2%), while the lowest was for safety climate (49.7%). An interesting finding was that nurses exhibited more positive attitudes (63.3%) than doctors (54.3%), with statistically significant differences in dimensions such as job satisfaction, stress recognition, and management perceptions (AL-Mugheed et al., 2022). The researchers also identified significant factors influencing safety attitudes. Staff with less professional experience (1-5 years) and those working more than 48 hours per week or reporting more adverse events exhibited lower positive attitudes toward patient safety. These results indicate the need for appropriate training, management support, and institutional regulations to improve patient safety in hospitals (AL-Mugheed et al., 2022).

Patient safety culture varies significantly depending on geographic and cultural context. Granel-Giménez et al. (2022) conducted a comparative study in four European countries: Croatia, Spain, Sweden, and Hungary. Mixed research methods were used, combining quantitative data collected via the HSOPSC questionnaire from 538 nurses with qualitative data from in-depth interviews and work observations (Granel-Giménez et al., 2022). The results showed that teamwork was the highest-rated aspect of safety culture, particularly in Sweden. The biggest weaknesses were staff shortages and excessive workload. In countries like Croatia and Hungary, discrepancies were observed between declared positive attitudes toward safety culture and actual practices and hierarchical work cultures. In Sweden, better work organization and higher safety culture were noted, though further improvements were still needed. The researchers emphasize that most studied countries exhibited only average patient safety cultures despite being part of the European Union (Granel-Giménez et al., 2022).

Hesgrove et al. (2024) examined the relationship between staff safety culture and patient safety culture in hospital settings based on data from 28 hospitals in 16 U.S. states, analyzing responses from 6684 healthcare workers. The study found a strong link between these two aspects of safety culture—69 of 110 analyzed relationships were statistically significant (Hesgrove et al., 2024). The strongest correlations with patient safety culture were observed in three aspects of staff safety culture: overall hospital management support for workplace safety, the ability to report safety concerns without negative consequences, and general workplace safety ratings. Particularly strong relationships were found between general workplace safety ratings and hospital management support for patient safety, and between management support for workplace safety and management support for patient safety (Hesgrove et al., 2024). This study provides empirical evidence that staff safety culture and patient safety culture are fundamentally interconnected and jointly contribute to creating a strong and healthy safety culture in healthcare facilities (Hesgrove et al., 2024). Lu et al. (2022) investigated the relationship between patient safety culture and healthcare worker well-being using the Conservation of Resources (COR) theory. Analyzing data from a large group of hospital staff

in Taiwan (N = 3,232), the researchers demonstrated that patient safety culture is significantly associated with lower burnout levels (β = -0.74) and higher work-life balance (β = 0.44) (Lu et al., 2022). Importantly, these effects were consistent regardless of age, gender, position, or patient contact, suggesting the universal nature of this phenomenon. This study indicates that investing in safety culture can serve as an organizational resource protecting staff well-being while simultaneously improving patient care quality (Lu et al., 2022). These findings align with the study by Hesgrove et al. (2024), who observed that higher stress and burnout levels were linked to lower patient safety culture scores, particularly in areas of staffing and work pace (Hesgrove et al., 2024). The presented studies clearly highlight the need for comprehensive strategies to improve patient safety culture in healthcare facilities.

AL-Mugheed et al. (2022) emphasize the necessity of improving patient safety in hospitals through training, management support, and institutional regulations. They also note that negative attitudes can hinder the implementation of interventions aimed at improving care quality (AL-Mugheed et al., 2022). Azyabi et al. (2021) recommend regular monitoring of patient safety culture and considering cultural and systemic differences in research on this phenomenon. Bisbey et al. (2019) suggest that effectively developing a safety culture requires actions at all three levels: artifacts and behavioral norms, values, and basic assumptions (Bisbey et al., 2019). Hesgrove et al. (2024) advocate for a systemic approach that considers both staff and patient safety, which can lead to synergistic effects in improving healthcare quality. Meanwhile, Lu et al. (2022) propose that investments in safety culture can benefit not only treatment outcomes but also the well-being of medical staff (Lu et al., 2022).

A common conclusion from these studies is that patient safety culture should be treated as a key component of healthcare facility management strategies, requiring systematic monitoring, an interdisciplinary approach, and engagement at all organizational levels, from management to frontline staff.

4. The Impact of Healthcare Facility Management on Healthcare Quality and Patient Safety

Management in healthcare plays a crucial role in shaping healthcare quality, patient satisfaction, and organizational efficiency. Contemporary research, such as that conducted by Vehvilainen, Kang, and Tate (Vehvilainen et al., 2024; Kang et al., 2023; Tate et al., 2023), indicates that key factors such as leadership style, organizational culture, and employee engagement significantly influence healthcare outcomes. This chapter integrates the findings of these studies to provide a comprehensive perspective on how management can shape healthcare quality. Leadership in healthcare can take various forms, with transformational and authentic leadership being particularly significant. Research by Vehvilainen (Vehvilainen et al.,

2024) found that collaborative leadership, which challenges traditional hierarchies, fosters open communication and the reporting of concerns by employees. Leaders who promote psychological safety create an environment conducive to learning from mistakes (Edmondson, 1999). Tate (Tate et al., 2023) highlight the importance of authentic leadership, which is based on self-awareness, balanced information processing, and trust. In their study, a model incorporating authentic leadership and a developmental/group culture explained 50.7% of the variance in patient satisfaction in groups with high levels of such leadership. Authentic leadership combined with a collaborative organizational culture significantly improves care quality. Leaders who are transparent and build trust influence increased employee engagement, which translates into better treatment outcomes and higher patient satisfaction (Tate et al., 2023).

An organizational culture based on trust and fairness increases employees' willingness to take initiative and report errors, which is critical for improving patient safety (Vehvilainen et al., 2024). In such environments, employees feel safe expressing concerns, leading to faster problem resolution. Tate (Tate et al., 2023) distinguish between developmental/group cultures (focused on collaboration) and hierarchical/rational cultures (focused on efficiency). Developmental/group cultures are strongly correlated with better care quality outcomes, while hierarchical cultures may limit innovation and flexibility. Rigid hierarchies in healthcare can marginalize the voices of younger employees and patients, negatively impacting care quality (Vehvilainen et al., 2024). Solutions include training that supports teamwork and involving employees at all levels in decision-making processes. Kang (Kang et al., 2023) demonstrated that values such as excellence and innovation have a strong positive impact on patient satisfaction, even when employee well-being is not high. However, long-term neglect of staff well-being can lead to burnout and declining care quality. Research shows that in hospitals with high levels of authentic leadership and a developmental/group culture, care quality and patient satisfaction are significantly higher (Tate et al., 2023). In such organizations, patients feel more cared for, and staff are more motivated to provide high-quality services. Implementing anonymous reporting systems for concerns can improve communication and patient safety, enabling faster responses to potential risks (Vehvilainen et al., 2024). The integration of research findings confirms that effective healthcare management requires a combination of authentic leadership, an organizational culture based on trust, and actions to reduce the negative impact of hierarchies. Implementing these recommendations can lead to improvements in care quality, patient safety, and staff satisfaction. Effective hospital management directly impacts patient treatment outcomes by streamlining organizational processes.

Bhati, Deogade, and Kanyal (2023) highlight the importance of elements such as leadership, financial management, human resources, quality, and patient safety. The authors also emphasize the value of a patient-centered approach, interdisciplinary collaboration, and data-driven decision-making as strategies for improving care quality (Bhati, Deogade, Kanyal, 2023). Credible leadership plays a key role in shaping the organizational culture of medical

facilities, which in turn translates into staff engagement. A study by Srimulyani and Hermanto (2022) demonstrates that there is a significant positive impact of credible leadership on organizational culture, which subsequently increases employee engagement at work. Higher staff engagement directly translates into better quality of medical services provided (Srimulyani, Hermanto, 2022). Frontline managers have a significant impact on patient safety by shaping safety culture in medical facilities. Hedsköld et al. (2021) identified strategies used by effective managers, such as valuing staff competencies, organizing work to increase resilience to errors, and learning from reported incidents. The study emphasizes that frontline managers' engagement and their role-modeling behavior are crucial for patient safety, despite challenges in bridging theory and practice (Hedsköld, Sachs, Rosander, von Knorring, Pukk-Härenstam, 2021).

Healthcare quality is directly linked to effective management at various levels of a medical organization—from strategic leadership to operational frontline management. Key aspects include building a positive organizational culture, promoting patient safety, increasing staff engagement, and implementing patient-centered care while leveraging modern technologies and data for decision-making.

5. Changing Organizational Culture to Improve Healthcare Quality and Patient Safety

The role of organizational culture in improving patient safety: A comparative analysis of two programs. Organizational culture is a fundamental element determining patient safety in healthcare facilities. The two studies presented, though conducted in different socio-economic contexts, highlight the crucial role that transforming organizational culture plays in improving care quality and patient safety. A comparative analysis of these studies provides valuable insights into effective strategies for implementing cultural changes in different healthcare systems. The program implemented at the University of Washington represents a systematic, multi-year approach to shaping safety culture through resident education. A key element of this program was integrating educational activities with the operational aspects of the medical center, maximizing both educational and practical value (Chen et al., 2021). The program's gradual structure, based on the Kirkpatrick model, enabled the building of patient safety culture from the ground up—starting with raising awareness and promoting the reporting of adverse events, through learning quality improvement methodologies, to implementing specific projects to streamline processes at the medical center (Chen, Wolpaw, Vande Vusse, Wu, Meo, Staub, Hicks, Carr, Schleyer, Harrington, Klein, 2021).

In contrast to the Washington program, the study conducted at an Ethiopian hospital in Gondar focused on diagnosing the existing organizational culture and identifying barriers to implementing changes in the cardiology unit. The results of this study revealed significant deficits in psychological safety among employees and limited opportunities for organizational learning, despite high levels of declared staff engagement (Mengstie et al., 2023). Identified barriers to change, such as employee resistance, lack of management support, and inequalities in access to medical services, underscore the complexity of challenges associated with transforming organizational culture in resource-limited settings (Mengstie, Biks, Cherlin, Curry, 2023). Comparing the two studies allows for the identification of common features of effective strategies for changing organizational culture to improve patient safety. Key elements include: building psychological safety to enable open reporting of adverse events, engaging facility management in the change process, creating multidisciplinary teams, and systematically monitoring the effectiveness of implemented initiatives. The Washington program demonstrates that integrating education with clinical practice can effectively break down communication barriers between different organizational levels, which was identified as a significant problem in the Gondar hospital (Chen et al., 2021).

A particularly important aspect emphasized in both studies is the role of psychological safety in shaping a culture conducive to improving care quality. The Washington program placed strong emphasis on creating an atmosphere that encouraged residents to report patient safety events, while the Gondar hospital identified low psychological safety as one of the main barriers to change. This convergence confirms that without an environment where employees feel safe reporting problems and proposing improvements, it is impossible to effectively implement safety culture and care quality (Chen et al., 2021). An interesting aspect of the Washington program was the creation of specialized positions: a Quality Improvement and Patient Safety (QIPS) director and an associate program director for healthcare systems. These roles served as a bridge between residents and medical center leadership, enabling the effective implementation of changes proposed by residents. In the context of the Gondar study, where lack of management support was identified as a significant barrier, a similar structural solution could help overcome this obstacle (Chen et al., 2021). The gradual approach to building safety culture used in the Washington program could serve as a valuable model for facilities facing challenges similar to those identified in the Gondar hospital. Starting with building awareness and psychological safety, followed by systematically developing competencies in quality improvement methodologies, may be more effective than attempting to implement comprehensive changes without adequate cultural preparation (Chen et al., 2021; Mengstie et al., 2023). It is also worth noting that both studies emphasized the importance of multidisciplinary collaboration in the process of organizational culture change. The Washington residency program enabled horizontal integration of training across different medical specialties, supporting the development of a comprehensive approach to quality improvement.

Similarly, the authors of the Gondar study recommend supporting multidisciplinary teams as a strategy for strengthening organizational culture (Chen et al., 2021; Mengstie et al., 2023).

In summary, the comparative analysis of the two studies indicates that effective organizational culture change to improve patient safety requires a systematic, multifaceted approach that considers both staff education and structural aspects of the organization. Key elements include building psychological safety, engaging leadership, creating multidisciplinary teams, and integrating educational and operational activities. Although the contexts of the two studies differ significantly, the common elements of effective strategies for organizational culture change can provide valuable guidance for other healthcare facilities striving to improve patient safety (Chen et al., 2021; Mengstie et al., 2023).

6. Quality in Healthcare: The Role of Organizational Culture, Leadership, and Quality Improvement Systems

Healthcare quality is a key factor determining the effectiveness of healthcare systems, patient satisfaction, and clinical outcomes. Research shows that high-quality care translates into better population health, reduced medical errors, and increased trust in medical institutions (West et al., 2011). This chapter discusses key elements influencing healthcare quality, with particular emphasis on the role of organizational culture, leadership, staff engagement, and quality improvement systems. Organizational culture in medical facilities plays a crucial role in shaping care standards. As Swensen and Mohta (Swensen, Mohta, 2019) note, organizational culture is the way organizations make decisions and how employees experience their work. In healthcare, culture can be both a barrier and a catalyst for change, influencing staff readiness to implement innovations and improve quality (Davies et al., 2000). According to Schein (Schein, 2004), organizational culture consists of three levels:

- Artifacts—visible manifestations of culture, such as organizational structure, procedures, or dress code.
- Values—beliefs and norms that influence decision-making.
- Basic assumptions—deeply rooted, often unconscious beliefs that shape behaviors.

In healthcare, culture can vary across professional groups (e.g., doctors vs. managers), leading to the emergence of subcultures or even countercultures that hinder collaboration and change implementation (West, 2012). Empirical studies such as NEJM Catalyst (2019) found that 59% of healthcare workers believe their organization's culture is changing for the better. However, 55% of respondents indicated that their organizations use a "top-down" approach to cultural change management, which the authors consider a sign of inefficiency. Swensen emphasizes that engaging employees in decision-making is crucial to prevent them from feeling that decisions are imposed "from above" (Swensen, Mohta, 2019). Leadership plays a key role

in shaping an organizational culture conducive to quality improvement. West (West, 2012) suggests that effective leaders should:

- Promote a shared vision—clearly communicate priorities related to care quality, e.g., through simple slogans like "patient needs come first" (Swensen, Mohta, 2019).
- Support staff engagement—encourage participation in decision-making processes, e.g., through daily team meetings.
- Build trust—through transparency and integrity in actions.

Research shows that organizations with strong quality cultures exhibit lower patient mortality, higher staff satisfaction, and better financial performance (West et al., 2011). According to the NEJM Catalyst study (2019), 33% of respondents believe that the CEO is primarily responsible for cultural change in the organization. However, Swensen and Mohta stress that responsibility should be distributed across the entire team to prevent culture from being dependent on a single individual (Swensen, Mohta, 2019). Quality improvement systems, such as accreditation, clinical audits, or risk management programs, play a crucial role in raising care standards. The DUQuE project (Groene et al., 2010) demonstrated that mature quality improvement systems are associated with:

- Better clinical outcomes—e.g., reduced medical errors.
- Greater patient engagement—involving them in decision-making processes.
- More effective risk management—through regular monitoring and analysis of adverse events.

Key elements of effective quality improvement systems include:

- Quality monitoring and measurement—using data to identify areas for improvement (Locke, Latham, 2013).
- Shaping organizational culture—promoting values such as collaboration and continuous improvement (Schein, 2004).

Analyzing the DUQuE project, which examined the relationships between quality improvement systems, organizational culture, professional engagement, and patient empowerment in European hospitals, the following recommendations for healthcare organizations can be made (Groene et al., 2010):

- Implement comprehensive quality improvement systems—instead of isolated quality tools, hospitals should develop integrated quality systems encompassing diverse improvement strategies.
- Consider organizational culture—quality improvement systems should be integrated with an organizational culture that supports change and staff engagement.
- Increase professional engagement—doctors and other medical staff should be actively involved in quality improvement processes, enhancing the effectiveness of implemented initiatives.

- Strengthen patient empowerment—hospitals should implement methods to increase patient participation in treatment decisions and use their experiences to improve organizational performance.
- Use maturity assessment frameworks—employ classification models for quality improvement system maturity to assess current status and plan further development.
- Adapt strategies to context—quality improvement strategies should be tailored to the specific hospital, country, and healthcare system.
- Measure impact on treatment outcomes—assessing the effectiveness of quality improvement systems should include their impact on clinical outcomes, patient safety, and patient experiences.
- Develop self-assessment tools—use catalogs of tools developed in the project to build and evaluate quality and safety programs.

Citing the bibliometric analysis conducted in the study "Organisational Culture Research in Healthcare: A Big Data Bibliometric Study" (Qin, Wang, Huang, Zhao, Chiu, Tung, Harrison, Wang, 2023), there is dynamic growth in interest in organizational culture in healthcare. The increase in publications from 1990 to the present, with predictions of further intensification in the coming years, reflects the growing importance of this area. The most active countries, such as the United States, the United Kingdom, Australia, and Canada, are also leaders in publication quality, as evidenced by citation metrics. Such data highlight that research on organizational culture is becoming not only a theoretical tool but also a practical instrument supporting care quality by identifying key areas, such as:

- Leadership—leaders play a decisive role in shaping organizational culture, motivating employees to adhere to high-quality standards and supporting patient safety initiatives.
- Care quality—research clearly indicates a correlation between positive organizational culture and better outcomes in service quality, including improved communication, safety system implementation, and reduced medical errors.
- Innovation and knowledge management—a culture that promotes openness to change and continuous learning enables medical facilities to quickly adapt new technologies and evidence-based practices.

Understanding organizational culture as a complex, multi-layered phenomenon is crucial for strategies to improve medical service quality. First, facility management must recognize that effective culture management involves not only implementing procedures and control systems but also building a shared vision that integrates diverse subcultures within the organization. Second, integrating qualitative research with bibliometric analytical tools enables the identification of trends and key areas requiring intervention. As a result, actions taken are more precise and targeted at specific facility needs, leading to improvements in patient safety, team efficiency, and overall service quality.

7. Discussion

The results of the analysis indicate that effective shaping of organizational culture in healthcare facilities requires an integrated approach, encompassing supportive leadership, open communication, and creating an environment conducive to learning. Mechanisms enabling two-way information exchange, psychological support, and promoting shared responsibility for healthcare quality and patient safety are of key importance here. These actions contribute to reducing the risk of burnout, increasing employee satisfaction, and improving clinical outcomes.

It is also important to adapt change strategies to the local organizational context. Rather than implementing standardized solutions, an approach based on needs assessment, gradual implementation of changes, and utilizing the opinions of internal leaders proves more effective. Such actions increase acceptance among staff, facilitate the implementation of innovations, and promote sustainable improvement in healthcare quality and patient safety. Key recommendations supporting these findings are summarized in Table 1.

Table 1.
Recommendations

Area	Recommendetion	Bibliography
Organizational culture	Strengthen clan culture through collaboration, adaptability, and team engagement.	D'Silva, R., Balakrishnan, J.M., Bari, T., Verma, R., Kamath, R. (2024). Organizational culture and burnout...
Safety culture	Implement 'just culture': promoting open communication and management support in error management.	Dekker, S. (2012). Just culture: Balancing safety and accountability...
Impact of management on healthcare quality	Promote authentic and transformational leadership styles to increase staff engagement and improve quality of care.	Tate, K., Bloodworth, L., Rezai, K., Taylor, R. (2023). Authentic leadership, organizational culture, and patient...
Changing organizational culture	Combine resident education with clinical practice to build a safety culture.	Chen, A. et al. (2021). Creating a framework to integrate residency program...
Quality in medical care	Implement comprehensive quality improvement systems, integrate organizational culture and patient involvement.	Groene, O. et al. (2010). Investigating organizational quality improvement systems, patient empowerment, organizational culture...

This table presents key recommendations for improving healthcare organizations across five critical areas. Each recommendation is supported by recent research cited in the bibliography column.

The findings presented in this chapter underscore the critical importance of a holistic approach to organizational culture development in healthcare settings. The evidence strongly suggests that healthcare facilities benefit most from integrating supportive leadership practices, fostering open communication channels, and establishing learning-oriented environments. These elements collectively create a foundation for two-way information exchange, psychological support systems, and shared accountability for quality care and patient safety.

The recommendations outlined in Table 1 provide actionable guidance across five key domains: organizational culture development, safety culture implementation, leadership impact on quality, cultural change management, and comprehensive quality improvement. By addressing these interconnected areas with evidence-based strategies, healthcare organizations can create environments that reduce burnout, enhance job satisfaction, and ultimately deliver better clinical outcomes for patients.

8. Summary and Conclusions

The article shows that organizational culture is not limited solely to formal structures – it is also a sphere in which intangible but key elements manifest, such as unwritten rules, traditions, or rituals that integrate the team and give it a common character. These subtle aspects are of great importance because they shape the way staff interpret everyday challenges, respond to crises, and implement changes. In the context of improving the quality of medical care, a strong, positive organizational culture fosters an environment in which patient safety and effective risk management are priorities. As a result, medical facilities with a well-established culture are better prepared to implement innovations, execute evidence-based strategies, and continuously improve processes.

The presented study constitutes a comprehensive analysis of the role of organizational culture in healthcare facilities, with particular emphasis on its impact on healthcare quality and patient safety. The author reviews current global scientific literature, indicating multidimensional relationships between organizational culture, healthcare quality, and patient safety. At the same time, they recognize a gap in this area of research.

Organizational culture in healthcare has a significant impact on quality of care, patient safety, and staff well-being. The article shows that a culture based on collaboration, openness, and mutual trust fosters the effective functioning of medical facilities. Clan culture, promoting team bonds and flexibility, contributes to greater employee engagement and job satisfaction. On the other hand, a safety culture, in which staff can report errors and hazards without fear, forms the foundation for effective clinical risk management and reduction of adverse events.

Management plays a key role in shaping desired cultural patterns. Effective leadership, both transformational and authentic, plays an important role in building an environment conducive to learning, open communication, and psychological safety. Leaders who promote engagement and transparency have a direct impact on the quality of services provided and the level of trust within the organization. The article demonstrates that leadership style and the nature of organizational culture are inextricably linked and jointly determine the effectiveness of corrective and developmental actions.

Transforming organizational culture requires a systemic and long-term approach. It is indicated that combining education with clinical practice, developing multitasking teams, and creating structural support mechanisms for employees are effective tools for introducing changes. Effective cultural change is only possible when it is embedded in the realities of a given organization, takes into account local needs and barriers, and actively involves all participants in the system – from management to frontline workers.

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EMBRACING INDUSTRY 5.0: HUMAN-CENTRIC DESIGN OF IIoT ENABLED DIGITAL TWINS IN THE PRINTING INDUSTRY

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Purpose: Investigating the human-centered frameworks for Industry 5.0 (I5.0), such as the Industrial Internet of Things (IIoT) and Digital Twins (DTs) within the automated printing industries is the study's key. It also explores the factors impacting the industry adoption and implementation of IIoT and DTs.
Design/methodology/approach: The research follows a qualitative and conceptual approach based on systematic literature review of recent research papers and industry reports. Key technologies, such as collaborative robots and DTs, are explored in their role in enhancing Human-Machine Collaboration (HMC) especially in the printing industry sector.
Findings: I5.0 technologies like IIoT as well as DTs in the printing industry improve efficiency, product development, Predictive Maintenance (PdM), and overall performance. As per the findings, the practices and approaches required to implement IIoT in the printing industry.
Research limitations/implications: IIoT and DTs are transforming businesses' operations in today's world. The use of these technologies helps to enable real-time monitoring, PdM, optimized processes, and improved Decision-Making (DM) in automated printing industries, ultimately boosting efficiency and quality while reducing costs.
Originality/value: This study pioneers by examining I5.0 technology role in the printing industry. The study provides insights into interoperability, digital transformation and integration, PdM, optimized operations, and data-driven DM in automated printing environments.
Keywords: Industry 5.0, IIoT, Human-Centric, Printing Industry, Industry Internet of Things, Predictive maintenance.
Category of the paper: Research article.

1. Introduction

There is a constant evolution in the industrial background, determined by technological advancements and the chase of greater efficiency as well as productivity. Different industrial eras are transformed by emerging technologies. Traditional industrial practices' transformation into novel methodologies, conquered by the technologies open at that time, is termed the

industrial revolution. Building upon the early '4' industrial revolutions, I5.0 introduces a paradigm emphasizing the synergy betwixt advanced technologies and human values (Bazel et al., 2024; Sarioglu, 2023; Santhi, Muthuswamy, 2023; Kumar, 2024). Unlike Industry 4.0, which prioritized automation and data exchange, I5.0 aims on engendering a Human-Centric (HC), resilient, and sustainable industrial ecosystem (Toth et al., 2023; Pacheco, Iwaszczenko, 2024). It addresses Industry 4.0's limitations by placing human well-being together with collaboration at the center of industrial processes (Alves et al., 2023; Khan et al., 2023). In this era, industrial operation convergence with technologies like the IIoT permits real-time data processing, PdM, together with enhanced DM across manufacturing environments. In Figure 1, the key benefits of IIoT implementation in industries are given.

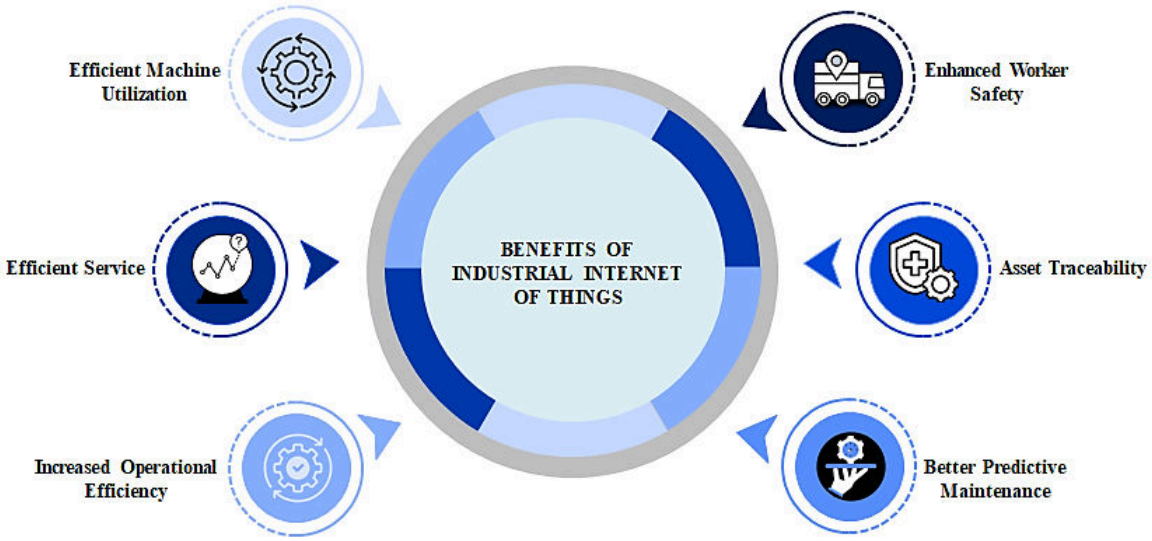

Figure 1. Benefits of IIoT systems.

Source: own elaboration.

Due to sensing, data storage, and intelligent control capabilities within innovative manufacturing environments, IIoT technologies are witnessing exponential growth (Hu et al., 2021; Hussain et al., 2021; Zheng et al., 2020; Alhuqay et al., 2024; Ayeni, 2025). IIoT incorporates huge sensors meant for smart and connected monitoring of machine conditions (Kan et al., 2018; Abuhasel, Khan, 2020). The IIoT potential automation, efficiency, and data-driven DM by real-time data collection and analysis (Jamil et al., 2024). These developments significantly increase productivity and reduce capital and operational costs in industries (Alabadi et al., 2022; Ahmed et al., 2023). However, disparities in productivity and performance still exist, especially while machine-to-machine communication is combined with big data analytics without human oversight or coordination (Jaidka et al., 2020; Hou et al., 2023). Besides, the printing industry faces critical challenges in integrating I5.0 technologies, such as IIoT and DTs, due to limited awareness, lack of implementation strategies, and interoperability issues. While previous studies have examined the adoption of IIoT in broader manufacturing contexts, there is a clear research gap in exploring human-centered

frameworks for I5.0 within automated printing environments. Thus, the present research scrutinizes the role of I5.0 and IIoT in the automated printing industry.

The research objectives are:

- To investigate the IIoT's adoption and implementation in production along with manufacturing environments under the I5.0 model.
- To identify the practices together with the approaches of organizations toward implementing IIoT solutions in the printing industry.
- To assess the implementation of HC DTs technology for industrial automation scenarios that support and augment interactions among humans and machines in the printing industry.
- To identify the key technologies facilitating the collaboration of autonomous machines and robots with humans in automated printing industries.

Despite a growing body of literature exploring the integration of Industry 5.0 technologies, particularly IIoT and Digital Twins (DTs), within broader manufacturing and engineering contexts, there is a notable lack of research that directly addresses their application through a human-centric lens in the automated printing industry. Most existing studies (e.g., Arnold, Voigt, 2018; Kumar, Iyer, 2019; Paliwoda et al., 2023; Ghafari et al., 2024) focus on:

- Generic industrial sectors such as packaging, engineering, or general manufacturing without considering the specific operational, technological, and human factors of the printing domain.
- The technological feasibility and performance impact of IIoT and DTs, with limited attention to human-machine collaboration (HMC)—a core tenet of Industry 5.0.
- The challenges of IIoT adoption in SMEs, but do not distinguish or investigate sector-specific barriers (e.g., high customization needs, legacy equipment, data variability in printing processes).
- Digital transformation and interoperability challenges in general terms, without contextualizing these within the complex workflows, error margins, and quality control demands of the printing industry.

Moreover, no prior study has systematically synthesized the adoption practices, enabling technologies, implementation strategies, and socio-technical barriers specific to human-centric IIoT and DT deployment in automated printing environments. The role of collaborative technologies like cobots and human-in-the-loop Digital Twins, though often mentioned conceptually, lacks empirical or contextual analysis within the printing industry sector. According to what we were able to find, there are no studies referring and reporting on this crucial topic.

After the introduction, the paper is structured as: the paper's literature review and research methods is elucidated in Section 2 and further in Section 3. The implementation of a basic IIoT under I5.0 model together with practices along with approaches toward IIoT implementation in

printing industry, technologies facilitating the HMC in the automated printing industry and elaborates of DTs' role in the printing industry, together with addressed challenges and barriers related to the implementation of I5.0 can be found in Section 4; lastly, Section 5, 6 and 7 focuses on results, discussion and conclusions.

2. Related literature review

The systematic literature review clearly reveals a significant research gap regarding the adoption and integration of Industry 5.0 (I5.0) frameworks specifically the Industrial Internet of Things (IIoT) and Digital Twins (DTs) in the automated printing industry. Although existing studies have extensively addressed IIoT and DTs within broader manufacturing contexts, such as engineering, general production environments, and packaging sectors, there remains an evident lack of focused research explicitly tailored in different printing technologies within the printing industry.

For instance, Arnold and Voigt (2018), Paliwoda et al. (2023), and Ptak and Lis (2024) primarily explored broader industrial contexts without specific attention to the nuanced demands of the printing sector. Similarly, research by Kumar and Iyer (2019), Ghafari et al. (2024), and Hsu (2023) identified general benefits and challenges of IIoT and DTs but did not specifically address the unique complexities and operational variables of the printing industry.

The thematic review also identified critical areas where research remains sparse:

- No studies have explicitly examined the human-centric implications of integrating I5.0 technologies within the automated printing sector.
- Existing literature predominantly focuses on technological adoption and implementation without adequately exploring the combined human-machine collaboration (HMC) dimensions essential to I5.0.
- Limited empirical research is available regarding the specific operational benefits, barriers, and strategic solutions unique to digital transformation in the automated printing context.

According to this, there are no existing studies comprehensively reporting on the application, integration, and implications of human-centered I5.0 frameworks, particularly IIoT and DT technologies, within automated printing environments. Therefore, this study fills an essential research gap by providing detailed insights into this unexplored area, highlighting how human-machine collaboration and advanced technologies can cohesively enhance productivity, sustainability, and operational efficiency within the automated printing industry. (Arnold, Voigt, 2018) scrutinized IIoT adoption factors. The data required for the study were gathered from 197 manufacturers through a survey questionnaire in Germany. By using logistic regression analysis, the data was tested. The study's findings showed that the factors from

technology, organization, and environmental perspectives significantly impacted the adoption of the IIoT. The study included firm size as an independent variable, but it failed to differentiate the firm size between small and large companies.

Paliwoda et al. (2023) assessed the practices of organizations toward implementing IIoT solutions in the packaging industry. The quantitative data was collected through a questionnaire and Computer Assisted Telephone Interview (CATI) from 132 companies in Poland. As per the results, the companies within the packaging industry were not early adopters of IIoT. Also, the companies were digitally immature, with poor IIoT implementation and quality system digitization. Yet, the sample only consisted of companies in Poland.

Ptak and Lis (2024) scrutinized IIoT's role and impact on augmenting engineering operations via process automation. From 142 enterprises in Poland, the data was obtained based on a questionnaire survey. Descriptive statistics analyzed the data. It indicated that IIoT implementation increased the competitiveness of enterprises. Also, the lack of sufficient machine monitoring, recurrent breakdowns as well as downtime, and the high cost were the IIoT implementation challenges. Yet, survey respondents were medium-sized enterprises.

Peter et al. (2023) examined how the IIoT transformation impacted the performance of manufacturing enterprises. It was centered on a qualitative research approach. The study data was taken from 21 experts through semi-structured interviews from Morocco, the United States, Nigeria, and South Africa. The challenges of IIoT are data security and confidentiality, authenticity, data integrity, cultural behavior, and user acceptance of the technology. Yet, not all the experts were attentive in participating in an interview, which might result in bias.

Rajkumar et al. (2025) applied a HC approach to improve manufacturing's productiveness, creativity, and standard efficiency. The study included quantitative data, qualitative observations, and case research. The study found that I5.0 permitted sustainable manufacturing processes by incorporating loftier technology with collaborative robotics and Artificial Intelligence (AI); also, amplified fact with human capabilities as well as creativity.

Sivathanu (2019) scrutinized the adoption of IIoT through the Technology-Organization-Environment (TOE). The data was amassed via face-to-face interviews with 45 managers using a questionnaire. By employing PLS-SEM, the data were analyzed. As per the study, IIoT adoption was impacted by factors like IIoT expertise, relative advantage, IIoT infrastructure, compatibility, security, cost, organizational readiness, competitive pressure, top management support, as well as support from technology vendors. Yet, it failed to explore the challenges along with resistance factors inhibiting IIoT's adoption intention.

Annavarapu (2024) discovered the transformative impact of IIoT on manufacturing processes. A mixed-method approach was employed. Through surveys and interviews, the data had been collected. The data was analyzed using statistical techniques. By enabling real-time monitoring and PdM, IIoT integration improved manufacturing efficiency. Also, the integration of IIoT led to enhanced visibility into manufacturing processes, better

resource utilization, and improved product quality. Yet, the study did not explore the longer-term impacts of IIoT on the manufacturing sector.

Kumar and Iyer (2019) explored the benefits and challenges of IIoT in the engineering and manufacturing industries. The data had been collected through interviews with industry experts. As per the study, the benefits of IIoT in industries were digitally connected and remote management, facility management, auto supervision, real-time asset as well as inventory management, plant safety and security, and quality control. Besides, the challenges of IIoT are security issues, connectivity, and visibility. But, the study only focused on the engineering and manufacturing industries.

Ghafari, Shourangiz and Wang (2024) aimed to conduct the cost-effectiveness of the adoption of IIoT in the manufacturing industries. The study appraised the data from the Industrial Assessment Centers database, aiming on 62 U.S. manufacturing smaller-scale enterprises across 10 states and 25 Standard Industrial Classifications. By employing inferential statistics, the data was analysed. As per the result, the adoption of IIoT wasn't just operationally beneficial for SMEs but also for financial prudence, which causes a key cost-trade-off. The study only considered the manufacturing industries. Thus, the same results were not applicable to other industries.

Hsu (2023) aimed on the interplay between IIoT and the business-to-business customer experience in the manufacturing industry. A qualitative research approach was employed. Through semi-structured interviews with 9 participants, the data required for the study were collected. To analyze the data, thematic analysis was utilized. The study highlighted that IIoT technologies contributed to significant internal business value and fostered longer-term and mutually valuable business relations in the manufacturing sector. However, the size of the sample was very limited, thus affecting the accuracy of the result.

3. Research methods

To achieve the research objectives and to identify the existing gap in the literature on Industry 5.0 implementation within the automated printing sector, this study employed a systematic literature review as the primary research method. This approach was selected because it enables a structured synthesis and critical evaluation of existing research, helping to uncover underexplored areas, trends, and theoretical and practical gaps in the field.

Search strategy and databases: The literature was searched systematically using a combination of academic databases and platforms, including Scopus, Web of Science, IEEE Xplore, SpringerLink, ScienceDirect, and Google Scholar. The search included peer-reviewed journal articles, conference proceedings, white papers and relevant industry reports.

Search keywords: The search was guided by a combination of terms such as: ("Industry 5.0" OR "Fifth Industrial Revolution") AND ("IIoT" OR "Industrial Internet of Things") AND ("Digital Twins" OR "DT") AND ("printing industry" OR "automated printing") AND ("human-machine collaboration" OR "human-centric").

Inclusion and exclusion criteria

Inclusion criteria were:

- Peer-reviewed articles, book chapters, or conference papers.
- Publications in English.
- Articles published between 2018 and 2025 to reflect the most recent developments.
- Studies related to IIoT, DTs, and human-centric applications in industrial or manufacturing contexts.

Exclusion criteria included:

- Non-English publications.
- Articles not addressing IIoT, DTs, or human-centric approaches.
- Studies focusing solely on Industry 4.0 without implications for Industry 5.0.

Review and analysis procedure: After the initial screening, abstracts and titles were reviewed to assess relevance. Selected articles were then subjected to full-text analysis. A thematic analysis approach was employed to identify recurring themes, implementation practices, enabling technologies, benefits, and barriers. The studies were categorized by sector, focus area (e.g., technological, organizational, human-centric), and geographical scope to gain a holistic understanding of the field.

Justification of method selection: The systematic literature review was deemed appropriate due to the conceptual and exploratory nature of the topic, and the scarcity of direct empirical studies in the specific context of automated printing within I5.0. This method allowed for the collection, classification, and interpretation of a wide range of insights to establish a comprehensive understanding of the current knowledge landscape and its limitations. The results derived from this method supported the formulation of informed conclusions regarding the technological readiness, socio-technical integration challenges, and strategic pathways for adopting I5.0 technologies in the printing industry.

4. A Human-centric design of IIoT enabled digital twins in the printing industry

Industry 5.0: A Human-Centric Approach a comparison to Industry 4.0

I5.0 represents the new evolution in industrial development, building upon Industry 4.0's advancements in (1) automation, (2) data exchange, and (3) smart technologies. It presents a human-focused model that includes the creative and cognitive strengths of people with the capabilities of advanced systems. For utilizing human brainpower along with creativity to augment process efficiency by joining workflows with intelligent systems, the 5th Industrial Revolution paired humans and machines. The new era focuses on fostering a collaborative partnership betwixt humans and machines, boosting productivity while emphasizing human well-being together with sustainable industrial practices.

This HC direction shifts focus away from purely technology-driven outcomes and gives more weight to individual needs, worker development, and ethical responsibilities. As a result, industry workers can take on new roles as their value is increasingly recognized not as a cost, but as a strategic investment. Golovianko et al. (2023) critically explore the conceptual and technological evolution from Industry 4.0 (I4.0) to Industry 5.0 (I5.0), emphasizing the importance of a hybrid model that integrates the efficiency of automation with the ethical, resilient, and human-centric values of modern industrial development. The paper highlights that while I4.0 focuses on machine autonomy, cyber-physical systems, and data-driven decision-making with humans largely "out of the loop", I5.0 reintroduces the "human-in-the-loop" paradigm to address societal, ecological, and workplace challenges. In line with this vision, It is crucial to extend this insights to the printing industry by presenting a comparative analysis of how these two industrial paradigms manifest differently in practice.

Table 1.
Comparison of Industry 4.0 and Industry 5.0 in the Printing Industry

Aspect	Industry 4.0 in Printing Industry	Industry 5.0 in Printing Industry
Core Focus	Automation, digitization, and data exchange	Human-centricity, sustainability, and human-machine collaboration
Role of Humans	Marginalized; seen mainly as operators	Central; seen as collaborators and creative contributors
Technology Use	IoT, cloud computing, big data	Builds on I4.0 tech + IIoT, DTs, cobots, AI-human synergy
Objective	Efficiency and autonomous operation	Balance of productivity and human well-being
Human-Machine Interaction	Limited; full automation focus	Collaborative HMC with shared tasks
Decision-Making	Data-driven with minimal human input	Data-informed, with ethical and cognitive human oversight
Digital Twin Role	Simulation and monitoring	Real-time interaction, predictive capabilities, human-in-the-loop decisions
PdM Capabilities	Emerging, machine-based analytics	Real-time sensor integration with human response

Cont. table 1.

Customization Flexibility	Emphasis on mass production	Supports mass personalization and rapid adaptation
Workplace Impact	Job displacement risk, limited creative roles	Empowerment, safer and more meaningful human work
Challenges	Data integration, system complexity, cybersecurity	Adds ethics, talent gaps, interoperability, regulation uncertainty
Sustainability Goals	Often implicit	Explicit and essential component of strategy
View of Workforce	Operational cost to optimize	Strategic asset and innovation driver

Source: own elaboration.

This integration illustrates how Golovianko et al. (2023) approach can directly inform sector-specific implementations such as printing by harmonizing technical progress with human involvement. The table serves as a practical lens for visualizing the shift from efficiency-centric to human-centric industrial systems

Industrial Internet of Things (IIoT) as a Core Enabler of Industry 5.0

I5.0 is enabled by various technologies, namely (1) Internet of Things, (2) AI, (3) big data analytics, (4) cloud computing, along with (5) collaborative robots. The IIoT is a specific application of IoT within the industrial sector, focusing on connecting and analyzing data from industrial equipment, machines, and processes. It has already ushered in transformative changes across industries by connecting machines, systems, and processes. IIoT plays a key role in enabling along with driving advancements of I5.0 as it connects machines, systems, and methods, allowing for better communication and collaboration betwixt humans as well as machines. IIoT could subsidize to more sustainable industrial practices by enabling energy efficiency, resource optimization, and real-time monitoring of environmental impacts.

Determinants of IIoT Adoption in manufacturing and production environment

The industry's success and growth depend on the individual performance in an organization and the adoption of technology in the environment. Adopting IIoT in the manufacturing along with production industry leads to growth and success with enhanced productivity, efficiency, and competitiveness. Yet, several factors could influence IIoT's successful adoption in the industry. The adoption of IIoT in industries is influenced by technological, organizational, environmental, and individual factors.

Individual Factors

- Individual factors are personal attributes like knowledge, trust, skills, ability, acceptability, adaptability, self-efficiency, and reliability, that affect individuals' behavior, including the employees and clients in the industry.
- Individuals in the industries must possess the necessary knowledge along with skills to use and adapt to the technology effectively.
- In many small and medium enterprises, personal willingness to accept changes often influences how new tools are introduced.

Organizational Factors

- The organizational factors influencing the adoption of IIoT include growth rate, cost, information sharing, compatibility, readiness, support, training, and infrastructure. Organizations must consider these factors for successful adoption.
- These factors can improve the manufacturing and production industry's productivity, efficiency, and overall performance.

Technological factors

- Competitive pressure, complexity, big data, real-time tracking, privacy and security, innovation, efficiency, scalability, robustness, and Technical support are the technological factors influencing IIoT adoption.
- The organization should address these factors to unlock IIoT's potential to increase productivity, efficiency, along with competitiveness in industrial operations.

Environmental Factors

- The environmental factors impact the performance and functions of an industry. The environmental factors include government policy, legal and ethical issues, regulatory support, operational intelligence, resources, and sustainability.
- Public regulations and national goals also affect how and when organizations begin using IIoT systems.

Practices and approaches towards the implementation of IIoT in the printing industry

The IIoT is transforming sectors like industrial printing by linking physical devices through sensors and internet-enabled technology to facilitate data exchange. In industrial settings, IIoT leverages smart machines and advanced analytics to optimize operations, reduce downtime, and enhance productivity. It also enables the development of flexible, efficient production lines that could rapidly adapt to shifting demands. Implementing IIoT in the printing industry requires a focus on interoperability, digital transformation, integration, PdM, optimized operations, along with data-driven DM to enhance efficiency and productivity (Table 2). In Figure 2, a pictorial illustration of the IIoT model of the printing industry is depicted.

Table 2.
Practices and Approaches to Implementing IIoT

Practices and Approaches	Definition	Importance	IIoT Implementation
Focus on interoperability	Interoperability ensures that different systems and devices can communicate and share data effectively.	Various machines, software, and networks in the printing industry can work together seamlessly, thus enabling efficient workflows and data exchange.	Implement standardized protocols and communication interfaces to facilitate data exchange between devices and systems.

Cont. table 2.

Digital Transformation and Integration	Digital transformation involves leveraging technology to improve processes, business models, and customer experiences.	In the printing industry, digital technologies are adopted to streamline workflows, automate tasks, and enhance data analysis capabilities.	Integrate IIoT technologies with existing systems to create a connected and data-driven environment.
PdM	PdM employs data analytics and machine learning for detecting potential equipment failures before they happen.	This proactive approach diminishes downtime, lessens maintenance costs, and optimizes resource utilization.	Equip printing equipment with sensors to crease real-time data on performance and condition; then, this data is wielded to detect potential issues.
Optimized operations and Data-Driven Decision Making	Optimizing operations involves streamlining workflows, improving efficiency, and reducing costs.	Data-driven DM uses insights from collected data to make informed choices that improve performance and reduce waste.	Use IIoT data to detect bottlenecks, optimize resource allocation, and make data-driven decisions to augment operational efficiency.

Source: own elaboration.

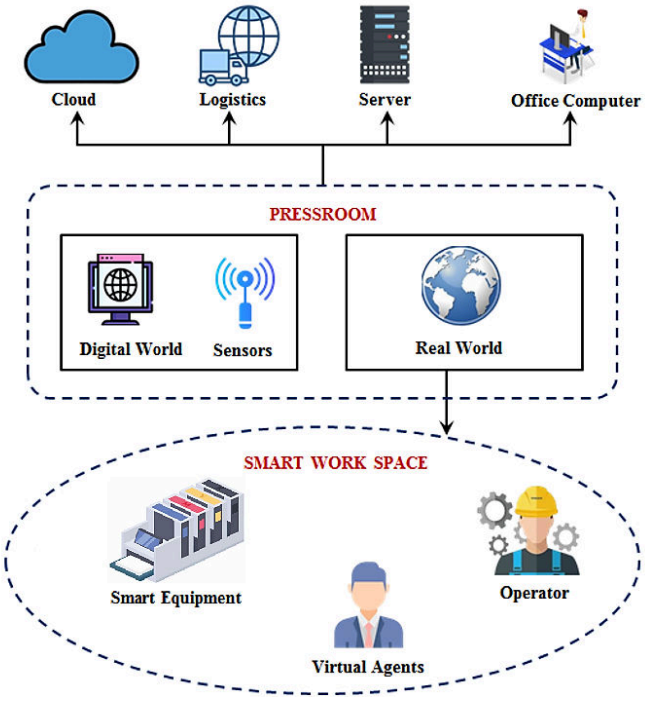

Figure 2. Basic IIoT model of a printing industry.

Source: own elaboration.

Technologies facilitating human-machine collaboration in the automated printing industry

A kind of association betwixt a human and a machine is HMC. It highlights humans as well as machines co-operating simultaneously on tasks and goals, permitting robots to influence their strength, repeatability, as well as accuracy. But, humans fund their higher-level (1) cognition, (2) flexibility, and (3) adaptability. I5.0 takes humans to the workspace's center, avoiding their involvement in non-added value tasks, which machines can automate. The I5.0 technologies

that facilitate HMC are collaborative robots (cobots) along with DTs. The IIoT powers both cobots and DTs.

Collaborative robots

Cobots, unlike conventional industrial robots confined behind safety barriers, are built to collaborate with humans within a shared workspace. HMC using cobots involves robots and humans working together in shared workspaces in the printing industry, thus enhancing productivity, safety, and flexibility by automating repetitive or hazardous tasks. In contrast, humans focus on more complex tasks. Equipped with advanced sensors and vision systems, these robots can adjust to changing environments and operate safely alongside humans. This close collaboration enhances efficiency and unlocks new opportunities for more flexible printing processes.

Digital twins

They are central to enabling HMC in I5.0. They provide user-friendly interfaces, real-time data, and collaborative tools that empower human operators to enhance processes and make well-informed decisions. As I5.0 evolves, HC DTs play a key role in bridging the gap betwixt humans and technology, aligning their strengths in joint applications. They offer a holistic view of the printing process, helping operators track performance, detect issues early, and implement real-time adjustments.

The Role of Digital Twins in the Human-Centric Transition for Industry 5.0

DT technology, which gained prominence during Industry 4.0, has seen significant advancements and plays a key role in the emerging paradigm of I5.0. It is one of the essential technological enablers of I5.0. Nine initial technological pillars, including IIoT, Autonomous Robots, Big Data Analytics, Simulation, Additive Manufacturing, Horizontal and Vertical Cybersecurity, System Integration, the Cloud, and Augmented Reality, are identified within the Industry 4.0 context. These pillars are the enabling technologies that drive the evolution of DTs along with their applications in industrial systems. Constructing on DTs' foundation, the Human DTs has arisen as a transformative notion tailored to support the HC focus of I5.0. DTs are changing to more advanced architectures, including sensors to attain real-time data from a product or else its environment in the entire lifecycle to deal with complexity and unpredictable events. Simultaneously, DTs enable automated real-time analysis across interconnected machines and data sources, rushing the detection and resolution of errors. Moreover, DTs contribute significantly to enhancing efficiency and reducing costs in industrial manufacturing.

Factors to be considered before implementing digital twins in the printing industry

In the printing industry, high initial capital costs, the complexity of workflows, the need for reliable data, and the management of multiple variables in physical assets should be considered before implementing DTs. Ensuring a thorough assessment of these factors is crucial for a successful implementation.

Heavy capital cost: Implementing DTs requires significant upfront investment in sensors, IIoT devices, modeling tools, analytics platforms, and IT infrastructure. Beyond the initial investment, ongoing costs are associated with maintenance, updates, and data management. Thus, their deployment is justifiable, in which capital-intensive machinery as well as operations like printing and deadlines, are significant. Moreover, logistics depend upon the material's timely delivery.

Requirement of reliable data: The DTs must be input with higher-quality data meant for physical assets' accurate virtual image. For data regarding physical assets to be useful, it must be consistent, measurable, as well as reliable across each parameter. Also, peculiar problems can arise during printing, where precise data is required to initiate the corrective action.

Complicated workflow: In printing, where products are unique and influenced by factors, such as pressroom atmospheric conditions, designs of punches, time factor, substrate properties, and finishing operations, DTs can be beneficial by providing a virtual replica of the printing process.

Multiple variables in the physical assets: The numerous and complex variables inherent in physical assets within the printing industry are equipment, materials, and processes. DTs need real-time data from the physical assets to reflect their current state along with behavior accurately. Each physical asset must be accurately modeled in the DT, including its physical characteristics, operational parameters, and potential failure modes.

Advantages of using Digital Twin in the Printing Industry

DTs could be extremely useful in optimizing process parameters in printing by observing the process along with detecting possible faults by employing in situ sensors' data as input. DTs offer significant advantages, including increased production efficiency, PdM capabilities, improved product development, and easier testing and optimization of processes in the printing industry.

Increased efficiency of the production system

- DTs provide a real-time, virtual representation of printing processes, allowing for continuous monitoring of equipment and operations.
- By collecting data from the DT, printing companies can optimize their processes to enhance workflows and improve overall production efficiency.

Predictive maintenance

- DTs can predict potential equipment failures by appraising real-time data from sensors as well as historical performance data.
- By anticipating failures, printing companies can schedule maintenance proactively, minimizing downtime and production disruptions.

- PdM permits for targeted maintenance efforts, minimizing the requirement for costly emergency repairs along with augmenting overall maintenance efficiency.

Improved product development

- DTs enable printing companies to test new products and processes in a virtual environment before physical production, reducing risks as well as costs.
- By identifying potential issues early in the development process, DTs can accelerate product development cycles and time-to-market.

Ease of testing

- DTs permit printing companies to simulate different scenarios along with test various parameters without disrupting real-world operations.
- DTs can reduce the requirement for costly as well as time-consuming real-world testing by providing a virtual testing environment.

Challenges and barriers associated with the implementation of Industry 5.0

I5.0 holds considerable promise for improved sustainability, increased efficiency, and customized production; yet, its implementation is complex. Some of the challenges are:

- ***Technology integration complexity*****:** Combining tools like IIoT, AI, robotics, along with DTs into existing systems could be resource-intensive as well as technically challenging. Likewise, incorporating I5.0 technologies faces scalability, compatibility, and standardization challenges.
- ***Moral and sociological aspects of Human-Machine collaboration:*** I5.0 highlights HMC, requiring careful consideration of moral along with sociological aspects to ensure a responsible as well as sustainable transition. Automation and the employment of technologies could cause job losses in certain sectors, exacerbating economic inequality.
- ***Workforce education and training talent shortages:*** The workforce of I5.0 must be proficient in technology and human-centered production techniques. Large-scale retraining and education may be necessary because many workers lack the requisite skills.

Challenges with Regulation and Standards:

- ***Lack of Standardization:*** I5.0 technologies may not be widely adopted without global standards, which can cause inconsistent results.
- ***Regulatory ambiguity:*** Businesses may have ambiguity regarding sophisticated technologies due to unclear instructions from governments and regulatory agencies.

5. Results

The research brings together key insights about how Industry 5.0 technologies, especially the Industrial Internet of Things (IIoT) and Digital Twins (DTs) which are being used in the automated printing industry. The findings are organized into three main areas: what influences the adoption of IIoT, how companies are putting these technologies into practice, and how collaborative tools like robots and digital models are helping people and machines work better together.

Adoption of IIoT in Automated Printing

- ***Individual Factors***: Employee knowledge, trust in technology, adaptability, and digital skills significantly influence IIoT uptake. In particular, small and medium-sized printing enterprises exhibit varied readiness levels, often constrained by skill gaps and limited exposure to digital tools.
- ***Organizational Factors****:* Infrastructure readiness, implementation cost, digital maturity, and training availability emerged as critical enablers or barriers. Organizational inertia and budget limitations often slow down the integration of IIoT technologies, particularly in enterprises with legacy systems or limited IT expertise.
- ***Technological Factors****:* The complexity of IIoT systems, requirements for real-time tracking, and concerns around data privacy and cybersecurity were consistently cited as implementation hurdles. Additionally, the need for scalable and interoperable systems that can adapt to diverse printing equipment was emphasized.
- ***Environmental Factors****:* Government policy, legal compliance, and sustainability objectives increasingly shape IIoT strategies. Regulatory ambiguity and the absence of industry-specific standards often delay adoption, particularly among SMEs.

Multiple studies, including those by Arnold and Voigt (2018) and Paliwoda et al. (2023), highlight that digital immaturity, poor interoperability, and underdeveloped infrastructure remain the primary obstacles in smaller enterprises attempting to modernize their operations using IIoT.

Identified Practices and Implementation Approaches

- ***Interoperability Enablement****:* Standardized communication protocols and data exchange frameworks are prioritized to ensure smooth interaction among diverse machines and digital systems.
- ***Digital Transformation and Integration****:* Enterprises are progressively integrating IIoT platforms with existing infrastructure, allowing for more holistic and data-driven workflows. Automation and system connectivity are key themes in facilitating smoother operations.

- ***Predictive Maintenance (PdM)****:* The use of sensors and real-time data analytics enables early fault detection, minimizing machine downtime and supporting proactive maintenance regimes. PdM contributes to reduced operational disruptions and improved asset longevity.
- ***Data-Driven Decision-Making (DM)***: Collected data is increasingly utilized for optimizing production planning, resource allocation, and performance monitoring. Insights derived from IIoT platforms support faster and more informed decision-making processes.

Role of Collaborative Technologies in Human-Machine Collaboration (HMC)

- ***Collaborative Robots (Cobots)****:* Cobots support shared workspaces by automating repetitive or hazardous tasks. These robots operate safely alongside humans and are equipped with adaptive sensing technologies. Their use allows human workers to concentrate on complex, high-value tasks, improving both productivity and safety.
- ***Digital Twins (DTs)****:* DTs enable real-time monitoring, process visualization, and data analysis, supporting informed decision-making by both operators and managers. These systems create digital replicas of machines or entire workflows, enabling better oversight and optimization.

The integration of these technologies plays a pivotal role in transitioning from traditional automation models to more inclusive, human-centered production ecosystems.

Application of Digital Twins in Printing

- ***Predictive Maintenance****:* DTs use real-time data inputs from IIoT sensors to detect potential issues before they impact production, enabling condition-based maintenance strategies.
- ***Virtual Testing****:* DTs allow the simulation of various production scenarios, minimizing disruptions in real-world operations and facilitating safer and faster innovation cycles.
- ***Product Development****:* By simulating product behavior and identifying defects in early stages, DTs reduce the time-to-market and support rapid prototyping in design processes.

However, the effective implementation of DTs requires addressing several prerequisites such as:

- High-quality and reliable data is essential to maintain an accurate virtual representation of physical systems.
- Significant upfront investments are needed for sensor networks, modeling software, and supporting IT infrastructure.
- The complexity and variability of workflows in printing environments demand highly customizable and sophisticated modeling capabilities.

These findings underscore the transformative potential of DTs when supported by robust data ecosystems and well-integrated infrastructure.

6. Discussion

This research significantly addresses a notable gap in the literature, emphasizing human-centric frameworks of Industry 5.0 (I5.0), particularly examining the roles of Industrial Internet of Things (IIoT) and Digital Twins (DTs) in the automated printing industry. By highlighting human-machine collaboration (HMC), the study responds effectively to contemporary demands for integrating human values into technologically sophisticated industrial environments (Rajkumar et al., 2025; Alves et al., 2023).

A critical insight derived from this study is the essential role of interoperability, especially when we mix the printing techniques and technologies which we want to implement in the pressroom. Successful IIoT implementation fundamentally requires seamless integration across various systems and platforms (Hussain et al., 2021; Hou et al., 2023). Enhanced interoperability supports data-driven decision-making (DM) capabilities, robust predictive maintenance (PdM), optimized resource allocation, and reduced downtime, significantly improving overall productivity and cost efficiency within the printing industry (Jamil et al., 2024; Ptak, Lis, 2024).

Furthermore, the study emphasizes that the human-centric aspect of Industry 5.0 extends beyond technological advancement, encompassing socio-technical factors such as workforce training, ethical considerations, and human welfare. The human-centric approach redefines traditional automation-driven perspectives of Industry 4.0 by integrating advanced technologies with human skill enhancement (Rajkumar et al., 2025; Kumar, 2024). Technologies such as collaborative robots (cobots) and DTs significantly enhance human capabilities, ensuring safer, more ergonomic, and creatively stimulating workplaces vital for sustainable human-machine synergy (Santhi, Muthuswamy, 2023; Sarioglu, 2023).

The integration of DTs within the printing industry, highlighted by this research, is crucial for developing predictive capabilities, enhancing real-time monitoring, and promoting proactive maintenance strategies (Ghafari et al., 2024; Annavarapu, 2024). However, substantial challenges, including high initial investments, data reliability issues, and complexity in managing physical and operational variables, pose barriers requiring strategic solutions (Peter et al., 2023; Kumar, Iyer, 2019). Therefore, implementing robust data collection practices and cybersecurity measures is essential for safeguarding sensitive industrial information like intellectual property of design, graphics which are still not known as printed and released to the market (Kumar, Iyer, 2019; Sivathanu, 2019).

Additionally, this study highlights the urgent need for consistent global standards and regulatory frameworks to streamline the adoption and integration of new technologies. Without these standards, implementations could be fragmented, leading to inefficiencies and heightened risks of interoperability issues and cybersecurity threats (Arnold, Voigt, 2018; Hou et al., 2023).

Moreover, the research identifies a substantial gap in workforce preparedness for Industry 5.0 technologies. Organizations must therefore prioritize extensive training programs and continuous skill enhancement strategies, maintaining a workforce that remains agile, adaptable, and competent in integrating advanced technological tools into daily operations (Rajkumar et al., 2025; Paliwoda et al., 2023). Policy-makers and industry leaders must collaboratively establish educational frameworks and training initiatives explicitly targeted at technology integration and human-centric industrial principles. To further contextualize these insights specifically for the printing industry, Table 3 summarizes key technological considerations essential to the successful implementation of Industry 5.0 in printing.

Table 3.
Key technological considerations essential to the successful implementation of Industry 5.0 in printing (own elaboration)

Technological consideration	Importance	Implementation strategy
Interoperability	Ensures seamless communication between diverse systems and devices	Adopt standardized communication protocols and integration frameworks
Predictive Maintenance (PdM)	Reduces downtime, enhances operational efficiency, and lowers maintenance costs	Deploy sensor networks and advanced analytics for real-time condition monitoring
Collaborative Robotics (Cobots)	Enhances productivity and worker safety by automating repetitive or hazardous tasks	Integrate cobots equipped with advanced sensors and vision systems into shared workspaces
Digital Twins (DTs)	Facilitates real-time monitoring, predictive analytics, and informed decision-making	Develop comprehensive DT models accurately reflecting physical assets and workflows
Cybersecurity	Protects sensitive data and maintains operational integrity	Implement robust cybersecurity measures and continuous risk assessments
Workforce Training and Development	Ensures workforce readiness and adaptation to new technologies	Provide continuous training, skill enhancement programs, and hands-on workshops
Regulatory Compliance	Ensures adherence to global and local standards and regulations	Stay updated with international regulatory frameworks and establish clear internal compliance practices

7. Conclusion

Research specifically illuminated critical individual, organizational, technological, and environmental factors influencing IIoT adoption, highlighting the complex ecosystem required to ensure successful technological integration in industrial printing.

In addition, this research underscored several key considerations that impact the effective deployment of Digital Twins (DTs) in the printing industry. High capital investments, the necessity for consistently reliable data, intricate workflow processes, and the complexity of managing numerous variables inherent in physical assets were identified as significant barriers. Addressing these challenges strategically will be essential for achieving the full potential of DTs, particularly in enhancing productivity, efficiency, and predictive maintenance capabilities.

The investigation further revealed critical challenges specifically associated with the implementation of Industry 5.0 technologies, including technological integration complexities, ethical and sociological concerns surrounding human-machine collaboration (HMC), workforce education deficiencies, skill gaps, and regulatory ambiguities. Unlike Industry 4.0, which primarily focused on automation, efficiency, and data-driven decision-making, Industry 5.0 emphasizes a human-centric approach, incorporating ethical, societal, and sustainability concerns alongside technological advancement. This shift towards human-centricity offers new opportunities for creating safer, more inclusive, and creatively engaging work environments in the printing industry.

Industry 4.0 largely promoted a vision of fully automated, highly efficient, and interconnected systems, often marginalizing the role of human input. In contrast, Industry 5.0 integrates advanced technology with human creativity and cognitive skills, positioning employees not merely as operators but as active collaborators and innovators. Within the printing industry, this transition can significantly enhance operational flexibility and creative problem-solving capacities, facilitating faster adaptation to market demands and customization needs.

Nevertheless, despite the identified benefits and promising future, the current study acknowledges certain methodological limitations. Being conceptual rather than exploratory or descriptive in nature, the research findings might lack empirical depth and comprehensive validation. Therefore, future research is recommended to employ empirical methods such as surveys, case studies, and longitudinal analyses to gain deeper insights, validate the conceptual frameworks presented, and extend the generalizability of these findings.

Future research should also further explore comparative analyses between Industry 4.0 and 5.0 frameworks, particularly emphasizing empirical validation of human-machine interactions in practical printing industry environments. Such studies could provide clearer insights into optimal strategies for technological and human-centric integration, fostering a balanced, sustainable, and innovative industrial landscape.

Ultimately, the findings of this investigation suggest that embracing Industry 5.0, characterized by its holistic, human-centric perspective, can profoundly transform the automated printing industry. By addressing the identified challenges and leveraging the unique strengths of both technology and human expertise, Industry 5.0 can drive unprecedented levels of innovation, sustainability, and competitiveness in the printing industry sector.

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BRAND MARKETING COMMUNICATION CAMPAIGN ON THE INTERNET AND ITS EFFECTIVENESS. RESEARCH RESULTS

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Purpose: To present a brand marketing communication campaign on the Internet and its effectiveness based on the example of the mPay brand, its characteristics, generated impacts, and multifaceted benefits for all those involved, and to develop recommendations for interested marketers.
Methodology: analysis of secondary sources of information, case study of the selected brand: mPay from the fintech sector, from the perspective of online marketing communication activities and the resulting effects. Participant observation of selected activities, their evaluation, and suggested improvements. Survey research using a computer-assisted questionnaire on a sample of 222 young respondents.
Results: Expanded knowledge of brand marketing communication campaigns on the Internet and factors determining their effectiveness. Results of the case study with emphasis on the spectrum of mPay's brand online marketing communication ventures and their impact. Results of the survey about the perception of the object of the study, its market offering compared to the competition, and the functionalities of the innovative mPay mobile application.
Research limitations: The research problem undertaken should be analysed on the basis of a larger number of brands and their branded marketing communication ventures. Additionally, the authors plan to expand the survey to a nationwide sample.
Practical implications: The ability to emulate good and avoid less effective online marketing communications ventures in the fintech sector. In-depth knowledge documented by the results of the conducted case study and surveys with developed recommendations for the interested marketers, researchers, students.
Social implications: Research shows that brand marketing communication campaigns on the Internet influence the behaviour of customers, Internet users, and other stakeholders, their experiences, attitudes, engagement, changes in the ways they use the services provided using mobile applications. Such endeavours significantly influence the process of building brand communities and managing stakeholders' experiences.
Value: Given the approach presented in the article, this is the first study of its kind (at least in the Polish market) on the implementation of a brand marketing communication campaign on the Internet and its effectiveness in the fintech sector, with an assessment and suggestions for improvements to these activities, and the development of recommendations for marketers.

Keywords: brand marketing communication campaign on the Internet, branding projects and campaigns, building and engaging brand communities, marketing communication effectiveness on the web, services using mobile applications.
Category of the paper: research paper.

1. Introduction

Contemporary marketers are continually seeking effective methods to support their managerial activities. Moreover, in an era of constant technological innovation (Digital Poland, 2024; Aktualne trendy, 2025; Jóźwik, 2025; Trendy w social media, 2025), digital transformation has become a highly desirable element of market operations. In order to remain competitive, companies must invest in modern solutions (Kotler, Partners, 2024) and qualified personnel responsible for implementing digital transformation, as well as engage in appropriate marketing communication efforts (Chaffey, Smith, 2017; Chlipała, Rawski, 2023; Raport Digital, 2025). Branded (Gustafsson, 2008; Keller, 2013; Tarczydło, 2014; Tarczydło et al., 2018; Aglus, 2019; Foroudi, Palazzo, 2021; Goodson, Walker, 2021; Kotarbiński, 2021; Zschiesche, Errichiello, 2021; Lubin, 2022; Larsen, 2023) online marketing campaigns (Duralia, 2018; Tarczydło, Miłoń, 2019) seem to be one of the key components of such communication (Hajduk, 2019; Tarczydło, 2020; Trendy w social mediach, 2025).

This is supported by trends identified in the Accenture Life Trends Report (Drynko, 2025), which highlight the growing importance of fast, authentic, and engaging online communication. Companies that adapt their marketing communication strategies to meet these expectations stand a better chance of effectively reaching stakeholders and fostering lasting relationships with them.

Available research results (Raport Digital, 2025) clearly show that digitalisation in Poland is thriving, and that social media and search engines are crucial channels for marketing communication activities. Mobile devices dominate, which makes it necessary to adapt strategies to mobile-first users – for example, by offering mobile applications. It is also important to monitor shifting preferences in social media platforms and tailor marketing communication activities to align with actual audience expectations and broader contextual factors.

A significant trend is the "impatience economy". According to research (Drynko, 2025), 75% of customers expect companies to respond to their needs faster, and more than half prefer to receive immediate answers and guidance by turning to information shared by other Internet users, even in areas such as health or financial planning. Additionally, 33% of respondents reported encountering deepfakes or other online scams in the past year. Marketers should pay particular attention to selecting online marketing communication channels that deliver valuable

content in real time. The key message, however, should focus on building trust through transparent and authentic online messages.

Given that an average Polish Internet user spends 6 hours and 26 minutes online daily – of which 3 hours and 18 minutes on mobile devices – online communication is of critical importance (Raport Digital, 2025; Digital Poland, 2024; Drynko, 2025). Furthermore, according to the Fintech Poland (2023), Polish consumers are highly open to innovation and demonstrate considerable maturity in using digital solutions. This digital maturity further motivates marketers to undertake online marketing communication campaigns. A particularly relevant case is the fintech sector, which operates entirely online. Poland boasts a strong and rapidly growing fintech market, considered one of the most promising in this sector in Central and Eastern Europe. Between 2018 and 2022, the number of fintech companies in Poland rose from 167 to 299 – a 79% increase (Fintech Poland, 2023, p. 17).

Marketing communication is undoubtedly undergoing constant evolution (Dahlen et al., 2010; Wilk, 2014; Chaffey, Smith, 2017; Duralia, 2018; Taranko, 2018; Hajduk, 2019; Tarczydło, Miłoń, 2019; Tarczydło, 2020; Hansen, 2021; Kotler et al., 2021; Scott, 2022; Targiel, 2022; Chlipała, Rawski, 2023; Tarczydło et al., 2023; Wolniak, 2023; Effie Awards, 2024; Kolemba, 2024; Troian, 2023; Byczyk, 2025; Tomaka, 2025). It is important to emphasize the influence of several phenomena on this evolution, including the growing use of artificial intelligence (Bajak, Spendel, 2024), advancing hyper-personalisation, and increasing consumer expectations regarding the humanisation of brands (Kotarbiński, 2021; Kotler et al., 2021) and the development of the language of communication grounded in authenticity, transparency (Gustafsson, 2008; Laskin, 2010; Dahlen et al., 2010; Dziawgo, 2011; Bragg, 2014; Dmitruk, 2016; The handbook, 2018; Foroudi, Palazzo, 2021; Florczak, 2023), and genuine concern for stakeholders (Clatworthy, 2022; Freeman, 2022) and their well-being. These are underscored by both theorists and practitioners (Keller, 2013; Goodson, Walker, 2021; Egorova et al., 2022; Chlipała, Rawski, 2023; Kotler, Partners, 2024) as the key trends shaping the future of digital marketing and are essential for helping marketers maintain a competitive edge through appropriate online communication (Chaffey, Smith, 2017; Tarczydło et al., 2018; Troian, 2023; Kotler, Partners, 2024; Jóźwik, 2025; Strategia działań…, 2025; Tomaka, 2025; Zalety i wady, 2025).

This raises the question: what role do branded online marketing communication campaigns play in management practice, and how do they align with current conditions, trends, and accepted paradigms?

Therefore, the aim of this article is to explore the concept of a branded marketing communication campaign on the Internet and its effectiveness using the example of the mPay brand from the fintech sector, specialising in mobile payments for public transport and parking, and offering financial services and money transfers, all with the use of a mobile application (based on an analysis of available studies and the authors' own research), examining its specific

characteristics, generated impacts, and multifaceted benefits for all the stakeholders involved, as well as to develop recommendations for interested marketers.

A mixed-methods (Czakon, 2024) approach was applied, encompassing an analysis of secondary sources of information; a case study (Yin, 2012) of the selected fintech brand mPay from the perspective of its online marketing communication efforts and the outcomes thereof; participant observation of selected activities; and survey research conducted among young respondents who represent a key target group for the company under analysis.

The originality and scientific value of the article is related to the undertaking of research on brand marketing communication campaign on the Internet and its effectiveness in the fintech sector, the expansion of existing knowledge, the evaluation and proposals for improvement of these activities, the discussion of their impact on stakeholders, the resulting practical implications: social, economic, environmental, managerial, and the development of recommendations for all stakeholders, including researchers, marketers, students.

The defined scope of the article provides motivation to outline the key theoretical foundations.

2. Literature review

It is assumed that a brand marketing communication campaign on the Internet is a set of appropriately designed and selected communication techniques (advertising, public relations, additional promotion, personal selling, other network-specific) with the use of social media and other available functionalities, oriented at stakeholders and intended to achieve the desired objectives.

Table 1.
Description of selected issues concerning brand marketing communication campaigns

Criterion	Description of campaign elements
Marketing communication model	Includes: sender, recipient, message, channel, feedback, and communication context (Dahlen et al., 2010; Duralia, 2018; Hajduk, 2019; Chlipała, Rawski, 2023).
Marketing communication functions	In classical terms (Wilk, 2014; Kotler, Partners, 2024): informational (provides current and potential buyers with information, leading to breaking down the barrier of ignorance of the market); stimulative (evoking the desired attitudes and market behaviours of buyers); competitive (attractiveness and clout of the promotion programme, disruption of programmes launched by competitors). And in modern terms (Taranko, 2018; Hajduk, 2019; Hansen, 2021; Kotarbiński, 2021): educating; reducing access barriers; building buyer experience with the product/brand; increasing stakeholder involvement; creating additional instruments for market competition.

Cont. table 1.

Factors determining brand communication policy	the size and economic situation of the company; the adopted development strategies and system of objectives; the type and nature of the market (sector) of operation; the type of product; the nature of demand and the degree of its price and income elasticity; the activities of competitors; legal conditions (Smilansky, 2009; Schmitt, 2011; Keller, 2013; The handbook, 2018; Aglus, 2019; Foroudi, Palazzo, 2021; Kotler et al., 2021; Zschiesche, Errichiello, 2021; Clatworthy, 2022; Lubin, 2022; Florczak, 2023; Larsen, 2023; Bajak, Spendel, 2024; Kolemba, 2024; Kotler, Partners, 2024; Pabian, 2024; Aktualne trendy, 2025; Byczyk, 2025; Jóźwik, 2025; Raport Digital, 2025; Trendy w social media, 2025).
Stages of building an effective campaign	Identification of the audience, definition of objectives, message design, choice of communication channels, determination of total budget, decisions concerning the communication-mix, implementation and measurement of results (Dahlen et al., 2010; Duralia, 2018; Hajduk, 2019; Tarczydło, 2020; Targiel, 2022; Chlipała, Rawski, 2023).
Identification of the audience	The form of communication with the market can be: broad – the target audience is larger than the target market segment (so-called stakeholders) or narrow – the target audience is smaller than the group of potential buyers (Gustafsson, 2008; Dahlen et al., 2010; Bragg, 2014; Duralia, 2018; Taranko, 2018; Tarczydło et al., 2018; Hajduk, 2019; Kotler et al., 2021; Freeman, 2022; Chlipała, Rawski, 2023; Wolniak, 2023; Kolemba, 2024; Kotler, Partners, 2024).
Definition of objectives	Promotion objectives (derived from the company's overall objectives and the adopted marketing strategy): economic and social, for example: increase sales, improve brand image, raise awareness of the product and its features, increase loyalty (Hajduk, 2019; Kotler, Partners, 2024).
Message	formulating the message requires solving the following problems (Tarczydło, 2014; Chaffey, Smith, 2017; Duralia, 2018; Hajduk, 2019; Scott, 2022; Chlipała, Rawski, 2023; Tarczydło et al., 2023): what to say (message content), how to convey the message (message structure), what symbols to use (message shape), who should be the sender (message source).
Budget	Methods of determining the promotional budget include: percentage of sales volume; financial possibilities ("what we can afford"); imitation of the competition; established objective (Taranko, 2018; Hajduk, 2019; Chlipała, Rawski, 2023; Kotler, Partners, 2024).
Communication channels and media plan	The media through which to communicate (the Internet and therein social media in particular, but also: press, radio, television, outdoor media...); the media plan involves the purchase of airtime to achieve the appropriate intensity of the campaign (Dahlen et al., 2010; Duralia, 2018; Hajduk, 2019; Chlipała, Rawski, 2023; Tomaka, 2025; Zalety i wady, 2025).
Communication mix (a bundle of communication tools)	Includes: advertising, sales promotion, public relations and publicity, event and experience marketing, direct and interactive marketing, word-of-mouth marketing, and personal selling (Chaffey, Smith, 2017; Taranko, 2018; Kotler, Partners, 2024).
Measurement of effectiveness	Involves verification of the extent to which the objectives of the marketing communication campaign have been met (Delgado-Ballester, Munuera-Aleman, 2005; Dmitruk, 2016; Mosiejko, 2016; Badania efektywności, 2025; Polak, 2025). You can measure: the number of app downloads; the number of users using the app; the number of followers on social media; the analysis of sentiment (positive and negative online mentions), reach across social media, volume of mentions, interactions, user-generated content (UGC), identification of the most influential and most active content creators (Brand24 Team, 2019).

Source: authors' own elaboration.

The information provided in Table 1 is a kind of guideline/framework for modern brand marketing communications on the Internet, which should enable the design of methodical activities in the field in question. An effective marketing communication campaign, in turn, is a set of activities through which the given company manages to achieve the established economic, social, and other objectives, adapted to the expectations of stakeholders (including

buyers) and other conditions (e.g. competitive structure, legal conditions, market trends, buyer behaviours and habits, technical and technological conditions...).

In order to verify how the described phenomena are realised in business practice, it was decided that a study should be conducted for the mPay brand.

3. Methods

The revealed gap research concerns the scope and determinants of brand marketing communication campaigns on the web in the fintech sector in Poland, its instrumentation and examples of applications and effectiveness. The research problem addressed: how an entrepreneur can and should use the tools, methods and procedures of an Internet brand marketing communication campaign in generating multifaceted benefits for all stakeholders.

For the purpose of this study, own qualitative and quantitative studies were carried out using the following methods: case study (aimed at obtaining answers to the question of how marketing communication activities are carried out on the Internet for the mPay brand), participant observation, online content analysis, and survey research. The following research scopes were specified: the temporal scope: February 2024 – April 2025; the subjective scope: selected fintech operating under the mPay brand, active internet users, observers and other representatives of its stakeholders (investors, media), online marketing communication experts, representatives of competitors of the analysed brand; the objective scope: ways and forms of online marketing communication activities in the fintech sector with emphasis on mPay; and spatial scope: websites, the brand's profiles in social media and other available channels.

The aim of the research was to obtain information on the tools, methods and procedures for marketing communication of the studied brand on the Internet and the specifics of online marketing communication in the fintech sector. By design, the research was conducted online and, once the mPay Fair Play campaign was identified, also offline (outdoor, events, other manifestations of the campaign, competitions, promotional materials).

The research project was oriented at searching for answers to the following questions: Is a methodical online marketing communications strategy used for the mPay brand? Who is responsible for the actions taken? What kind of brand image is created? What marketing communication tools are used? In which communication channels are the campaigns, actions, and projects implemented? Who is involved in the communication activities of the brand under study and with what results? What effects does it bring? What kind of improvements could be suggested, if any? How are the implemented marketing communication practices perceived by young adults?

The use of a computer-assisted survey among young adults resulted from an analysis of the company's Growth Strategy and its transformation into a fintech solution (IR Service, 2025, p. 20), which identified two B2C segments (‘young out-of-staters’ demographically the 17+ segment, including students taking up their first jobs and ‘responsible rebels’ the 35+ segment, in the household the centre of inspiration and information about new technologies) and four B2B segments (banks, e-commerce, marketplace and education). Additionally, the limited capacity of the authors (self-directed research) and the opportunity in the form of accessibility to the student community for the academic and the student.

In the process of carrying out the research, rich empirical material was obtained, the most relevant results of which are summarised in the next section of the article.

3. Research results

The research assumes that for today's fintech managers, online marketing communication activities are particularly useful.

In addition, the authors define an effective online marketing communication campaign for a brand as one that should give the brand the opportunity to persist and grow, to be creative, to respond to market signals and to create appropriate value for staff, customers and all stakeholders (stakeholders) involved.

The key results of the case study (aimed at answering the question of how online marketing communication activities are carried out for the mPay brand and how effective they are), the participatory observation of its selected communication practices and the analysis of thematically related online content are summarised in Table 2.

Table 2.
Characteristics of mPay’s online marketing communication – findings from empirical research

Criteria	Study results obtained and comments
Basic information	mPay S.A. is a provider of mobile payment solutions. Since 2003, the company has been developing innovative tools that enable a wide range of financial transactions. Its flagship product is the mPay mobile application, which allows users to purchase public transport tickets, pay for on-street parking, top up mobile phones or games, and access streaming services. The company successfully translates its extensive experience and expert knowledge into unique solutions – for example, by launching Poland’s first in-app loan platform. The entire process – from receiving a financing offer equivalent to a loan decision, to the disbursement of funds and loan repayment management – is carried out within the mPay system. mPay S.A. is a licensed settlement agent and holds a National Payment Institution licence, authorising it to maintain customer settlement accounts and issue payment instruments, including debit cards. The company is listed on the Warsaw Stock Exchange (NewConnect) and has been awarded the title of Fintech of the Year in a nationwide competition held during the Invest Cuffs congress.

Cont. table 2.

Brand communication message	The brand presents itself as time-saving, life-simplifying, innovation-driven, and stress-reducing – focused on convenience in both everyday life and business, while being accessible and close to the user.
Target audience	Customers; Internet proficient users; students; investors; people travelling by car; residents of major cities; people using public transportation; people using online payments; tourists; media representatives; competitors.
Brand websites	The company's official website, www.mpay.pl, is attractive and professional, adhering to current industry standards. Its design is clear, well-organised, and fully responsive. The main categories – News, Services, Finance, For Business, About Us, Company, and mPay Store – are clearly labelled and intuitive to navigate, while the expanding subcategories encourage further exploration of the site's content. Overall, the website content appears sufficient and logically structured. However, the site gives the impression of being somewhat static. From a communication standpoint, noteworthy features include the Help and Contact sections (with segmentation based on customer type), as well as the option to consult with a customer service representative. The website features a range of content formats, including articles, infographics, images, and videos. The brand also maintains a corporate blog under the News tab. Social media profiles are linked via integrated redirects. Additionally, the brand operates other specialised websites dedicated to specific services, such as inwestorzy.mpay.pl (Serwis IR, 2025) (investments) and ubezpieczenia.mpay.pl (insurance). These, however, contribute to enhancing user engagement only to a limited extent.
Influencer involvement	The latest campaign introduces a new brand ambassador, Jakub Błaszczykowski, with the slogan: "fair play payments," which alludes to the values of honesty and respect, which are extremely important in the financial technology sector. It also engages Miss Częstochowa Region Milena Bilska, who has become the face of the content posted on the Internet. During the study period, mPay also collaborated with influencers from various sectors, including travel (travelmatespl, asiajakubiec), finance (pani_od_oszczedzania, oszczedzanie_ przez_ogarnianie), and entertainment (d.koleczko). Additionally, the company sponsors Adam Zentner, the Polish rally champion in 2022 and 2023, and involves him in a variety of initiatives.
Visual identity system	During the study period, the company underwent a rebranding strategy. The current logo features the brand name, with white and purple as the dominant colours – chosen to reinforce associations with transparency, professionalism, and security. Visual standards are consistently applied across all communication channels, including the official website, the brand's social media profiles, the mobile application, supporting materials, and virtually every medium within the comprehensive visual identity system. This consistency supports the development of a strong visual identity, effectively distinguishes the company from its competitors, and enhances the impact of communication efforts on stakeholders.
Mobile app	The mPay – Mobile Payments application is designed for both individual and institutional customers. It is compatible with both the iOS and Android operating systems. The app offers a wide range of functionalities. In the Products and Services section, users can access features such as parking ticket purchases, PKP Intercity and local public transport tickets and schedules, admission tickets, mobile top-ups, prepaid cards, and insurance. In the My Finances section, available features include digital wallets, payment cards, money transfers, loans, investment options, bill payments, and vouchers. This way, it innovatively combines financial management and services making customers' daily lives easier. For institutional customers, the primary categories of use are parking services and railway ticketing. From the perspective of desirable mobile app functionalities, the tested application performs very well. Notable benefits include the ease of paying for parking, the possibility to purchase tickets, and the functionality of sending push notifications. The app interface is intuitive and user-friendly, featuring a bottom navigation panel and clearly distinguished categories. Throughout several months of testing, no operational issues were encountered. The application also enables personalisation of functions according to user preferences. Users can join the mPay Club, which fosters relationship-building and user loyalty. Special offers and rewards appear to be an important element of this programme. Additionally, the mPay platforms provide educational videos explaining how to use various app functions, both for individual and institutional users. The observations made indicate that the application runs smoothly, and the service categories are divided in a logical way. This translates into easy, efficient, and enjoyable use of mPay's products and services. Introducing an automatic logout feature would significantly enhance the user experience by increasing the sense of security.

Cont. table 2.

User reviews of the mPay app on the Google Play Store	User feedback on the Play Store platform for downloading and installing applications for Android devices was analysed. On a 5-degree scale, the mPay mobile payment app received an average rating of 2.9. The comments mainly show dissatisfaction with the operation of the payment section, topping up the wallet or the app crashing and its constant updates.
Communication tools used in the mPay Fair Play marketing campaign	A series of 10 videos shared via social media (Instagram, Facebook, YouTube, TikTok); outdoor: city light ads, ads on public transport stops, billboards; social media posts; sports sponsorship.
Communication via Instagram and Facebook	Engagement with online users is achieved through humorous content (e.g., memes on how to manage personal finances), themed posts (such as "travel on the Tricity SKM with mPay"), competitions (e.g., the summer #PłatnościFairPlay competition), polls, and calls for support in winning awards. The platforms are also used to communicate updates about service offerings, new partnerships, brand ambassadors, and other relevant information. Both static images and videos are utilised, including a dedicated video series with Milena Bilska created specifically for the Fair Play Payments campaign. Influencer collaborations on these platforms include personalities from the finance, travel, and entertainment sectors.
YouTube activities	The mCast technology and finance podcast provides inspiring content on topics such as work-life balance, mental health, and women's stories, along with investment advice, company plans, key projects, activity summaries, and partnerships. The YouTube channel features video productions, promotional and educational content, and event coverage – including Invest Cuffs 2024 and mPay's 20th anniversary conference.
Communication on TikTok	Dialogue with stakeholders is conducted through themed and humorous content, in a style consistent with the brand's presence on other social media platforms.
Activities on LinkedIn and X (formerly Twitter)	Communication on these platforms is business-oriented, with content primarily targeting partners and investors. Posts include coverage of business events (such as WallStreet), announcements of new partnerships (e.g., with SynospisAI and Żabka), and the promotion of significant achievements.
Promotion of artificial intelligence integration	mPay actively publicises the implementation of an innovative AI system for User Hyper-Monetisation, highlighting related developments such as contract signings, scopes of cooperation, intended applications of the technology, and benefits of AI.
The brand community and its activity during the study period	A key element of contemporary marketing communication is the role played by the brand's community, particularly users of its services, followers on social media, and app users. mPay maintains an active presence across the following social media platforms: Instagram (562 followers), Facebook (14,000 followers/likes), X (316 followers), LinkedIn (1000 followers), TikTok (4246 followers and 55,000 likes). Additionally, the company operates its official website, www.mpay.pl, which receives an average of 53,000 monthly visitors.
Quality of MPay's communication with stakeholders	A moderate level of engagement was observed in the brand's communication with stakeholders. In particular, there was a lack of response to user questions, interactions with comments, or efforts to clarify issues reported in the mPay Store. Overall, mPay's communication efforts provide an informative knowledge base concerning its service offerings, mobile application, and content relevant to both individual and institutional customers, including information related to security.

Source: authors' own elaboration based on the studies conducted.

The approximate online marketing communication of the analysed brand and its effectiveness were evaluated by young adults in a completed survey. The main results are summarised in Table 3.

Table 3.
Survey results

Criteria	Study results obtained
Study sample characteristics	The survey sample included 222 people, among whom 55% were women and 43% were men; a few people (1%) did not address the question. The largest group of respondents (91%) were young people aged 18-27. In terms of the place of residence, more than a half (54%) of the respondents were from cities with a population of more than 200,000, 15% from rural areas and another 15% from cities with a population of more than 50,000 but less than 200,000, and 16% from smaller cities. Most of the participants had secondary education (75%) or higher education (22%), and the remaining 3% had vocational or primary education. Students made up 89% of the study group, of which 43% declared concurrent employment. Convenience sampling was used (the availability of students from the Faculty of Management at the AGH University of Science and Technology in Kraków was used, majors: Management, Computer Science and Econometrics, and Management and Production Engineering, as well as friends), the survey proper was preceded by a pilot involving 33 respondents. The survey was conducted online from 4 to 19 December 2024.
Brand awareness	Only 26% of the survey group said that the mPay brand was familiar to them, 21% were aware of the brand, and the majority of respondents cited the brand as previously unknown to them. Similar statistics could be observed in the context of use of the mPay Mobile Payments mobile app. The vast majority of respondents (60%) do not use the app, 27% of respondents use a competitor's app, and 13% of respondents did not address the question. The use of the brand's website was declared by just over 2% of respondents, the vast majority (98%) of respondents said they did not use it and did not interact with the mPay brand.
Evaluation of mPay's commercial featuring Miss Częstochowa Region Milena Bilska	The average rating of the commercial on a scale of 1-5 given by the respondents was 3.2. Despite the positive reception of the video, it encouraged only slightly more than 12% of viewers to declare their intention to use the mPay app.
Evaluation of the brand's selected marketing communication tools	Brand application Among the 222 respondents, only 10% declared use of the mPay mobile app. Among the 22 app users, the average rating on a scale of 1-5 was 3.5. Visual Identity System The vast majority of respondents (69%) found mPay's visual identity to be consistent and visually pleasing to the viewer.
Communication activities observed	The vast majority of respondents responded "No" to the question "Have you encountered mPay brand's communication activities on the Internet?" for each social media website. The social media portal where the most frequent communication activity of the brand was observed turned out to be Facebook with the answer to the above question being "Yes" in 14% of cases.
Social media communication	The vast majority of respondents do not follow any of mPay's profiles on social media. Among the 27% of respondents who are followers, the most important benefit they perceived from doing so was the ability to keep up to date with the news.
Position against the competition	When asked to rate the brand on a scale of 1 to 5 against other brands they know in the sector, the respondents gave an average rating of 2.54.
Effectiveness of the studied brand's online communication	65% of respondents did not encounter any of the brand's promotional activities online, and 30% of respondents said that they rarely noticed any activities. The respondents were also unable to identify mPay's brand ambassadors. The surveyed group rated the effectiveness of mPay's online marketing communications on a scale of 1-5. The average results are as follows: Facebook: 2.02; LinkedIn: 1.86; mPay website: 2.2; Dedicated channel on YouTube:1.98; Purchase of online advertising space: 2.04; Blog: 1.82; Interaction with social media users: 2.18.

Source: authors' own elaboration based on the studies conducted.

The results of our own research, summarised in the tables above, will be discussed in the next section.

4. Discussion

Based on the conducted research, mPay demonstrates a deliberate and strategic approach to online communication. The company actively publicises its collaborations with other entities, the launch of new services and products, the development of the mobile app and its functionalities, and – as a publicly listed company – communicates with investors via a dedicated platform (investorzy.mpay.pl).

A notable example of the company's innovative efforts is its collaboration with SynapsisAI to implement an AI-based User Hyper-Monetisation system, aimed at enhancing business operations and optimising processes through artificial intelligence.

In partnership projects, promotional synergy was observed – for instance, the collaboration between mPay and Żabka. This cooperation benefits both parties: customers receive loyalty points in the żappka app for every public transport trip made using mPay, while mPay's offering becomes more widely accessible.

Both internal staff and external agencies are involved in mPay's communication activities (notably, CEO Andrzej Basiak and marketing specialist Jarosław Grzesica, responsible for the mPay strategy, contribute alongside external agencies such as Partner of Promotion and FirMedia).

A key initiative during the study period was the "Fair Play Payments with the mPay VISA card" communication campaign for the mPay financial application, aimed at increasing brand awareness and educating potential users about the app. Its ambassador is Jakub Błaszczykowski – a widely recognised and trusted footballer – whose involvement supports brand values such as transparency and security. The campaign is implemented locally in various cities and focuses on building the brand community.

A significant element of the company's long-term public relations strategy was the refreshment of its visual identity and the consistent implementation of new visual standards across all communication channels.

The basis for the changes and the rebranding campaign (Kopańko, 2024) was research that concluded that mPay did not differentiate itself sufficiently. The design, communication and image changes were geared towards harnessing the potential of technology combined with the right emotions and building a unique value proposition. The new brand claim 'Always with you' is reinforced by the base elements of the visual identity system, i.e. the colour scheme, the typeface and the graphic element - the dot (in variations depending on the type of customer). Before the change, the logo was very contrasting, more warning than sympathetic, now softer colours mainly purple and white, have a better psychological and subliminal effect. Finally, the 'M' is meant to symbolise the brand's bond with mobility, and the rounded and slightly flared letters reinforce the associations of a 'friendlier' and 'companionable' brand necessary for stakeholders in different life situations, according to their needs and lifestyles. In summary,

mPay's new visual identity system is designed to reinforce a sense of comfort and support in the daily lives of stakeholders.

During the study period, the communication content was tailored to different audience segments, including individual customers (young investors, tourists, city residents, social media users), institutional customers (investors, entrepreneurs, partners, prospective partners), and broader market entities such as media representatives.

The company's competitive advantage is built on three pillars: technology, lifestyle, and convenience. For individual customers, the main benefits include time savings, comfort, elimination of queues, stress reduction, and access to services through personal mobile devices. For institutional customers, advantages are related to improved processes such as expense monitoring, consolidated accounting, business travel management, use of corporate tools (e.g., the mFlota panel), cost optimisation, and cashless payment methods.

In the group of (222) respondents, the studied brand has low recognition and its application is rarely used, which may be due to the limited nature of the quantitative research, which had a complementary purpose (and resulted from the intentions and limitations described in the own research methodology section). Studies published on the web (Serwis Ekonomiczny, 2025; Raport Kwartalny, 2025; Rozpoznawalność, 2025) on brand recognition of the fintech sector in Poland indicate the leading position of mPay.

Measurement tools and performance indicators such as: Google Trends (2025), Brand24 (Brand Team, 2019) and many others (Badania efektywności, 2025; Polak, 2025) make it easier to plan, execute and evaluate activities to efficiently communicate and create relationships with stakeholders. Characteristics of a brand's community, the number of likes and followers, mentions, sentiment, active followers are important indicators of the effectiveness of a brand's online marketing communications, its campaigns and campaigns, or real time communications practices (as described in Table 2).

In order to further investigate the effectiveness of the studied brand's communications, we used the Brand24 analytical tool. With the use of test accounts, the effectiveness of the Fair Play campaign in 2024 (February-April) and subsequent communication practices (November-December) was studied, and again, courtesy of Brand24.pl representatives, an opportunity was obtained to measure the resonance of the mPay brand's marketing communication activities in 2025 (April-May). Among other things, the mPaybuzz Infographic (Infografika, 2025) and detailed reports on mPay's communications in selected social media and in other Internet canals (Raport dla mPay, 2025) were generated.

The evaluation of the effectiveness of the analyzed communication activities came out positively. The communication policy is implemented content-wise, with the involvement of Internet users and in line with current trends and available functionalities of social networks, mPay communication platforms and fintech sector websites. In the period under review, on average, the sentiment towards mPay is neutral, the reach of communication activities in social media is sufficient, mentions dominate outside the brand's social networks and most often

appear in sector portals: bankier.pl, PremiumGPW, StockWatchPL, Bankrucik1, fintekpl. Most interactions occur in the mobile app and through the Newsy tab (mPay w gronie Gazel, 2024; mPay Liczba, 2024; mPay Liczba, 2025) on the brand's website.

In the light of the research carried out, mPay's online communication has little focus on stakeholder engagement (UGC). Evidence of concern for user feedback is found only in a mention of planned surveys on the company's website at www.mpay.pl. Features such as live chat and the FAQ section support user interaction. The company strives to provide necessary information to customers through the news section on its website and the corporate blog, in line with the real-time communication trend.

The authors also noted the brand's use of local targeting and hyper-targeting, both of which contribute to effectiveness and community-building.

Particularly noteworthy is the skilful use of a 10-episode video series divided into two themes: "A Trip to Kraków" and "A Business Journey". The involvement of micro-influencers from sectors aligned with the brand's offerings (finance management, travel) further supports communication success.

However, certain weaknesses were identified in the audited communication activities. These include: difficulty accessing current summaries and reports, irregular publication schedules, the use of specialist language and English insertions, lack of communication regarding the brand's sustainability practices, vague media relations efforts (e.g., no accessible press info section), and an underdeveloped investor relations site that falls short of best practices for publicly listed companies.

The review of the communication activities leads to several recommended improvements:

1. Increasing interaction with app users by responding to comments on social media posts and app distribution platforms.
2. Gathering insights from user feedback and implementing improvements accordingly.
3. Expanding content related to security and undertaking educational initiatives in this area.
4. Increasing the frequency of publishing content on social media profiles.
5. Keeping pace with trends in contemporary communication.
6. Clearly presenting the brand's position on its sustainable strategy.
7. Greater focus on providing up-to-date reports and activity summaries.
8. The innovative use of storytelling, in line with current market trends (elements of storytelling were observed in the video series, but they were not fully utilised in accordance with industry standards).
9. Efforts to increase user engagement and stimulate the creation of UGC would be desirable.
10. Staying vigilant and consistently communicating valuable content for individuals and within the sector.

5. Conclussions

The article is based on a study of the literature and available secondary sources of information and primary research, including a case study of a fintech company, the authors' participant observation and a survey of young people.

In the light of the literature study and own research, the following observations and conclusions are justified: network marketing communication is conducted for the mPay brand at a satisfactory level; it generates sufficient traffic and involvement of individual and institutional customers, which translates into a stable increase in the number of downloads of the application and an increasingly wider use of its functionalities already in more than 90 cities in Poland, which also promotes the gradual improvement of the mobile application and development of services for fleet customers.

The spectrum of observed marketing communication activities of mPay in the period under study gives the authors grounds to conclude that these are methodical marketing communication activities with such elements as:

1. setting objectives,
2. precise definition of addressees divided into individual and institutional,
3. a unique value proposition dedicated to representatives of a given market segment,
4. personalisation of communication and product activities (differentiated offer for individual and institutional customers),
5. planning communication activities using available channels and their functionalities, campaigns, actions and communication ventures,
6. identification of resources for activities,
7. selection of tools taking into account functionality, ease of use, integration and support,
8. schedule of implementation work,
9. control activities and improvements

which can serve as an example for other marketers to follow.

The research problem addressed: how an entrepreneur can and should use the tools, methods and procedures of a fintech brand's online marketing communication campaign to generate multi-faceted benefits for all stakeholders should be analysed on a larger number of such entities.

It is also the intention of the authors to extend the survey to a nationwide sample, including representatives of all B2C (‘young out-of-staters’ and ‘responsible rebels’) and B2B segments (banks, e-commerce, marketplace and education) that the brand under study wants to reach as a fintech.

It would also be worthwhile to explore how stakeholder experiences are created through marketing communication activities, taking into account the target groups and mapping out the

individual customer experience pathways and the institutional customer experience pathways identified above.

The growing popularity of mobile finance applications and the rapid development of digital services show that Poles are increasingly willing to use modern tools such as the mPay app. It covers almost all the user's needs: from phone payments and parking, to purchasing tickets or making transfers. The authors would like to emphasise that users' financial awareness and openness to using technology is growing, saving time and improving the delivery of services that are useful in everyday life.

In conclusion, in light of the literature and research studies conducted and their results, branded online marketing communication campaigns serve as an important managerial tool for modern businesses.

The need to undertake them is determined by: customer expectations, technological advances, increasing competition, the development of social media, and the strategy adopted by the brand.

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PREVENTION OF REVENUE SHIFTING TO TAX HAVENS IN POLISH ECONOMY

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Purpose: The purpose of this study is to examine the effectiveness of Poland's anti-haven regulations against global tax avoidance challenges, analyze the impacts of legislative changes on transfer pricing, and identify directions for future research and policy enhancements.
Design/methodology/approach: The analysis employs a comprehensive methodology to study revenue shifting to tax havens, focusing on the Polish economy's experience. It includes statistical data analysis, literature review, and examination of legal frameworks, especially highlighting amendments to transfer pricing regulations effective from January 1, 2021. The research offers a thorough insight into the mechanisms of income shifting and the efficacy of regulatory interventions against tax avoidance.
Findings: The findings indicate a challenging and ongoing effort against tax avoidance, with changes in transfer pricing regulations showing partial success in reducing profit shifting. Despite national and global measures, tax avoidance strategies continue to adapt, presenting persistent challenges.
Research limitations/implications: The research faces limitations, notably its dependence on public data, potentially overlooking some aspects of revenue shifting. Given the fluidity of tax avoidance tactics and regulatory actions, results may evolve with future developments. It recommends further detailed studies and case analyses to deepen understanding of tax avoidance mechanisms and assess regulation impact.
Practical implications: The research underscores significant implications for policymakers, tax authorities, and businesses. It advocates for a continuous update and refinement of tax regulations to address emerging avoidance schemes. The findings suggest that effective counteraction requires not only national but also international cooperation to close loopholes and enhance transparency.
Social implications: The research underscores the negative social impacts of tax avoidance, showing how it compromises public finance and equitable tax distribution, affecting the funding of vital services and societal welfare. It advocates for tax policy reforms that balance fairness with economic competitiveness, potentially informing public and industry policies to enhance quality of life and foster responsible corporate practices.
Originality/value: The paper adds to the tax avoidance dialogue with an in-depth look at Poland's anti-haven measures, analyzing legislative impacts and guiding future research and

policy. It benefits academics, policymakers, and tax professionals interested in global tax avoidance strategies.
Keywords: Tax Havens, Transfer Pricing, Tax Avoidance, Polish Economy, Anti-Avoidance Regulations.
Category of the paper: Research paper.

1. Introduction

Harmful tax competition in the form of escaping to tax havens is not only a local Polish problem, but has been a problem on an international scale for many years (OECD, 1998). About 15% of the world's countries are considered tax havens (Dharmapala, Hines, n.d.). For example, according to a 2017 study by the International Monetary Fund, the global loss due to tax avoidance is approximately USD 600 billion each year (Zoromé, 2007), while the Tax Justice Network estimates that the loss is USD 500 billion annually (Tax Justice Network, 2019). The lack of data makes it difficult to precisely estimate the total financial scale of jurisdictions applying unfair tax competition. There are many different methods of tax avoidance, one of the main ones being income shifting through transfer pricing (Contractor, 2016).

The concept of an offshore financial center (OFC), commonly referred to as a "tax haven", is not clearly defined (Zoromé, 2007). Benefits achieved in the OFC are not only of a tax nature (Folfas, 2008). Different approaches to the criteria for recognizing countries or territories as a tax haven have developed, in particular: zero or low taxation, creating a favorable regulatory environment, disparity between the scale of the domestic financial sector and the financial needs of the domestic economy, willingness to perform financial operations using currencies other than the domestic one (so-called multi-currency), separation (geographical/regulatory) of these centers from regulators (Wiśniewski, 2012).

The Polish legislator has created a list of countries and territories applying harmful tax competition, specified in a regulation issued by the minister responsible for public finance. The Polish list of tax havens is getting shorter and shorter (Podatki ABC, 2023). Also, the OECD monitors progress in the implementation of its recommendations on an ongoing basis and publishes a "black" list of countries that are not willing to cooperate in the field of taxation.

The main purpose of the article is to analyze and evaluate anti-haven regulations in the area of transfer pricing, in particular the changes in force from January 1, 2021.

It is hypothesized that in the dynamically changing economic environment, transfer prices are financial instruments that are increasingly used to transfer income to tax havens. These activities result in the need to constantly adjust the transfer pricing mechanism in order to ensure fair market competition and fair payment of tax liabilities by business entities.

2. Anti – paradise initiatives

Items Unfair tax competition by shifting profits to tax havens was of particular interest, especially after the 2008 financial crisis. At that time, attention was directed primarily towards international corporations, whose sometimes sophisticated activities in the area of tax avoidance have a negative impact on the budget revenues of the world's largest economies (Feust, Spengel, Finke, Heckemeyer, Nusser, 2013). Economist Gabriel Zucman presented his accounts of the scale of profit shifting by economic entities to tax havens. His calculations show that about 8% of the global national wealth of households is located in tax havens (Zucman, 2014). Since the 1980s, the use of tax havens has been steadily increasing. The author estimates that about 55% of the American national income generated by American companies abroad is located in six tax havens: the Netherlands, Bermuda, Luxembourg, Ireland, Singapore, and Switzerland (Zucman, 2014). According to Zucman, the share of capital held "abroad" in developing countries ranges from about 10% for European countries, through 20-30% for African and South American countries, to about 50% for Russia and the Gulf countries. In addition, the author points out that with the current tax system, it is impossible to determine the exact value of this type of transaction.

The most important global initiative to counteract Base Erosion and Profits Shifting (BEPS) was the project initiated at the G20 summit in Los Cabos in 2012, and then co-created by 130 countries (OECD, 2015). In 2015, an OECD report called "Action Plan on Base Erosion and Profit Shifting" was created, published over the years 2013-2015, consisting of 15 activities, e.g., regarding the exchange of information on harmful tax practices or anti-abusive activities (OECD/G20 Base Erosion and Profit Shifting Project, 2015).

In the discussion on the effects of tax avoidance by international corporations, the reduction of revenues to the budget of the countries where they conduct business and generate revenues (profits) is mentioned in particular. In order to approximate the fiscal effects and the scale of aggressive tax planning, six indicators were used (Feust et al., 2013). This was due to the fact that a single indicator, despite directing researchers to certain conclusions, was not a sufficient source of evidence for the phenomenon, but several indicators giving the same or very similar results can serve as evidence of it. As part of the BEPS activities, the OECD specified the following indicators (OECD, 2015):

- ratio of foreign direct investment in relation to Gross Domestic Product,
- ratio of differentiated profit rates to effective tax rates,
- the rate of profit differential between locations with low tax rates to the global business operations of multinational companies,
- the ratio of the effective tax rates of large affiliates of multinational enterprises to non-international enterprises with similar characteristics,

- concentration ratio of high levels of revenues from royalties in relation to expenditures on research and development (R&D),
- ratio of above-average interest-to-income ratio of affiliates of multinational enterprises in relation to the ratio of interest-to-income in countries with higher taxation.

In the European Union, in 2016, the ATAD directive and its amendment ATAD 2 were also passed. the obligation to implement the clause on combating tax avoidance and evasion (Council Directive (EU) 2016/1164; Council Directive (EU) 2017/952). The loss of tax revenue within the European Union was estimated at EUR 50-70 billion in 2013 (European Commission, 2017). Unfortunately, it is currently very difficult to conduct more thorough research on the topic of tax avoidance. This is due to the lack of available information on the finances of entire corporations and their subsidiaries. Information contained in tax returns is a particularly important source of estimating the scale and effects of this problem (OECD, 2015). According to the OECD, only eight of the thirty-seven countries surveyed were able to report the share of the tax paid by multinational corporations in the overall corporate income tax (OECD, 2015). Jost Heckemeyer and Michael Overesch, economists dealing with the problem of shifting income to tax havens or tax systems with more favorable tax rates, have empirically estimated that the elasticity of reported income (in the country where the income was generated) in relation to the difference in income tax rates (between two tax jurisdictions) is 0.8 (Heckemeyer, Overesch, 2013). This means that if the difference in the tax rate between these tax jurisdictions increases by, for example, 10%, the amount of income reported for taxation will change by 8%.

The figure 1 shows two situations. For simplicity, it has been assumed that the change in the tax difference between jurisdictions is 10% in each case. In the first case, it was assumed that in a country with a high tax rate, taxes fell from 30% to 20%. The tax difference has changed by 10% in favor of country A. Using the results of Heckemeyer and Overesch's research, this means that the company will reduce the transfer of capital to country B by 0.8 of the change value - i.e., by 8% - 8000 monetary units. Example 2 shows a similar situation, but this time the tax rate in country A increases from 10% to 20%. The difference in taxation between countries has also changed by 10%, only this time the change increases the tax competitiveness of country B. In example 2, the company, as a result of increasing the tax rate in country B, where the income is actually generated, transfers 8% more capital to the tax jurisdiction of country B.

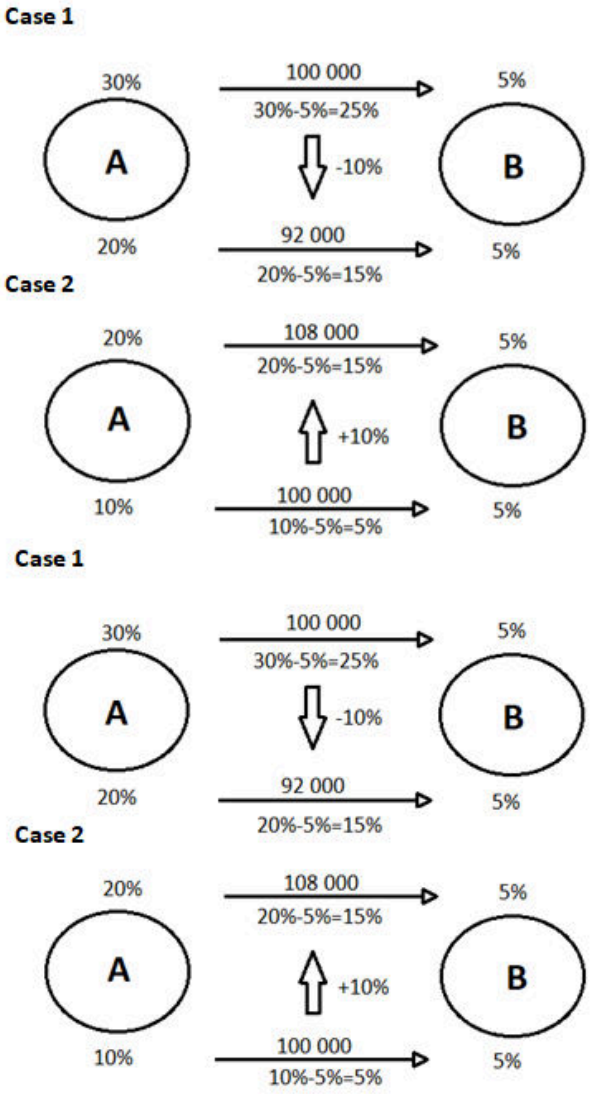

Figure 1. Elasticity of reported income (in the country where the income arose) in relation to the difference in income tax rates.

Source: own study.

Dhammika Dharmapala, an economist dealing with the problem of income shifting, in his research takes the result of Heckemeyer and Overesch elasticity (1/0.8) as a representative consensus (Dharmapala, Year). Dharmapala notes that the consensus on the elasticity of capital transfer to the difference in tax rates across tax jurisdictions has changed over the years. Previous estimations of the phenomenon indicated a higher vulnerability of income shifting. In the author's opinion, determining whether such a level of flexibility is high or low is difficult to determine, because there is no conventional "borderline" in this type of research. In the attempt to determine the nature of this phenomenon, the current economic situation as well as the nature of the transfer and the role of the (given) tax jurisdiction in the whole scheme play a huge role.

3. The background of the fight against tax avoidance in Poland

Figure 2 graphically presents the relationship between the number of CIT taxpayers and budget revenues for Poland.

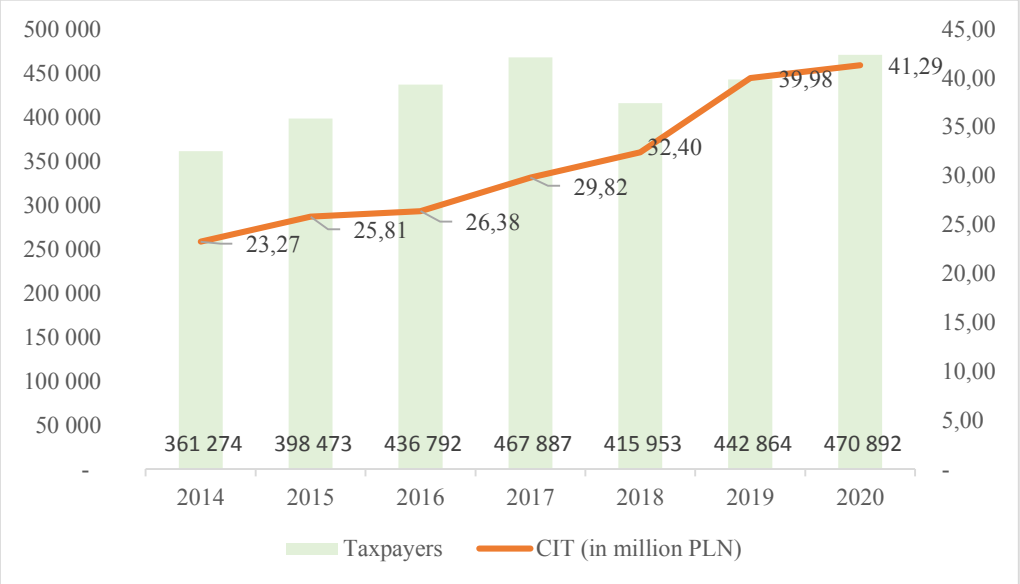

Figure 2. Number of CIT taxpayers and budget revenues in 2014-2018.

Source: own study based on: Budget Execution Reports for the years 2014, 2015, 2016, 2017, 2018, 2019, and 2020, and Structural Changes of Groups of Entities in the National Economy in the REGON Register for the years 2014, 2015, 2016, 2017, 2018, 2019, 2020. Central Statistical Office.

Figure 2 shows that in the years 2014-2020 there is an increase in budget revenues from CIT by an average of 10%. The highest increase in CIT revenues took place in 2019 - 23%. It should be noted that corporate tax revenues in the analyzed period grew faster than GDP. The increase in CIT tax revenues in 2014-2018 was undoubtedly due to the good economic situation prevailing in this (pre-pandemic) period in Poland and in the world. The steps taken to achieve the so-called tightening the tax system in Poland have contributed to this growth. The average increase in the number of CIT payers in the analyzed period was 5% (twice less than the growth rate of CIT tax revenues). The average number of CIT taxpayers in the analyzed period was 438,810. Despite the relative stabilization of CIT revenues, the level of the corporate income tax gap remains at a relatively high level. According to the Polish Economic Institute, the amount of the CIT tax gap in 2014-2018 for Poland was on average 1.6% of Polish GDP (Sawulski, Bąkowska, Gniazdowski, 2020).

It should be noted that this process is a continuous one that requires changes to meet the changing economic environment (Sawulski, Bąkowska, Gniazdowski, 2020).

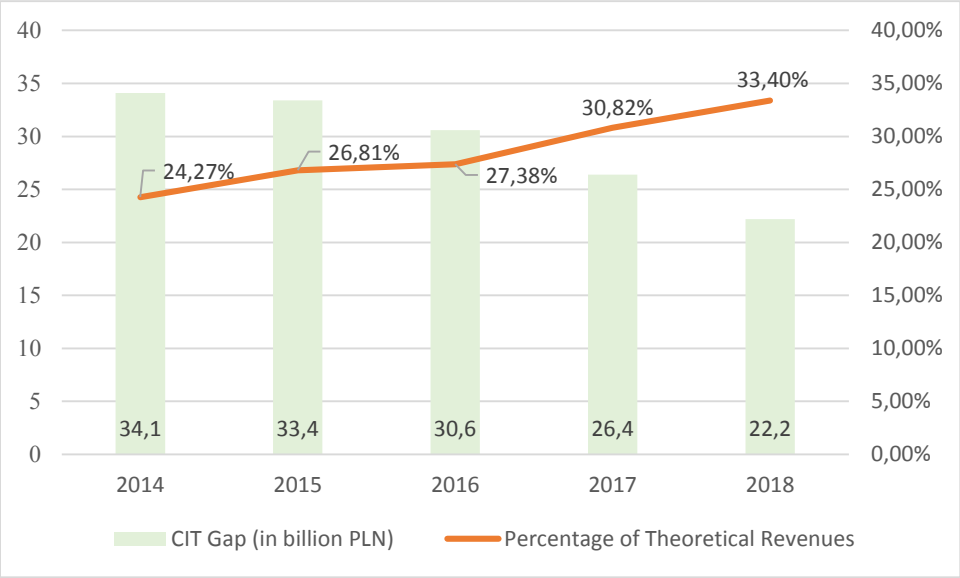

Figure 3. Corporate Tax Gap in Poland in 2014-2018.

Source: Own study based on: Sawulski, Bąkowska, Gniazdowski, 2020, p. 10; Budget Execution Reports for the years 2014, 2015, 2016, 2017, Budget Law for 2018 of January 11, 2018 - signed by the President of Poland on January 29, 2018 (Journal of Laws of 2018, item 291).

The problem of the tax gap arises in particular when BEPS (Base Erosion and Profit Shifting) is used to shift profits to other tax jurisdictions. The figure 4 presents losses of CIT revenues as a result of profit transfer as a % of total CIT revenues in 2016.

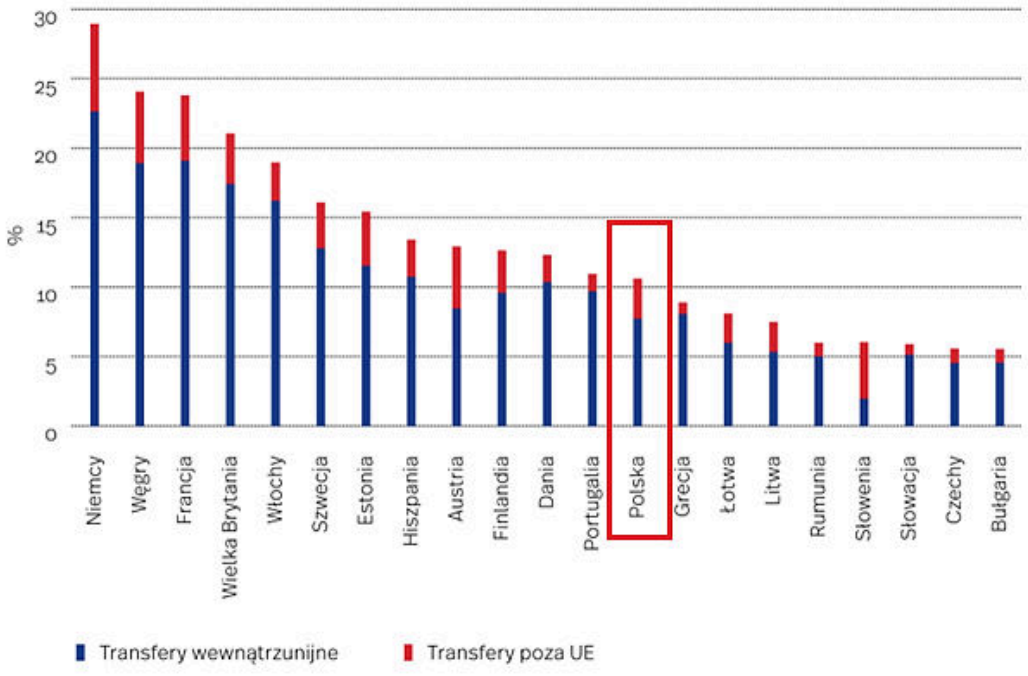

Figure 4. Losses of CIT Revenues as a Result of Profit Shifting as a Percentage of Total CIT Revenues in 2016.

Source: Sawulski, 2020, p. 16.

Data for 2016 show that the countries most affected by losses resulting from the artificial transfer of profits by corporations are Germany (around 28% CIT), France and Hungary (around 24% CIT) and the UK (around 21% CIT). According to the research of the Polish Economic Institute, in 2016 Poland lost about 11% of the CIT tax, the vast majority of which was transferred to other EU countries.

One of the indicators that the OECD specified as part of the fight against the erosion of taxation and profit transfer is the ratio of foreign direct investment in relation to Gross Domestic Product. The table below contains data for this indicator for Poland.

If the table was borrowed from a publication, the source should be provided underneath. You should not insert tables as figures, but as Microsoft Word tables. The text must contain a reference to a given table (Table 1).

Table 1.
Foreign direct investment ratio in relation to Poland's Gross Domestic Product in 2015-2020

FDI	Poland					
year	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
USD value	3 172	12 389	1 908	1 239	1 404	320
as % GDP	0,66%	2,62%	0,36%	0,21%	0,24%	0,05%

Source: own elaboration.

The table above presents the size of foreign direct investment (FDI) in the form of capital that flows out of Poland every year. The highest outflow in the analyzed period was recorded in 2016 - over USD 12 million, which accounted for nearly 3% of the Polish Gross Domestic Product (GDP). Compared to the previous year, FDI increased almost three times. The year 2016 is also the year in which FDI was the highest in the analyzed period. The highest decrease in the outflow of capital from Poland in the form of FDI was recorded in 2017 (decrease by 85% compared to the previous year) and in 2020 (decrease by nearly 77% compared to the previous year). The average share of FDI in the analyzed period amounts to approximately USD 3.5 million and constitutes approximately 0.69% of Polish GDP.

The Polish Financial Supervision Authority (KNF) is a state institution that deals with the broadly understood security of financial markets. In 2018, the Office of the Polish Financial Supervision Authority prepared (for the needs of the General Inspector of Financial Information) an analysis of the main directions of the flow of funds directed to the Polish financial system and outside, and also defined the places of origin of non-residents using this system. In the document constituting an annex to the National Money Laundering and Terrorist Financing Risk Assessment Report, the Office of the Polish Financial Supervision Authority specified a number of criteria determining financial security in the area of money laundering and terrorist financing. One of them was the criterion of foreign transfers originating from Poland in relation to countries and territories considered as tax havens (Ministry of Finance, 2019; Financial Supervision Authority, 2018). This information is presented in the table below.

Table 2.
Values of foreign transfers from Poland to countries and territories beyond tax havens

Country	Transaction value (in billions PLN)
Hongkong	10 308,08
Mauritius	475,56
Panama	172,50
Monako	133,00
Makau	112,38
British Virgin Islands	66,06
Bahrajn	61,74
Seychelles	53,10
Maledives	23,25
Curaçao	16,42
Andora	15,44
Antigua and Barbuda	14,88
Anguilla	10,24
Saint Lucia	6,56
Marshall Islands	6,32
Dominica	2,66
Nauru	2,12
Cook Islands	1,53
Vanuatu	0,85
Samoa	0,54
Liberia	0,32
Grenada	0,14
Saint Maarten	0,08
US Virgin Islands	0,04
Niue	0,04
Tonga	0,01
Isle of Sark	0,00

Source: Financial Supervision Authority (2018). Analysis of statistical information provided by entities supervised by the PFSA for the purposes of the National Risk Assessment (NRA), Warsaw, p. 19.

The table presents a list of countries recognized as countries or territories applying aggressive tax competition in the field of corporate income tax. The analysis showed that to these countries, nearly PLN 11.5 billion was transferred, which is about 0.8% of the total of all transactions outgoing from Poland in the analyzed period (Ministry of Finance, 2019). By far the largest amount of funds was transferred to Hong Kong - PLN 10.3 billion, which accounted for nearly 90% of all funds transferred. The research indicates that it is much more than the value of Poland's trade in goods with this country (Ministry of Entrepreneurship and Technology, 2017). The reason for such high cash flows to Hong Kong may be the desire to illegally hide income and take advantage of tax optimization.

The issue of foreign direct investment carried out only for the purpose of transferring income to "more friendly" tax jurisdictions is also the subject of research on the international arena.

Table 3.
Foreign direct investment FDI (receipts) in the world in 2014-2019 (in USD billion)

Lp.	Country/Year	2014	2015	2016	2017	2018	2019
1	United States	2,945	3,354	3,561	3,786	4,127	4,458
2	Netherlands	4,334	3,939	4,184	4,958	4,569	4,369
3	Luxembourg	3,230	3,697	3,775	4,217	3,632	3,495
4	China	2,331	2,579	2,534	2,688	2,814	2,938
5	United Kingdom	1,744	1,530	1,475	1,607	1,864	1,974
6	Hong Kong	1,330	1,395	1,418	1,588	1,705	1,732
7	Singapore	0,914	0,943	0,966	1,173	1,289	1,465
8	Switzerland	0,826	0,982	1,282	1,427	1,418	1,453
9	Ireland	0,416	0,888	0,840	1,057	1,048	1,152
10	Germany	0,859	0,781	0,794	0,963	0,934	1,023
	Total FDI	29,242	29,947	31,285	35,466	35,145	36,395

Source: own study based on data from the International Monetary Fund, IMF Coordinated Direct Investment Survey Guide for 2014-2019.

The table above presents FDI flows (in the form of capital inflows) in descending order for 2019 for individual countries in the world. It should be emphasized that the national economies of countries such as the Netherlands, Luxembourg, Ireland, Singapore and Switzerland have been the main centers of influence of FDI for years. Moreover, in FDI flows for the presented period, 60% of FDI beneficiary countries are European countries, among which the leader in attracting foreign direct investments is the Netherlands.

4. Counteracting the shifting of income through transfer pricing – assumptions of a new anti-abusive regulation

The growing importance of transfer pricing leads to the introduction of comprehensive regulations aimed at counteracting the erosion of tax bases and profit shifting. From the tax point of view, transactional transfer prices "divide" the income of entities participating in the transaction (as a rule: related entities, e.g., belonging to the same capital group), determining their revenues and costs, and consequently also how they are distributed territorially income and how much it will be taxed.

The criterion used in international relations to examine the terms agreed between related parties and the resulting prices is the arm's length principle. A certain decision-making freedom in the field of transfer pricing policy results from the fact that the market prices of a given good are within a certain range of values. The market level of prices (margins, etc.) determines many factors, such as individual characteristics of a given good, functional profiles of entities participating in the transaction, location and characteristics of the market, intensity of competition, or transaction conditions.

In the area of transfer pricing, the regulations on estimating and documenting transactions with so-called paradise entities concern in particular (Ministry of Finance, 2019):

- the possibility of estimating the value of the transaction when the beneficial owner is located in a so-called "tax haven",
- extending the scope of transactions subject to the obligation to prepare transfer pricing documentation,
- introduction of the so-called benefit test,
- extending the scope of transaction value estimation, in particular to non-controlled transactions, if the beneficial owner has a tax residence in a so-called tax haven.

As a consequence of extending the powers of tax authorities to assess income from transactions with paradise entities, the scope of transactions requiring documentation has been extended, in particular to (Art. 4a point 29 of the CIT Act; Ministry of Finance, 2019):

- uncontrolled sales transactions, as a result of which payment of receivables is received directly from the paradise entity, if the value of this transaction for the tax year exceeds PLN 100,000,
- controlled transactions or transactions other than controlled, if the actual owner has a tax residence in a tax haven, if the value of this transaction for the tax year exceeds PLN 500,000.

At the same time, the scope of elements required in the local tax documentation of transactions with entities from so-called tax havens includes an economic justification, including a description of expected economic and tax benefits. It is worth noting that the basic documentation requirements are the result of the implementation into the Polish legal system of the results of OECD work carried out under the BEPS project, e.g., following the recommendations contained in Action 13 BEPS, the concept of three-stage transfer pricing documentation was adopted (OECD, BEPS Actions 8-10 and 13).

It seems correct to see the fundamental problem of shifting income to havens in transactions of an indirect nature.

On the downside, one should first of all point out the nuisance in the field of compliance. There are practical difficulties in determining the "beneficial owner".

With this in mind, a presumption has been introduced that the actual owner has a place of residence, registered office or management in the territory or in a country applying harmful tax competition, if the other party to the transactions referred to in par. 1a, shall make settlements in the tax year or financial year with an entity having its registered office or management board in the territory or in a country applying harmful tax competition. As a result of determining the circumstances that the other party to the transaction is making settlements with a paradise entity, there is a presumption that the actual owner is a paradise entity. In order to challenge this presumption, it is necessary to prove the opposite circumstance, i.e. that the actual owner is not a paradise entity. As a result of challenging the presumption, there is no obligation to prepare local transfer pricing documentation.

Due diligence should be exercised in determining these circumstances. Due diligence is a certain standard of expectation from taxpayers. There should be no negative legal consequences in relation to a taxpayer who has complied with the due diligence standard. As a rule, in order to exercise due diligence when making transactions with unrelated entities, regardless of their place of residence, it is sufficient for the taxpayer to obtain a declaration of knowledge from the other party to the transaction, which shows that the other party to the transaction does not make any settlements in the tax year taxpayer, with a paradise entity.

5. Conclusion

The need to counteract tax avoidance, including tax evasion to tax havens, is rather beyond discussion. The legitimate interest of each state is to tax the income of taxpayers that have been earned in the area under its tax jurisdiction. A country in whose jurisdiction the erosion of budget revenues occurs, due to agreeing or imposing non-arm's length conditions, must introduce mechanisms to adjust income (tax due).

Artificial shifting of income may lead to an unauthorized competitive advantage on the market, causing de facto market distortion. Competition with such companies that illegally use tax schemes that result in shifting tax revenues to tax havens is difficult. Entities recognizing that they are unable to compete with companies optimizing their tax liabilities, start using the same solutions themselves. However, aggressive tax planning has many other (usually negative) effects, such as: debt market distortion; inefficient allocation of resources; intensification of tax competition between countries. In the Polish economic space, capital in the form of foreign direct investments is predominantly transferred to Hong Kong, which is recognized in Polish legislation as a jurisdiction applying aggressive tax competition. Taking into account the global directions of the flow of this type of capital, Polish FDI flows seem to be part of the global trend of using Hong Kong's tax jurisdiction to hide income. It is worth noting that not all capital flowing from Poland to Hong Kong in the form of foreign direct investment should be treated as an attempt to hide income/avoid taxation in the home country. However, trade with this country, its economic specificity, as well as the research presented in this article suggest a large size of this financial phenomenon.

The new regulations in the area of transfer pricing are an expression of the policy of tightening regulations aimed at combating the shifting of income to the so-called tax havens. An effective fight against tax avoidance requires the introduction of non-standard mechanisms to combat such phenomena, but it must also assume cooperation of taxpayers with tax authorities in the fight against tax abuses. The dynamically changing economic environment is a challenge for tax authorities. Regulatory trends are clear, the complexity and detail of information provided to tax authorities is increasing, including sensitive financial data.

However, it is not about excessive bureaucratization of tax obligations, but about making the profit generated in the economy of a given country work for the benefit of its citizens.

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PAY TRANSPARENCY IN THE ORGANISATION IN THE OPINION OF GENERATION Z

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Purpose: One of the most important challenges in the modern labour market is to ensure equal pay for equal work or work of equal value between men and women. The lack of such equality causes the gender pay gap phenomenon. To eliminate this unfavorable phenomenon, a directive introducing regulations on pay transparency (PT) was developed in EU countries. The article aims to assess the results of implementing pay transparency in an organisation from the perspective of employees of Generation Z.
Design/methodology/approach: The theoretical part of the paper discusses the essence and objectives of implementing the concept of pay transparency in an organisation, presents selected provisions of Directive EU 2023/970, as well as attitudes of employees from Generation Z towards organisational transparency are described. The second part of the article presents the results of the survey conducted among 386 students in Poland in 2024.
Findings: The vast majority of Generation Z respondents confirm the need to implement PT in organisations. Most respondents recognize that it can reduce the pay gap between women and men. They positively assess the potential benefits of PT for the company and employees. Representatives of Generation Z attach greater importance to the benefits that they themselves will gain, and are less interested in the benefits of the organisation.
Research limitations/implications: The size of the research group does not allow for general conclusions to be formulated. However, the obtained results may constitute a basis for further in-depth research on this issue. Similar studies could be conducted in 2026 after the implementation of the Directive, to determine the opinions of both employees and employers, taking into account additionally various variables, for example, gender, seniority, and level of remuneration received.
Practical implications: Using the survey results can help managers better implement the provisions of the Directive into management systems, taking into account the needs and expectations of Generation Z.
Originality/value: The obtained results fill the research gap concerning the assessment of benefits and threats of employers' implementation of pay transparency provisions in the organisation from the perspective of Generation Z.
Keywords: pay transparency, Directive EU 2023/970, Generation Z, gender pay gap.
Category of the paper: Research paper.

1. Introduction

After entering the keyword "pay transparency" in the Science Direct and Web of Science Core Collection databases, it is possible to obtain a list of several thousand articles on this topic, assigned to such research areas as: Social Science, Economics, Econometrics and Finance, Business, Management and Accounting, Environmental Science, Medicine and Dentistry, Energy, Engineering, Computer Science, Decision Sciences, Public Administration, Psychology.

To reliably assess the possibilities of implementing the concept of pay transparency in an organisation, as well as the benefit obtained by doing so, at the individual and organisational levels, the research were conducted using a variety of methods, including case studies (Král, Kubisová, 2021), in-depth interviews (Stofberg et al., 2022), surveys (Smit, Montag-Smit, 2018), analysis of statistical data (Blundell, 2021), as well as analysis of legislation applicable in various countries (Bennedsen et al., 2023).

However, a review of the literature on pay transparency indicates that there are no clear results regarding the consequences of its introduction in organisations (Brütt, Yuan, 2022; Gallen et al., 2019). On the one hand, there may be many benefits, but there may also be various risks for employers and employees (Avdul et al., 2023; Schnaufer et al., 2022). Pay transparency can influence employee attitudes and organisational effectiveness, but this area also lacks consistent findings and unambiguous guidelines for its implementation (Brown et al., 2022).

The lack of such unambiguous results is particularly unfavorable to Generation Z employees now entering the labour market and the actions employers take towards this generation. These are individuals who highly value honesty, openness, and fair treatment in the workplace. They have a strong sense of moral and ethical values and a concern for social justice. What this means for organisations is that there needs to be a greater emphasis on transparency, fairness in employee relations, and attention to ethical operating standards. Companies that can align themselves with these expectations and values of Generation Z can enjoy the loyalty and engagement of these employees (Lazanyi, Bilan, 2017).

Assessing the results of implementing pay transparency in an organisation by representatives of Generation Z is therefore particularly important, but this issue has not yet been studied very widely in the literature. Therefore, this area has been identified as a research gap, which is the subject of consideration in this article.

The article aims to assess the results of implementing pay transparency in an organisation from the perspective of Generation Z employees. The main question is as follows: What is Generation Z's view of the benefits and risks of implementing pay transparency in the organisation?

The first part of the article reviews the literature on pay transparency and the characteristics of Generation Z in terms of preferred work-related values. The second part presents the results of the empirical research conducted by the author of the article. The research methodology, results obtained are described, the conclusions of the research and their limitations are formulated.

2. Pay transparency and expectations towards work of Generation Z

2.1. Pay transparency in the organisation

Pay transparency is defined as the degree to which employers disclose information about how they determine pay (process transparency), how much they pay (outcome transparency), and how much they permit employees to discuss pay (communication transparency) (Stofberg et al., 2022). Pay transparency is considered a shift from a highly secretive to a very open system of employee compensation (SimanTov-Nachlieli, Bamberger, 2021). It is an employer's practice of disclosing information about employees' compensation strategies to others – stakeholders inside and outside the organisation. Pay transparency is also described as the extent to which employers can opt for different degrees of transparency based on legislation or their human resources strategy. Pay transparency is linked to the principle of equal pay and is essential to establish whether there is equality in compensation between men and women, which is key to identifying and closing the gender pay gap (Conley, Torbus, 2018).

To date, how pay transparency has been implemented across the EU has been inconsistent, with different countries defining the possibilities and modalities of legislating and principles for implementing legislation in those countries differently (Hofman et al., 2020). Thus, the concept of pay transparency in the organisation has therefore been regulated in EU countries through the development of Directive (EU) 2023/970 of the European Parliament and of the Council of 10 May 2023 to strengthen the application of the principle of equal pay for equal work or work of equal value between men and women through pay transparency and enforcement mechanisms.

The implementation of Directive (EU) 2023/970 in an organisation is linked with many key provisions, including:

- "In order to ensure a uniform presentation of the information required by Directive, pay levels should be expressed as gross annual pay and the corresponding gross hourly pay" (22);
- "Applicants for employment should receive information about the initial pay or its range in a manner such as to ensure an informed and transparent negotiation on pay, such as

in a published job vacancy notice, prior to the job interview, or otherwise prior to the conclusion of any employment contract" (32);

- "Employers should ensure that job vacancy notices and job titles are gender neutral and that recruitment processes are led in a nondiscriminatory manner, so as not to undermine the right to equal pay" (33);
- "Employers should make accessible to workers the criteria that are used to determine pay levels and pay progression" (35);
- "All workers should have the right to obtain information, upon their request, on their individual pay level and on the average pay levels, broken down by sex, for the category of workers performing the same work as them or work of equal value to theirs" (36);
- "Employers with at least 100 workers should regularly report on pay" (38);
- "Pay reporting should allow employers to evaluate and monitor their pay structures and policies, allowing them to proactively comply with the principle of equal pay", (…) "The sex-disaggregated data should assist competent public authorities, workers' representatives and other stakeholders in monitoring the gender pay gap" (…) (39).

The implementation of the pay transparency Directive will allow for the effective application of the principle of equal pay in practice. It will enable the disclosure of potential bias or gender discrimination in pay systems and contribute to raising awareness and a better understanding of the causes of the gender pay gap (Hofman et al., 2020). While pay transparency is seen as a potential solution to the pay gap and a factor in ensuring gender pay equity, its effectiveness, and implementation are influenced by many factors, including the legal framework, the organisational context, and the company's existing practices (Mignano, 2024).

The regulations for implementing pay transparency in an organisation are related both to the three mentioned areas of transparency in its definition, but also to the similar distinction of three aspects of transparency, i.e. related to the amount of information an organisation makes available about employees' pay levels, the amount of information an organisation shares about how it makes pay decisions, and the restriction or permission to openly share employees' information about their pay (Montag-Smit, Smit, 2021). All three aspects are of significant importance to employees and have many implications for the organisation and employees, which can shape employees' attitudes towards the concept. Discrepancies between employees' preferences and the organisation's PT policy may reduce job satisfaction and perceptions of fairness in informational, interpersonal, and procedural contexts.

In practice, the consequences of implementing PT are closely intertwined and often affect the three aspects of transparency mentioned earlier at the same time. For example, disclosing employees' pay salary information may result in a lack of control over who will have access to it and for what purposes they will use it, which may consequently result in conflicts between employees (Smit, Montag-Smit, 2018).

2.2. The results of implementing pay transparency in the organisation

The implementation of pay transparency in an organisation forces employers to review and organise the solutions contained in their employees' compensation systems, which can help to eliminate possible conflicts between them and avoid allegations of discrimination against them. Such a process of cleaning up the existing remuneration system is time-consuming and costly but can bring many benefits to the organisation (Torbus, 2022).

When considering the implementation of a remuneration transparency policy in an organisation, it is important to bear in mind the measurable and non-measurable (or difficult to measure) costs of implementing this process. They are often ignored in the analyses carried out, although they burden the budgets of employers, employer and employee organisations, and government institutions. Of course, their existence cannot be a basis for deciding not to implement pay transparency legislation, but it should be borne in mind that certain costs will have to be incurred (Bennedsen et al., 2023).

One of the benefits of pay transparency is increasing the efficiency of recruitment processes – disclosure of salary ranges in an offer eliminates those candidates who will not accept it because of a salary that does not meet their expectations, and better employee retention – pay transparency promotes employee trust and loyalty (Inc.com, 2021) and productivity. Transparency can encourage employees to improve their results, thereby increasing internal competitiveness. However, it can be perceived by some employees as forcing them to work harder and as a manipulative act by the employer, particularly disadvantageous for such individuals who do not accept a highly competitive work environment (Marquis et al., 2011).

By allowing employees to share and discuss pay information, organisations can foster a more open work environment. This can lead to a reduction in the perception of unfair pay practices (Načinović Braje, Kuvač, 2022). Pay transparency provides an opportunity to reduce discrimination and promote fairness, making pay differences more visible and justifiable. On the other hand, research indicates that pay transparency can lead to pay uniformity, as employers can standardise salaries to avoid conflicts arising from pay differences (Ramachandran, 2012). They will also need to ensure that they use appropriate methods and procedures for job valuation and job evaluation to fairly describe the responsibilities of different jobs within the company, and identify the necessary competencies to properly align job titles, and job content, and consequently, set appropriate overtime pay (International Labour Organization, 2019).

From the managers' perspective, ensuring pay transparency can be much easier and less risky when there is little variation in employee pay. This can reduce the number of conflicts, lawsuits, and the need to negotiate with employees about significant changes in their pay levels (Avdul et al., 2023).

Another outcome of implementing the PT concept is an increase or decrease in the level of employee trust in the organisation. The direction of these changes will depend on the assessment of the motives attributed to the company. If employees perceive transparency to be of greater benefit to the company rather than to the staff employed, then their trust may decrease significantly. For the same reason, there may also be a reduction in employee engagement and satisfaction (Colella et al., 2007).

While pay transparency can bring many benefits to an organisation by promoting a fairer and more equitable workplace, it also poses challenges, such as the need to implement the concept skilfully to avoid its negative effects (Načinović Braje, Kuvač, 2022). Opponents of pay transparency argue that gender pay disclosure is a challenge for companies because it is not practical, increases administrative burdens, and violates employee privacy (Bennedsen et al., 2023).

The implementation of pay transparency will have many positive effects on employees. There will be an opportunity to assess their position in the organisation and pay potential, and there may also be an improvement in well-being, resulting from the fact that they are aware that managers can be held accountable for pay decisions that are publicly known. Transparent pay can signal the organisation's commitment to employees and their well-being (Montag-Smit, Smit, 2021). Transparency also provides clues to employees about what the organisation values, e.g. high qualifications and job performance are linked to higher salaries. For employees, it communicates that the organisation values employees' contributions and is committed to their career success.

The implementation of pay transparency can have the fundamental benefit of reducing the pay gap for employees, which is considered a key objective of PT (Heisler, 2021; Kim, 2023). Obloj and Zenger argue that greater transparency may lead companies to focus attention on modifying the remuneration of those individuals who, based on pay equity data, are under or overpaid. It may also result in employers making fair pay offers to men and women (Obloj, Zenger, 2022). This is related to relating pay to the specifics of the job rather than to the pay of another employee, which perpetuates the gender pay gap more (International Labour Organization, 2019).

Lack of pay transparency can create many risks for employees. Secrecy is usually seen as a way to underpay employees. For example, withholding salary information can be considered an attempt by an organisation to limit employees' bargaining power by deliberately withholding information that would be useful for negotiating a salary increase (Colella et al., 2007). PT can paradoxically be a source of creating pay inequalities and treating people unfairly. This is because individuals with exceptionally high performance and commitment, who should be paid more than others, may be underpaid due to managers' desire to avoid conflicts between employees when they make salary comparisons (Belogolovsky, Bamberger, 2014). In addition, transparency may result in the alignment of employee and manager salaries, as managers will feel pressure to pay employees similarly because their salary levels will be public information.

Cullen and Pakzad-Hurson analysed the effects of introducing pay transparency when a company dynamically negotiates salaries with many employees. They found that in such a situation, pay transparency led to reduced and flattened salary levels (Cullen, Pakzad-Hurson, 2023).

Summarising the above discussion, it should be noted that Král and Kubišová found that pay transparency is more of an emotional issue for employees, and the intensity of their attitudes towards PT is related to their characteristics. Personal emotions and attitudes can therefore significantly influence the introduction of pay transparency and should not be overlooked (Král, Kubisová, 2021). This determinant may be significant for young employees, who represent Generation Z, and have particular attitudes towards work and expectations towards employers (Symplicity Recruit, 2023).

2.3. Generation Z – preferred values and expectations from work

In many articles, their authors point to different birth dates of representatives of Generation Z. The most common assumption is that they are those born between 1995 and 2010 (Mahapatra et al., 2022). The names by which representatives of this generation are usually referred to are iGen, Post-Millennial, Gen Tech, Digital Natives, Net Gen, and Facebook Generation (Popescu et al., 2019). Research by McKinsey indicates that all behaviours of Generation Z are related to the search for truth, which is why this generation is also often called the 'True Gen' (Francis, Hoefel, 2018). This means that, from the perspective of Generation Z candidates and employees, companies' actions should be based on truth and be directly linked to the ethics of the organisation, especially work ethics.

One of the important work-related values recognised by Generation Z is trust (Thessin et al., 2018). Generation Z perceives trust and responsibility as good motivators. Building and maintaining an atmosphere of trust, in which cooperation and knowledge sharing can develop freely, is considered a prerequisite for the success and competitiveness of companies with Generation Z employees (Bencsik et al., 2016). Managers must therefore make a conscious effort to nurture the trust of these employees with their superiors and colleagues.

Generation Z is perceived as transparent. In addition to compensation, among the most expected elements of transparency in the workplace is communication (Racolta-Paina, Irini, 2021). Most often, this context refers to communication with other people of this generation, as well as transparency related to the way activities are carried out in the organisation. Vilas believes that the need for transparency of representatives of this generation stems from the fact that they have grown up in a world that is as transparent as it has ever been. 90% of these individuals say it is important to work for a company that prioritises transparency (Vilas, 2016). This generation has highly developed skills in searching and processing information, using of Internet and social media, which enables relatively easy diffusion of information and verification of the content provided by managers (Paggi, Clowes, 2021). The employer should therefore be sincere and honest, as Generation Z will not be easily fooled.

Similar research findings are presented in the Deloitte report, which highlights that Generation Z employees expect a transparent organisational culture and appropriate transparency from their leaders. They also expect open conversations about business strategy and decision-making (O'Boyle et al., 2020). They believe that if this approach is not respected in their work environment, it is detrimental and leads to inefficient work, conflicts in the organisation, and results in low productivity (Abadan, 2023). An important need associated with employment in such an environment is egalitarianism and transparency in the workplace, which translates into equality for all employees and transparency in motivation and compensation policies (Nieżurawska et al., 2023). One of the key values for Generation Z is the equality of employees, including gender equality (Vilas, 2016).

Research conducted confirms that employees of different generations, i.e. Gen Z, Millennials, Gen X, and Baby Boomers, value pay transparency in their workplaces. Its absence may be one of the main reasons why they would resign from applying for a position (Robert Half Talent Solutions, 2023). Research confirms that, among the different generations, it is Generation Z that shows the greatest need for employer salary transparency. 53% of Generation Z representatives say they are less likely to apply for a job if the company does not disclose the salary range in the job advertisement (Symplicity Recruit, 2023).

Pay transparency is also an important factor influencing feelings of belonging in the work environment (Zhao, 2022). Denice, Rosenfeld, and Sun conducted a study, the results of which indicate that the likelihood of having pay conversations varies depending on, among other things, the pay secrecy rules in place at a workplace, or the managerial relationships within the organisation. Also, the age of employees is related to the need to discuss the salaries they receive, that is, younger employees are much more likely to talk about salaries and break organisational rules designed to suppress such discussions among employed staff (Denice et al., 2024).

Establishing strong ties with Generation Z, which values honesty and open dialogue above all else, therefore requires openness and employers to ensure transparency within the organisation (Benitez-Márquez et al., 2022; Ernst Young, 2020).

3. Methodology

The aim of the conducted empirical research was to assess the main benefits and risks of implementing pay transparency in an organisation, as perceived by Generation Z employees. The main research question is as follows: What is Generation Z's opinion on the need to implement pay transparency in the organisation, as well as the positive and negative consequences of this process? Tree detailed research questions have been formulated in the study:

Q1: What is the general opinion of Generation Z regarding the introduction of pay transparency in organisations?

Q2: What benefits for employers and employees do Generation Z perceive as a result of the introduction of PT?

Q3: What threats to employers and employees do Generation Z perceive as a result of the introduction of PT?

To achieve the research goal, the author developed a questionnaire consisting of 5 detailed closed-ended questions. The first of them concerned question Q1, the next two ones – question Q2, and the last two – question Q3. The author designed the questionnaire based on the literature analysis mentioned in the earlier parts of the paper. The 5-point Likert scale has been applied to the questionnaire. Answers have been given on the scale: definitely no, somewhat no, neither no nor yes, somewhat yes, definitely yes. The last part of the questionnaire, with detailed information about respondents, contained questions about seniority and gender.

Emails with a link to the online questionnaire were sent to students at public and private universities in Lublin (Poland). The data were collected in 2024 using Computer-Assisted Web Interviewing (CAWI). Generation Z respondents are referred to as "digital natives" and have excellent skills in navigating the digital world, and taking up online activities is very easy, common, and almost natural. For this reason, the risk of self-selection bias during online data collection using the CAWI method among Generation Z respondents was very low. For analysis, 386 questionnaires have been accepted. All respondents are Generation Z representatives and have knowledge about pay transparency and the concept of its implementation in organisations, which was verified in the first part of the questionnaire. Only questionnaires completed by people with at least half a year of seniority were included. 57% of respondents were women and 43% were men.

4. Results and discussion

Question 1 concerned general issues related to the introduction of pay transparency in organisations based on the EU Directive. These included: the need to implement PT in organisations, the need to formally regulate the process with EU legislation, the achievement of reducing pay discrimination between women and men, and the need to disclose remuneration reports to all employees as well as external stakeholders. The detailed distribution of respondents' answers is presented in Figure 1.

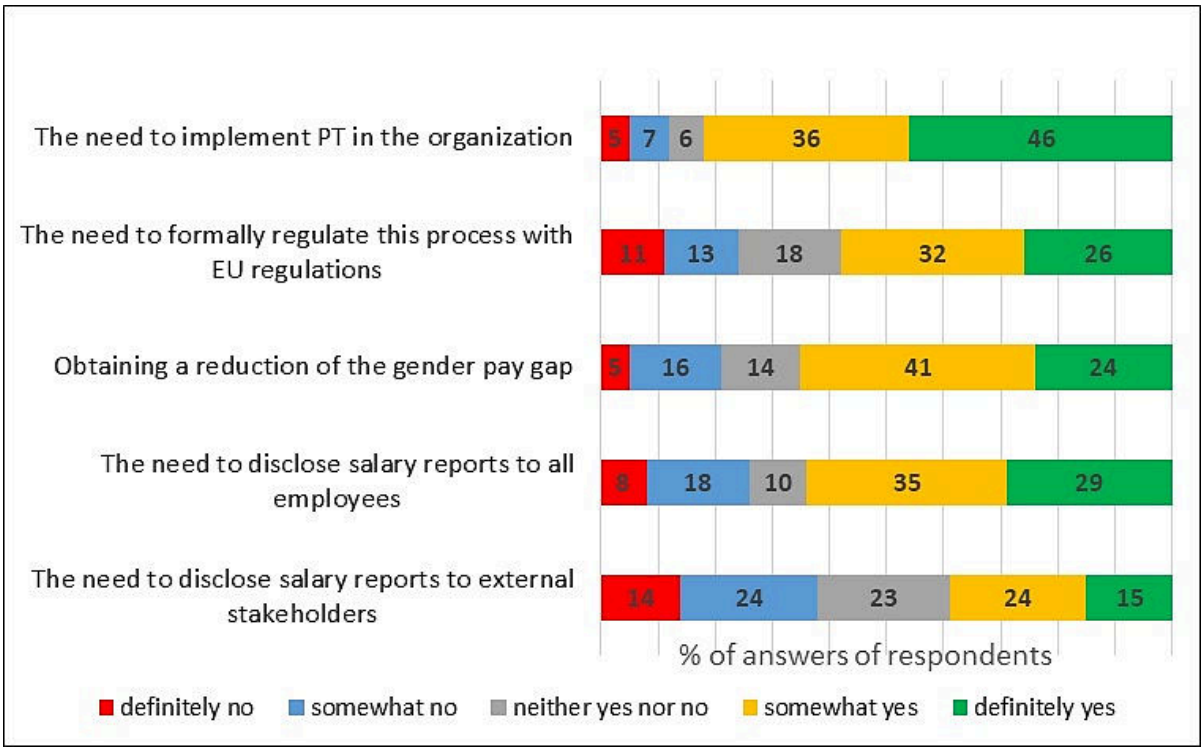

Figure 1. Opinions of Generation Z respondents regarding the concept of PT in the organisation.
Source: Own elaboration.

The results indicate that 82% of the surveyed persons believe that implementing pay transparency in the organisation is necessary (the total number of responses is definitely yes and somewhat yes), and 65% believe this will reduce the pay gap. 64% of respondents expect publication of pay reports on employee pay levels to all employees, and 58% support the introduction of this process through formal EU regulations. At the same time, only 39% of respondents expect publication of pay reports to external stakeholders.

According to the assumptions of the implementation of Directive EU 2023/970, it is precisely informing external stakeholders that can have a strong impact on employers stopping discriminatory practices, but it seems that Generation Z does not see such a connection and is interested in receiving reports addressed mainly to employees. This means a stronger focus on their own benefits, felt directly, and not on the perspective of other entities.

However, generally, it can be stated that respondents are very positive about the introduction of pay transparency in organisations, and the goals of developing the EU Directive on the introduction of PT are consistent with the views and expectations of Generation Z employees.

The second part of the questionnaire contained two more detailed questions. Their purpose was to obtain an answer – what benefits for employers and employees resulting from the introduction of PT, are perceived by respondents. The first stage of the analysis was about the benefits for employers. Based on the literature review, the most frequently mentioned areas were included in the questionnaire:

- increased trust of employees in the organisation,
- increased motivation of employees to perform their work better to achieve higher remuneration,
- better control of staff employment costs,
- fairness in setting employee remuneration,
- the possibility of acquiring and retaining the best specialists,
- better communication and relations in teams,
- identification of gender pay gaps,
- easier planning of the company's budget,
- increased employee engagement,
- improved image of the company as an employer in the labour market,
- reduced employee turnover,
- increased efficiency of recruitment processes.

The detailed distribution of respondents' answers is presented in Figure 2.

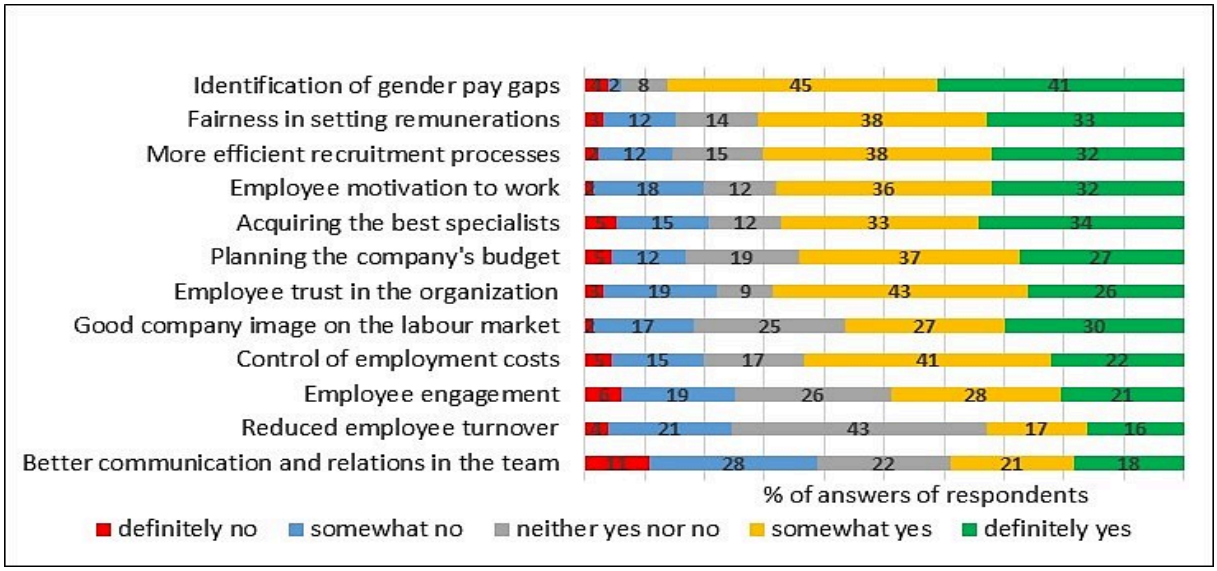

Figure 2. Opinions of Generation Z respondents regarding the benefits of PT to employers.

Source: Own elaboration.

Identification of gender pay gaps is the benefit identified by most respondents, with a total of 86% answering definitely yes and somewhat yes. This is a very high result and confirms that the objectives of the introduction of the pay transparency Directive, i.e. the elimination of pay inequalities, are in line with the views of Generation Z (Vilas, 2016). The second important benefit for these employees is fairness in setting employee remuneration (71%). As described earlier in this paper, fairness and fair treatment are the key values of Generation Z that they expect from their employers (Lazanyi, Bilan, 2017). Similarly high scores were given to benefits such as increased efficiency of recruitment processes (70%), increased trust of employees in the organisation (69%), increased motivation of employees to perform their work

better to achieve higher remuneration (68%), the possibility of acquiring and retaining the best specialists (67%).

These results are also consistent with the values presented in the literature on the subject, recognized by representatives of Generation Z, related to work and organization. They concern the expectations of transparent recruitment processes (Symplicity Recruit, 2023; Inc.com, 2021), meeting the need for trust in employers (Thessin et al., 2018) and a skillful way of building motivation to work (Nieżurawska et al., 2023).

The obtained results indicate that Generation Z employees positively assess the introduction of the pay transparency concept in organisations and see many benefits for employers. However, attention should be paid to those items that are less important to respondents: reduced employee turnover (33%), better communication and relations in teams (39%), increased employee engagement (49%), improved image of the company as an employer in the labour market (57%). These are areas that are not strongly and directly related to individual benefits for employees, but rather concern generally positive results for the entire organization.

This means that Generation Z representatives rate the benefits they themselves will gain more highly, and attach less importance to the benefits the organization will achieve.

The next question in the questionnaire was aimed at examining the respondents' opinions on the benefits for employees. The study included selected benefits, most frequently mentioned in scientific publications:

- transparency of criteria and principles for determining remuneration,
- motivation for professional development to achieve a higher remuneration,
- easier process of negotiating remuneration with the employer during the recruitment,
- easier decision to apply to a given company in response to its job offer,
- the possibility of assessing one's importance in the organisation in comparison with other people,
- objectification of arguments in communication with the superior regarding determining remuneration,
- easier personal budget planning,
- the possibility of monitoring one's career and remuneration,
- motivation to work more effectively to achieve a higher remuneration,
- a sense of fair treatment of employees by the employer in their remuneration,
- freedom to conduct discussions about remuneration between employees.

The detailed distribution of respondents' answers is presented in Figure 3.

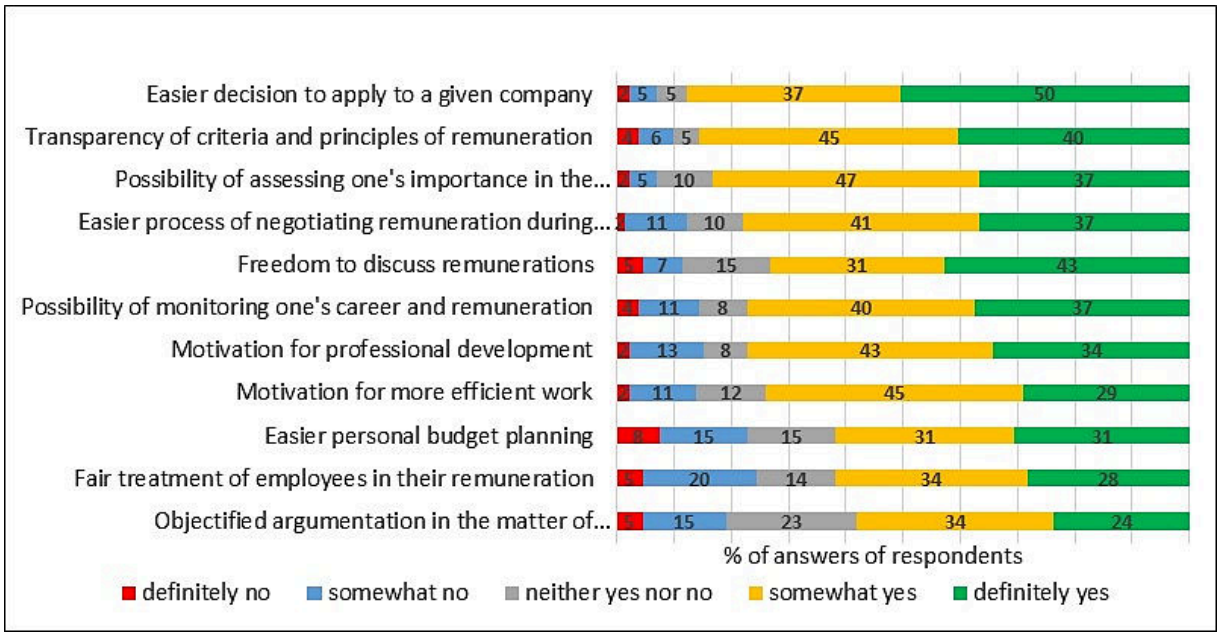

Figure 3. Opinions of Generation Z respondents regarding the benefits of PT to employees.
Source: Own elaboration.

The easier decision to apply to a given company in response to its job offer is the most important benefit, which was indicated by the largest group of respondents, i.e. 87% (total number of responses definitely yes and somewhat yes). This confirms the need for candidates from Generation Z to receive information about the proposed salary in the job offer, which is highlighted in many published reports (Symplicity Recruit, 2023; Inc.com, 2021). Two further benefits important to young employees are: transparency of criteria and principles for determining remuneration (85%) and the possibility of assessing one's importance in the organisation in comparison with other people (84%). Other benefits were also highly rated: easier process of negotiating remuneration with the employer during the recruitment process (78%), possibility of monitoring one's career and remuneration (77%), motivation for professional development to achieve a higher remuneration (77%). The other benefits listed in the questionnaire were also frequently selected by respondents.

It should be emphasized that the opinions expressed by the respondents are consistent with the values they recognize, described in the literature, such as the need for communication transparency (Racolta-Paina, Irini, 2021), open dialogue (Benitez-Márquez et al., 2022), and, in particular, open conversations about business strategy and decision-making (O'Boyle et al., 2020). An important value for Generation Z, to which the above areas refer, is also having trust in managers and leaders (Bencsik et al., 2016) in the context of their ethical conduct towards employees (Lazanyi, Bilan, 2017).

The analysis of the results obtained in this part of the questionnaire confirms that young employees from Generation Z have very positive opinions about the implementation of PT in organisations (Mignano, 2024), and see many potential benefits of this process both for themselves and employers (Nieżurawska et al., 2023).

The third part of the questionnaire contains two questions, which were similar and concerned with the respondents' opinions on the potential threats to employers and employees resulting from the introduction of PT in the organisation. The questionnaire included the following threats to the employer:

- employee dissatisfaction with low remuneration compared to other employees,
- activation of competition as a result of using information on remunerations to take over employees,
- the necessity to increase employee remuneration in the case of disclosure of discrimination,
- impossibility of maintaining secrecy regarding employee remuneration strategy,
- difficulties in maintaining remuneration balance among employees with different levels of experience and qualifications,
- pressure from employees to increase remunerations based on information on other people's remunerations,
- the possibility of conflicts between employees due to the disclosure of differences in remunerations,
- disclosure of information on remuneration inequalities may lead to image problems for the organisation,
- difficulties in managing the remuneration budget,
- the need to adapt recruitment and motivation processes to the regulations on PT,
- limiting the possibility of flexible remuneration changes in response to unexpected changes in the labour market,
- increased the risk of doing business.

The detailed distribution of respondents' answers is presented in Figure 4.

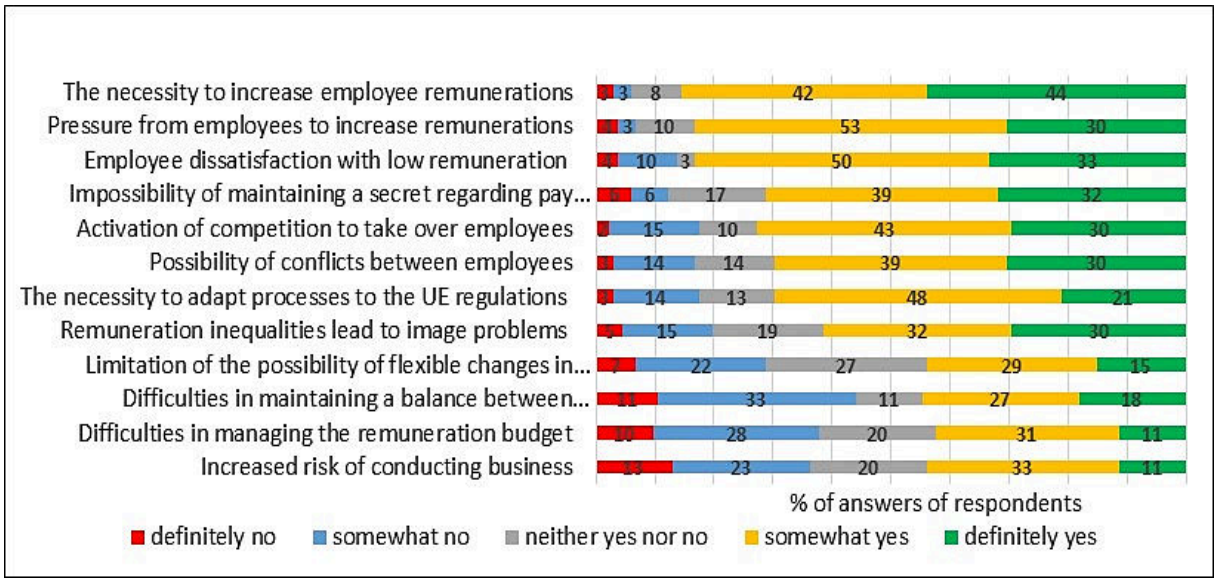

Figure 4. Opinions of Generation Z respondents regarding the threats of PT to employers.

Source: Own elaboration.

According to respondents, the biggest threat to employers is the necessity to increase employee remuneration in the case of disclosure of discrimination 86% (total number of responses definitely yes and somewhat yes). The problem is directly related to pressure from employees to increase remunerations based on information on other people's remunerations (83%) and employee dissatisfaction with low remuneration compared to other employees (83%). It is also worth noting that four further risks were considered important by respondents, all of which relate to some extent to the workers' perspective. These are: activation of competition as a result of using information on remunerations to take over employees (73%), the impossibility of maintaining secrecy regarding employee remuneration strategy (71%), the possibility of conflicts between employees due to the disclosure of differences in remunerations (70%), the necessity to adapt recruitment and motivation processes to the regulations on pay transparency (70%).

The obtained results are consistent with the previously described values preferred by Generation Z, such as: open communication eliminating the occurrence of conflicts at work (Abadan, 2023), reluctance to keep secret the information about received remuneration (Denice et al., 2024), or equality for all employees and transparency in motivation and compensation policies (Nieżurawska et al., 2023).

Summarising the results of this section of the survey, it is worth noting that the other four risks listed at the end of the questionnaire were mainly related to potential problems for managers and owners, but were not considered as important by the respondents, indicating that the respondents took the perspective of young workers who do not identify too strongly with their employers (Benitez-Márquez et al., 2022).

The last question in the questionnaire concerned potential threats to employees. The following threats were listed:

- envy with the remuneration of other employees in similar positions,
- the possibility of supervisors using information about remunerations in the organisation in salary negotiations with employees,
- reduced motivation to work for employees whose remuneration is lower than others,
- lack of a sense of privacy and discretion in matters of remuneration,
- pressure from colleagues to increase their remuneration based on comparisons with others,
- the possibility of discrimination or mobbing of employees,
- lack of work-life balance due to the need to match others in terms of remuneration,
- the need to cope with tensions and rivalry among employees resulting from differences in remunerations,
- the feeling unfair and not being recognized for work and achievements,
- the risk of disclosing one's financial situation to co-workers.

The detailed distribution of respondents' answers is presented in Figure 5.

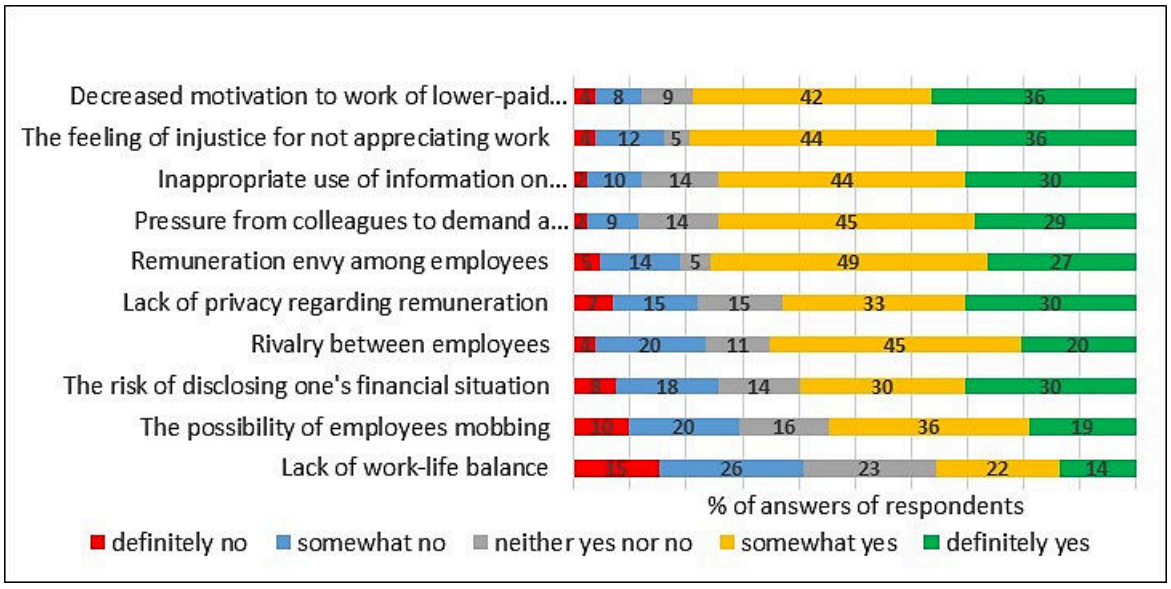

Figure 5. Opinions of Generation Z respondents regarding the threats to the employees.
Source: Own elaboration.

Analysis of the responses in this part of the survey indicates that the main problem for respondents is the feeling unfair and not being recognized for work and achievements (80% total number of responses definitely yes and somewhat yes), reduced motivation to work for employees whose remuneration is lower than others (79%), envy with the remuneration of other employees in similar positions (76%). Other potential risks for employees, such as a lack of work-life balance due to the need to match others in terms of remuneration (36%) or the possibility of discrimination or mobbing of employees (55%), are not very important in the respondents' opinion.

The results confirm that respondents attribute great importance to the employees being fairly rewarded for their performance (Načinović Braje, Kuvač, 2022) and in relation to others in similar positions (Obloj, Zenger, 2022), as well as the fair use of employee pay information by managers (Lazanyi, Bilan, 2017). These are both key objectives of the implementation of the pay transparency Directive EU 2023/970, as well as important values valued by Generation Z and expected by young workers from their employers (Belogolovsky, Bamberger, 2014).

5. Conclusion and Limitations

The empirical research aimed to assess the main benefits and risks of implementing pay transparency in an organisation, as perceived by Generation Z employees.

Based on the survey, it can be concluded that Generation Z has a positive attitude towards implementing PT in organisations and sees the possibility of reducing the gender pay gap through this, which is one of the main objectives of the implemented EU legislation in the

member states. The following were considered the most important benefits for employers: fairness in setting employee remuneration, increased efficiency of recruitment processes, increased trust of employees in the organisation, increased motivation of employees, and the possibility of acquiring and retaining the best specialists. For benefits of employees, they ranked: the easier decision to apply to a given company, transparency of criteria and principles for determining remuneration, the possibility of assessing one's importance in the organisation in comparison with other people, and the easier process of negotiating remuneration with the employer during the recruitment process.

The results regarding the need to implement pay transparency in the organisation, confirm that Generation Z sees not only the positive but also the negative consequences of this process. The biggest threats to companies were identified as: the necessity to increase employee remuneration in the case of disclosure of discrimination, pressure from employees to increase remunerations, and their dissatisfaction with low remuneration compared to other employees. The biggest problems for employees are feeling unfair and not being recognized for work and achievements, and envy of the remuneration of other employees in similar positions.

A detailed analysis of opinions on all the areas surveyed also allows us to conclude that Generation Z representatives rate the benefits they themselves will gain more highly, and attach less importance to the benefits the organization will gain.

Summarising the results obtained, it should be concluded that the young employees' generation expects transparency in the organisation in various manifestations, so employers should universally implement a transparency strategy in its many aspects. It is highly important for Generation Z, which will constitute a growing group of people employed in contemporary organisations with each passing year.

However, the results obtained have some limitations. The survey was conducted in the last quarter of 2024, i.e. more than a year before the date of mandatory implementation of the national provisions of the Directive in organisations in all EU countries, which was set for 7 June 2026. At that time, the national regulations were only at the stage of their preliminary drafting by legislators in Poland. Therefore, the survey participants had no real experience related to the application of the provisions of the Directive in their organisations and did not feel the real consequences of their implementation. This means that the answers provided were largely based on the respondents' previous experience and their expectations regarding the provisions of the new law. The survey should be repeated after the date of formal implementation of the Directive.

The size of the research group does not allow for general conclusions to be drawn. However, the results obtained may constitute a basis for further in-depth research on this issue. It would be worth additionally conducting an analysis taking into account various variables, such as gender, education, position, seniority, and level of remuneration received. It seems that the opinion of Generation Z respondents may depend on the variables mentioned. Similar studies could be conducted to compare the opinions of employees, managers, and employers, because

each of these groups may have a different perspective in assessing the benefits and threats of pay transparency in the organisation.

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IMPACT OF RESILIENCE ON STABILITY COMMANDER'S EMOTIONAL STABILITY

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Purpose: The main purpose of the article is to present issues related to the effective building of mental resilience (resilience), in the socio-professional situations of commanders, to prevent professional burnout or other risks of military service.
Design/methodology/approach: Given the purpose of the article, a study of the literature was conducted, as well as the application of relevant research methods. The survey was conducted with a sample of 141 military students in February-March 2025. The selection of the sample was random. Within the framework of the considerations carried out, it was decided to use a survey as a research methodology, while the research tool used within this method was a standardized survey questionnaire.
Research limitations/implications: It would certainly be worth repeating representative surveys in the future, among military students because of the changing environment, in the context of security.
Practical implications: The importance of building mental toughness (resilience) in various situations. The article also highlights factors that promote better decision-making by the commander, as well as affect the morale of subordinates, creating an atmosphere of trust and support.
Originality/value: The article addresses the timely and relevant topic of building mental resilience, the ability to cope with difficulties, adapt to changing conditions, and the ability to maintain emotional balance in the face of stress, all of which are key to successfully leading a team of people (a subdivision).
Keywords: resilience, mental toughness, emotional stability, emotion management.
Category of the paper: Research paper.

1. Introduction

As a social being, humans are exposed to a variety of stressors that can lead to stress and depression. Modern life is characterized by many challenges, such as social pressure, interpersonal relationships, work and career, technology and social media, and crisis situations.

Despite the above challenges, not all people experience chronic stress or depression. Much depends on individual psychological resources, coping strategies, social support and emotion management skills. People who are able to build healthy relationships, enjoy the support of loved ones, and take care of their mental health can better cope with the challenges of living in society. It is also worth emphasizing the importance of mental health prevention and the availability of psychological help.

The theoretical part realized the theoretical goal of a comprehensive literature review of mental resilience (resilience), in socio-occupational situations, as well as stress management issues. In the second part of the study, empirical research was presented, and the cognitive objective was realized. For this purpose, a survey method was used. An important value of the conducted research is the attention to issues such as stress and depression, which have become key topics that affect the efficiency of the organization and the well-being of its employees, including commanders.

2. Literature review

Stress is a physical or chemical, emotional factor (such as trauma, allergen or fear) to which the body cannot sufficiently adapt and which causes physiological tensions that may be beneficial to the body or contribute to an outbreak of disease (...). A stress factor, a stress stimulus, is a stressor (Sekścińska, 2011; Streulau, 2024). Depression, on the other hand, is a morbid despondency, an inhibition, to varying degrees, of mental activity manifested in general despondency and frequent delusional inhibitions (Shevchuk, 1985; Gembalska-Kwiecień, 2022).

It is worth noting that it is possible to be depressed and not experience high levels of stress, and it is also possible to experience high levels of stress without depression. Depression is a complex disorder that can occur with different symptoms and under different circumstances:

- depression without high levels of stress - some people can be depressed due to biological factors, such as chemical imbalances in the brain, genetic or hormonal problems. They may not experience intense external stress, and their depression may be due to internal emotional or mental problems.
- High levels of stress without depression - on the other hand, stress can result from various life situations, such as work, interpersonal relationships or financial problems. A person may be highly stressed, but not necessarily depressed. Stress can be temporary and not lead to long-term health problems if a person can effectively cope with difficulties.

It is worth noting that stress and depression can intersect, and long-term stress can increase the risk of depression. Therefore, it is important to pay attention to one's mental well-being and seek support when needed (Bialczyk, 2023).

Resilience, or the ability to cope with adversity as it arises in life or as others understand it-mental resilience is the aspect that allows anyone to adapt to changing conditions and recover from crises (Heller, 2024; Hanson, Hanson, 2022).

Considering the much-desired emotional stability of any commander, especially during the occurrence of crises or day-to-day military leadership, resilience affects, among other things, several aspects, such as:

- stress management - commanders who demonstrate high levels of resilience are better equipped to deal with pressure and stress, allowing them to make more rational decisions in difficult situations,
- emotional intelligence - resilience often goes hand in hand with emotional intelligence, allowing commanders to better understand themselves and others, and thus manage their teams more effectively,
- adaptability - in dynamic operational conditions, the ability to adapt quickly is crucial. Resilient commanders are able to respond flexibly to changing circumstances, which increases their effectiveness,
- motivation and commitment - commanders with high resilience are often more motivated and committed, which affects team morale and overall performance.
- social support - resilience fosters strong interpersonal relationships, Commanders who are able to support their subordinates create an atmosphere of trust, resulting in better cooperation and efficiency within the team,
- skill development - resilience supports the process of learning from mistakes. Commanders who can learn from failures and difficult experiences become better leaders.

Of critical importance, in the above context, is the ability of every commander to manage stress (McLarnon et al., 2021; Miller, 2021). Stress can be managed, and stress management techniques can help reduce its negative impact on daily life (Nowak, 2021; Smith, 2019). Here are some ways that can be effective in managing stress:

- relaxation techniques - meditation, deep breathing, yoga or mindfulness can help reduce tension and improve mood.
- physical activity - regular exercise, such as jogging, swimming or dancing, can increase the production of endorphins, which helps combat stress.
- time organization - planning tasks and setting priorities can help reduce feelings of overwhelm.
- social support - talking to friends, family or a therapist can provide relief and help put the situation into perspective.

- thought management - working on negative thoughts and beliefs can help you better cope with stress. Techniques such as cognitive behavioral therapy can help.
- hobbies and interests - spending time on favorite activities can be a great way to relax and get away from daily worries.
- healthy diet: proper nutrition affects mood and energy levels, which can help manage stress.

Stress management is a process that can take time and practice, but implementing the above strategies can bring significant improvements in daily functioning (Jedrzejko, 1997; Bailey, 2002; Dziwinski, 2022). Stress and depression, on the other hand, are closely related and can influence each other's severity. A proper understanding of this relationship is crucial for effective treatment and support for people struggling with these problems (Seligman, 1996; Rekha Sahoo, 2016).

Stress management and resilience, on the other hand, are two related concepts that relate to an individual's ability to cope with difficult situations (Schiraldi, 2019).

The difference between stress management and resilience is that the former term refers to techniques and strategies that help people cope with tension, anxiety and other negative emotions that can arise from a variety of life situations.

Key elements of stress management include:

- identifying sources of stress - understanding what triggers stress is the first step to effectively managing it,
- elaxation techniques - practices such as meditation, deep breathing, yoga or other forms of physical activity can help reduce stress,
- mindset change - developing cognitive skills, such as positive thinking or forgiveness techniques, can help you better manage stress,
- social support - building strong relationships with family and friends can provide emotional support during difficult times,
- organization of time - planning and prioritizing can help avoid excess responsibilities and associated stress.

Resilience, on the other hand, is characterized by an individual's ability to adapt to difficulties, overcome adversity and recover from crises. Resilient individuals are able to:

- adapt to change - change is inherent in life, and resisters are able to adapt their approach and actions to new circumstances,
- learn from mistakes - instead of giving up, resellers analyze their experiences and learn from them,
- maintain a positive outlook - optimism and hope for the future are key characteristics of resilience,
- make use of support networks - residuals often benefit from the help of others, which allows them to better cope with difficulties.

The difference between stress, emotions and feelings is as follows: stress is a reaction to stimuli, emotions are intense reactions to specific situations, and feelings are long-lasting states that result from reflection on emotions. All these elements are interrelated and affect our daily lives (Lewandowska-Akhvlediani, 2020). One of the elements of personal fitness is the ability to deal with emotions (Strycharczyk, 2022). The need to educate emotions has been postulated by many authors, but especially these problems were dealt with by D. Goleman and J. Kozielecki. On the other hand, modern psychologists pay attention to the broad aspectuality of emotions, which, as a complex set of bodily and mental changes (Orhon, 2020), include physiological arousal, feelings, cognitive processes and behavioral reactions, performed in response to a situation, perceived as important for a person (Borowska, 2004; Figley et al., 2014).

One of the main causes of all kinds of negative emotions is our way of thinking, or rather our lack of control over our thoughts (Meredith et al., 2011). They are the main cause of our, sometimes spontaneous, uncontrollable reactions - and when we calm down and do a thorough analysis, we usually find that it is just "stuck in our head" - in the form of "bad habits of thought". S. Briers points out the fundamental errors in our thinking that are usually the beginning of our unfavorable emotions (Briers, 2011) are:

- catastrophizing - emotions of this kind most often occur when we start to rush and suddenly something doesn't work out for us. Then we begin to think in an unpredictable, nervous way - stress begins to mount and yet on top of that we just happen to have to go to the toilet, and it's just nowhere to be found, etc. Most often the word disaster comes to mind;
- generalizing (generalizing) is to focus on what is a common property of all elements. Words like "it's always the same ..." or "again, as usual ..." or "something always has to go wrong ..." - are indicative of generalizing;
- mind-reading - we often attribute to someone some behavior that is not true. The same happens with thoughts. This is due to the fact that we often analyze certain behaviors or spoken words of people towards each other in the past. In a way, this is the right way of thinking, but people change and their reasoning, sometimes also their character (disposition) changes! So - you can't know what another person thinks unless he tells you;
- polarized and inflexible thinking - thinking based on drawing conclusions that often do not correspond to reality, e.g., like "not black - it's probably white", or "you won or lost"; "if you're not skinny, you're probably fat";
- emotional reasoning - often telling myself things I haven't done yet, but "I certainly would". Emotional reasoning is when emotions are treated as "evidence" of the truth of negative feelings;

- blaming - some sentences indicate placing responsibility for “something” on others, e.g. “It's all your fault ...”. Such behavior is sometimes a defensive tactic to get rid of responsibility for one's failures;
- filtering and exaggeration is a distortion of one's thought process, leaving out those that fit one's own preconceptions of bias, and leaving out others. Exaggeration is the attribution of excessive importance or frequency to events that fit one's own views and beliefs;
- emotive language - some words or sentences are emotionally tinged. Sometimes people say sentences in an emotive way - they convince themselves that they will not be able to do something, cope with something, etc. Emotional coloring of statements - can also be telling prejudices.

Developing emotional intelligence and Emotion Management are becoming increasingly popular and widespread. Negative emotions affect health, moreover, they can cause psychosomatic disorders It is worth noting that positive or negative emotions usually occur in response to certain types of events. Moreover, properly interpreted, the negativity of emotions is that their appearance heralds a threat to the realization of human interests and goals.

3. Studies and research methodology

The authors focused on the analysis of the available literature on building mental resilience - resilience - in socio-professional situations of commanders. The authors based their considerations on Polish and foreign literature, studying scientific articles.

The main purpose of the article is to present issues related to the effective building of psychological resilience (resilience), in the socio-professional situations of commanders, to prevent professional burnout or other risks posed by military service.

The realization of the goal focused on the research procedure involving planes:

- theoretical-cognitive, which presented a theoretical treatment of issues related to residualism, depression, stress,
- empirical, focused on conducting empirical research, including the relationship between depression and stress levels,
- utilitarian, which aimed to demonstrate the need to consciously build mental resilience (resilience) among commanders (managers).

The content and conclusions presented in the article are based on an in-depth analysis of the literature on the subject, as well as on a survey study, in which 141 military students were randomly selected out of 707, a representative sample of the study. The respondents were subjected to two tests.

The first was to determine their level of depression, and the second was to determine their level of stress. The test results were then correlated, and the results are presented in the next section of the article.

4. Studies Results and Discussion

Of the 141 respondents, more than 90% of the students realize that the ability to control their own emotions in any life situation is very important. Only nearly 8% do not give this personal competence much importance, and 2%, it is to be believed, do not have sufficient knowledge on this subject (Fig. 1).

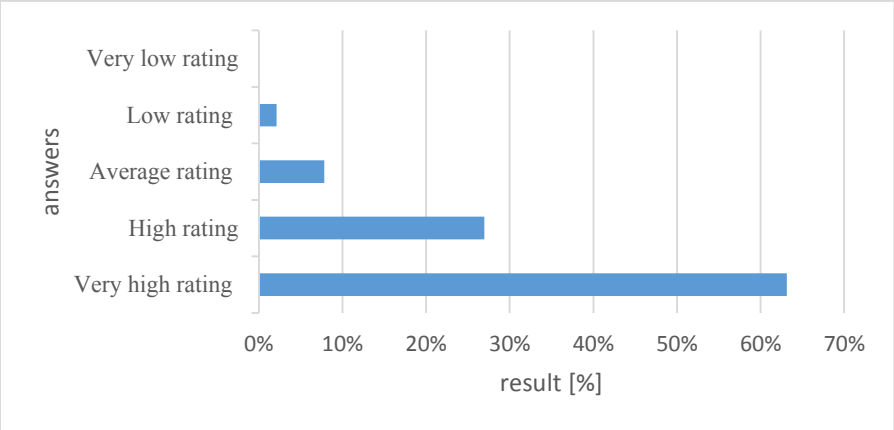

Figure 1. The level of knowledge among students about controlling their emotions.
Source: own study on the basis of the collected empirical material.

When it comes to determining one's own level of depression (Fig. 2), using the test, the results can be a definite concern. This is due to the fact that out of 141 people surveyed, 81% show the absence of depression or its mild level (60% and 21%, respectively). On the other hand, a dose of concern is that nearly 20% of those surveyed show moderate and deep depression (13% and 6%, respectively). Given that these are first-year students, one can anticipate that their personalities will change over the course of the 5 years of study and they will begin to approach life differently, and as a result, will no longer show such significant distressing depressive states. There is, of course, a big role here for the commanders-turned-subunit commanders, who should devote a lot of attention and work to this issue in the fields of both psychology, pedagogy and the personal development of subordinates, especially the formation of their emotional intelligence, their acquisition of soft skills or teaching them relaxation methods and techniques and applying them to stressful situations and depressive states, etc.

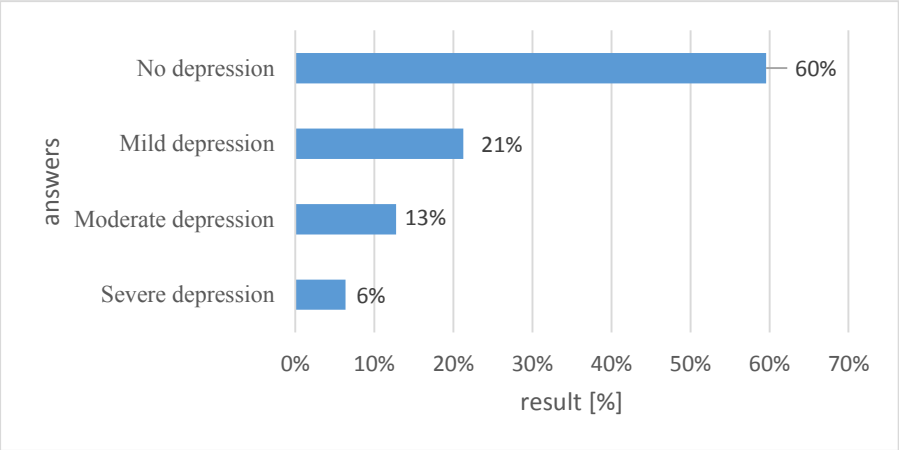

Figure 2. Depression levels among students.

Source: own study on the basis of the collected empirical material.

The study showed (Fig. 3) that there is an unquestionable relationship between the level of depression and the level of stress. Similarly, as in determining the level of depression of the students surveyed, about 92% of the subjects show low and medium levels of stress (74% and 18%, respectively). In contrast, 8% of respondents show very high and high levels of stress (6% and 1%, respectively).

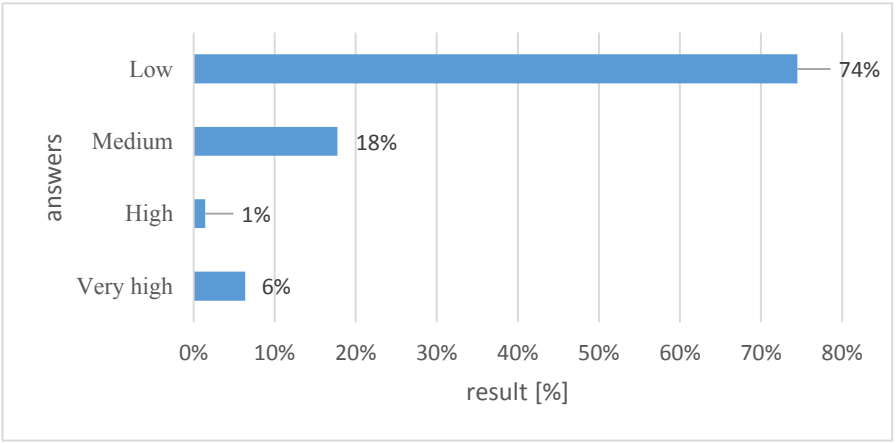

Figure 3. Stress levels among students.

Source: own study on the basis of the collected empirical material.

Those with deep depression (56% of respondents) also showed very high stress, 33% medium stress, and 11% low stress. It seems that in this case, as was to be expected - the vast majority of deeply depressed respondents also had high levels of stress (Fig. 4).

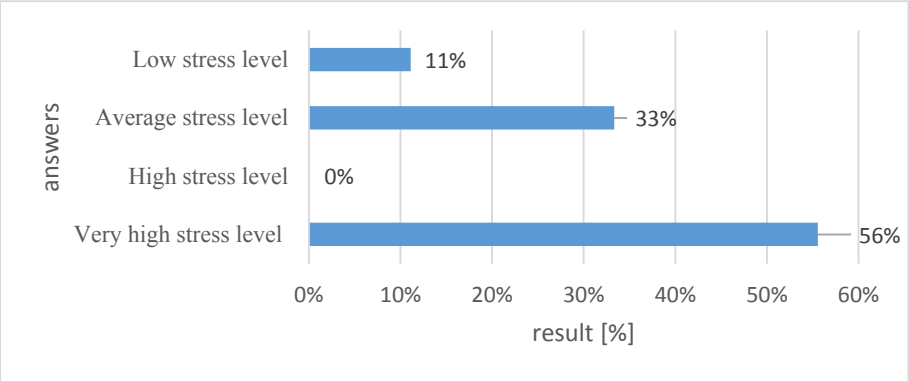

Figure 4. Correlations of severely depressed students with their stress levels.

Source: own study on the basis of the collected empirical material.

Those with moderate depression (11% of respondents) showed very high levels of stress, 6% showed high levels of stress, 17% showed moderate levels of stress, and 6% showed low levels of stress (Fig. 5)

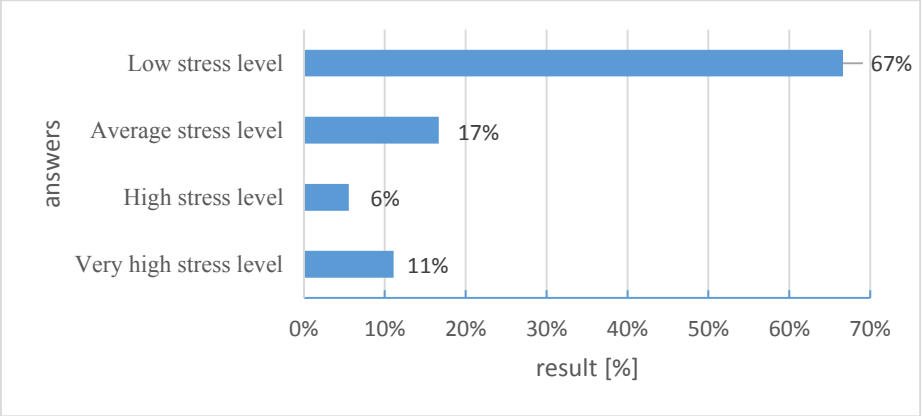

Figure 5. Correlations of moderately depressed students with their stress levels.

Source: own study on the basis of the collected empirical material.

Respondents who showed mild levels of depression (11% of respondents) showed high levels of stress, 30% showed medium levels of stress, and 63% showed low levels of stress (Fig. 6).

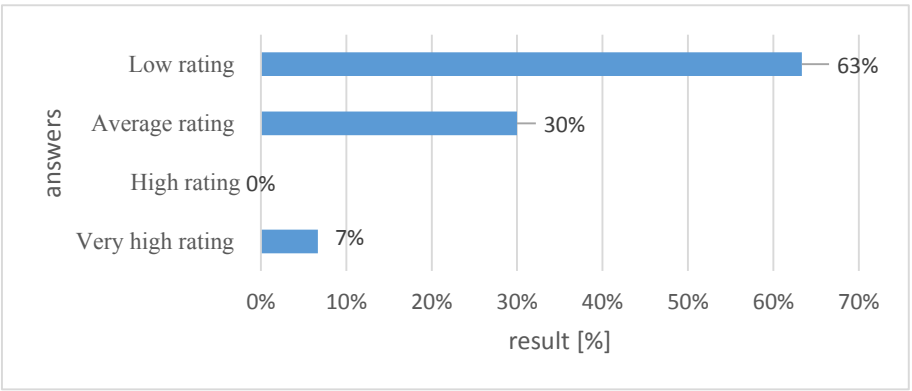

Figure 6. Correlations of mildly depressed students with their stress levels.

Source: own study on the basis of the collected empirical material.

In the present comparison, it was also possible to predict the final result. Namely, non-depressed subjects) in 97% show low stress levels, and only- 3% of the state of the subjects showed, despite the absence of a depressive state- high stress levels (Fig. 7).

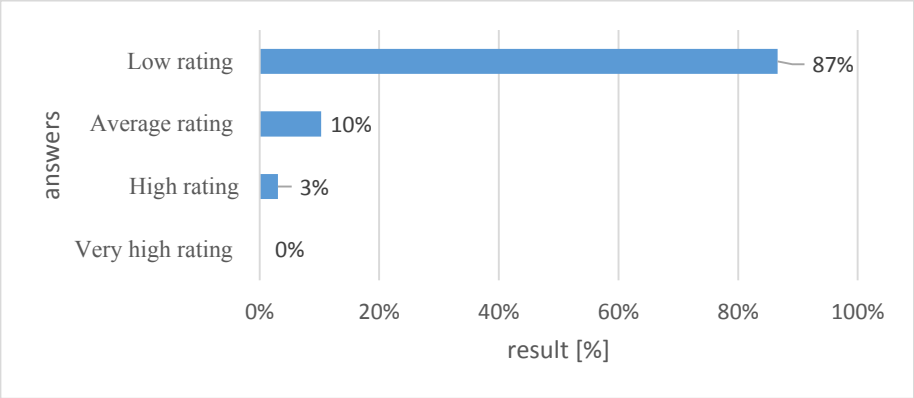

Figure 7. Correlations of non-depressed students with their stress levels.

Source: own study on the basis of the collected empirical material.

There is a close relationship between the level of depression and the level of stress. Higher levels of depression entail higher levels of stress and vice versa. Everyone should determine his or her level of depression and level of stress in order to know what forms, methods or techniques of therapy to use in order to be able to restore the desired state of his or her daily socio-occupational functionality.

Discussion

In view of the research, the following is a selection of therapies, methods, techniques, influencing problems related to the alleviation of stressful and depressive states and restoring a person's daily functionality.

A therapy with an impact on problems related to the alleviation of stressful and depressive states is the so-called Cognitive-Behavioral Therapy (CBT), which is a scientifically validated method of psychotherapy that focuses on the relationship between thoughts, emotions, behavior and physiology. Its goal is to change maladaptive thought patterns and behaviors that maintain mental problems. Here are key principles, techniques and examples from Polish practice. TPB is widely used to treat a variety of psychological problems, including depression, anxiety, phobias, obsessive-compulsive disorder, and to work on interpersonal relationship difficulties. It is an evidence-based method, meaning that its effectiveness has been confirmed in numerous scientific studies (Briers, 2011; Beck, 2011).

On the other hand, M.E.P. Seligman believes that the best way to oppose negative, very often - intrusive thoughts, laden with aspects of negativity, and even those that are the beginning of many stressful or frustrating states - is to “change their course” and change their

mentality (disposition) through positive thinking. It is difficult for people who "move in the world of negative thoughts" on a daily basis, and especially for those who live in constant stress, sometimes without realizing it at all - that it is possible to have a different picture of the surrounding reality, that is, to perceive everything around quite differently, that is, positively. Sometimes it may be necessary to visit a therapist, if a person's mental state is significantly strained by an onslaught of only negative thoughts. Therefore, it is hardly surprising that the best remedy for this whole situation is to change one's attitude to life, to see many problems and everyday situations in a completely different way - positive, cheerful, happy, enthusiastic, etc. M.E.P. Seligman believes that "An optimist faces as many failures and tragedies in life as a pessimist, but an optimist endures it better. In addition, the optimist recovers quickly after a setback, and even though he lives a little worse, he picks himself up and begins to act again. In contrast, the pessimist gives up and falls into depression. Thanks to his resilience in the face of adversity, the optimist is more successful than the pessimist at work, at school and on the playing field" (Seligman, 1996).

Another example is the relaxation technique developed by German physician J.H. Schultz in the 1930s. It is a form of self-soothing that aims to achieve a state of deep relaxation and stress reduction. Autogenic training is based on the principles of autosuggestion and aims to put a person into a state of relaxation by focusing on bodily sensations and suggestions for relaxation (Schultz, 1932). Autogenic training consists of a series of exercises that help achieve a state of relaxation. The participant focuses on his or her physical sensations, such as heaviness and warmth, which leads to a reduction in muscle tension and an improvement in mental well-being. Schultz autogenic training is an effective relaxation method that can benefit many areas of life. By focusing on bodily sensations and using autosuggestion, practitioners of this technique can improve their mental and physical well-being.

In addition, Jacobson's Progressive Training is worth mentioning. This method is often used in stress and anxiety therapy, as well as in preparation for stressful situations such as public speaking or exams (Jacobson, 1938). The training consists of tensing and relaxing individual muscles, with an inhalation you tense the muscles in question for 5 seconds, and with an exhalation you relax the tense muscles and stay like this for 10 seconds. It is important that you really pay attention to the tension and relaxation. When you tense your muscles focus on that, feel that tension. When you relax the muscles focus on that relaxation, feel it. Also pay attention to the difference between tensed and relaxed muscles. Finally, you can take a few calm, conscious breaths and move around for a while.

Conclusions

The survey conducted showed that:

- the vast majority of respondents (90%) realize that the ability to control one's emotions in any life situation is very important. In addition, 81% of respondents report no or mild levels of depression;
- research has shown that there is an unquestionable link between the level of depression and the level of stress. Similarly, as in determining the level of depression of the students surveyed, about 92% of the respondents show low and medium levels of stress;
- higher levels of depression entail higher levels of stress and vice versa. Everyone should determine their level of depression and level of stress in order to know what forms, methods or techniques of therapy to use in order to be able to restore the desired state of their daily socio-occupational functionality.

Despite the above challenges, related to the need to master the "art" of building mental resilience (resilience) in various situations - not all people experience chronic stress or depression. Much depends on individual mental resources, coping strategies, social support and emotion management skills. People who are able to build healthy relationships, enjoy the support of loved ones, and take care of their mental health can better cope with the challenges of living in society. It is also worth emphasizing the importance of mental health prevention and the availability of psychological help. Undoubtedly, it is important to realize that disregarding resilience and improving one's mental resilience can lead to rather unpleasant consequences over time. One of them is the so-called professional burnout.

Resilience not only promotes better decision-making by the commander, but also influences the morale of subordinates, creating an atmosphere of trust and support. In the face of today's challenges posed by a dynamic world, investing in the development of resilience among leaders becomes an essential part of building effective and resilient teams. Therefore, it is worthwhile for organizations to pay attention to training programs and psychological support that can support commanders in developing this important trait. After all, the commander's emotional stability is the foundation on which the success of the entire team (subdivision, squad, etc.) rests.

How important, in the context of the research conducted for the purpose of this article, becomes the importance of resilience in the formation of soldiers' mental resilience. And this applies not only to subordinates, but also to their superiors - commanders.

The authors of the paper plan to expand the research on countering one's own emotions, thus the ability to restore one's emotional equilibrium after moments of nervousness, or, for example, depression, but also excessive euphoria. In addition, the authors plan to explore how willingness to take risks, Openness to change, and flexibility in behavior and thinking affect coping with challenges in young people. It is worth noting that this type of research is particularly important for stressful occupations, as well as those with a high mental and emotional burden.

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ORGANIZATION AND MANAGEMENT SERIES NO. 223

COMPARISON OF KEY WEIGHTING METHODS IN MULTI-CRITERIA DECISION ANALYSIS

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Purpose: The paper aims to conduct a structured comparison of key weighting methods used in Multi-Criteria Decision Analysis (MCDA)
Design/methodology/approach: The study provides a qualitative assessment of eight selected weighting methods, categorized as subjective (AHP, SMART/SWING, Direct Rating, BWM), objective (Entropy, CRITIC, PCA), and hybrid (Fuzzy AHP + Entropy). A set of seven evaluation criteria is proposed: ease of use, data requirements, transparency, resistance to subjectivity, group applicability, compliance with decision theory, and stability of results. A comparative matrix was developed using a structured Likert-scale-based scoring system.
Findings: No single method proved to be universally superior across all evaluation dimensions. Subjective methods offer greater intuitiveness and simplicity, while objective methods provide better stability and theoretical soundness. Hybrid methods present a balanced compromise but may suffer from computational complexity. The Best-Worst Method (BWM) and hybrid approaches achieved the highest overall scores.
Research limitations/implications: The evaluation is based on the author's subjective judgment and literature review. The scoring reflects synthesized knowledge rather than empirical testing. Future research could include sensitivity analyses or the application of fuzzy/probabilistic evaluation to account for uncertainty.
Practical implications: The study provides decision-makers with contextual recommendations for selecting appropriate weighting techniques depending on the nature of the decision environment, the availability of data, and the level of stakeholder involvement.
Originality/value: This paper offers a unique synthesis and structured comparison of key weighting methods within the MCDA framework, combining theoretical classification with a multi-criteria quality assessment matrix. It contributes to both academic research and practical guidance for analysts and policy-makers.
Keywords: criteria weighting, multi-criteria decision analysis, subjective and objective methods, hybrid weighting, comparative evaluation.
Category of the paper: Research paper.

1. Introduction

Contemporary decision-making challenges in management, engineering, public policy, and environmental analysis (Belton, Stewart, 2002) increasingly require the use of multi-criteria evaluation approaches. In such contexts, Multi-Criteria Decision Analysis (MCDA) has gained particular importance, as it enables a structured decision-making process that accounts for multiple, often conflicting, aspects (Cinelli et al., 2020). One of the key components of this process is the determination of criteria weights, which reflect the relative importance of individual factors influencing the selection of alternatives.

Numerous weighting approaches have emerged in both the literature and practice, differing in terms of the source of information (e.g., empirical data vs. decision-maker preferences), methodological complexity, interpretability, and robustness to error (Cinelli et al., 2020; Mardani et al., 2015). These methods are commonly classified into three categories: subjective, objective, and hybrid. Each of these categories offers specific advantages and limitations, and their use may lead to significantly different outcomes in MCDA. Therefore, the selection of an appropriate weighting method is a critical stage in the entire decision-making process.

The aim of this paper is to evaluate and compare selected weighting methods applied in the MCDA context. Eight representative methods from the three major categories were analyzed:

- Subjective methods: AHP (Saaty, 1987), SMART/SWING (Edwards and Barron, 1994), Direct Rating (French, 1986), BWM (Rezaei, 2015),
- Objective methods: Entropy (Mukhametzyanov, 2021), CRITIC (Diakoulaki et al., 1995), PCA (Jolliffe, 2002),
- Hybrid method: Fuzzy AHP combined with Entropy (Kahraman et al., 2003).

In contrast to many previous studies (Agar et al., 2023; Agarski et al., 2019; Dereli, Tercan, 2021; Esmaili, Karipour, 2024; Khan, Purohit, 2024; Mahmoodi et al., 2023; Németh et al., 2019), this paper does not rely solely on illustrative decision-making datasets. Instead, it focuses on a qualitative comparison of methods using a multi-criteria evaluation framework based on an author-developed comparison matrix. Seven evaluation criteria were applied: ease of use, data requirements, transparency, resistance to subjectivity, group applicability, theoretical soundness, and stability of results.

This paper offers a novel synthesis by comparing eight widely used weighting methods within a unified multi-criteria evaluation framework, which has not yet been systematically addressed in prior literature.

The structure of the article includes a theoretical background, classification of weighting methods, justification of evaluation criteria, description of the analyzed techniques, construction and interpretation of the comparison matrix, and a discussion of the findings. The paper concludes with final remarks and recommendations.

2. Classification of weighting methods and evaluation principles

The determination of criteria weights in MCDA is a crucial process that defines the structure of preferences and significantly influences the final outcome of the decision analysis. Depending on the decision-making context, the availability of data, the competence of decision-makers, and the requirements for transparency and repeatability, the choice of an appropriate weighting method can have a substantial impact on the accuracy and practical usefulness of the solution.

This study focuses on the qualitative evaluation of selected weighting methods, namely AHP, SMART/SWING, Direct Rating, BWM, Entropy, CRITIC, PCA, and Fuzzy AHP combined with Entropy. The goal of this evaluation is not to identify a single universally "best" method, but rather to provide a foundation for an informed selection of a method tailored to the specific context.

2.1. Classification of weighting methods

In the literature, weighting methods are typically classified according to the source of information used to determine the weights. Most commonly, three main categories are distinguished.

2.1.1. Subjective methods

Weights are determined based on the preferences, judgments, or intuition of the decision-maker. These methods are characterized by their simplicity and directness but may be prone to cognitive biases, inconsistencies, and a lack of objectivity. Selected methods include: Analytic Hierarchy Process (AHP), SMART / SWING, Direct Rating, and Best-Worst Method (BWM).

2.1.2. Objective methods

Weights are derived from empirical data, without the direct involvement of the decision-maker's judgments. These methods are typically based on the analysis of data structure, variability, and correlations between criteria. Their main advantages include high repeatability and independence from subjective assessments. The considered methods are: Entropy (Shannon Entropy Method), CRITIC (CRiteria Importance Through Intercriteria Correlation), and Principal Component Analysis (PCA).

2.1.3. Hybrid methods

These methods combine elements of both subjective and objective approaches, incorporating, for example, empirical data as well as the preferences of the decision-maker. They are particularly useful in situations where decisions must account for uncertainty or imperfect information. One method considered in this study is Fuzzy AHP combined with Entropy. It should be noted, however, that the range of hybrid methods and their potential applications is very broad.

2.2. Scope of comparison and evaluation approach

The analyzed methods were compared based on qualitative evaluation criteria including ease of application, resistance to errors and uncertainty, data requirements, and compliance with decision theory. To ensure consistency and comparability, each method was rated using a standardized 0-5 Likert scale. In this scale, a score of 0 indicated no compliance with a given criterion, while higher values represented increasing levels of adequacy—ranging from very poor (1) to very good compliance (5).

2.3. Comparative criteria for weighting methods – description and justification

*2.3.1. Ease of use (**EU**)*

This criterion refers to the level of difficulty involved in applying the method—both in terms of computational complexity and cognitive demand for the decision-maker or analyst. In situations with limited time and expertise (e.g., public consultations or fast-paced operational decisions), the simplicity of a method becomes a key factor (Edwards, Barron, 1994; Goodwin, Wright, 2014; Vaidya, Kumar, 2006).

*2.3.2. Data requirements (**DR**)*

This criterion indicates whether a method can be applied when quantitative data are limited or when only qualitative data are available. In many real-world cases, numerical data are not accessible, which makes information-light methods preferable (Cinelli et al., 2020; Mardani et al., 2015).

*2.3.3. Transparency (**TR**)*

This criterion refers to the comprehensibility of the method's underlying logic and the ease with which its results can be interpreted by non-experts. Decision outcomes should be communicable and acceptable—methods that function as "black boxes" tend to reduce stakeholders' trust (Agar et al., 2023; Bączkiewicz, Wątróbski, 2022; Li et al., 2024).

*2.3.4. Resistance to subjectivity (**RS**)*

This criterion indicates the extent to which a method minimizes the influence of subjective judgments, cognitive biases, and inconsistencies on the part of decision-makers. Reducing arbitrariness improves the repeatability and objectivity of the results (Jia et al., 1998; Krishnan et al., 2021; Pamucar, Ecer, 2020).

*2.3.5. Group Applicability (**GA**)*

This criterion evaluates the method's ability to function in group decision-making settings, such as workshops, consultations, or team-based environments. In practice, decisions are often made collectively, so the method should support the aggregation of multiple opinions (De Feo, De Gisi, 2010; Mahmoodi et al., 2023; Vavrek, 2019).

*2.3.6. Compliance with decision theory (**CT**)*

This criterion refers to the extent to which a method is grounded in established foundations of decision theory, information theory, or preference theory. A method aligned with formal theoretical principles enhances the credibility and scientific rigor of the analysis (Dytianquin et al., 2023; Saaty, 1987; Zhu et al., 2020).

*2.3.7. Stability of results (**ST**)*

This criterion measures the method's resistance to small changes in input data or decision-maker evaluations. Stability increases confidence in the results and enhances their repeatability (Du et al., 2019; Esangbedo et al., 2024; Vagiona, 2025).

3. Characteristics of selected weighting methods

This section presents eight selected weighting methods representing the three main categories of approaches: subjective, objective, and hybrid. The selection of methods was based on their popularity in the literature, widespread use in MCDA applications, and conceptual diversity. Each method has its unique characteristics, advantages, and limitations, which are described in detail below.

3.1. Subjective methods

3.1.1. AHP (Analytic Hierarchy Process) (Saaty, 1987)

The AHP method, developed by Thomas Saaty, is based on a hierarchical structure of the decision problem and pairwise comparisons of criteria made by the decision-maker. Each pair of criteria is evaluated in terms of their relative importance, and the weights are derived accordingly.

AHP is one of the most well-known MCDA methods. Its main strengths lie in its systematic approach and the ability to assess the consistency of the responses. However, a notable drawback is the rapidly increasing number of comparisons required as the number of criteria grows, which can lead to decision-maker fatigue and inconsistent judgments. Nevertheless, AHP remains a widely used and popular method.

3.1.2. SMART/SWING (Edwards, Barron, 1994)

The SMART and SWING methods belong to the category of point allocation techniques. They involve assigning a numerical score to each criterion to reflect its importance. In the SWING method, the decision-maker considers which criterion should be "activated" first in a hypothetical scenario where all criteria initially hold the lowest possible level.

These methods are very simple, fast, and intuitive. Due to their transparency, they are widely used in expert evaluations, public consultations, and educational settings. Their main drawback is the lack of mechanisms to verify the consistency of judgments and a strong dependence on the subjective beliefs of the decision-makers.

3.1.3. Direct Rating

Direct Rating is the simplest approach to determining weights. It involves directly assigning a weight to each criterion without the need for pairwise comparisons or intermediary evaluations. This method often uses percentage or rating scales, such as 0-10 or 0-100.

The main advantage of Direct Rating is its simplicity and speed of application—it requires no specialized knowledge or tools. It is particularly useful in situations where quick results are needed or where the analysis is limited in scope. However, its greatest limitation lies in its high degree of subjectivity and the absence of any mechanisms to control the quality or consistency of the assessments.

3.1.4. BWM (Best-Worst Method) (Rezaei, 2015)

The Best-Worst Method (BWM) is based on the decision-maker's selection of the best (most important) and worst (least important) criteria from the set under consideration. The decision-maker then evaluates all remaining criteria relative to these two reference points. The final weights are derived from these assessments.

BWM requires fewer evaluations than AHP and offers better control over the consistency and intensity of preferences. The method is gaining popularity due to its simple decision structure and suitability for both individual and group analyses. However, in its more advanced form, it may require familiarity with optimization tools.

3.2. Objective methods

3.2.1. Entropy (Shannon Entropy Method)

The entropy method is based on analyzing the variability of data in the decision matrix. The greater the variation in the values of a given criterion across alternatives, the higher its informational value—and consequently, its assigned weight.

This is a fully objective approach that does not require any expert judgments. It performs well when numerical and complete data are available, and the goal is to eliminate the influence of decision-maker preferences. However, its main limitation is that it considers only the statistical properties of the criteria, without accounting for their decision-making relevance.

3.2.2. CRITIC (CRiteria Importance Through Intercriteria Correlation) (Diakoulaki et al., 1995)

The CRITIC method takes into account both the variability of criterion values (i.e., their informational strength) and the interrelationships between them (e.g., correlations). A criterion that shows high variability and low correlation with others is considered more important.

Compared to the entropy method, CRITIC offers a more refined approach, as it accounts for interdependencies between criteria, thereby enhancing the relevance of the weighting results. However, the method requires a complete numerical data matrix and the calculation of inter-criterion correlations, which may present a barrier in certain applications.

3.2.3. PCA (Principal Component Analysis) (Jolliffe, 2002)

Principal Component Analysis (PCA) is a statistical method used for data dimensionality reduction and for identifying patterns of dependence. In the context of weighting, it can be applied to determine the contribution of each criterion to the overall variance in the dataset—and thus to assign corresponding weights.

PCA is primarily used in the development of composite indicators (e.g., sustainability indices) and in situations where the goal is to automatically identify the most influential variables. Its advantages include high objectivity and resistance to redundancy. However, its limitations involve low transparency and difficulty in interpreting the results for individuals without statistical expertise.

3.2.4. Hybrid method: Fuzzy AHP + Entropy (Kahraman et al., 2003)

The hybrid method combines the subjective approach (Fuzzy AHP) with the objective one (Entropy). In Fuzzy AHP, expert preferences are expressed not through precise numerical values but using fuzzy numbers, which allows for the incorporation of uncertainty and vagueness in the assessments. The resulting weights are then complemented with information derived from the entropy analysis of the data matrix.

The advantage of this method lies in its flexibility—it enables the consideration of uncertainty while still relying on real data. It is particularly useful in risk assessments, quality evaluations, and situations involving incomplete or imprecise data. Its main drawbacks are its high computational complexity and the need for advanced interpretation of results.

4. Methods

The methodological approach adopted in this study is based on a structured literature review combined with a comparative evaluation framework developed by the author. The primary objective was to assess and contrast selected weighting methods used in Multi-Criteria Decision Analysis (MCDA) based on a set of predefined qualitative criteria.

4.1. Selection of weighting methods

The selection of the eight weighting methods included in this study was guided by three criteria: (1) frequency of use in academic and applied MCDA literature, (2) conceptual and methodological diversity (subjective, objective, and hybrid approaches), and (3) relevance to decision-making problems in management, engineering, and policy contexts. The final set

consists of four subjective methods (AHP, SMART/SWING, Direct Rating, BWM), three objective methods (Entropy, CRITIC, PCA), and one hybrid method (Fuzzy AHP combined with Entropy).

4.2. Literature sources and scope

The literature review supporting the evaluation was conducted using academic databases such as Scopus, Web of Science, and Google Scholar. The search focused on peer-reviewed journal articles, review papers, and methodological studies published primarily between 2000 and 2024. Keywords included: criteria weighting, MCDA methods, subjective weighting, objective weighting, hybrid MCDA, and the names of specific methods (e.g., "Entropy method", "BWM", "Fuzzy AHP"). Publications in English were prioritized due to their international relevance and broader citation base.

Inclusion criteria required that sources describe, apply, or compare MCDA weighting methods in a documented decision context. Methodological syntheses and comparative reviews were particularly emphasized. Gray literature, conference abstracts, and non-peer-reviewed content were excluded to ensure quality.

4.3. Evaluation framework

The comparative evaluation was carried out using a multi-criteria framework composed of seven qualitative criteria: ease of use, data requirements, transparency, resistance to subjectivity, group applicability, compliance with decision theory, and stability of results. These criteria were selected based on their recurrence in existing literature (e.g., Cinelli et al., 2020; Mardani et al., 2015; De Feo, De Gisi, 2010) and their practical relevance in decision-making contexts.

Each method was rated on a 0-5 Likert scale, where: 0 – does not meet the criterion at all, 1 – very poor compliance, 2 – poor, 3 – moderate, 4 – good, 5 – very good or fully compliant.

Scores were assigned based on a synthesis of findings from the reviewed literature, complemented by the author's academic experience and prior applications of the methods. While the evaluation follows a structured approach, it remains qualitative in nature and should be interpreted as a reasoned support tool rather than a definitive ranking.

Future research may benefit from validating the ratings through expert elicitation, fuzzy logic, or probabilistic methods to better address uncertainty in comparative assessments.

5. Results

The evaluation of weighting methods in this study is qualitative in nature and based on a review of relevant literature. Although a numerical scale (0-5) was adopted, it is important to

emphasize that the assigned values reflect synthesized conclusions from comparisons available in academic sources as well as the authors' research experience. The assessments were conducted in a structured manner; however, they involve a certain degree of subjectivity and uncertainty, which is typical for review-based studies. These values should be regarded as a starting point for further analysis rather than absolute measures of method quality. The summarized results are presented in Table 1.

Table 1.
Qualitative evaluation of selected criteria weighting methods in MCDA

Method	EU	DR	TR	RS	GA	CT	ST
AHP	5	3	3	1	4	5	4
SMART_SWING	5	5	5	1	4	4	3
Direct_Rating	5	5	5	1	5	2	2
BWM	4	5	4	2	5	5	5
Entropy	4	1	2	5	2	5	5
CRITIC	3	1	3	5	2	5	5
PCA	3	1	2	5	3	5	5
Fuzzy_AHP_Entropy	2	2	2	4	4	5	5

EU – ease of use, DR – data requirements, TR – transparency, RS – resistance to subjectivity, GA – group applicability, CT – compliance with decision theory, ST – stability of results.

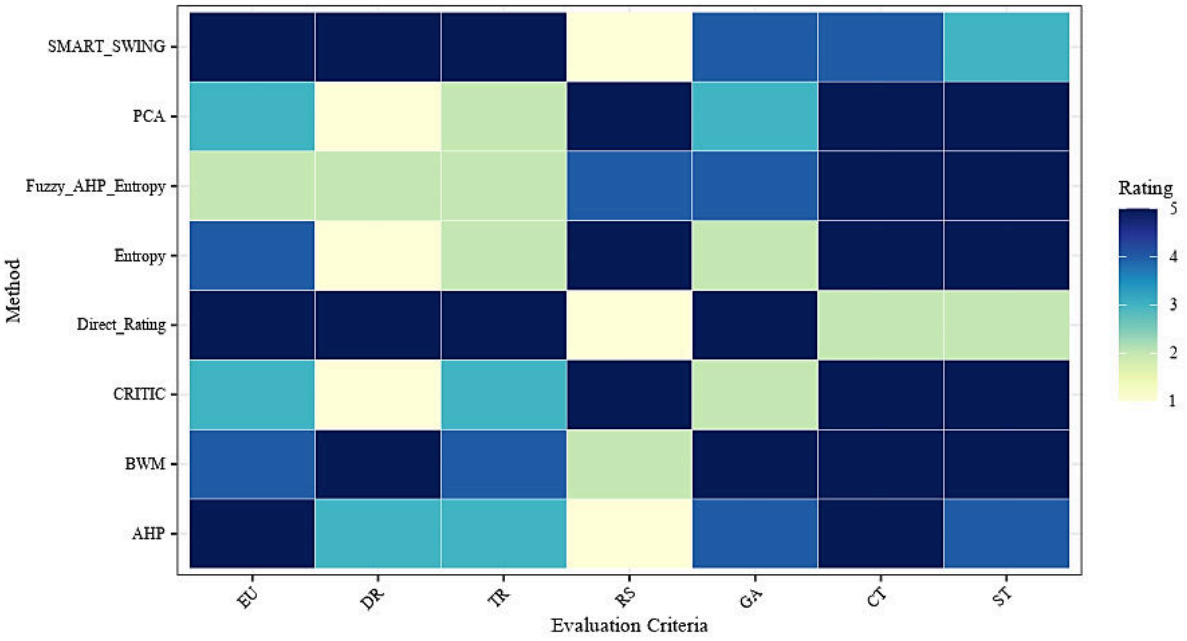
Source: Based on the author's own analysis.

Justification of the evaluations assigned to each method with respect to the considered criteria is grounded in a synthesis of findings from key literature sources (Agar et al., 2023; Agarski et al., 2019; De Araújo et al., 2022; De Feo, De Gisi, 2010; Du et al., 2019; Dytianquin et al., 2023; Ecer, 2024; Mahmoodi et al., 2023; Mukhametzyanov, 2021; Németh et al., 2019; Pliego-Martínez et al., 2024; Vagiona, 2025; Wolny, 2015; Wu et al., 2022; Zhu et al., 2020):

- AHP (EU: 5 – widely recognized as intuitive, DR: 3 – requires pairwise comparisons but not a complete data matrix, TR: 3 – moderate transparency for non-experts, depending on the number of criteria, RS: 1 – highly dependent on the preferences and inconsistencies of the decision-maker, GA: 4 – well-suited for group aggregation, CT: 5 – strong axiomatic foundation, ST: 4 – moderately stable but sensitive to inconsistency),
- SMART/SWING (EU: 5 – exceptionally simple and transparent methods, DR: 5 – require only basic input data, TR: 5 – highly understandable for non-experts, RS: 1 – evaluations are entirely subjective, GA: 4 – easy to apply in group settings, CT: 4 – consistent with utility theory, ST: 3 – sensitive to changes in point-based ratings),
- Direct Rating (EU: 5 – the fastest and easiest form of weight assessment, DR: 5 – no need for complex data, TR: 5 – fully transparent and easy to interpret, RS: 1 – no control over subjectivity, GA: 5 – particularly useful in consultations and social research, CT: 2 – lacks formal theoretical foundations, ST: 2 – high risk of result variability),

- BWM (EU: 4 – simpler than AHP but requires optimization, DR: 5 – can be applied without numerical data, TR: 4 – logical structure and limited number of judgments, RS: 2 – partially reduces subjectivity, GA: 5 – easy to aggregate in group settings, CT: 5 – strong theoretical foundation, ST: 5 – highly repeatable and stable results),
- Entropy (EU: 4 – requires only basic statistical knowledge, DR: 1 – demands a complete and fully populated numerical matrix, TR: 2 – low understandability for non-technical users, RS: 5 – fully objective, GA: 2 – limited applicability in group settings, CT: 5 – fully aligned with information theory, ST: 5 – high stability and repeatability),
- CRITIC (EU: 3 – somewhat more complex to apply, DR: 1 – requires numerical data and correlation analysis, TR: 2 – moderate transparency for general users, RS: 5 – strong resistance to subjectivity, GA: 2 – limited suitability for group use, CT: 5 – robust statistical foundation, ST: 5 – high resistance to variability),
- PCA (EU: 3 – requires statistical knowledge, DR: 1 – a complete matrix and data normalization are necessary, TR: 2 – difficult to interpret without analytical background, RS: 5 – highly objective, GA: 3 – applicable in group settings but requires adaptation, CT: 5 – strong theoretical foundation, ST: 5 – high result stability),
- Fuzzy AHP + Entropy (EU: 2 – complex concept of fuzzy numbers, DR: 2 – moderate data requirements (depending on the version), TR: 2 – low transparency due to methodological complexity, RS: 4 – high flexibility and partial objectivity, GA: 4 – suitable for group use but requires facilitation, CT: 5 – strong theoretical integration of data and preferences, ST: 5 – robust and stable outcomes).

Figure 1 presents a synthetic overview of the results in the form of a heatmap.



EU – ease of use, DR – data requirements, TR – transparency, RS – resistance to subjectivity, GA – group applicability, CT – compliance with decision theory, ST – stability of results.

Figure 1. Heatmap of weighting method ratings.

Source: Own study.

The heatmap presents a comparative evaluation of eight weighting methods used in Multi-Criteria Decision Analysis (MCDA) with respect to seven qualitative criteria: ease of use, data requirements, transparency, resistance to subjectivity, group applicability, compliance with decision theory, and result stability. Each method was assessed using a 0-5 Likert scale, and the scores are visually encoded through a color gradient, where darker shades indicate higher ratings. The visual analysis reveals that subjective methods, such as AHP and SMART/SWING, score highly in terms of intuitiveness and theoretical grounding but exhibit lower resistance to subjectivity. Objective methods, including Entropy and CRITIC, demonstrate strong resistance to bias and low data requirements but are generally less transparent. Hybrid approaches, such as Fuzzy AHP + Entropy, offer high result stability but tend to be more complex and less interpretable. No single method outperforms others across all dimensions, highlighting the importance of selecting a weighting technique in alignment with the specific decision-making context.

6. Discussion

6.1. Summary of the qualitative evaluation

The conducted evaluation of weighting methods revealed that no single approach consistently achieves the highest scores across all considered criteria. Each technique displays a distinct profile of strengths and weaknesses, indicating that the selection of an appropriate method should be context-dependent rather than standardized.

According to the analysis:

- Subjective methods (AHP, SMART/SWING, Direct Rating, BWM) offer high simplicity, transparency, and ease of use, but their results are more susceptible to cognitive biases and lower stability. BWM is an exception—it combines high accuracy and clarity with better resistance to subjectivity.
- Objective methods (Entropy, CRITIC, PCA) score highest in terms of resistance to subjectivity, theoretical soundness, and result stability. However, they are more difficult to implement and require complete numerical datasets.
- The hybrid method (Fuzzy AHP + Entropy) received high marks for flexibility, integration of information sources, and stability, although its complexity and lower transparency may limit its practical applicability.

In summary, the evaluation confirms that the choice of a weighting method should be tailored to the specific decision-making context, as each approach involves trade-offs between usability, robustness, and methodological rigor. The observed differences underscore the need for informed selection rather than reliance on a universally optimal technique.

6.2. Contextual method selection – recommendations

Based on the multi-criteria evaluation, it is possible to identify preferred methods for various decision-making scenarios, as presented in Table 2.

Table 2.
Recommended weighting methods depending on decision-making context

Decision-making context	Recommended methods	Justification
Group decision-making	AHP, BWM, SMART/SWING	High transparency and ability to aggregate preferences
Lack of numerical data	Direct Rating, SMART, BWM	Do not require an empirical data matrix
High repeatability and objectivity	Entropy, CRITIC, PCA	Lack of subjectivity, stability, and compliance with information theory
Decision-making under uncertainty	Fuzzy AHP + Entropy	Integration of fuzzy and objective data
Need for interpretability and communication	SMART/SWING, AHP	Well-understood logic and transparent results
Rapid operational decisions	Direct Rating, SMART	Minimal time and cognitive cost of application

Source: Based on the author's own analysis.

6.3. Limitations of the approach and uncertainty of the evaluations

Despite efforts to ensure objectivity, it is important to emphasize that:

- The evaluations are expert-based and rely on literature reviews and methodological analyses (Belton, Stewart, 2002; Cinelli et al., 2021).
- The numerical values in the comparison matrix (0-5) are not absolute measures—they should be regarded as an analytical tool to support decision-making.
- The degree of uncertainty in the evaluations could be formally estimated in future research, for example, using fuzzy or probabilistic approaches.

Despite efforts to ensure methodological rigor, the presented evaluations remain inherently judgment-based and should be interpreted as a structured support tool rather than definitive measurements. Future research may enhance robustness by incorporating uncertainty modeling techniques such as fuzzy logic or probabilistic analysis.

6.4. Implications for practice and future research

For practitioners:

- It is recommended to begin by defining decision-making requirements, including data availability, number of stakeholders, and model acceptability.
- The selection of a weighting method should be treated with equal importance as the choice of an aggregation method, as both stages influence the final outcome of MCDA.

For researchers:

- Further comparative studies are encouraged, particularly those involving empirical decision cases where different weighting methods are applied to the same dataset.
- Hybrid methods show promising potential by combining the strengths of various approaches, including automated weighting systems designed for complex environments.

The results of the multi-criteria analysis demonstrate that weighting methods differ significantly in terms of usefulness, theoretical soundness, robustness to errors, and result stability. The highest-rated methods—such as BWM and hybrid approaches—offer a balanced compromise between simplicity, flexibility, and methodological rigor.

A conscious selection of the weighting method—tailored to the specifics of the decision problem—is a critical element of effective MCDA.

7. Conclusion and final remarks

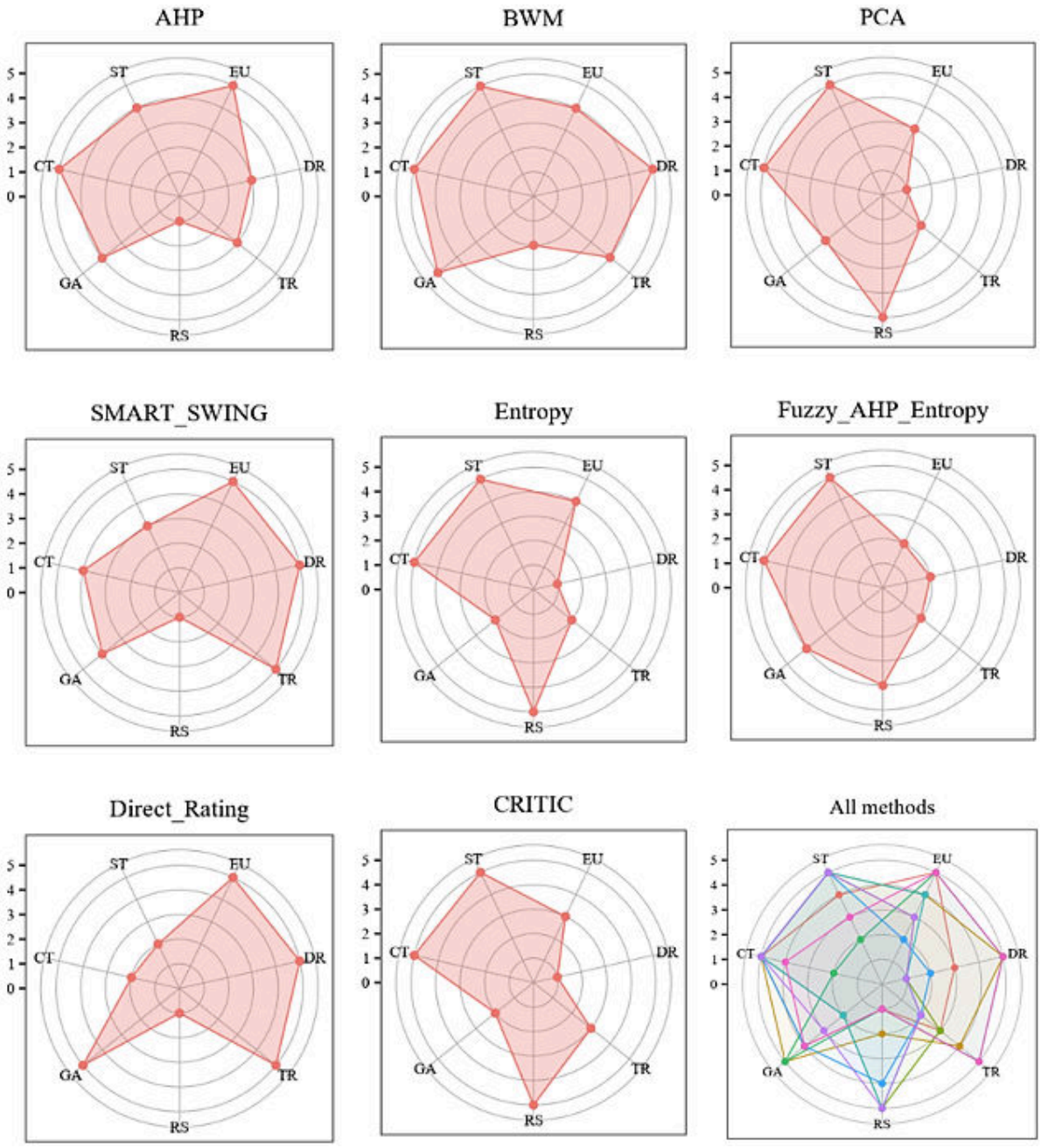
This paper presented a multi-criteria comparison of selected weighting methods used in Multi-Criteria Decision Analysis (MCDA). Eight representative techniques were examined and classified as subjective, objective, or hybrid. The evaluation was based on seven qualitative criteria related to ease of use, transparency, resistance to subjectivity, stability, and compliance with decision theory.

The results indicated that:

- Subjective methods, such as AHP and SMART/SWING, offer high intuitiveness but lower repeatability.
- Objective methods (CRITIC, PCA, Entropy) provide strong stability and theoretical consistency but require more demanding data inputs.
- Hybrid methods, such as Fuzzy AHP combined with Entropy, offer flexibility at the cost of greater complexity.

It was also emphasized that the choice of a weighting method should be adapted to the specific decision-making context, rather than relying solely on formal efficiency or methodological rigor.

The visualization shown in Figure 2, presented as a radar chart, provides an intuitive qualitative comparison of the methods, supporting the identification of their functional differences.



EU – ease of use, DR – data requirements, TR – transparency, RS – resistance to subjectivity, GA – group applicability, CT – compliance with decision theory, ST – stability of results.

Figure 2. Comparison of criteria weighting methods.

Source: Own study.

Figure 2 presents a series of radar charts visualizing the performance profiles of individual weighting methods across the seven evaluation criteria. Each plot highlights the specific strengths and weaknesses of a given method, forming a distinct polygonal area that reflects its evaluative footprint. The composite chart ("All methods") provides a consolidated view, illustrating the diversity of profiles and trade-offs among the methods. As a final summary visualization, Figure 2 reinforces the conclusion that no single method consistently outperforms others across all dimensions. Instead, each technique offers context-specific advantages and

limitations, indicating that method selection should be guided by the priorities and constraints of the particular decision-making scenario.

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MARKET REACTIONS TO CORPORATE REGULATORY ANNOUNCEMENTS: EVIDENCE FROM POLISH STOCK EXCHANGE

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Purpose: This research examines stock price reactions to corporate regulatory announcements on the Warsaw Stock Exchange (WSE), testing semi-strong market efficiency in an emerging European market by analyzing high-frequency intraday price movements following mandatory disclosures. The study determines information incorporation speed, reaction pattern differences, and implications for market efficiency theory.
Design/methodology/approach: Using event study methodology adapted for high-frequency data, the study analyzes 696 regulatory announcements (ESPI) from 52 liquid companies (WIG20 and WIG40 indices) from November 2024 to March 2025. Price reactions are measured at 1-120 minute intervals post-announcement, with raw returns as abnormal return proxies and significance assessed via t-tests, Wilcoxon tests, and sign tests.
Findings: Results reveal gradual price adjustment, with only 5% of total 2-hour impact occurring within the first minute and 74% within the first hour. Neutral reactions dominate initially (97% at 1 minute) but decrease to 57% by 2 hours. While average price changes are minimal, sign tests show significant deviation from random distribution. Volatility increases steadily over the 2-hour window, contrary to expectations that information resolves uncertainty.
Research limitations/implications: Limitations include the short study period, sample dominated by Financial Reports, and potential microstructure effects in high-frequency returns. Findings challenge strict semi-strong efficiency applicability in Polish markets, suggesting efficiency models need adaptation for emerging markets.
Practical implications: For investors, findings suggest potential trading opportunities despite limited profitability after transaction costs. For regulators, results highlight the importance of effective disclosure dissemination. For corporate managers, understanding gradual market reactions can inform communication strategies.
Originality/value: This study provides detailed empirical evidence on intraday market reactions in Poland by: (1) documenting information incorporation patterns at high frequency; (2) analyzing diverse ESPI messages beyond typical studies; (3) providing specific evidence on WSE efficiency; and (4) identifying anomalies like increasing post-announcement volatility that challenge traditional market efficiency models.
Keywords: Market efficiency, regulatory announcements, intraday price reactions, emerging markets, Warsaw Stock Exchange.
Category of the paper: Research paper.

1. Introduction

The link between corporate news and stock prices is central for financial economics and market efficiency theory (Fama, 1970). Understanding how markets process information, especially mandatory regulatory announcements containing material information, is vital. This study focuses on Polish stock market, a key emerging market in Central Europe, where information processing might differ from developed markets due to unique institutional settings, investor behaviors, and market microstructures. The Warsaw Stock Exchange (WSE), reestablished in 1991, represents significant part of the regional capital market, making it important case for study.

Regulatory announcements, often mandated by bodies like Polish Financial Supervision Authority (KNF), provide critical informations that can influence investor expectations about company future performance, risk, and value. These announcements cover wide range of topics, from financial results and dividend decisions to significant contracts, management changes, and strategic initiatives. How quickly and accurately market prices reflect these information is a direct test of semi-strong market efficiency.

We analyze large dataset comprising 696 regulatory announcements (ESPI messages) from 52 diverse Polish companies during specific period 15.11.2024-14.03.2025. (Available here: https://github.com/mzgrb/espi) We examine high-frequency intraday price reactions at multiple intervals (1 minute, 5 minutes, 10 minutes, 30 minutes, 1 hour, 2 hours) following each announcement. This granular approach allows us to assess not only if the market reacts, but also speed and pattern of this reaction, providing deeper insights than studies relying solely on daily data. Key questions guiding this research include: How fast do prices react in Polish market? Does magnitude and speed of reaction differ by announcement type? Is there evidence of post-announcement drift or reversal? What are the implications of these findings for market efficiency hypothesis in context of emerging European market?

This research offers several contributions. It provides detailed empirical evidence on intraday market reactions in Poland, adding to limited literature on this specific market. By analyzing wide range of regulatory announcements, it offers a comprehensive view compared to studies focusing on single event type. Furthermore, findings have practical implications for investors considering trading strategies around announcements, for regulators assessing effectiveness of disclosure rules, and for corporate managers aiming to understand market perception of their communications. The analysis of reaction speed and patterns helps to characterize efficiency level of WSE.

2. Literature Review

2.1. Event Study and Market Efficiency

Event studies are standard method in finance to measure impact of events, like corporate announcements, on stock prices (MacKinlay, 1996). Core idea is that efficient markets quickly reflect new information. Methodology involves calculating abnormal returns (ARs) – difference between actual and expected returns – around event time. Early work by Ball and Brown (1968) and Fama et al. (1969) established modern framework. Our study uses this method with high-frequency intraday data, using raw returns as proxy for ARs, common for short intervals (Busse, Green, 2002).

This relates directly to Efficient Market Hypothesis (EMH) by Fama (1970), especially semi-strong form, which state prices reflect all public information. If Polish market is semi-strong efficient, prices should react fast and accurately to ESPI messages. However, EMH faces challenges from behavioral finance (Shleifer, 2000) and concept of "efficiently inefficient" markets (Pedersen, 2015). Testing EMH in emerging markets like Poland is key, as they may have features leading to slower information processing.

2.2 Reactions to Announcements and Emerging Markets

Many studies examine reactions to earnings (Ball, Brown, 1968), dividends (Pettit, 1972), and M&A (Jensen, Ruback, 1983). Regulatory announcements, our focus, are less studied as broad category, especially intraday in emerging markets. Research in emerging markets often finds slower or smaller reactions compared to developed markets (Griffin et al., 2011), possibly due to lower liquidity or transparency. Studies on Poland (e.g., Gurgul, Majdosz, 2007; Bohl et al., 2009) found significant reactions but hinted at slowness. Our study add to this by analyzing broad set of ESPI messages at high frequency for recent period (15.11.2024-14.03.2025), focusing on speed and pattern of reaction to assess WSE efficiency level.

3. Data and Methodology

3.1. Data Source and Description

Our primary dataset consist of regulatory announcements, known as ESPI messages (Elektroniczny System Przekazywania Informacji), filed by companies listed on Warsaw Stock Exchange (WSE). We collected 696 such announcements from 52 distinct companies during specific time window from 15 November 2024 to 14 March 2025. These companies were selected based on liquidity, primarily including constituents of WIG20 and WIG40 indices,

ensuring focus on most actively traded stocks. This period was chosen to reflect recent market conditions. For each announcement, we obtained full text content and precise timestamp (date, hour, minute) of its release through official WSE channels (PAP – Polska Agencja Prasowa). This high granularity in timing is crucial for our intraday analysis.

To measure market reaction, we collected corresponding stock price data for each company around time of its announcements. We obtained prices at exact moment of announcement (t = 0) and at several subsequent intervals: 1 minute (t = 1), 5 minutes (t = 5), 10 minutes (t = 10), 30 minutes (t = 30), 60 minutes (t = 60, or 1h), and 120 minutes (t = 120, or 2h) after announcement. This high-frequency price data allow us to track evolution of market response over short time horizons. Price data was sourced from reliable financial data provider (Yahoo Finance API) ensuring accuracy and synchronization with announcement times. We carefully addressed potential issues like non-trading periods (weekends and polish holidays) or data gaps, excluding announcements where reliable price data was unavailable for required intervals. (ESPI issued after trading hours).

We performed preliminary classification of announcements based on their textual content. Using keyword analysis and topic modeling techniques, we categorized messages into broad types such as Financial Reports (e.g., quarterly results, annual reports), Share Transactions (e.g., insider trading, buybacks), Contracts (e.g., significant new agreements), Management Changes, Strategy/Planning updates, and Other miscellaneous regulatory filings. Our analysis revealed that Financial Reports are largest category, accounting for 583 out of 696 announcements in our sample. This dominance reflect importance of periodic financial disclosures.

3.2. Event Study Methodology Implementation

We employ standard event study methodology, adapted for high-frequency intraday data, to assess market impact of these regulatory announcements.

- **Event Definition**: The event of interest is public release of ESPI regulatory announcement by listed company.
- **Event Time**: Time zero (t = 0) is defined as exact minute announcement was released.
- **Event Window**: We focus on short-term reaction within two hours following announcement. Our measurement points are t = 1, 5, 10, 30, 60, and 120 minutes relative to announcement time.
- **Return Calculation**: For each company *i* and time interval *t* post-announcement, we calculate raw percentage return relative to price at announcement time (P_{i,0}): R_{i,t} = (P_{i,t} - P_{i,0}) / P_{i,0} This measures total price change from announcement moment up to time *t*.
- **Abnormal Return (AR) Definition**: Given very short intraday intervals, expected normal return is assumed to be close to zero. Therefore, we follow common practice in high-frequency event studies (e.g., Busse, Green, 2002) and use raw returns (R_{i,t})

as our primary measure of abnormal returns (AR_{i,t}). This approach avoids complexities and potential biases of estimating normal returns using models like market model over very short horizons where microstructure effects can dominate.

- **Aggregation**: To analyze average market reaction, we calculate Average Abnormal Return (AAR) across all *N* events in sample (or subsample) for each time interval *t*: AAR_t = (1/N) * Σ_{i=1}^{N} AR_{i,t} We also analyze average absolute abnormal return to understand magnitude of reaction regardless of direction: Average |AR|*t = (1/N) * Σ*{i=1}^{N} |AR_{i,t}|
- **Statistical Significance Testing**: To determine if observed average abnormal returns are statistically significant (i.e., different from zero), we employ several tests. Given potential non-normality in high-frequency returns, relying solely on standard t-test can be misleading. Therefore, we use:
  - **Cross-sectional t-test**: Tests if mean AAR_t is significantly different from zero.
  - **Wilcoxon signed-rank test**: Non-parametric test based on ranks, robust to non-normality, testing if median AR_t is different from zero.
  - **Sign test**: Non-parametric test comparing proportion of positive and negative ARs, testing if proportion significantly deviates from 50%. This test is particularly useful when many returns are exactly zero (neutral reactions). We consider result significant if p-value is less than 0.05.
- **Further Analysis**: Beyond average returns, we analyze speed of reaction by calculating proportion of total 2-hour price change (measured by average absolute AR at 2h) that occurs at earlier intervals. We also examine evolution of volatility (measured by standard deviation of ARs across events) over event window. Finally, we perform analysis separately for different announcement types where sample size permits, to check for differential reactions.

3.3. Potential Limitations

We acknowledge several potential limitations exist in this type of study. First, co-existing events: Other news or market-wide movements might occur around announcement time, potentially influencing observed price changes. While using short intraday window helps mitigate this, it cannot be fully eliminated. Second, market microstructure effects: Bid-ask bounce, price discreteness, and non-synchronous trading can introduce noise into high-frequency returns, especially for less liquid stocks, however this was potentially adressed by picking the most liquid shared for analysis. Third, thin trading: Some stocks in sample might trade infrequently, meaning observed price at specific minute might not reflect immediate reaction but rather first trade occurring sometime after announcement. Our focus on returns relative to t=0 price helps, but issue remains for interpreting exact timing. Fourth, announcement timing accuracy: While we use official release times, slight delays in dissemination or market access could affect precise reaction start time. Fifth, announcement

classification: Our text-based classification is useful but might miscategorize some complex or ambiguous announcements. Some of them are lengthy and provided in various formats. Sixth, causality: While event study suggests announcement causes reaction, reverse causality (e.g., price movement before announcement) is unlikely for mandatory filings but cannot be entirely ruled out for all types. This could be potentially an area for further investiagtions.

4. Results

This section presents empirical findings from our analysis of market reactions to 696 regulatory announcements on Warsaw Stock Exchange during period 15.11.2024-14.03.2025. We examine descriptive statistics, overall price impact patterns, speed of reaction, volatility dynamics, statistical significance, and briefly touch upon differences across announcement types.

4.1. Descriptive Statistics of Price Changes

This section present concise summary of key findings across different time intervals following regulatory announcements. Table below compile important metrics for each interval, allowing reader to quickly grasp patterns and trends without navigating multiple textual sections.

Table 1.
Comprehensive Summary of Market Reactions by Time Interval

Metric	**1m**	**5m**	**10m**	**30m**	**1h**	**2h**
Returns						
Mean Return	-0.000014	0.000330	0.000158	0.000417	0.000445	0.000747
Median Return	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Min Return	-0.020000	-0.030000	-0.030000	-0.070000	-0.080000	-0.110000
Max Return	0.020000	0.090000	0.070000	0.060000	0.080000	0.110000
Volatility Standard Deviation	0.001897	0.004978	0.005637	0.007175	0.009757	0.012875
Reaction Distribution						
Positive Reactions (%)	1.29	5.60	7.18	12.50	18.97	22.70
Negative Reactions (%)	1.44	3.74	6.47	9.48	16.24	20.55
Neutral Reactions (%)	97.27	90.66	86.35	78.02	64.80	56.75
Statistical Significance						
T-test p-value	0.8416	0.0803	0.4597	0.1260	0.2289	0.1263
Wilcoxon test p-value	0.8429	0.0838	0.5163	0.0819	0.2226	0.1736
Sign test p-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Key Observations from Summary Table:

1. Gradual Price Adjustment: Data clearly show that price impact materialize gradually, with only 5% of total 2-hour impact occurring in first minute and 74% by first hour.
2. Increasing Magnitude: Both mean absolute returns and volatility (standard deviation) increase steadily over time, indicating growing price dispersion as market process information.
3. Dominance of Neutral Reactions: Extremely high percentage of neutral reactions (97.27%) at 1-minute mark, which decrease steadily but remain majority (56.75%) even after 2 hours.
4. Statistical Significance Pattern: Traditional tests (t-test, Wilcoxon) generally fail to reject null hypothesis of zero abnormal return, while Sign test consistently show high significance ($p < 0.001$) across all intervals.
5. Balanced Directional Impact: Positive and negative reactions increase at similar rates over time, explaining why average raw returns remain close to zero despite increasing absolute impact.

First, mean price changes are extremely small across all time intervals, very close to zero. The largest mean change is only 0.000747 (or 0.07%) at 2-hour mark. This suggest that, on average, these regulatory announcements (ESPI) do not trigger large directional price movements in Polish market in the observed period. Second, median price change is exactly zero for all intervals. This indicate that for majority of announcements, price does not change at all within measured timeframe.

Third, standard deviation (Std Dev) show clear increasing trend over time. It starts at low 0.0019 (0.19%) at 1 minute and steadily rise to 0.0129 (1.29%) at 2 hours. This increasing dispersion shows that while average reaction is small, magnitude of individual reactions (both positive and negative) tend to grow as more time passes after announcement. Market seems to diverge more in its assessment or reaction intensity over time.

Fourth, minimum and maximum values reveal the existence of substantial price reactions for some specific announcements, despite small average effect. For instance, at 5-minute mark, one announcement was followed by 9% price increase, while at 2-hour mark, another saw 11% price decrease. This highlight heterogeneity of information content and market responses within our sample.

Fifth, and perhaps most striking, is distribution of reaction types. Percentage of neutral reactions (zero price change) is extremely high immediately after announcement (97.27% at 1 minute). While this percentage decrease steadily over time, it remain very substantial even after two hours (56.75%). Correspondingly, percentages of positive and negative reactions start very low (around 1.3-1.4% at 1 minute) and gradually increase, reaching about 23% positive and 21% negative by 2-hour mark. The slow decline in neutral reactions and slow rise in active reactions strongly points towards gradual information processing for many announcements immediately after release.

4.2. Overall Price Impact and Speed of Reaction

To visualize overall impact magnitude and speed, we examine average absolute abnormal returns and cumulative proportion of total 2-hour impact realized over time.

Consistent with descriptive statistics, average raw abnormal return (AAR) remains close to zero throughout 2-hour window. However, average *absolute* abnormal return show a clear upward trend, starting near 0.0003 at 1 minute and reaching approximately 0.0063 at 2 hours. This confirms that magnitude of price movements increase over time, even if average direction is neutral.

Analysis of reaction speed reveals very gradual price adjustment process. Only about 5% of total 2-hour absolute price impact is observed within the first minute. This proportion rise to about 18% by 5 minutes, 28% by 10 minutes, 45% by 30 minutes, and 74% by 1 hour. It takes full two hours for complete average impact (as measured at 2h) to materialize. This slow incorporation contrasts sharply with near-instantaneous adjustments often documented in highly liquid, developed markets for significant news events. This gradual pattern is strong indicator of market inefficiency or significant frictions in information dissemination and trading process in Polish market during studied period.

4.3. Evolution of Reaction Types and Volatility

The changing distribution of reaction types over time further illustrates gradual response. The dominance of neutral reactions in the first few minutes, followed by their steady decline and corresponding increase in both positive and negative reactions, paint picture of market slowly waking up to news. The fact that positive and negative reactions increase at roughly similar rates explains why average raw return stays near zero.

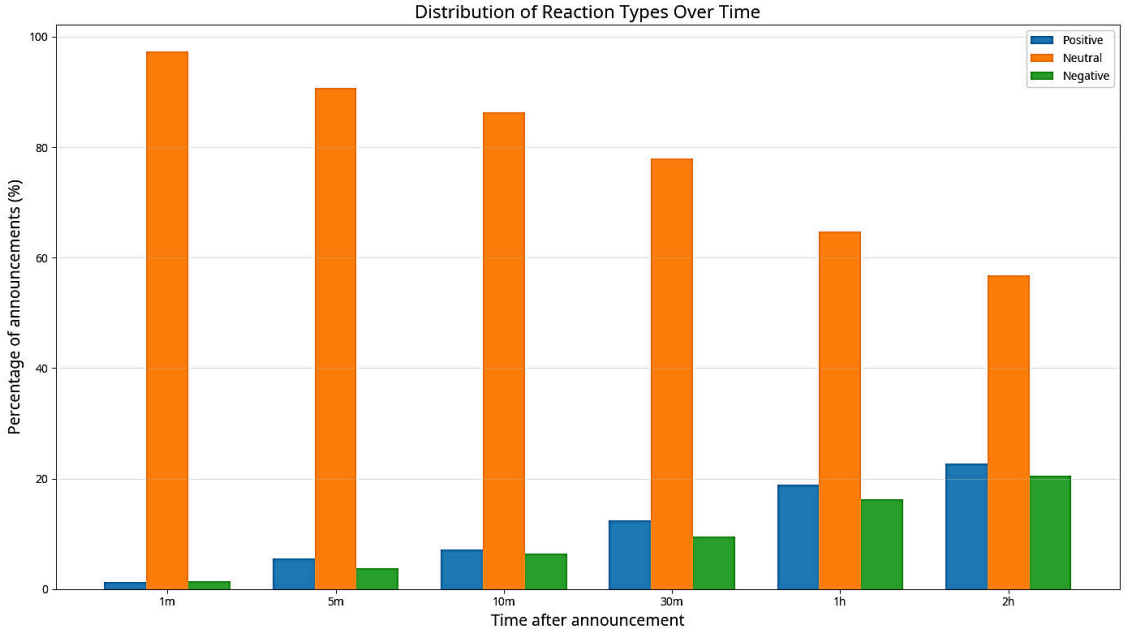

Figure 1. Distribution of Reaction Types Over Time.

Volatility, measured by standard deviation of abnormal returns across events, also shows consistent increase over 2-hour window.

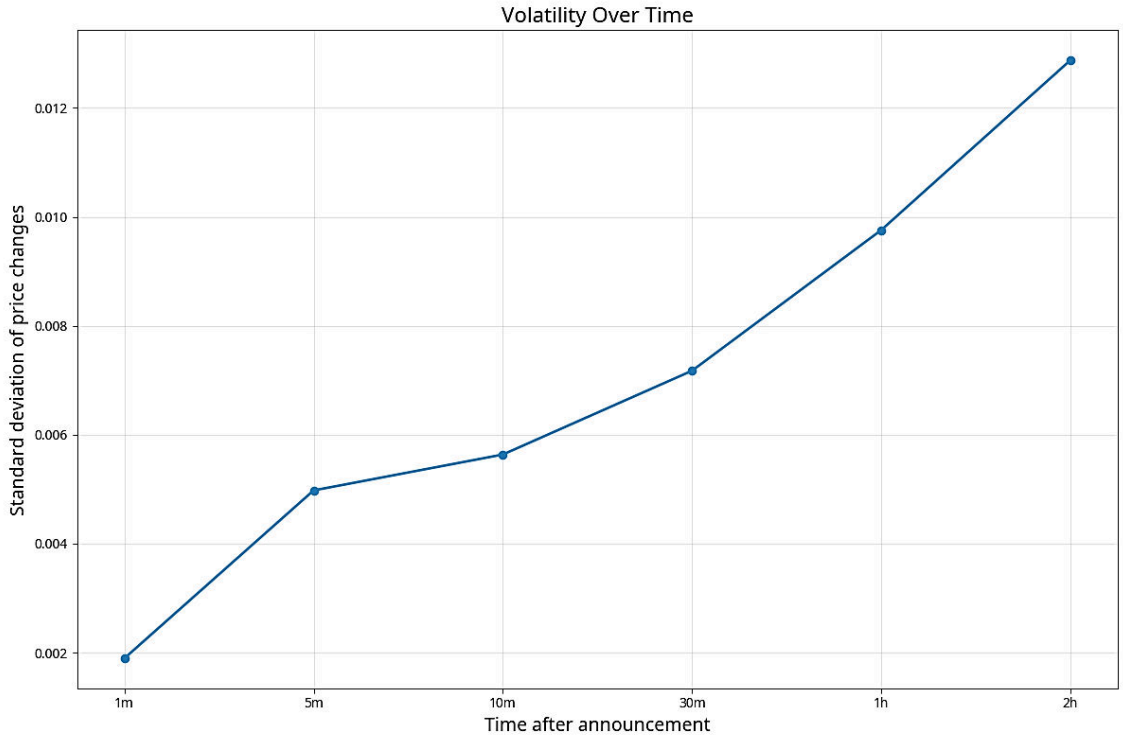

Figure 2. Volatility Over Time.

Volatility rise from about 0.19% at 1 minute to 1.29% at 2 hours. This increasing volatility is somewhat counter-intuitive from perspective of efficient markets, where new information should ideally resolve uncertainty, leading to decrease in volatility after the initial spike. The observed pattern might suggest that announcements trigger ongoing information search, diverse interpretations, or perhaps attract different types of traders with varying reaction times, leading to sustained or even growing price dispersion.

4.4. Statistical Significance Tests

We did statistical tests to assess if observed price changes, despite being small on average, are statistically distinguishable from zero. Table 2 presents p-values from cross-sectional t-test, Wilcoxon signed-rank test, and Sign test.

Table 2.
Statistical Significance Tests

Test	T-pvalue	Wilcoxon-pvalue	Sign-pvalue	Significant
1m	0.8416	0.8429	< 0.001	Yes
5m	0.0803	0.0838	< 0.001	Yes
10m	0.4597	0.5163	< 0.001	Yes
30m	0.1260	0.0819	< 0.001	Yes
1h	0.2289	0.2226	< 0.001	Yes
2h	0.1263	0.1736	< 0.001	Yes

Results show interesting divergence. Standard t-test (testing mean) and Wilcoxon test (testing median) generally fail to reject null hypothesis of zero abnormal return at conventional 5% significance level (p-values are mostly > 0.05, except marginally at 5m and 30m for Wilcoxon). This aligns with observed small mean and zero median returns.

However, Sign test yield highly significant results ($p < 0.001$) for all time intervals. Sign test compares number of positive versus negative returns. Its significance indicate that proportion of positive and negative returns is statistically different from 50/50 split expected under null hypothesis of no reaction. Given slightly higher percentage of negative returns compared to positive ones at most intervals (see Table 1), sign test significance likely reflect small but persistent prevalence of negative reactions in sample, even if average magnitude is near zero. This suggests market does react, but perhaps with slight negative bias or asymmetry not captured by mean/median tests due to big number of zero returns.

4.5. Analysis by Announcement Type

Given dominance of Financial Reports (583 announcements), detailed analysis by type is challenging for other categories due to small sample sizes. Preliminary analysis suggest:

- **Financial Reports**: Exhibit patterns very similar to overall sample – gradual adjustment, high initial neutral rate, increasing volatility.
- **Share Transactions**: Often associated with small, sometimes negative reactions, possibly reflecting signaling or liquidity effects.
- **Contracts**: Reactions likely depend heavily on contract significance, but average effect in our limited sample was not distinct.
- **Strategy/Planning**: Tentative evidence suggest these might elicit slightly more positive reactions on average, consistent with forward-looking positive news.
- **Other/Unknown**: This residual category showed varied reactions, sometimes more negative, reflecting uncertainty associated with uncategorized or unusual disclosures.

However, these type-specific observations should be treated with caution due to limited data points in non-Financial Report categories.

5. Discussion

Our research establishes several new findings regarding information processing in Polish stock market. First, we document precise speed of price adjustment following regulatory announcements, showing that information incorporation is gradual process extending well beyond first few minutes. Second, we identify pattern where neutral reactions dominate initially but decrease substantially over time, suggesting delayed price discovery. Third, we find counterintuitive pattern of increasing return volatility over post-announcement window,

contrary to theoretical expectation that information resolution should reduce uncertainty. Fourth, we demonstrate that while statistical inefficiencies exist, their economic exploitability is severely limited by transaction costs, especially for retail investor.

Previous research on market efficiency in emerging markets has generally found slower price adjustment compared to developed markets (Griffin et al., 2011). Studies specific to Polish market (Gurgul, Majdosz, 2007; Bohl et al., 2009) documented significant but sometimes delayed reactions to corporate news. However, these studies typically used daily data, obscuring intraday dynamics. Our high-frequency analysis provides much more granular view of price formation process, revealing that even within single trading day, adjustment is far from instantaneous. While previous research established that Polish market reacts to corporate news, our study quantifies exactly how this reaction unfolds minute by minute, providing unprecedented detail on information processing mechanics in this market.

5.1. Interpretation of Key Findings

Our analysis paint picture of Polish stock market where information contained in regulatory announcements is incorporated into prices, but in notably gradual manner. Several key findings warrant detailed interpretation:

1. **Gradual Price Adjustment**: The slow speed of reaction, with only 5% of 2-hour impact occurring in first minute and 74% by first hour, is perhaps most significant result. This stand in contrast to near-instantaneous adjustments often observed in highly liquid, developed markets like US (Busse, Green, 2002). This slowness suggest presence of considerable frictions in price discovery process on WSE. Market participants do not seem to react immediately or uniformly to new public information.
2. **Magnitude and Direction**: While average *absolute* price change increase steadily over two hours (reaching 0.63% on average), average *raw* price change remain statistically indistinguishable from zero based on t-tests and Wilcoxon tests. This imply that announcements in our sample, covering diverse regulatory filings from 15.11.2024 to 14.03.2025, do not have strong systematic positive or negative impact on average. However, existence of large individual price swings (up to +9% and -11%) confirm that *some* announcements carry significant value-relevant information.
3. **High Neutral Reaction Rate**: Extremely high proportion of zero price changes immediately after announcement (97% at 1 min), which decrease slowly but remain substantial (57% at 2h), is another critical finding. This could mean several things: (a) Many regulatory filings might contain little new, price-sensitive information (e.g., routine administrative updates). (b) Market depth might be insufficient, meaning news does not immediately trigger trades at new price levels. (c) Investors might adopt wait-and-see approach, especially for complex information. (d) Price discreteness or tick size rules might prevent small price adjustments from being registered.

4. **Increasing Volatility**: The steady increase in standard deviation of returns over 2-hour window is puzzling from traditional efficient market perspective, where new information should resolve uncertainty. This pattern might suggest that announcements trigger prolonged period of disagreement among investors, differential information arrival, or attract noise traders, leading to greater price dispersion over time. It could also reflect gradual arrival of related news or analysis following initial announcement.
5. **Sign Test Significance**: Despite insignificant mean/median returns, highly significant sign test results indicate subtle but persistent imbalance between positive and negative reactions (leaning slightly negative in our sample). This suggest market *is* reacting directionally, but effect is weak and perhaps asymmetric, or masked by large number of zero returns. This finding warrant further investigation into potential biases or specific types of news driving this slight negative skew.

5.2. Market Efficiency Implications

Our findings present challenge to semi-strong form of Efficient Market Hypothesis (EMH) in context of Polish stock market during studied period. The observed gradual price adjustment directly contradict notion that prices should rapidly reflect all publicly available information. If prices take up to two hours (or potentially longer) to fully incorporate news, it imply existence of inefficiencies.

However, question arise whether these inefficiencies are economically significant. Can traders consistently profit from this slow adjustment? The small average magnitude of immediate price changes (e.g., 0.03% absolute change at 1 min) suggest that exploiting this initial delay might be difficult after accounting for transaction costs (bid-ask spreads, commissions) and execution risk. Even larger average absolute changes at later intervals (0.63% at 2h) represent average magnitude; predicting direction for specific announcement remains challenging. Therefore, market might be described as "efficiently inefficient" (Pedersen, 2015) – inefficiencies exist, but exploiting them is not costless or guaranteed, thus providing incentive for information gathering without allowing easy arbitrage profits.

The high rate of neutral reactions also complicate efficiency assessment. If many announcements truly lack information content, then lack of price reaction is consistent with efficiency. However, if information-rich announcements also fail to trigger immediate price changes due to market frictions, it represent clear inefficiency. Distinguishing between these possibilities require deeper analysis of announcement content.

Overall, evidence point towards WSE being less informationally efficient, particularly regarding speed of incorporation, compared to major developed markets, at least concerning intraday reactions to broad set of regulatory filings.

5.3. Comparisons with Existing Literature

Our finding of gradual price adjustment align broadly with studies suggesting lower efficiency in emerging markets compared to developed ones (Griffin et al., 2011). Specific studies on Poland, like Bohl et al. (2009), also hinted at slower reactions to regulatory events. Our high-frequency analysis provide much more granular view of this slowness, showing it persists over minutes and hours.

The high neutral reaction rate also echo findings in some less liquid markets or for specific types of news where immediate impact is unclear. It contrast with studies focusing on major, clearly impactful events (like large earnings surprises or M&A) in liquid markets, where reactions are typically swift and widespread.

The increasing volatility pattern is less commonly reported but might relate to studies on information-induced trading and volatility clustering, although typically volatility is expected to decay after initial information shock.

5.4. Anomalies

The results present some anomalies: the persistence and even increase in volatility post-announcement, the extremely high initial neutral reaction rate despite covering mandatory disclosures, and the divergence between sign test significance and mean/median tests. These suggest that simple models of information incorporation may not fully capture dynamics of Polish market. Further research is needed to understand drivers behind these specific patterns, potentially involving more complex models of investor behavior, market frictions, and information diffusion.

6. Conclusion

This study examined market reactions to corporate regulatory announcements (ESPI) on Warsaw Stock Exchange using high-frequency intraday data. Our analysis of 696 announcements from 52 companies over four-month period reveals gradual price adjustment process that challenges strict interpretation of semi-strong market efficiency. Only 5% of total 2-hour price impact occurs within first minute after announcement, with full adjustment extending well beyond first hour of trading. Neutral reactions (no price change) dominate initially but decrease substantially over time, suggesting delayed price discovery process.

While statistical tests confirm non-random price movements following announcements, economic significance of these patterns is limited by transaction costs and execution risks. Our profitability analysis demonstrates that even with perfect foresight of announcement direction, typical investor would struggle to generate consistent profits 1. after accounting for

transaction costs. This creates situation where market exhibits statistical inefficiencies but remains "efficiently inefficient" from practical perspective.

The findings have important implications for various stakeholders. For investors, results suggest caution when trading around announcements, as initial price movements may not reflect full information content and transaction costs can easily overwhelm potential gains. For regulators, slow price adjustment indicates potential need for improved information environment, possibly through enhanced disclosure requirements or market structure reforms to facilitate more efficient price discovery. For corporate managers, understanding gradual nature of market reactions can inform communication strategies, particularly timing and clarity of disclosures.

Our research contributes to literature on market efficiency in emerging economies by providing detailed empirical evidence on intraday dynamics of information processing. The findings highlight need for nuanced view of market efficiency that recognizes both statistical evidence of inefficiency and practical limitations on exploiting these patterns. Future research should explore whether similar patterns exist in other emerging markets and investigate specific market characteristics that might explain cross-sectional variation in information processing efficiency

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Full data set available on github: https://github.com/mzgrb/espi

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PROBLEMS OF THE IPO MARKET AND DIVESTMENT OF PRIVATE EQUITY FUNDS

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Purpose: Initial Public Offering (IPO) offers on the stock markets are well documented in literature. IPOs emerge when companies decide to enter the equity market by selling their stock to the public. Studies on the effectiveness of IPOs of companies powered by Venture Capital and Private Equity funds suggest clear differences between four groups of factors, which are: size of the capital market, sector classification, rates of return on the first day of listing and key operational characteristics at the time of debut. In fact, IPOs backed by private equity are more valuable in terms of sales and assets, and therefore more profitable. That is why a liquid capital market is so important for funds, enabling an effective debut process. Problems with the possibility of exiting through the stock exchange lead to a decrease in investment profitability and fund performance, and as a consequence, extending the period of time companies remain in the portfolio and problems with the return of funds to its investors. The main aim of the article is to examine trends on the global stock market as well as local one in Poland and their impact on the number and value of disinvestments of private equity and venture capital funds in the period of 2000-2022. During this period one could observed many hot and cold periods at the stock exchanges regarding IPO transactions. Currently we have some slow down in IPO transactions witch has an effect on private equity and venture capital industry. This study examined the problems of IPO transactions conducted by venture capital and private equity funds at Warsaw Stock Exchange. The article analyses the relationship between private equity and venture capital backed IPO and situation at the stock exchange that influence type of exits for the funds. An additional goal was to present a classification of selected type of divestments conducted by private equity and venture capital funds in the period of 2000-2022 in Poland.
Design/methodology/approach: The study employed data form Warsaw Stock Exchange as well as from Invest Europe, (formerly known as EVCA - European Private Equity & Venture Capital Association) which represents the venture capital and private equity funds and community in Europe. Data was combined with cycles of investments and divestments of PE and VC funds that operated in Poland in the period of 2000-2022. The article uses a simple methodology to calculate the shares and dynamics of the analyzed phenomenon of IPO transactions conducted by private equity funds.
Findings: The empirical studies helped to identify a positive correlation between situation at the stock exchange and private equity and venture capital divestments methods, especially IPO. Data shows that in recent years IPO market is not effective in Poland, what influence Private Equity backed IPO and its investments. Number of IPO is lowering and almost 60% of PE/VC backed IPO are held at the foreign stock exchanges. IPO market is not effective in Poland,

what influence VC/PE backed IPO and its investments. Studies finds shrinking number and value of VC/PE backed IPO which also influence the future level of fund's investments.
Originality/value: This paper examine problems of IPO at the Warsaw Stock Exchange and how it influence private equity backed IPO in Poland. This is rare study that highlights problems of divestments of PE funds through IPO.
Keywords: Private equity, Venture capital, Venture capital backed IPO, IPO problems.
Category of the paper: Research paper, Viewpoint**.**

1. Introduction

The first Initial Public Offering that resembles a market vehicle we would recognize today was conducted in 1602 in the Netherlands. IPO of shares in the United East India Company at the Amsterdam Stock Exchange we can consider as founding of the first modern stock market. Many different and complex factors influence the growth and construction of a company are often volatile. In the 1950s, one could observed many institutional investors began shifting their investing at the market from bonds to stocks. Many different type of institutions, mostly corporate and public pension funds, were changing and growing rapidly. Second, a professionalized venture capital and private equity funds had developed rapidly, they raised huge amounts of new capital and was moving its capital into start-ups, many of them companies developing and exploiting the latest technological advances. Those investments were introducing new segments of the economy and give fundaments to sectors such as semiconductors or digital electronics. IPOs became a very important and a key component of a sophisticated capital market structure. The Initial Public Offering market can be viewed from a variety of perspectives, including by the number of IPOs and the total amount of capital raised. Sector and size can also be an attribute in this matter. New Venture Capital sector as high-risk vehicles was organized to support culture of start-ups, entrepreneurs and innovation as well as to profit from it. Venture stakes were in many cases extremely illiquid and in time there was a need to transform it into public shares, through mergers and acquisition or IPO transactions. High-risk was combines with high-reward opportunities and was the fundament for VC and PE market development. To secure and drive long time growth, many companies required the bigger and cheaper (not traditional bank capital) level of capital provided by public markets: permanent equity capital. However there were a lot of issues and problems with keeping the number of IPOs at the required level. One can remember problems with the dot-com bubble in 2000, after which the annual number of IPO has fallen and not recovered for many years. Since that year, the number of IPOs has averaged 135 annually, less than a third of the average in the 1990s. That sharp drop has long been viewed as a problem to IPOs of technological innovation, competitiveness and job creation. That situation influence global markets and cause problems of IPO transactions worldwide. Venture capital and private equity funds use capital

markets to conduct their divestments. This paper examines and surveys the extensive research and discussion about Initial Public Offering, particularly declining IPO number in Poland and how it influence venture capital and private equity divestments through IPO on Warsaw Stock Exchange. It analyzing the question of identifying the factors behind the decline in IPO number and volume. The terms private equity, venture capital and Initial Public Offering are closely related. Private equity or venture capital investment funds are very eager to use the capital and stock market to complete their portfolio investments, using an IPO. In the years 2000-2022, divestments of funds through IPOs on the Warsaw Stock Exchange accounted for about 14% of the number and value of all transactions carried out there. Global and European problems of the IPO market affect the possibility of a smooth and effective completion of investments by private equity and venture capital funds. Various studies indicate that disinvestment through IPO allows funds to obtain the highest possible valuation of the portfolio company and leads to the maximization of the return on investment. Studies on the effectiveness of IPOs of companies powered by PE and VC suggest clear differences between four groups of factors, which are: size of the capital market, sector classification, rates of return on the first day of listing and key operational characteristics at the time of debut. In fact, at most markets IPOs backed by PE/VC funds are more valuable in terms of sales and assets, and therefore more profitable (NVCA 2010). That is why a liquid capital market is so important for funds, enabling an effective debut process. Problems with the possibility of exit through the stock exchange lead to a decrease in investment profitability and fund performance, and as a consequence, extending the time companies remain in the portfolio and problems with the return of funds to fund investors. This is complex problem and there are no simple solutions. Multiple factors appear to have played a role not just in the recent decline in IPOs, but in the inflow in volume and number of Initial Public Offerings that started at the beginning of the 80s. Just to name few of the which include: financial system that features consolidation and greater scale in both financial institutional investors and intermediaries; the rise of private capital, from venture capital and private equity to liberalized rules on other forms of private capital offerings; a shift in institutional investing from active to passive strategies; and an increasing burden of regulation on all public companies. The aim of the article is to analyze the trends on the stock market in Poland and their impact on the number and value of disinvestments of private equity and venture capital funds in the period of 2000-2022.

2. Literature review

Academic literature reveals that venture capital funded companies show superior and much advanced performance to regular companies that does not have venture capital support. Those firms contribute in many ways to the development of economies through boost of the

turnovers, innovations, the creation of jobs as well as an exceptional growth rate. Their high level of investments also influences many different areas of the economy and their global experience and expansion help in employee's self-development. However in general, in the macro economy the proportion of companies that receive venture capital funding is limited and very small. Despite that, there has been a rapid growth in the availability of VC/PE funds over the years in the different branches and economies. One can observe that there is still lack of this kind of investors in many sectors. Researchers conclusions have indicated that significant variance in performance between companies that are supported by VC/PE and regular firms can be attributed to the VC/PE investors. This outcome should then led us to the important question—what capabilities of VC/PEs contribute to the performance variation of the supported companies. There has been high number of research evidence to indicate that managerial and value addition capabilities of venture capital dominate the selection capabilities in explaining the performance variation. The relationship between entrepreneur and investor is a broad area for VC/PE value added research. Most important might be acceptance of the investment manager (in most cases its and current owner of the company) through the management of the venture. Cable and Shane conclude that a cooperative relationship between entrepreneur and investor is even more important for the positive development of a company than a provision of money itself. This relation is characterized by as a socially complex inter-organizational relationship. They argue that the relationship between two parties increases in its social complexity and therefore becomes more and more difficult to imitate (Cable et al., 1997). This in turn led to an improvement in the company's performance. At the certain period in the investment time span venture capital funds should conduct an effective divestment process. IPO as desirable exit for the funds is the outcome of that process. When a venture capital or private equity sponsor conducts an IPO of a portfolio firm, it not often sells significant stake of its investment, usually remaining a large block holder in the newly listed firm for a longer and much extended period. This practice is consistent with the recognition that retention of shares in an IPO is a signalling device that mitigates adverse selection intrinsic to equity issuance (Leland and Pyle, 1977). There were clearly benefits of a healthy IPO market. Research suggests that IPOs finance growth and stimulate innovation, productivity and job creation. After an IPO, venture capital funds generally block and hold its governance rights, maintains board representation, monitor managers, influences corporate decisions and sometimes is bound by regulations that restrict its share trading. Because a sponsor influences a firm's operations until its ownership is sold (typically some years after an IPO), venture capitalist is the type of block holder that researchers (Demsetz, 1986) viewed as an effective corporate monitor. At the same time, the limited horizon intrinsic to VC/PE's business model, creates pressure for sponsor divestment after an IPO, including the fact that a sponsor's limited partners pay high fees for managing. Venture capital and private equity contracts govern long-term relations between entrepreneurs and their investors in a way that establishes path for growth, cash flow, control rights and exit horizon. The long-term nature of VC/PE–entrepreneur

relationships leave entrepreneurs open to exploitation by VC/PE funds (Fried, Ganor, 2006; Atanasov et al., 2006), and VC/PE funds open to expropriation by entrepreneurs (Gompers, 1998; Casamatta, 2003; Schmidt, 2003; Kaplan, Strömberg, 2003). It is therefore natural for relation and its contracts to depend on the bargaining power of the VC/PE funds and the entrepreneurs. Further, as high-tech start-up entrepreneurial firms do not have sufficient cash flows to pay interest on debt or dividends on equity, contracts are established in a way that control rights are allocated over divestment decisions (Sahlman, 1990; Black, Gilson, 1998; for related theoretical work, see Aghion and Bolton, 1992; Berglöf, 1994; Trester, 1998; Garmaise, 2000; Bascha, Walz, 2001; Schwienbacher, 2007; Neus, Walz, 2005). A successful divestment may involve an IPO, or an merger or acquisition (often referred to as a "trade sale").

Given that after IPOs, VC/PE sponsors are transitional owners that intend to exit their ownership, they confront the challenge of disposing of large illiquid stakes in listed firms within a limited horizon. While several studies (e.g., Degeorge, Zeckhauser, 1993; Cao, 2011; Cao, Lerner, 2009) focus on the timing and performance of private-equity backed IPOs, private equity and venture capital divestment from holdings maintained beyond lockup expiration is an under-researched facet of VC/PE. An exception is Gompers and Lerner (1998) who examine a sample of post-IPO distributions to limited partners of shares retained by VC/PE groups in start-up firms. They report a negative share price reaction of 2% for such distributions. Unlike secondary offerings, these distributions are small in size and are not immediately disclosed to the public, so Gompers and Lerner view them as a form of permitted insider trading. Other researchers have tried to point and categorize these value-adding actions and responsibility of VC or PE investor. However this approach (All of these categorizations) has disadvantage that they do not clearly differentiate one category from another one. So one way was to differentiate between social or supportive value added, strategic value added and networking value added. Introduced two additional categories: strategy, finance, organization and operations, network and cooperation, and personnel (Gompers et al., 2001).

The often pointed diametrical contrast between the two main exit channels of VC/PE funds from their investment in young entrepreneurial firms trade sales and IPOs (Bayar, Chemmanur, 2011) becomes somewhat blurred from the point of view of the firm. What looks like a firm ending up on the exchange and with dispersed ownership (via the IPO) is in essence, in a significant number of cases, a delayed trade sale: afterwards, the firm is no longer listed itself and has a concentrated ownership. This finding sheds new and detailed light on the exit decisions of VC/PE funds as well as the governance of their portfolio firms.

This work is also closely associated to the literature on the exit choice that is considered by VC and PE investors. Starting with Black and Gilson (1998), a vast majority of papers have addressed the VC/PEs choice of divestment mode via Initial Public Offering or acquisitions (see e.g. Giot, Schwienbacher, 2007, Bayar, Chemmanur, 2011), as well as the issue of exit timing (see e.g. Giot, Schwienbacher, 2007, Neus, Walz, 2005). Divestment activity in the Cantal and Eastern Europe showed also significant fluctuations in the period 2000-2022.

In this sense, the values of exits were the highest starting with 2011. Observed structure of exit type mechanisms in the given period are characterized by similar patterns in other European states (Diaconu, 2017).

The literature on VC/PEs exit decisions via IPO has also examined the implications of this decisive decision on the contractual relation between the VC/PE and the entrepreneur (Cumming, 2008, Cumming, Johan, 2008). However, most of these papers only address the time during or prior to the IPO, with the only exceptions being those papers which investigate the post-IPO financial performance of VC/PE-backed firms (see, e.g., Brav, Gompers, 1997). Also costs of IPO are an important factor that influences IPO dynamics. What was observed in many researches which conducted analysing on "hot periods" in the market, pattern was that there is increased activity in the IPO market (Ritter, 1984; Boulton et al., 2018). Aggarwal and Rivoli (1990) report empirical findings that are supportive of IPOs being subject to overvaluation of given stocks. An inclusion of a market momentum measure is intended to proxy for such periodic market conditions (Lyn, Zychowicz, 2003). Therefore, it can be assumed that IPO market activity is closely correlated with total costs of the whole process. On the one hand, higher direct costs can be expected during such periods but on the other hand, lower direct costs can be anticipated resulting from greater competition among advisors assisting in the offering. It is also interesting whether the macroeconomic variables affecting the cost of money in the debt market, such as the prime rate LIBOR or WIBOR, affect the cost of the Initial Public Offerings. One could observe that during periods of higher interest rates on the debt market, offering costs would also fall. Companies listing on the stock exchange because of the decision of the main shareholder to exit are characterised by a lower total cost of offer, which is due to two reasons. Firstly, such a shareholder is not willing to leave money on the table, so it has the impact on indirect costs. Research on VC backed IPOs in Poland shows that underpicing is mostly reduced in funds public offers. Second, the direct costs are shared by the company and by the shareholder. The cost is lower in a combined offer, which is also due to the selling shareholder contribution in bearing part of the costs. However, it is important to bear in mind that the costs incurred during an IPO for individual companies vary significantly and their components depend on few different factors (see Podedworna-Tarnowska, 2022). The dynamics of the corporate governance of VC/PE backed firms on the stock exchange in the aftermath of an divestments via IPO has not yet been analysed.

3. The IPO market in the years 2000-2022 in the World and in Poland

IPO is the first public offer to purchase a company's securities to a wide group of investors. After the day of the company's debut on the stock exchange, the shares bought in the IPO are used for ordinary market trading and can be sold on the first day of listing. Companies that

decide to make an initial public offering expect that thanks to the debut on the stock exchange they will gain funds to finance the company's development. In this way, it will be possible to accelerate growth or acquisitions of other companies and further development by entering new markets. It is crucial to thoroughly prepare for the IPO. Therefore, the preparation of the strategy and planning the IPO often starts 24 months before the debut. Shares in the IPO process are offered for a fixed price or with a reserve price. If there is too much interest in shares, a proportionate reduction in orders is necessary. The IPO process ends when the shares are admitted to trading and debut on the stock exchange.

The initial public offering on the global markets has long been associated with the activity and vitality of the main capital markets such as US one. But since 2000, near the height of the dot-com bubble, the number of offers (both VE/PE exits and classic ones) began a long decline. The average annual number of IPOs fell by over 61% between the 1990s and the 2000s. In the early periods offers were inflated by the waves of high-tech companies willing to sell public shares and exit their venture capital portfolios. The sharp drop since that time is hardly just a correction in the IPO market, but represents a more persistent, longer-term trend. In fact, the decline in IPOs persisted throughout the recession that followed the dot-com bust, through the subsequent recovery, through the market collapse that led to the Great Recession, and through the nearly decade-long recovery (Lux, Pead, 2018). The current situation analyzed in the EY Global IPO Trends reports confirms the collapse of the IPO market in 2022 and early 2023. After a record-breaking 2021, the situation has changed quite dramatically. In the period from January to December 2022, only 1333 transactions were recorded worldwide, the proceeds of which amounted to USD 179.5 billion. These are decreases - year on year - by 45% and 61%, respectively. The situation is even less favorable if we single out only the fourth quarter, with the results lower by 50% (number) and 73% (value). It should be noted, however, that compared to 2019, the full-year transaction volume increased by 16%. Analyzing the IPO market in Poland, it should be pointed that in the analyzed period of 2000-2022 it developed properly and was a leader among the countries of Central and Eastern Europe. In the years 2000-2022, 520 companies debuted on the WSE. The most dynamic period falls on the years 2004-2011, when 308 IPOs were made. Unfortunately, the last period of 2020-2022 is only the transition of companies from the New Connect market to the main market. Record braking 2021 in US and Worldwide hasn’t happened in Poland. Thus, the typical IPO process is losing its importance in the current period, and companies do not decide to carry out this process. It is important to emphasize the fact that, similarly to global markets, companies withdraw from it even after the initial decision to start the official IPO process, observing the current market situation. This situation on the market in Poland is intensified by the fact that companies are quite overvalued on the day of their debut. Most companies record a fall in the value of shares on the day of the debut, and in addition their prices fall in the long term (Sieradzki, Zasępa, 2016). The corporate bond market offers much higher rates of return, which is an alternative for investors. Observed decline in IPOs has lead us to a search for an explanation and most

important for possible policy action from regulatory bodies. The situation on the IPO market in the period 2000-2022 in Poland is presented in Figure 1.

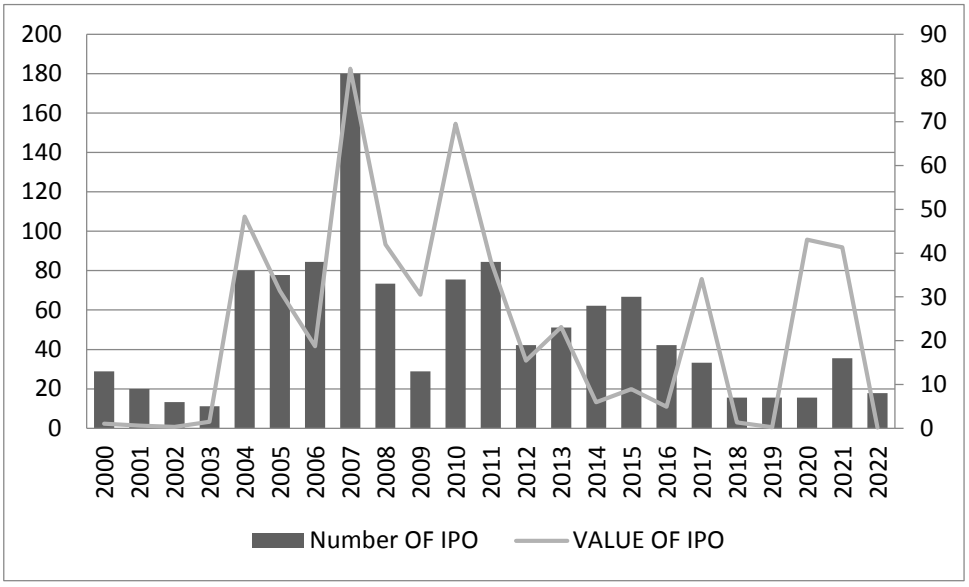

Figure 1. Number and value of IPO transactions on the Polish market in 2000-2022.

Source: study based on data from the WSE data. Number, left scale, value in PLN thousand, right scale number of IPO.

The situation on the Polish IPO market is closely correlated with global and European trends in the field of IPOs. According to PWC analyses, the global and European stock markets recorded a significant decrease in the activity of companies in the field of IPOs. In 2022, only 102 IPO transactions worth EUR 15.6 billion were recorded on European stock exchanges, which is the lowest result since 2012. When analyzing the data on the value of IPOs carried out in Poland, it should be noted that in 2000-2022 companies raised PLN 120 billion from the stock exchange. The record year was 2007, when the companies acquired as much as PLN 18.2 billion. The period of prosperity is the time of 2004-2011, similarly to the number of IPOs. The favorable situation on the IPO market was also used by Private Equity and Venture Capital funds, carrying out numerous disinvestments with the help of IPOs.

The listing of a prosperous company on the stock exchange seems to be a natural sequence of events in the investment process of PE/VC funds. The IPO process is associated with successive stages of preparation, which must be followed step by step. All this leads to the final stage, which is the submission of an application to the Warsaw Stock Exchange and, in the best case scenario, debut on the stock exchange. It allows the funds to obtain the highest possible valuations of their shares and stocks and to successfully complete the investment process in their portfolio companies. It can be observed that liquidity drives stock markets, so candidates for IPOs should consider entering the market when it offers an opportunity and favorable conditions. In boom periods, liquidity is the highest, the number of investors reaches record levels and IPO underpricing records the lowest values, which is extremely important for VC/PE funds due to the possibility of conducting an effective disinvestment process.

4. Private equity/venture capital funds as an important participant in the IPO market in Poland

The term venture capital is often used interchangeably with the term private equity, but the former covers a narrower fragment of the financial market. The term private equity covers such market segments as: venture capital, buyout capital and mezzanine capital. In general terms, private equity investments can be defined as: medium- and long-term equity investments in private enterprises, often on the private market, combined with the company's managerial support, which have a chance of achieving an above-average increase in value in the period specified by the investor. The investment process ends with the disinvestment process, i.e. the sale of shares in the portfolio company. Each way a fund disinvests has different consequences. They depend on the nature of the selected transaction, but also on the state of the stock market and the economic situation of the industry in which the company operates. The existing advantages and disadvantages may also depend on the goals that the fund wants to achieve by selling its shares in companies. The characteristics of investment exits also change with the change of the market or country in which the transaction is made and it depends on the maturity of the venture capital institution. In all markets, the two primary ways of disinvestment are the initial public offering and the sale of shares to a strategic investor. The IPO method is more desirable due to the possible high valuation of the portfolio company's shares. Analyzing the developed stock markets, it should be noted that in the USA IPOs of technology companies powered by PE/VC funds account for a share of up to 50% of the value and number of debuts. Table 1 shows the number of transactions of companies funded by PE/VC funds in relation to the total number of IPOs on the Polish and US markets.

Table 1.
The number of IPOs conducted by Private equity/Venture capital funds in the period 2000-2022 in Poland and the USA

Year	Number of IPO in Poland	PE backed IPO in Poland	Share in %	Number of IPO in USA	PE backed IPO in USA	Share in %
2000	13	0	0.00%	397	238	59.95%
2001	9	2	22.22%	141	37	26.24%
2002	6	1	16,67%	183	24	13.11%
2003	5	0	0,00%	148	26	17.57%
2004	36	5	13.89%	314	82	26.11%
2005	35	7	20.00%	286	59	20.63%
2006	38	9	23.68%	220	68	30.91%
2007	81	6	7.41%	268	92	34.33%
2008	33	2	6.06%	62	7	11.29%
2009	13	0	0.00%	267	10	3.75%
2010	34	2	5.88%	190	45	23.68%
2011	38	3	7.89%	171	46	26.90%
2012	19	1	5.26%	157	60	38.22%
2013	23	2	8.70%	251	87	34.66%
2014	28	6	21.43%	304	126	41.45%
2015	30	1	3.33%	206	86	41,75%

Cont. table 1.

2016	19	3	15.79%	133	43	32.33%
2017	15	3	20.00%	217	69	31.80%
2018	7	1	14.29%	255	94	36.86%
2019	7	7	10.,00%	232	90	38.79%
2020	7	6	85.71%	480	109	22.71%
2021	16	1	6.25%	1035	191	18.45%
2022	8	1	12.50%	181	36	19.89%
Total	520	69		6098	1725	

Source: Warsaw Stock Exchange, NVCA Yearbooks 2012-2023, EVCA Yearbooks.

Analyzing the data (Table 1), it should be stated that PE/VC funds are quite a significant participant in the IPO market. In Poland, the number of offers in the analyzed period of 2000-2022 accounted for a share of 13.26%, while on the American market it was already 28.28%. This is a relatively high share, which indicates the funds' potential for developing portfolio companies (creating their value - in a fairly short investment process) into mature listed companies.

5. Private equity/venture capital funds divestments using IPO on the Polish market

There are many ways for a venture capital fund to end its investment. The use of each of them depends to a large extent on the results achieved by the share company, the state of development of the capital market and often the reputation of the fund itself. The method of divestment is also influenced by the negotiations preceding the investment, specifying the possible method of sale of shares by the fund. The most important ways of completing capital investments used by venture capital/private equity funds include the introduction of the company to the stock exchange (IPO) and the sale of shares to a strategic investor (trade sale). Analyzing the fund's data from the period 2000-2022, it can be stated that these ways of terminating the investment by the fund account for more than half of the number and value of all divestment transactions.

Table 2.
Number and value of disinvestments of private equity and venture capital funds on the Polish market in the period of 2000-2022

Exit route	Number of divestments 2000-2022	Share in %	Value of divestments 2000-2022 (in millions of euro)	Share in %
Trade Sale	320	33,33%	1 994,06	35,51%
IPO	171	17,81%	937,76	16,70%
Write off	58	6,04%	350,31	6,24%
Repayment of preference shares/loans or mezzanine	65	6,77%	214,98	3,83%
Sale to another private equity firm	68	7,08%	996,36	17,74%
Sale to financial institutions	65	6,77%	708,38	12,62%

Cont. table 2.

Management/Owner buy-back	116	12,08%	289,87	5,16%
Divestment by other means	97	10,10%	123,46	2,20%
TOTAL	960	100,00%	5615,18	100,00%

Source: own calculations based on EVCA and InvestEurope data.

The most important method of completing investments in the period 2000-2022 was the sale of shares by funds to a strategic investor, which accounted for over 33.33% of all transactions. Transactions involving the introduction of companies to stock exchanges, in the number of 171, accounted for almost 18% of all transactions, and in terms of value, it was 16.7%. This seems to be a significant share in the entire structure of divestment transactions. The value and number of divestments through IPOs on the Warsaw Stock Exchange are presented in Figure 2.

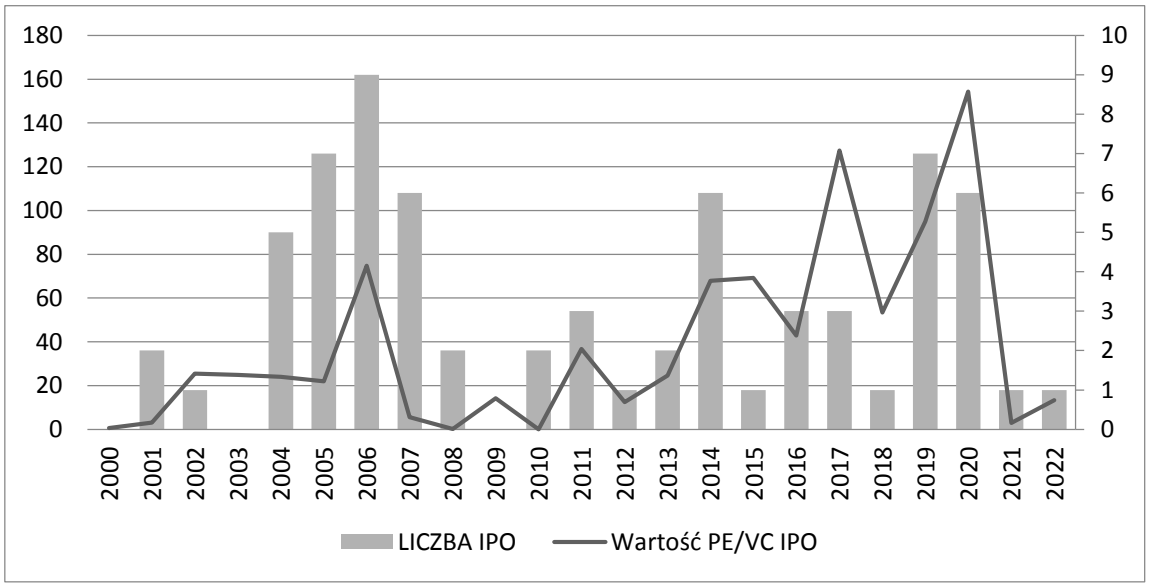

Figure 2. Number and value of IPO transactions on the Polish market carried out by private equity and venture capital funds in the period of 2000-2022.

Source: own calculations based on EVCA and InvestEurope data. Left scale value of the IPO transactions, right scale number of IPO transactions.

Analyzing data from individual years in the period 2000-2022, it should be pointed that the problems of the global IPO market have a huge impact on the number and value of IPOs offered by PE/VC funds in Poland. The period of 2002-2007 was the best period for funds and disinvestment opportunities through IPOs. The end of this period coincides with the bull market on the Warsaw Stock Exchange, which, as stated in many studies, is conducive to the IPO process. It is important to emphasize the fact that the period 2019-2022 is characterized by a huge slowdown on the IPO market, and funds generated the majority of offers during this period (although these were only transitions from the New Connect market to the main market). This has its consequences related to IPO problems on the European market. The PwC report shows that in 2021, IPOs worth EUR 75 billion were carried out on European stock exchanges, i.e. 269 percent more than in the previous year, higher than in 2020. In turn, the number of debuts increased to 422 from 135. After a great 2021, in the next 2022, greater volatility could

be observed on the financial markets, which affected the statistics on primary offers. The value of canceled or suspended IPOs exceeded USD 6 billion, which is more than twice as much as in the corresponding period of 2021. In turn, the value of initial public offerings carried out on European exchanges in 2022 amounted to EUR 15.6 billion - a decrease of 79.2% in 2022. Compared to 2021 (EUR 75.0 billion). Investors in the markets have faced rising inflation, aggressive interest rate hikes, the ongoing war in Ukraine and the energy crisis in Europe. The above factors undoubtedly affected the Polish market as well. As a result, for the Warsaw Stock Exchange, 2022 is the first period in the 21st century without an influx of new issuers to the main market (the only debutants on the main market were companies that decided to move their listings from the NewConnect market). Despite lower uncertainty and increases in most major European indices, in the first quarter of 2023, fewer IPOs were recorded on the IPO market than in the same period last year. No major surprises on the WSE - the main market is still waiting for the return of confidence and stability and for the first IPO in almost two years. The value of initial public offerings carried out on European exchanges in the first quarter of 2023 amounted to EUR 1.7 billion (20 IPOs in total). This is a decrease by as much as 39.3% compared to the same period last year (EUR 2.8 billion, 30 debuts in total). In the first quarter of 2023, there were 2 debuts on the Warsaw Stock Exchange (both on the NewConnect non-regulated market) compared to 5 in the same period last year. The total value of IPOs of debuting companies amounted to PLN 3.6 million (EUR 0.8 million), which means a decrease by 77.4% compared to the previous year, when the total value of IPOs in the first quarter was PLN 16.0 million (4 .4 million euros). In 2022, the funds invested in about 100 companies in Central and Eastern Europe, while in the very good year 2021 they took over shares in 140 companies. However, in terms of the direction of changes, the situation in our region does not differ from global trends. According to the Bain & Company report, globally, the number of acquisitions made by funds decreased by 10%, and the value of transactions decreased by 35% to USD 654 billion. On the Polish market, investor activity fell from EUR 1 billion (119 investments) to only EUR 300 million (102 investments). This is not a positive trend and, combined with the inefficient IPO market, will force PE/VC investors to look for alternative sources of disinvestment. This may lead to a decrease in the results achieved by the funds on the Polish market. Moreover, only 40% of divestments were IPO transactions on the Polish market (69 vs 171). This proves that the funds are looking for other alternative capital markets or completely different ways of disinvestment. Good companies are also often noticed by other large PE/VC funds, which, by offering the necessary capital, actually end planning their debut on the stock exchange.

6. Summary

Despite the revival on the IPO market or the increase in turnover on the stock market, the capital market has been fundamentally stagnant for 10-15 years in terms of its share in financing the Polish economy. The capitalization of the regulated market to Poland's GDP is about 27%, while the average in the European Union is 55%, and countries such as France has a ratio of 75%, Great Britain over 100%, and the United States 140%. There is an excess of cash in the banking system and the Polish capital market is underdeveloped in relation to the needs of the economy. Over 60 percent of savings of Polish households lies in bank deposits and this percentage is twice as high as the average in developed countries. According to NBP, at the end of 2021, deposits (in PLN and foreign currency) of individuals in banks amounted to PLN 1,060 billion, and deposit of non-financial companies - PLN 416 billion - a total of PLN 1.5 trillion. Another fact is the relatively low level of domestic capital on the Warsaw Stock Exchange. Another important aspect that should be noted is the undermined confidence of Poles in institutions dealing with investing on the market and the excessive role of the state in financing new companies, such as PFR funds. In developed economies, this is not the role of the state but the domain of private capital. Research show that there has been a long-term significant decline in initial public offerings since the dot-com bubble. The drop in IPOs has continued through several economic cycles and has also disproportionately affected smaller start-ups that might want and willing to sell shares in the public markets. The decline in IPOs and the number of publicly listed companies has triggered a search for an explanation as well as demands for policy action. Capital market participants should argue that the decline in Initial Public Offerings and drop in publicly listed companies is cause for current concern. This research also strongly suggests that there is no single cause of this decline; that, in fact, a variety of different factors have played roles, from fundamental shifts in the structure of capital markets and investing, to successive waves of re-regulation. In the process of maturing of private equity and venture capital funds, they could provide many of the benefits that public markets were struggling to offer: plentiful supply of fresh capital, significant and lucrative bonuses for senior managers, a long-term perspective and a governance regime that is tightly focused on portfolio companies. And companies that remained private, whether through venture capital ownership or continued reinvestment by private equity funds, are able to operate without many of the regulatory burdens of their public peers, and without concerns that they will be taken over through mergers or acquisitions.

Summing up local market activity large transactions, in particular in Poland and the countries of Central and Eastern Europe, should not be expected in the coming periods. This is reflected in the number of IPOs made by PE and VC funds, where 60% of IPO transactions in the analyzed period were carried out on foreign exchanges, which seem to be much more attractive for companies from our region.

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