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FOREWORD

Presented number of Silesian University of Technology. Scientific Papers. Organization and Management Series. Contemporary management. Presented papers contain result of researches conducted by various universities from Poland. The number consists of 42 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: sustainable development, CSR, risk management, industry management, human resource management, Industry 4.0, information management, technology commercialization, strategic management, financial management, SMEs management, public management, entrepreneurship, innovation management, leadership, knowledge management, marketing, business analytics, and smart cities.

Radosław Wolniak

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2023
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GREEN UNIVERSITIES: BIBLIOMETRIC ANALYSIS OF THE CURRENT STATE OF THE ART AND FUTURE RESEARCH SCENARIOS

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Purpose: Sustainable development, and in particular aspects related to the natural environment, including energy management, is one of the key problems of the last decades. All organizations and institutions have been called upon to solve these problems. However, a special role is played by universities, which should not only become green organizations, but also disseminate knowledge about problems and possible solutions, develop the required green competencies of society, including current and future decision-makers, and conduct research aimed at defining specific problems and developing optimal solutions. The article aims to present the current state of the art and future research scenarios in the field of green universities.
Design/methodology/approach: This article presents a systematic review of the literature on green universities using the Preferred Reporting Items for Systematic Reviews Meta-Analyses (PRISMA) method associated with a bibliometric analysis of papers published in 2009-2022. For this purpose, the Web of Science Core Collection (WoSCC) database was used. A total of 82 papers were included for meta-analysis and categorized into 8 fields: author(s), title, published year, country, university, journal, paper citations, and journal citations. In addition, VOSviewer software supported the bibliometric analysis and allowed analysis of the citation link between authors and universities as well as co-authored documents by country.
Findings: In the years selected for analysis, there are no clear relevant research problems, leading research teams, and research centres. Moreover, the dynamics of research in this area are starting to decline. To support universities in their green transformation, it is, therefore, necessary to create a research program and tools to support them at the national and regional levels.
Originality/value: The results of the analysis prove that the concept of green universities, although widely discussed and present in global politics and rankings, does not find a corresponding level of reference in scientific research.

Keywords: sustainable development, green university, green campus, green curriculum, PRISMA, VOSviewer.

Category of the paper: Literature review.

1. Introduction

Our planet produces clean air, water, and essential food, but people are increasingly disrupting its natural processes. Growing pollution of water, air, and land resources on the one hand and the loss of natural resources on the other are caused by human behaviour. Some scientists say we have entered a new geological epoch known as the Anthropocene - an age where humans are increasingly influencing the planet (Lewis, Maslin, 2015; Steffen et al., 2011; Stevens et al., 2022; Tong et al., 2022). Therefore, only humans can stop the devastation process leading to self-destruction. As climate change intensifies, humanity experiencing the negative effects of these changes attaches greater importance to the topic of sustainable development, defined in the World Commission on Environment and Development's 1987 Brundtland report Our Common Future as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

Sustainable development is currently one of the biggest global trends and challenges. In 2015, the United Nations established the 2030 Agenda for Sustainable Development agreed upon by 195 countries and consisting of 17 goals and 169 measures related to economic, environmental, and social goals (Biggeri et al., 2019; Pradhan et al., 2017; Pedercini et al., 2019). As a result of a global commitment to these goals, and the scale of the effect that humans were having on the climate system (Pörtner et al., 2022), in the European Union alone, environmental protection expenditure increased by 54% from 2006 to 2021 (EC, June 2022).

Sustainable development, climate change, and energy management are also widely discussed at the higher education level. Over time, a new phenomenon has emerged, so-called green universities, that's to say higher education institutions involved in sustainable development, with particular emphasis on its environmental aspects. Although the term green university was coined in 1972 in the Stockholm Declaration, which was the first declaration of the sustainable development of higher education (UNEP, 1972), it was introduced to higher education at the institutional level in the early 1990s with the introduction of the concept of greening universities. Globally, the colloquial meaning of the term green university refers to various activities of universities, whose vision is the concept of sustainable development and the environmental responsibility assumed by them and other representatives of higher education (WU, 2021). More specifically, a green university implements environmental sustainability in all its dimensions - institutional framework, campus activities, teaching, research, community involvement, accountability, and reporting (Fissi et al., 2022; Bekessy et al., 2007; Biasutti, Frate, 2017). Since 2000, and especially in the last decade, the term has evolved and diversified to include more specific terms such as green campus referring to the university's infrastructure and administration, or green curriculum referring to the educational aspects of higher education. The term green university includes both academic and administrative subsystems and

infrastructure, as well as their related synergies (Beringer, Adomßent, 2008). Moreover, a green university seeks structural transformation to meet the challenges of sustainable development, recognizing that the university has the potential to learn and change (Albrecht et al., 2007; Gough, Scott, 2007). Green culture, created and developed in green universities, has become an important way of promoting several aspects of sustainable development in environmental activities. As a result of growing awareness of sustainability and environmental issues, universities are now part of environmental sustainability not only through research but also through the upgrading of campus infrastructure and processes to be more environmentally friendly, as well as updating curricula to include courses on the environment and sustainability development.

Scientists increasingly emphasize the role that universities can play in achieving sustainable development goals. Jardali et al. (2008) write: "Universities are in a unique position to lead the cross-sectoral implementation of the sustainable development goals and the implementation of the 2030 agenda". According to a QS survey (2019), 94% of students believe that universities "can do more to be environmentally friendly". They also believed that institutions should take further measures to reduce the negative impact on the environment. In 2021, Forbes argued that Gen Z is emerging as the "generation of sustainable development". In the case of research conducted by the UK National Union of Students (2018), as many as 81% of students are interested in the idea of sustainable development. Research by Deloitte (2021) shows that environmental concerns are the most important personal concern of 26% of Generation Z. These attitudes of young people are increasingly being supported by action. A study by Mastercard (2021) showed that concern for social and environmental issues is reflected in real support for foundations and non-governmental organizations (58%).

Universities should be pioneers in green transformation due to their significant contribution to environmental impacts, high level of social responsibility, and the crucial role they play in the development of social behaviours. (Heravi, Aryanpour, 2021) In 2012, the United Nations Conference on Sustainable Development confirmed the leading role of higher education with its educators and researchers, know-how, influence, and resources. Researchers have also confirmed that universities are viewed as having a deep responsibility to raise public awareness of social issues, increase knowledge and skills, promote ethical values, and guide society's transformation towards sustainable development (Cortese, 2003; Corcoran, Wals, 2004). Sustainable and green universities are also at the heart of the European strategy for universities, with an emphasis on interdisciplinary and transdisciplinary education and tackling contemporary and future global challenges. Universities are playing a role in educating future leaders in sustainable development and informed and sustainable consumers and citizens who are active actors in regional green transformation by sharing opinions, testing, and exploiting the results of SDG R&D activities. In November 2020, the ministers of the European Higher Education Area (EHEA) signed the Rome Communiqué, which emphasizes the key role of higher education in achieving the UN's Sustainable Development Goals (SDGs) and noted the

support and skills development of higher education institutions (universities) and the ability to prepare students for green work and other activities that achieve the SDGs. According to the communiqué, learners should be offered up-skilling and re-training opportunities within the Lifelong Learning Plan and should be encouraged to develop and apply new technologies and approaches (Rome Communique).

The development of green universities is also supported by several international initiatives. The United Nations Environmental Education and Training Unit (EETU), as part of its flagship program, GUPES, works with universities to develop and implement national and regional green university networks. It is a network of higher education institutions that incorporate low-carbon climate resilience development strategies and sustainability aspects in their education, training, campus activities, and increased student engagement. The network also aims to support universities in introducing the Greening Universities Toolkit and Greening Universities Toolkit V.2.0 in their day-to-day operations through Green Campus Development and Practices, Curriculum Development, Community Engagement, and Student Engagement. An important role in the development of green universities is played by the Higher Education Sustainability Initiative (HESI) - an open partnership between several United Nations entities and the higher education community launched in preparation for the Rio + 20 conference in 2012. With a strong link to the United Nations, HESI aims to provide higher education with a link between higher education, science, and policy-making by raising the profile of the higher education sector in supporting sustainable development, convening multilateral discussions and activities, and sharing best practices. HESI already represents over 30 networks with a reach of 18,000 universities around the world. The initiative also has over 300 signatories (universities). It is currently chaired by the United Nations Department of Economic and Social Affairs (UN DESA) and the Sulitest Association, a non-profit organization and online platform dedicated to improving knowledge on sustainable development for all. Other UN partners include UNESCO, the United Nations Environment Program, the UN Global Compact's Principles for Responsible Management Education, UN University, UN-HABITAT, UNCTAD, UNITAR, and the United Nations Office for Partnerships.

Also, the rankings of green and sustainable universities play a huge role in promoting and developing the concept of green universities. Alonso-Almeida et al. (2015) emphasize the importance of reporting on sustainable development (necessary for participation in the rankings) due to the analysis of the current situation and the presentation of prospects for the future, based on both qualitative and quantitative methods. Four leading rankings deserve special mention here:

- UI GreenMetric aimed at ranking world universities in terms of their activities related to green university and sustainable development (2022).
- Academic Ranking of World Universities (ARWU) - an academic ranking system of world universities introduced by the Center for World-Class Universities (CWCU) at the Graduate School of Education of Shanghai Jiao Tong University (SJTU) (2022).

- QS World University Ranking (QS), introduced by Quacquarelli Symonds (QS) (2022), and
- Times Higher Education World University Rankings (THE), one of the most famous academic rankings of world universities (2022).

Growing interest in environmental issues at the higher education level has led to the emergence of a research stream on green universities. A huge amount of research has been carried out, especially after 2009, concerning discussions on how to institutionalize the greening of university campuses, as well as how to evaluate and compare universities in terms of green activities (Okanović et al., 2021). Therefore, the aim of this study is a bibliographic analysis of scientific publications relating to the issues of green universities in the years from 2009 to 2023 (early access). More detailed knowledge on this issue will give a helicopter view of the current state of the art. Scientific relationships on the international and authorship levels will also prompt research agendas for the years to come that would support the HEIs in the green transformation (Holdsworth, Thomas, 2016)

The current paper is organized as follows. In the introduction, global trends in the topic of sustainability related to green universities are given. Attention is drawn to the international initiatives undertaken on this topic. Section 2 describes the methodology and data sets. In Section 3, the main findings of the reviews and the results of additional analyses are presented. Section 4 discusses the implications of the empirical results and concludes the paper.

2. Search Method and Procedure

This article presents a systematic review of the literature on green universities published in 2009-2022 using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method (Moher et al., 2009) associated with bibliometric analysis. A bibliometric analysis is used in this study as a well-established and reliable method of providing a full picture of research trends in the literature. The definition proposed by Laengle's team reflects the concept of bibliometric methods: "Bibliometrics is a research area of library and information sciences that studies bibliographic documents by using quantitative methods. It is very useful for collecting a set of documents to provide a general overview of leading trends" (Laengle et al., 2021). Bibliometrics involves applying various approaches to identify the quantitative and qualitative changes in a theme of scientific research, establishing the profile of publications on a particular topic, and determining structural aspects within a subject (Rey-Martí et al., 2016). According to Bjork et al. (2014), the advantage of bibliometric analysis lies in gaining a general overview of a specific research field.

The search was carried out in August 2022. The search process used the Web of Science (WoS) Core Collection database, which is the leading database for classifying academic research. The Web of Science Core Collection (WoS) contains over 21,100 peer-reviewed, high-quality scholarly journals published worldwide in over 250 scientific disciplines. Conference proceedings and book data are also available. The WoS Core Collection from 2009 to 2023 (early access) was analyzed to find related publications based on the keyword combination "green university". We searched for articles that have this phrase anywhere (not just in keywords or titles). The results of these searches contributed to the selection of a database consisting of 268 documents that matched our query. The WoS database was downloaded as a file in TXT format because we planned to use it for visualization in VOSviewer software, which requires CSV or TXT files.

All research results were also exported into the spreadsheet program Excel. However, it was decided to limit the search to articles in English only, which allowed for substantive verification. We therefore deleted 4 records with articles in Russian, Turkish, and Portuguese.

To focus on scientific contributions and avoid editorials and other related material, reviews, editorial materials, and notes were excluded. The database was narrowed to articles, proceedings, and book chapters only, which limited the database to 256 records. All unpublished early-access articles for 2023 were collected.

Additionally, publications were excluded if they neither corresponded to the research interest nor covered the university context. As shown in Figure 1, the final database consisted of 82 documents including 42 articles, 2 early access articles, 4 book chapters, and 33 proceedings papers. Scientific results regarding green universities are therefore mostly communicated via journal articles.

A visualization was prepared with the help of the VOSviewer 1.6.11 software. Since its introduction in 2010, VOSviewer software has been widely used in the scientific community.

In this study, to analyze the information in a bibliometric way, several bibliometric indicators were considered including the following calculated in Excel:

1. The total number of articles published in the years 2009-2022 (and 2023 early access).
2. The total number of publications per university.
3. The total number of publications per journal.
4. The total number of citations per journal.
5. The total number of citations per paper.

In addition, VOSviewer allowed analysis of the following:

1. The citation link between the authors.
2. Citations between universities.
3. Co-authored documents by country.

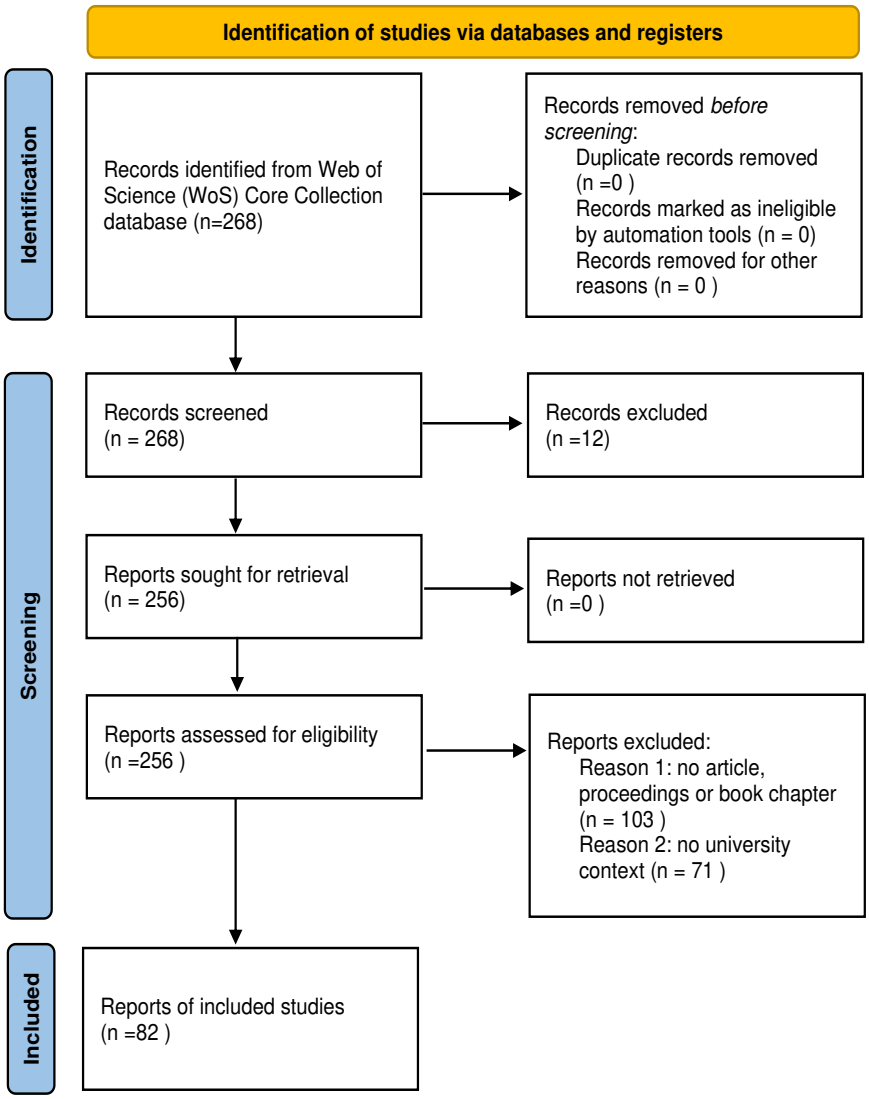

Figure 1. PRISMA flow chart (Page et al., 2020).

3. Results

3.1. Results - the total number of publications

Eighty-two articles were published in the last 14 years including 2 early access articles. In the final database, the oldest article is dated 2009 (Figure 2). The growth of annual numbers of published articles in 2013 reflects the growing popularity of the subject of green universities around the world.

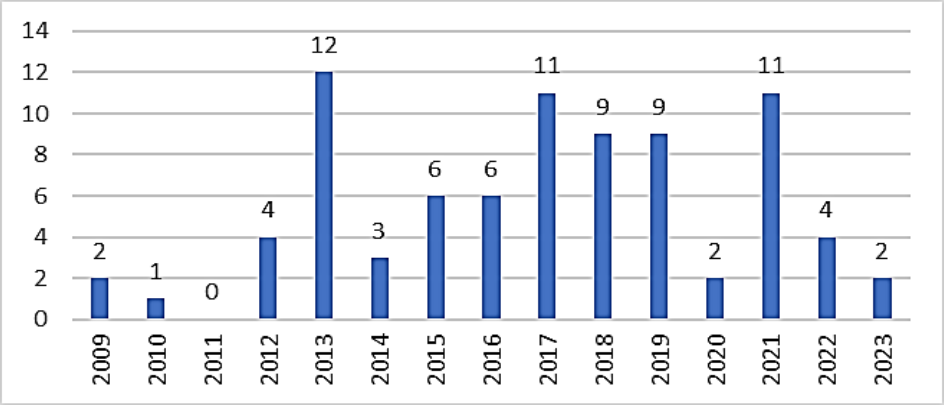

Figure 2. Number of articles published in the years 2009-2022 (and 2023 early access).

Unfortunately, subsequent fluctuation shows that this subject is not receiving much attention despite many international initiatives, which we have listed and described in Section 2.

Table 1.
Article titles by the publication year

Date of Publication	Titles of the papers selected for the review
2009	• Research on the Process Evaluation of **Green University** Based on Concordance Analysis (Li *et al*., 2009) • Study the Statistical Indicators System of the Process of Building **Green University** (Tao *et al.,* 2009)
2010	• Study on the Access Assessment on the Process of Building **Green University** (Li *et al.,* 2010)
2011	-
2012	• Measuring whole-building performance with dynamic LCA: a case study of a **green university** building (Collinge *et al*., 2012) • Integrating operations and research to demonstrate bioenergy heating at the University of Northern British Columbia (Claus, 2012) • An Exploratory Study of Readiness and Development of **Green University** Framework in Malaysia (Hooi *et al*., 2012) • Eco-campus: applying the ecocity model to develop **green university** and college campuses (Finlay and Massey, 2012)
2013	• Evaluating UI Green Metric as a tool to support **green universities** development: assessment of the year 2011 ranking (Suwartha, Sari, 2013). • A vision on the role of environmental higher education contributing to the sustainable development in Malaysia (Foo, 2013) • Indoor environmental quality in a dynamic life cycle assessment framework for whole buildings: Focus on human health chemical impacts (Collinge *et al*., 2013) • Smart Mobility for **Green University** Campus (Longo *et al*., 2013) • Moving towards an ecologically sound society? Starting from **green universities** and environmental higher education (Wang *et al*., 2013) • To Build a **Green University** Library - Architectural Design of Hefei Institute Library (Guo *et al*., 2013) • The Evaluation of **Green University** Based on Analysis Hierarchy Process (Liu *et al*., 2013) • The Empirical Study on Evaluation of **Green University** (Liu *et al*., 2013) • Creating a **green university** in China: a case of Shenyang University (Geng *et al*., 2013) • Research on Evaluation Index System and University's Green Degree Evaluation Model (Chen *et al*., 2013) • **Green Universities** in China - what matters? (Yuan *et al*., 2013) • **Green University** Star Rating Evaluation Based on the Multi-Level Grey Approach (Chen *et al*., 2013)

Cont. table 1.

2014	• The environment in post-secondary education and the **'green university'** in China McBeath *et al*., 2014) • Tentative Analysis on Fundamental Thinking and Realizing Approach of the Construction of **Green University (**Li and Chao, 2014) • Green Campus Culture Construction of **Green University (**Wang *et al*., 2014).
2015	• **Green university** initiatives in China: a case of Tsinghua University (Zhao and Zou, 2015) • Developing a Green Computer Science Program (Zalewski and Sybramanian, 2015) • Study on The Correlation of Web Repository Ranking to the Green Campus Ranking of Indonesian Universities (Rochim and Sari, 2015) • Encouraging sustainability in the workplace: a survey on the pro-environmental behaviour of university employees (Blok *et al.,* 2015). • Theory and Practice of Sustainability in Higher Education - From the Perspective of **Green University (**Mu *et al.,* 2015) • Comparing Sustainable Universities between the United States and China: Cases of Indiana University and Tsinghua University (Zou *et al.,* 2015)
2016	• Analyzing the Efficiency of a **Green University** Data Center (Pegus *et al.,* 2016) • The University of Northern British Columbia's Green Fund: Crafting a Tool for Sustainability Transformation (Wilkening, 2016) • E-Mailed Prompts and Feedback Messages to Reduce Energy Consumption: Testing Mechanisms for Behavior Change by Employees at a **Green University (**Pandey *et al*., 2016). • Valuation supports **green university**: case action at Mediterranean campus in Reggio Calabria (Massimo *et al*., (2016). • Strategic planning for the transformation of a university campus towards smart, eco and green sustainable built environment: a case study from Palestine (Hijazi, 2016) • Water reuse possibilities at students dormitories (Valentukeviciene and Rynkun, 2016)
2017	• Green Campus Study by using 10 UNEP's **Green University** Toolkit Criteria in IPB Dramaga Campus (Sisriany and Fatimah, 2017). • Design and Operational Analysis of a Green Data Center (Sharma *et al.,* 2017) • Integrating Between Malay Culture and Conservation In Green Campus Program: Best Practices From Universitas Riau, Indonesia (Suwondo and Yunus, 2017) • The Application of green construction in the Universities in South China (Xiong, 2017) • **Green University**: A New Perspective on Construction of Heterogeneous Competence of Application-Oriented Universities (Huang, 2017) • Building on Management Model of Modern **Green University (**Tu and Hu, 2017) • Research on **green university** operation mode based on Mercedes-benz models (Zhao and Zhao, 2017) • Research on the Advantages of Local Universities to Establish **Green University** Taking Linyi University as an Example (Zeng and Zeng, 2017) • Using emoticons to encourage students to recycle (Meng and Trudel, 2017) • The Strategy of **Green University**: Russian Experience of Implementation Lukina et al., 2017) • The Role of Non-academic Staff in Designing the **Green University** Campus (Katiliūtė *et al*., 2017)

Cont. table 1.

2018	• Supporting Sustainability and Healthy Learning Environment through Smart Green Management System (SGMS) (Abdullah *et al*., 2018) • Predictors of behaviour intention to develop a green university: a case of an undergraduate university in Thailand (Ounsaneha *et al.,* 2018) • What about greenhouse gas emissions from students? An analysis of lifestyle and carbon footprints at the University of Applied Science in Konstanz, Germany (Sippel *et al.,* 2018) • Management of Ecologization of Professional Education (Dlimbetova *et al*., 2018) • Measuring food waste and creating diversion opportunities at Canada's **Green University** (TM) (Rajan et al., 2018) • Variation of greenness across China's universities: motivations and resources (Zhao and Zou, 2018) • Promoting and implementing urban sustainability in China: An integration of sustainable initiatives at different urban scales (He et al., 2018) • What does environmentally sustainable higher education institution mean? (Freidenfelds et al., 2018) • Sustainability at universities: Students' perceptions from **Green and Non-Green universities (**Dagiliūtė et al., 2018)
2019	• Key strategies of sustainable and energy-saving development for **green universities (**Cai, *et al*., 2019) • Reflections of a **green university** building: from design to occupation (Moore and Iyer-Raniga, 2019) • Understanding Undergraduate Students' Perceptions on **Green University (**Siregar and Tenoyo, 2019) • Environmental education policy for pursuing sustainable campus: experience from Taiwan Higher Education (Tsai, 2019) • Formation of Youth Readiness to the Development of Environmental Volunteering at University (Dlimbetova et al., 2019) • An applied framework to evaluate the impact of indoor office environmental factors on occupants' comfort and working conditions (Andargie and Azar, 2019) • Getting a drink: An experiment for enabling a sustainable practice in Thai university settings (Thongplew and Kotlakome, 2019) • Environmental sustainability features in large university campuses: Jordan University of Science and Technology (JUST) as a model of a **green university (**Qdais *et al*., 2019) • Evolutionary Game Analysis of Green Building Promotion Mechanism Based on SD (Xue et al. 2019)
2020	• Corporate Governance and Sustainability in HEIs (de Oliveira *et al*., 2020). • The Impact Assessment of Campus Buildings Based on a Life Cycle Assessment-Life Cycle Cost Integrated Model (Xue et al., 2020)
2021	• Diversity and causality of university students' energy-conservation behaviour: Evidence in hot summer and warm winter area of China (Wang *et al.,* 2021) • **Green University** and academic performance: An empirical study on UI GreenMetric and World University Rankings (Atici et al., 2021) • An empirical study on discussion and evaluation of green university (Wu et al., 2021) • Developing a **green university** framework using statistical techniques: Case study of the University of Tehran (Heravi *et al.,* 2021) • Internet of Things (IoT) as Sustainable Development Goals (SDG) Enabling Technology towards Smart Readiness Indicators (SRI) for University Buildings (Martínez et al., 2021) • An integrated photovoltaic/wind/biomass and hybrid energy storage systems towards 100% renewable energy microgrids in university campuses (Al-Ghussain et al., 2021) • Romanian Students' Environment-Related Routines during COVID-19 Home Confinement: Water, Plastic, and Paper Consumption (Gherheş et al., 2021) • The path toward a sustainable **green university**: The case of the University of Florence (Fissi *et al.,* 2021) • Developing the Ecological Footprint Assessment for a University Campus, the Component-Based Method (Vaisi et al., 2021) • Addressing plate waste and consumption practice at university canteens: realizing **green university** through citizen-consumers (Thongplew *et al*, 2021)

Cont. table 1.

2022	• Possibilities of Adapting the University Lecture Room to the **Green University** Standard in Terms of Thermal Comfort and Ventilation Accuracy (Kosiński and Skotnicka-Siepsiak, 2022) • **Greening Universities** with Mode 3 and Quintuple Helix Model of Innovation-Production of Knowledge and Innovation in Knowledge-Based Economy, Botswana (Liyanage and Netswera, 2022) • Are university living labs able to deliver sustainable outcomes? A case-based appraisal of Deakin University, Australia (Martek *et al*., 2022) • Sustainable **Green University**: Waste Auditing, German Jordanian University as a Case Study (Hindiyeh *et al*., 2022)
2023 (early)	• Development of assessment framework for environmental sustainability in higher education institutions (Menon and Suresh, 2023) • Moving towards **green university**: a method of analysis based on multi-criteria decision-making approach to assess sustainability indicators (Yadegaridehkordi and Nilashi, 2023)

Source: Own studies.

When analyzing the titles of articles sorted by the year of publication (Table I), it can be noticed that throughout the period analyzed they focus on the search for the framework, model, methods, tools, and measures of building and managing campuses and universities. Often the research is based on the case study method illustrating solutions at the level of a selected university, campus or country. However, it is difficult to observe clear trends in research issues. On the other hand, there is a very limited number of cross-sectional studies examining selected aspects of green universities, such as energy, water, waste, biodiversity management, and so on. The publications also do not use the potential of the data of various rankings and sustainability reports, which could indicate trends, barriers, and challenges to the green transformation of HEIs.

3.2. The total number of publications per location

To provide a more general picture of the most productive regions of green University initiatives, Figure 3 presents the 6 most productive universities with more than 1 publication in the database we have worked on. The country selection criterion for a publication with multiple authors was the corresponding author's country.

We can say that Chinese scientific centres constitute pro-environmental initiatives at the university level, followed by universities in Canada and Indonesia. Certainly, this number is influenced by the number of researchers in such a huge country as China. In 2020, about 1,585 people per million inhabitants worked in research and development in China. (Statista statistics/239158, 2022) It is interesting to note that universities in Europe have output on this subject scattered across the continent and we cannot speak of a leading scientific center. In alphabetical order, the European countries can be listed in the database we are working on as Austria, England, Germany, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, and Spain.

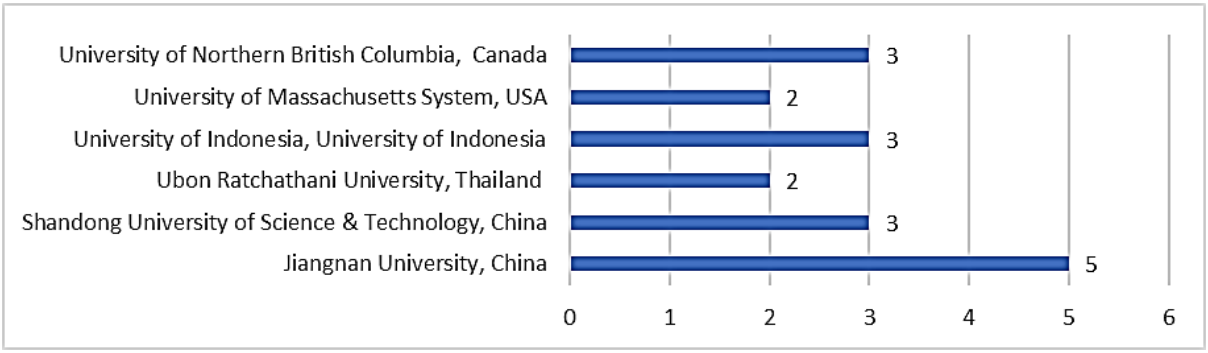

Figure 3. Number of articles per university.

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Caption placed under figures should be justified, TNR 12 pt. font with single line spacing. Complex captions consisting of the main caption and explanatory notes for figure details should have a width equal to the text width. Continuous numbering should be used. The distance of an item from the text above it should be 12 pt. Remember to refer text to a given figure (Figure 1).

3.3. The total number of publications per journal

Out of 82 scientific journals, we identified three which are the most popular with researchers (Figure 4). The remaining 96% of journals occasionally publish articles about green universities.

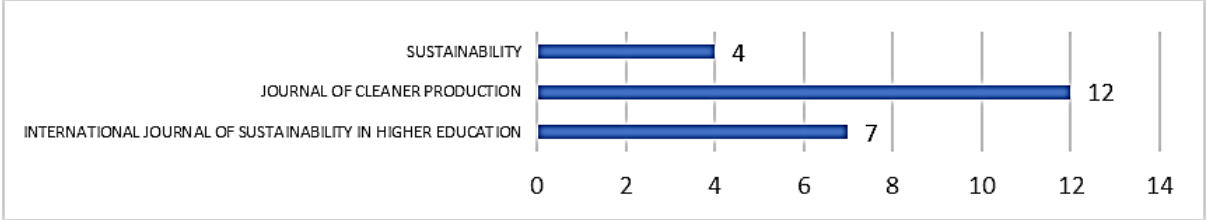

Figure 4. Number of papers per journal.

The most popular is published by Elsevier. The Journal of Cleaner Production is a leading international journal focusing on the field of green universities. The Journal of Cleaner Production is a transdisciplinary journal focusing on cleaner production, environmental, and sustainability research and practice. The purpose of this publication is to help societies become more sustainable. The Impact Factor of this journal is 11.072. The second most popular journal is the International Journal of Sustainability in Higher Education (Emerald Publishing) which aims to provide up-to-date information on new developments and trends in sustainability in a higher education context and to catalyze networking and information exchange on sustainable development as a whole, and on the SDGs in particular, on a global basis. The Impact Factor of this journal is 4.120. The third most popular journal is Sustainability (MDPI) an international, cross-disciplinary, scholarly, peer-reviewed, and open-access journal on the environmental, cultural, economic, and social sustainability of human beings. The Impact Factor of this journal is 3.889.

3.4. The total number of citations per journal

The journal that is most frequently cited is that published by Elsevier the Journal of Cleaner Production (Figure 5). It is a popular journal in which scientists are most likely to publish their articles. The others are: Habitat International (Elsevier), and the International Journal of Sustainability in Higher Education (Emerald Publishing) mentioned before.

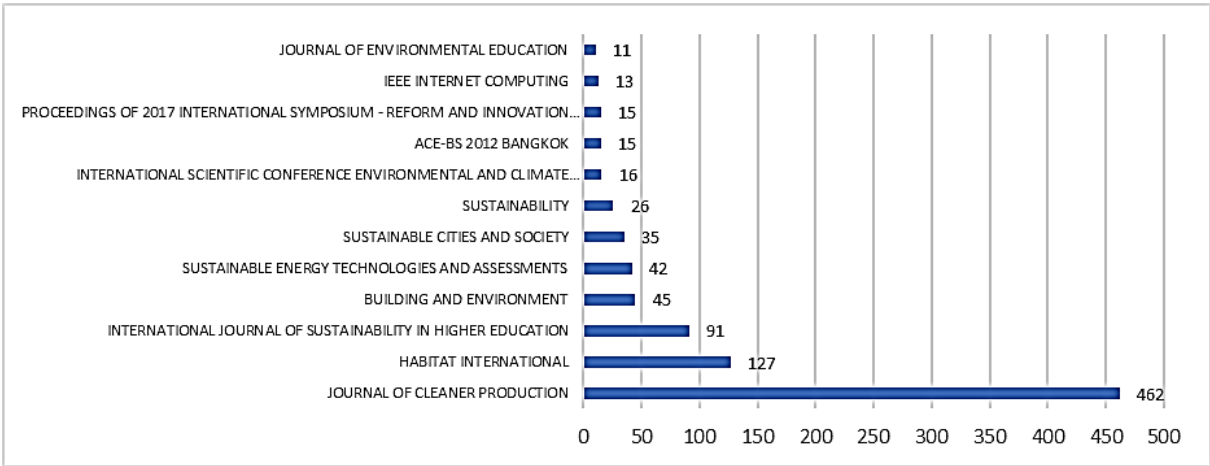

Figure 5. Total number of citations per journal.

3.5. The total number of citations per paper

The most cited article has more than twice as many citations as other articles in the field (Figure 6).

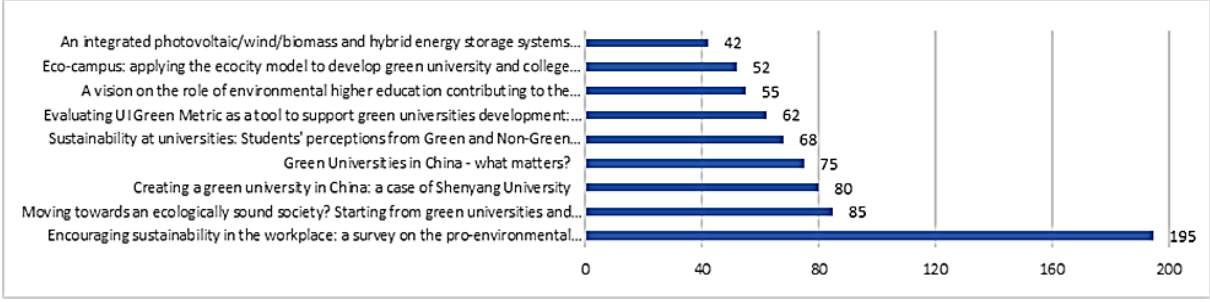

Figure 6. The total number of citations per paper.

The most cited article was published in the Journal of Cleaner Production in 2015 by researchers from the Netherlands. The title of the article is "Encouraging Sustainability in the Workplace: A Survey on the pro-environmental behaviour of university employees" (Blok et al., 2015). The research focuses on the identification of factors that have an impact on sustainable or pro-environmental behaviour. In second place is the article "Moving towards an ecologically sound society? Starting from green universities and environmental higher education" (Wang et al., 2013), published in 2013 by an international team from Asia, the USA, and Europe. The third one is "Creating and green university in China: case study of Shenyang University" (Geng et al., 2013) also published in 2013 by a team from China and Japan. The paper proposes an integrated model for the green university.

3.6. Scientific author cooperation

In Figure 7, we have tried to represent scientific collaboration between authors in the field of green universities. The authors with the greatest total link strength are presented in 4 clusters: the blue one represents researchers from Chinese universities, the green one represents researchers from Europe (Lithuania and Italy), the yellow one Malesia and Latvia, and the last one (red) represents international a team from Canada, Indonesia, Malesia, China, Turkey, United Kingdom.

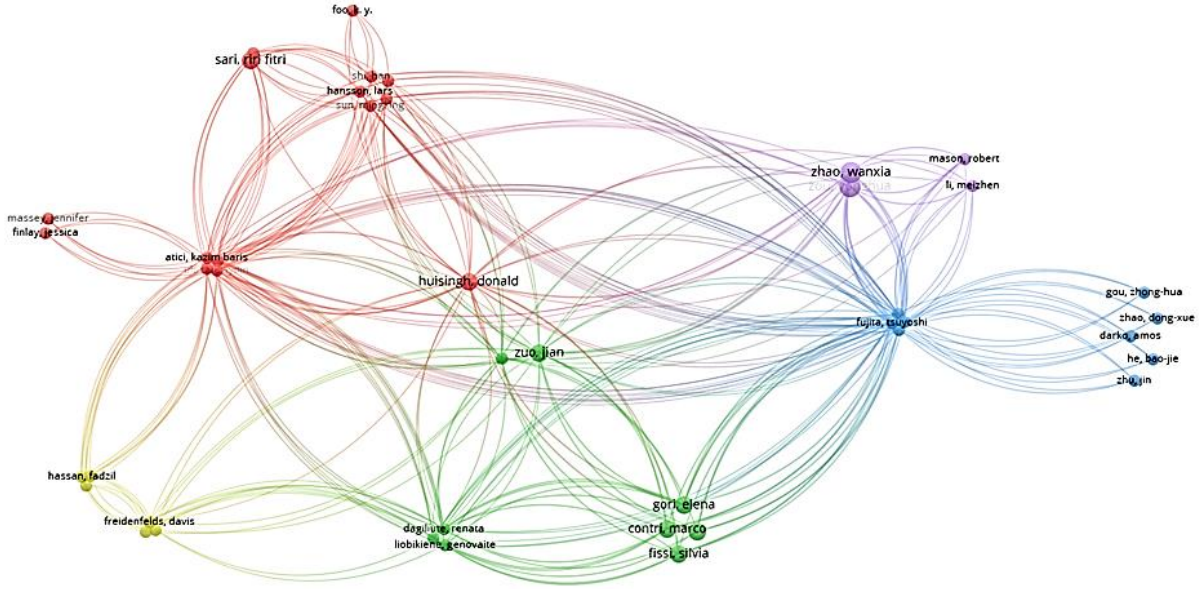

Figure 7. Scientific author cooperation.

The size of the dots in each cluster is similar, indicating that there is no world-leading centre for earth-based solutions at the university level.

3.7. Citations between universities

Another interesting issue is to consider the bibliographic connections between universities (Figure 8). For this analysis, a minimum of one document per university was chosen and a minimum of 10 citations per university. Finally, 44 universities were selected using VOSviewer.

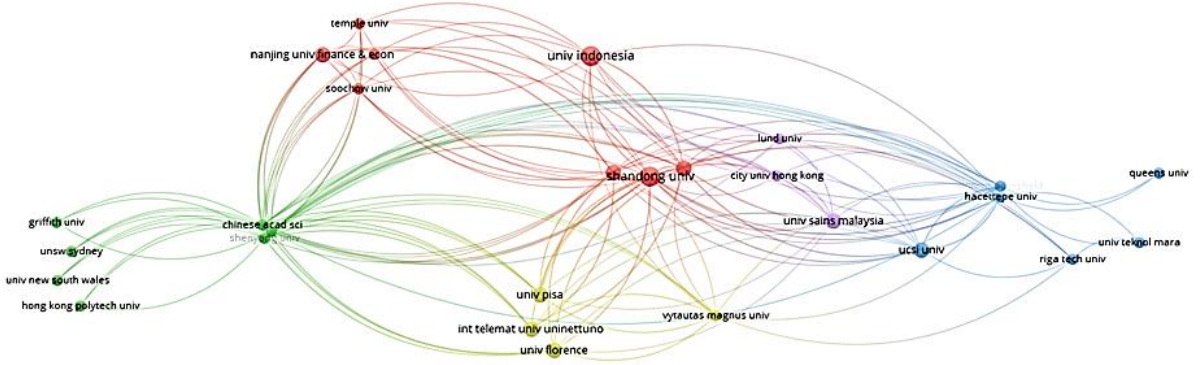

Figure 8. Citations between universities.

Asian universities represent the red cluster. Only a few universities from Europe appear in the yellow cluster (Italy). Universities from Australia and China are represented in the green cluster. The blue cluster represents international teams. We cannot say that some institutions from the same region and continent tend to connect more than institutions from other regions.

3.8. Co-authored documents by country

Do authors from individual countries share their experiences in the international field? The response is visualized in Figure 9.

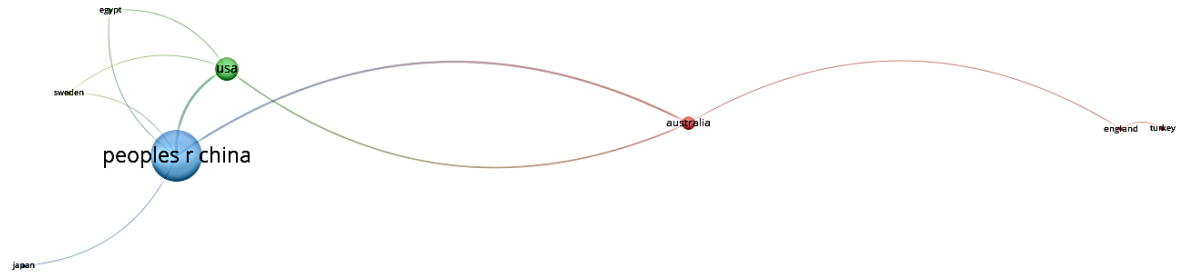

Figure 9. Co-authored documents by country.

The lines of connection between individual universities are singular, which means that international cooperation has been singular. All these data are for the countries that the researchers are affiliated with. Here, we do not track their migration to research centres in other countries, which would undoubtedly be an interesting field of research.

4. Discussion and Conclusions

Universities are driving a creative and innovative approach to economic, social, and environmental change in line with the directions set by the SDGs. Green universities are higher education institutions that educate global citizens about the most important environmental challenges and shape their awareness, strive to minimize the environmental footprint of campus activities, and enable students and staff to understand and engage in ongoing research and development to work towards environmental sustainability and make it a priority.

This article aimed to conduct a bibliometric analysis of scientific publications on green universities from 2009-2022 (and early 2023) based on the WOSCC database. 82 articles were eligible for the final analysis, and their analysis and visualization were supported by Vosevier software. As a result of the bibliographic analysis, it was found that the concept of green universities is not popular - the number of publications in the period analyzed ranged from 0 in 2011 to 12 in 2013. It is also difficult to identify the leading research issues or changes in these issues over the years. The articles identified mainly concern approaches, methods, and tools for

the evaluation of green universities, case studies of the implementation of green universities and campuses, green curriculum content, or the adaptation of various concepts and frameworks in the process of creating green universities and campuses. As the research results show, there is a lack of leading research centres or research teams, and no significant international cooperation has been observed. It is also difficult to identify the leading journals, although it is worth emphasizing that those with the highest number of publications are characterized by a high IF. Unfortunately, this does not translate into high citability of publications in the area of green universities.

Although the results of the analysis are not optimistic, the current support of international institutions and the growing role of diversified and green behaviours of HEIs in rankings and accreditations make it worth supporting research processes in this area, and thus the process of green transformation of universities, which will be based on the results of sound scientific research results. In particular, our recommendations are the following:

1. Consideration of the subject of green universities in grant programs at the national and international levels. In particular, it is worth encouraging research in the field of existing practices in the area of green universities and the development of models, tools, and green measures of universities, which will allow for objective and systematic research on the advancement of HEIs transformation towards green and diversified universities.
2. Encouraging high-quality magazines and publications in the area of green transformation and sustainable development to prepare special editions devoted to the issues of green universities in general and in specific areas such as energy management, waste management, water management, and so on.
3. Organization of scientific conferences entirely or partially devoted to green universities.

The study presented in this research paper has certain limitations that are important to acknowledge. Firstly, the analysis primarily relied on data from a single database, the Web of Science Core Collection (WOSCC). While this database is comprehensive, it may not encompass all relevant publications on the topic of green universities. Future research could benefit from considering multiple databases to provide a more comprehensive view of the field.

Secondly, our analysis exclusively focused on English-language publications. While this was done to maintain consistency in the dataset, it may have excluded valuable research in other languages. To gain a more holistic understanding of the topic, it would be worthwhile to explore publications in other languages, allowing for a comparison of findings across different linguistic research streams. Furthermore, it's important to note that our analysis in this study is primarily quantitative. While quantitative analysis provides valuable insights into trends and patterns, future studies could greatly benefit from incorporating qualitative content analysis. Such an approach would enable researchers to delve deeper into the available definitions, models, tools, and measures related to green universities, providing a more nuanced understanding of the subject matter. Lastly, a promising avenue for future research would be to analyze publications in terms of their research methodologies and the identification of best

practices presented in selected publications. This qualitative aspect would offer valuable insights into the practical application of research findings within the context of green universities.

In conclusion, this study on green universities has yielded valuable insights into the evolving landscape of higher education institutions about sustainability and environmental responsibility. It is clear from this research that universities play a pivotal role in fostering global citizens with a deep understanding of environmental challenges and a commitment to sustainability. Furthermore, the findings of this bibliometric analysis shed light on the current state of research in this area. While the concept of green universities may not have gained widespread popularity, the support of international institutions and the increasing recognition of green practices in rankings and accreditations highlight the growing significance of this field. Moving forward, it is imperative to support research efforts in this domain to drive the green transformation of universities based on robust scientific foundations. Recommendations include the inclusion of green universities in grant programs, the promotion of specialized publications, and the organization of dedicated scientific conferences. These actions will not only enhance our knowledge of green universities but also facilitate their practical implementation, contributing to a sustainable and environmentally conscious future in higher education.

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GAME-DEV SOCIALLY RESPONSIBLE. IS CSR IN THE VIDEO GAME INDUSTRY MORE THAN IMAGE-BUILDING ACTIVITIES? ANALYSIS AND DISCUSSION ON THE EXAMPLE OF SELECTED INDUSTRY PLAYERS

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Purpose: The study's primary purpose was to identify CSR activities performed by key players in the game-dev sector in the context of the brand's overall activities and the consistency of their cases. The specific objectives were to define CSR areas and isolate activities in these areas of selected game-dev industry entities - and then compare them with each other to determine whether, in their case, corporate social responsibility is an image-building tool or actual activities that build the image of a responsible brand.
Design/methodology/approach: The authors highlighted the CSR practices used by game developers and producers, their characteristics and their juxtaposition with other areas of these companies' operations. Then, using desk research analysis, the effects of such strategies on game-dev companies, such as Techland, Electronic Arts or Ubisoft, were studied, as well as the identified potential risks for gamers resulting from these practices - the problem of game jams and unclear copyright rules for ongoing projects, among others, was addressed.
Findings: Game developers can implement CSR activities through their products (by addressing social issues in the game's content and mechanics) and around them - by undertaking various projects that demonstrate social responsibility. While necessary and often valuable, CSR activities build a positive brand image, drawing attention away from unethical or questionable business practices, such as micropayment mechanisms that use gambling patterns.
Social implications: As a result of applying corporate social responsibility measures, game-dev companies are gaining trust from gamers, who view the gaming reality as more secure and comfortable, thus being more exposed to the risks of mechanisms such as lootboxes or vaguely designed game business models.
Originality/value: The article is primarily addressed to researchers and scholars dealing with the field of CSR in the context of its consistency with the main objects of companies. The work may also interest students in marketing, psychology, culture, and game studies. In addition, the article is also valuable for parents and guardians of those particularly vulnerable to abuse by game developers and producers - minors.

Keywords: game-dev, corporate social responsibility, CSR, game jam, video games.

Category of the paper: General review.

1. Introduction

Game-dev (video game development) is one of the key and fastest-growing industries in the creative sector, which includes companies that create, produce, distribute and disseminate creative goods and services (Kamiński, 2019). According to the report 'Perspectives from the Global Entertainment and Media Outlook 2017-2021: Curtain up! User experience takes centre stage; the games market is a key growth driver for the overall media and entertainment market (PwC, 2017).

The video game industry, the rapid growth of which is the aftermath of the digital technological revolution of the 20th century, represents a market evolving at a high rate. The pace of change in the game environment is becoming a severe challenge for game developers in the context of legal regulations, new channels of communication with audiences and the blurring of the traditional division between players and viewers (Sosnowski, 2017). Among the reasons for the growing interest in the video game industry tend to be the following (Krok, 2016):

a. changing the perception of e-entertainment as an integral part of everyday life,
b. the development of innovative technologies to modify and make games more attractive,
c. popularisation of mobile platforms and devices,
d. using exciting marketing messages, including the popularisation of non-standard forms of promotion,
e. using appropriate distribution channels, allowing the message to reach the target group,
f. organizing events dedicated to virtual entertainment.

Nowadays, many leading video game companies publicly report and provide information on the impact of their operations on the market, workplace, environment and communities in which they operate. However, according to (Jones et al., 2013), the CSR reports and information published by these companies do not highlight concerns about the need for greater regulation and statutory enforcement in the industry. Indeed, existing regulations, through which the controversies that video games stir up are mitigated, can create a negative image of the industry. Hence, many game-dev companies are trying to prevent this situation by implementing diverse CSR activities, and the differences in terms of their scale are mainly due to the will and commitment of the managers rather than the size of the company itself (Sobociński, Strzelczyk, 2019).

The article's main objective is to identify the issues available in the academic and professional literature regarding CSR activities by key game-dev sector players in the context of the overall brand activities and the consistency of the actions undertaken. The specific objectives were to define the areas of CSR activities of selected game-dev industry entities, to identify activities that may or may not contradict the idea of CSR, and to juxtapose them with

each other in order to determine whether CSR in their case, is a tool for simple brand development, or actual activities that build the image of a responsible brand.

The authors used a desk research method to review social responsibility in the video game industry. The following research hypotheses were adopted and verified in the course of literature analysis:

1. CSR in the video game industry is mainly a tool for creating a positive corporate image rather than an actual concern for the environment and society.
2. CSR in the video game industry is partly a way to divert attention from unethical activities the company undertakes for its benefit.

2. Research Methodology

The review of literature treating social responsibility in the video game industry was conducted using a desk research method. The bibliography includes 33 items, mainly from 2019-2023, including academic articles, books, monograph chapters, industry reports and electronic sources. The following databases were used to collect scientific literature: Google Scholar, ResearchGate, Taylor and Francis Online, ScienceDirect. The following combination of words using Boolean operators (AND, OR) was used in the literature search in the databases above: ('game dev' OR 'game development' OR 'game developer') AND ('video game industry' OR gaming) AND (CSR OR 'Corporate Social Responsibility'). Searches in the databases above complemented the literature collected for the following keywords: game jam, Electronic Arts, Ubisoft, Techland.

3. Corporate social responsibility in the games industry - limitations, benefits and directions for change

Carroll (1991) defines corporate social responsibility (CSR) in four dimensions: economic, legal, ethical and philanthropic (Figure 1). The economic dimension is related to providing a return on investment to owners, creating employment opportunities, reasonably compensating employees, finding new resources, encouraging technical/technological improvements and the development of innovative products/services. The legal dimension of CSR includes stakeholder expectations of legal compliance. The third dimension, ethical, is about morality and the prevention of social harm, while the philanthropic dimension is characterized by the most comprehensive range of discretion and choice in making charitable contributions to society (Jamali, Mirshak, 2007).

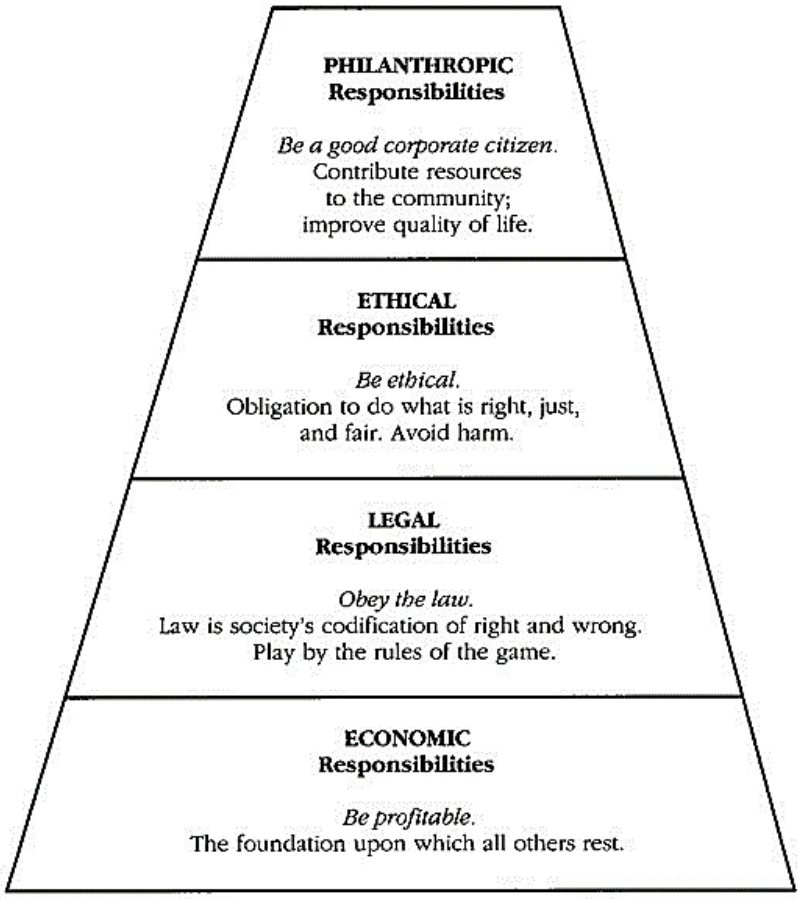

Figure 1. The four dimensions of the corporate social responsibility pyramid.
Source: Carroll, 1991.

According to Luo et al. (2019), corporate social responsibility is an essential tool to reduce the negative impact of the games industry on stakeholders, and the main barriers to implementing CSR were cognitive dissonance, management dilemma, resource constraints, negative image, unclear regulations and unsustainable impulse. The study's results (Kim, Lee, 2019) indicate that CSR's economic and philanthropic dimensions have the most substantial positive impact on perceived benefits in the gamedev industry, while the legal dimension proved to be an insignificant determinant.

A 2019 report prepared by the United States Chamber of Commerce Foundation proves that gaming companies that commit capacity and resources to corporate social responsibility activities enjoy greater employee engagement as long as these activities are directly linked to elements of the company culture. Effective and consistent actions also significantly improve brand recognition, especially among younger users - it is estimated that up to three-quarters of millennials will take a job for a lower wage if the values promoted by the company are in line with theirs (United States Chamber of Commerce Foundation, 2019).

According to the study (Bae et al., 2019), game companies can increase the purchase intentions of game users by investing in CSR initiatives - given that it is a crucial area of their value and profitability. The study also shows that engagement in CSR activities increases

consumer self-esteem and generates sympathy for game developers, which can be helpful to in-game executives and managers in developing CSR-based business strategies.

Therefore, how do we show that game developers are serious about corporate social responsibility and care about more than just revenue? According to (Griffiths, 2014), this is possible after implementing the following changes in games: shortening long quests, lowering the amount of experience points needed to reach the next level, more frequent rebirths to increase the chance of obtaining specifically sought-after items, speeding up the processes of challenging quests in the context of leaving the game earlier after completing their tasks. In addition, the most visible CSR action of video game publishers in the area of excessive game use is the initiation of warning messages and the possibility of setting a parental mode, allowing parents to limit their children's gaming time.

Further directions of change in the context of social responsibility of the game-dev industry are (Sosnowski, 2023):

a. providing accurate, clear, simple and understandable information by games on monetization methods and the business model adopted,
b. posting information about the actual value of purchasing the game,
c. marking the presence of loot boxes,
d. explaining the chance of obtaining the desired item in the game,
e. planning at the design stage of the game to include by default mechanisms to help parents control the content, timing and purchases made by their children,
f. informing the consumer of all purchases made by them or their children,
g. obtaining the consumer's consent to make a payment,
h. providing a variety of player experiences rather than favouring those experiences on which the user has spent the most time,
i. designing games that are divided into shorter levels,
j. introducing frequent opportunities to save the game state to break away from the game.

It is also worth mentioning that at companies affiliated with the American Gaming Association, more than half of the employees are women, and as many as 57% are from ethnic minorities, as shown in Figure 2. The gaming industry is also very diverse in terms of the age of the workforce, with as many as 28% of the workforce being Baby Boomers, i.e. people aged 53 and over, as shown in Figure 3. The industry places a high value on promoting diversity among the workforce, which, in addition to a sense of security and unity, also generates the benefit of a plurality of perspectives and attitudes towards the market and meeting its needs (United States Chamber of Commerce Foundation, 2019).

Figure 2. Participation of women and ethnic minorities in the games industry workforce compared to the total US workforce and Leisure and Hospitality industry.

Source: (United States Chamber of Commerce Foundation, 2019).

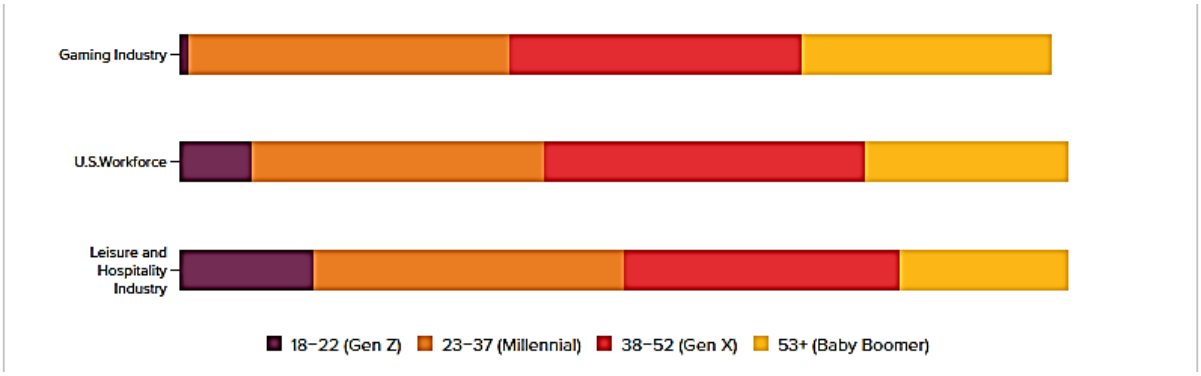

Figure 3. Generational diversity of workers in the games industry compared to the overall US workforce and Leisure and Hospitality industry.

Source: (United States Chamber of Commerce Foundation, 2019).

4. Models of ethical attitude in the game-dev Industry

According to SRT (Social Responsibility Theory), media behaviour can be characterized using four ethical attitude models: social resistance, social obligation, social responsiveness and social contribution (Nowakowski, 2008). Similarly, (Griffin, 2022) suggests four attitudes characterizing contemporary corporations: resistance to social responsibility, demonstrating fulfilment of social obligation, reactive attitude, and contributing to solving social problems. According to the authors of this article, the process of increasing social responsibility can also be applied to the behaviour of game developers.

In the case of social resistance, game developers are only oriented toward making profits by increasing the sales of their products regardless of the degree of harmfulness of the content conveyed through games. The second model of game developers' behaviour is adopting the principle of fulfilling social obligations imposed by legislative bodies. As part of the implementation of CSR activities, the following can be mentioned here: labelling games in the context of their intended use for specific age groups; respecting regulations prohibiting the

advertising of harmful content in games and hidden advertising; taking care of the proper physical and mental development of game users. These aspects are fundamental in the case of underage players who are gullible and submissive to persuasion and manipulation in advertising.

Under the third model, the reactive attitude, game developers should react to problems in games and actively seek possible solutions to any shortcomings perceived and reported by users. For the fourth model of ethical stance, the video game industry should highlight and publicize its social contribution to solving social problems that are important from the perspective of its stakeholders.

To summarise, game developers' whole process of increasing social responsibility can be depicted in Figure 4.

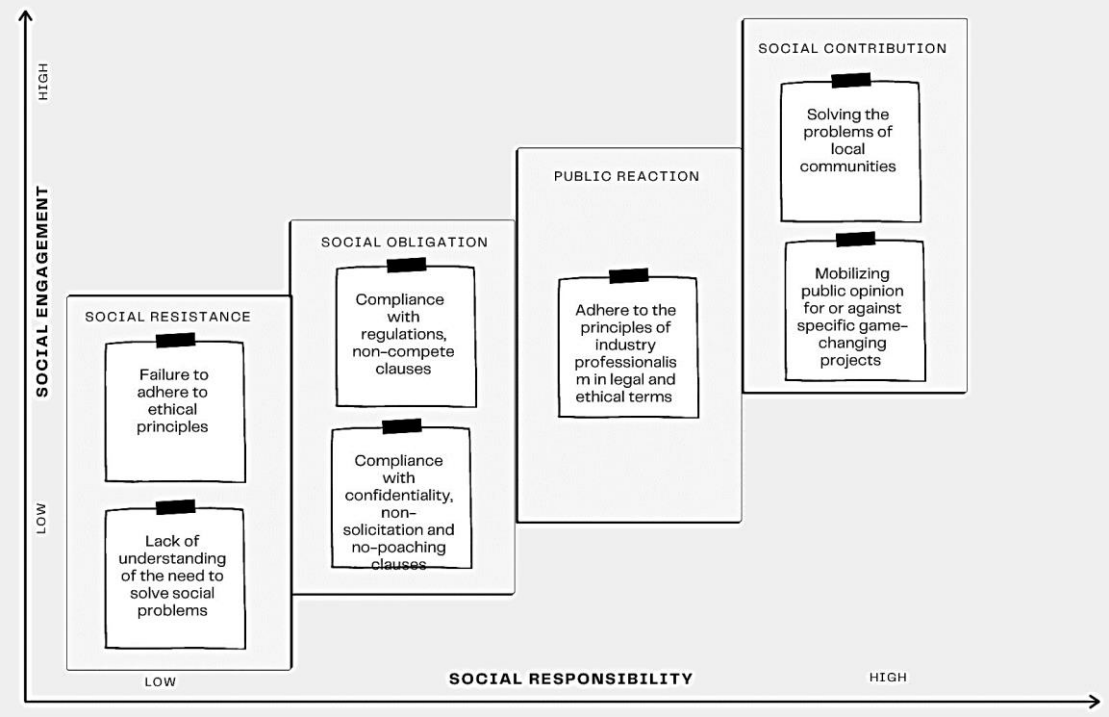

Figure 4. The process of increasing social responsibility by game developers.

Source: own study based on: (Nowakowski, 2008; Staniszewski, 2022).

5. Indications of social responsibility in the activities of selected players in the game development industry and their coherence with other related actions

Video game companies are paying increasing attention to CSR. It is worth observing that the game-dev industry has an additional, rather specific area called *responsible gaming*. Responsible gaming is primarily a concern for:

a. protecting vulnerable players,
b. stopping underage gambling activities,
c. policing the use of illegal mechanisms,
d. securing online payments,
e. protection of sensitive data,
f. secure virtual environment,
g. ethical and responsible marketing.

Both law and custom regulate responsible gaming policies. Nevertheless, it is essential to consider the CSR activities of key players in the industry and to assess some deviations and inconsistencies from the companies' declared values (United States Chamber of Commerce Foundation, 2019).

CSR plays a crucial role in multiplayer games - game developers and community managers are responsible for ensuring a safe and friendly gaming community. However, in many games, players display toxic behaviour towards each other, offensive messages and rudeness - this can be seen in games such as League of Legends and War of Warcraft, where the system for reporting inappropriate behaviour is still only marginally eliminating them (Yousafzai et al., 2013).

One of the most influential brands for Polish game development is Techland - founded by Paweł Marchewka in 1991; over the years, it has gained immense popularity thanks to, among others, productions such as *Dead Island* and *Dying Light* (Techland, n.d.). Although it is difficult to find specific information about the brand's CSR activities in the company's publications, Techland representatives are guests at various industry events, offering internships and junior positions to the youngest participants in the labour market. In 2022, Techland joined the initiative of the Polish Humanitarian Action, donating 1 million zlotys to help the citizens of Ukraine regarding the war crisis (*Techland – Milion Złotych Na Rzecz Polskiej Akcji Humanitarnej*, 2022). In the summer of 2023, it became official that Techland had been acquired by the Chinese company Tencent, becoming its majority shareholder. The political issues were particularly controversial about the whole situation, as China remains an ally of Russia, which has remained the aggressor and has been in an armed conflict with Ukraine since February 2022. In the context of previous pro-social activities on the part of Techland, the current situation, in addition to the general fear of the prevailing Chinese capital, has aroused numerous discussions and high-profile criticism of the Polish company (Luc-Lepianka, 2023).

Electronic Arts has spoken openly about its efforts towards corporate social responsibility. EA has several brands, including sports game developer EA Sports (*FIFA* series and the new *EA Sports FC* series) or RPG/action developer BioWare (*Dragon Age* series, *Mass Effect* series), and is also responsible for the popular life simulator series, *The Sims*. According to its declarations, the Canadian game-dev company in 2022, the company contributed $9.5 million in sponsorships, grants and employee benefits, devoted 6428 hours to volunteer work,

supported 4359 non-profit organizations and donated 3764 free game codes (Electronic Arts, n.d.).

Electronic Arts has been paying particular attention to issues of diversity and tolerance in its productions. One of the most critical manifestations of this activity is the implementation of co-educational football teams in the new *EA Sports FC* series, which was met with massive criticism from players. However, the company's stance, despite customer resistance, remained unchanged and supported by the thesis that the *Ultimate Team* mode is *fantasy football*, i.e. it should guarantee unlimited possibilities of creating teams and uniting the world around football regardless of gender and origin while building a positive image of women in football, who not only do not enjoy as much popularity as male players but also achieve much lower salaries (Yin-Poole, 2023).

In opposition to the concern for diversity and a safe space for gamers, however, is the use of micropayments, specifically lootboxes, which bring EA more and more revenue annually (Clement, 2022). Lootboxes pose a particular threat as the game is dedicated to age, exposing minors to direct contact with gambling-like mechanisms (Zendle et al., 2020). Therefore, the game's developers' practices may call into question statements of concern for underprivileged young people.

Another company with a considerable reputation is the creators of the *Assassin's Creed* and *Far Cry* series - Ubisoft. Their corporate social responsibility materials are published about making a long-lasting positive impact on players, teams, communities and the planet. Ubisoft declares that they work with and for the players, helping to create original and memorable gaming experiences. Regarding team members, the conglomerate reports providing a safe, inclusive working environment for its employees (*Corporate Social Responsibility*, n.d.).

In light of the high-profile discussion of 2021, the veracity of the information regarding employees is worrying - as Ubisoft has faced numerous accusations of bullying and a toxic workplace atmosphere. Despite firm denials from the authorities, the situation has left many scars on the company's image (Madsen, 2021).

CSR activities, although constantly present in the strategies of game-dev companies, are regularly controversial due to the scandals and ethically questionable practices that occur within the companies' actions. They are, however, an essential part of building a positive image for companies while partly masking those movements that are met with criticism.

6. Game Jam and its CSR dimension

A game jam is an intensive event focusing on the creation process and is now increasingly seen as a place for learning. Game jams include activities to develop the technical skills needed to create digital games. In addition, soft skills such as collaboration and communication skills

are developed. A game jam is also considered a way to teach and learn skills in science, technology, engineering, art and mathematics (Meriläinen et al., 2020). The largest such event in the world is the Global Game Jam (GGJ), which since 2009 has brought together thousands of video game enthusiasts each year to participate in this forty-eight-hour event to create games with the same theme (Fowler et al., 2013).

GGJ includes meetings (game jams) of participants in more than 60 countries and over 300 locations (game sites). This global event is organized and managed by the Global Game Jam Committee, while volunteers organize local events. During the event, participants gain valuable skills in prototyping, collaboration, creativity, learning and creating a space to support an independent game development ecosystem. The principles specific to game jams are (Fowler et al., 2013):

a. The event aims to create small, experimental and innovative games within a limited timeframe - for example, 24 or 48 hours over a weekend, usually online (Preston et al., 2012).
b. All games created during the game jam must have a common theme - previously unknown to the participants.
c. Game jams are usually open to anyone who can contribute to game development. However, some have age restrictions or school membership requirements.
d. Team formation before the event is discouraged, and team size is usually limited to less than five people.
e. Game development for any device is encouraged, and teams can choose their development platforms.
f. In some locations, there is a final presentation where other participants, the audience or the jury select the best games.

As a general rule, game jam organizers offer material prizes for the best participants, and games are judged on the originality and innovation of the solutions used, level of sophistication, playability, functionality, design, and relevance to the theme.

A critical issue during the game jam is that the preparation of works starts at the moment of the event - previously prepared assets, code fragments and other elements that could cause a breach of fair-play rules must not be used. The prepared games must also not contain illegal content, content commonly regarded as offensive (such as vulgarism, erotic and pornographic content, discriminatory content, drugs), malicious software, viruses, or anything related (PolskiGamedev.pl, 2021).

While community-organized game jams do not generate much controversy, there is the issue of jams organized directly by game developers. An example of such an event was the 2015 event of the Polish game-dev company Techland, which involved developing a mod for *Dying Light*. The developers provided participants with the development tools used to produce the game and used their own devices.

Involving the gaming community in the creation and development of a product certainly has a very positive effect on brand perception - the event reduces the distance between the brand and the player, making them prosumers and showing that their participation in the creation of the game is essential - such activities effectively support the building of relationships with players, providing them with the opportunity to participate in the development of the production, as well as to present their skills in front of an expert jury with the possibility of placing the project in the portfolio.

Doubts arise when analyzing the project in the context of intellectual property - the form of publication of the finished work of the participants of the event does not allow them to derive any financial benefit - the mods are placed on the Steam platform in a workshop dedicated to the *Dying Light* production, so it is not clear to whom the copyrights to the project belong and whether the creator of the parent game can freely use it for their needs. The competition rules also do not clearly explain the ownership rights to the project (Regulamin - Techland Game Jam, 2015).

As a particular risk in the case of game jam projects - especially those organized not by the gaming community but by game developers - we can therefore consider the potential possibility of not entirely ethical use of participants' ideas to achieve benefits such as, for example, development of a game at low cost. However, based on the available data, it is difficult to clearly state whether studios use the projects of event participants, although participation in an event does raise some risks in this matter.

7. Conclusions

The article's main objective was to identify the issues available in the academic and industry literature regarding corporate social responsibility activities by key players in the game-dev sector in the context of overall brand activities and consistency in the issues addressed and the specific objectives.

Achieving a competitive advantage for game-dev companies is the ultimate goal of implementing corporate social responsibility. In addition, stakeholders' expectations are changing and pushing companies to be more sustainable. Indeed, by communicating sustainability through games, environmental awareness can also be raised among gamers (Lin, 2022).

Regarding the conclusions resulting from the research, the Authors proved the validity of the following hypotheses:

1. CSR in the video game industry is mainly a tool for creating a positive corporate image rather than an actual concern for the environment and society.
2. CSR in the video game industry is partly a way to divert attention from unethical activities the company undertakes for its benefit.

An analysis of the CSR activities of selected video game industry players shows the novelty of the results in this regard. These companies strive to implement diverse CSR activities, which vary in scale. These differences are due to the will and commitment of game developers rather than the sheer size of a given company. Nevertheless, the CSR actions implemented by the game-dev companies benefit gamers, and they should be intensified to bring more advantages to society, especially those underprivileged and most vulnerable.

Several theoretical and practical implications were developed based on the analyzed academic and industry literature content. Firstly, game developers should be able to participate in philanthropic CSR activities, strengthening their position in the market and further binding them to the company. Secondly, game company executives should communicate the company's mission and vision and its commitment to the community, highlighting the benefits of this involvement. Third, besides publishing CSR documents and reports to communicate with stakeholders, game companies could communicate sustainability through their games by integrating sustainability into the game mechanics or as an additional feature. Finally, companies should be more consistent with their stated values and be wary of making moves that contradict them, as this reflects significantly on players' trust in the brand. Companies should also reduce the risks associated with the exposure of minors to gambling-like mechanisms.

This article has several limitations. Firstly, the literature review was based only on four selected scientific databases: Google Scholar, ResearchGate, Taylor and Francis Online, and ScienceDirect, which may have limited the number and value of search results for relevant items. Secondly, literature searches used a specific combination of keywords using Boolean operators, which may have omitted other scientific items in a given database. Selected industry reports and electronic sources were used in the subject matter covered to supplement the analysis.

Despite the identified limitations of the study, this paper may provide a basis for broadening the issues treating the social responsibility of the video game industry in the future. Furthermore, this paper may begin a series of articles on the game-dev industry regarding corporate social responsibility.

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OCCUPATIONAL RISK ASSESSMENT IN THE POSITION OF AN OPERATIONALEMPLOYEE ON THE EXAMPLE OF A SELECTED ENTERPRISE

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Purpose: The purpose of this paper is to conduct a detailed analysis of occupational risk using the methods of Preliminary Hazard Analysis (PHA) and the Five-Step Method. The paper aims to estimate the level of risk associated with specific operations performed by automotive sheet metal workers in a selected research facility.
Design/methodology/approach: The objectives are achieved by employing two main methods for assessing occupational risk: the Preliminary Hazard Analysis (PHA) and the Five-Step Method. The approach involves applying these methods to evaluate the potential risks associated with the tasks performed by automotive sheet metal workers. The theoretical scope of the paper covers the field of occupational risk assessment and the practical application of risk assessment techniques in a specific work environment.
Findings: In the course of the study, it was determined that the calculated risk values for the selected operations were within acceptable limits. The analysis revealed that both the PHA and the Five-Step Method were effective in identifying and assessing potential risks, providing insights into the level of risk associated with the tasks performed by automotive sheet metal workers.
Research limitations/implications: The research process was limited to a specific research facility and focused on a subset of operations performed by automotive sheet metal workers. Future research could expand the scope to other work environments and investigate a broader range of tasks to enhance the generalizability of the findings. Additionally, further investigation could explore the effectiveness of risk mitigation measures and their impact on reducing potential hazards.
Practical implications: The research outcomes have implications for enhancing occupational safety in the automotive repair industry. The findings suggest that the selected operations pose an acceptable level of risk, validating the effectiveness of current safety measures. Practitioners and managers can utilize these findings to make informed decisions regarding task assignments, employee training, and the allocation of safety resources.
Social implications: The research contributes to the broader social goal of promoting worker safety in the automotive repair sector. By providing evidence-based insights into the level of risk associated with specific tasks, this research may influence industry practices and policies related to employee safety and well-being.

Originality/value: This paper introduces a comprehensive analysis of occupational risk using the PHA and Five-Step Method, specifically applied to automotive sheet metal workers. The value of the paper lies in its practical application of established risk assessment methods to a specific work context, addressing the occupational safety concerns of a critical industry sector.

Keywords: Occupational Risk Assessment, Preliminary Hazard Analysis (PHA), Five-Step Method, Ergonomics, WCM.

Category of the paper: Case study.

1. Introduction

Risk accompanies us at every moment of our lives, in every profession, and during every activity we undertake. Its nature, level, and consequences may differ, but it is present nonetheless. There are various methods available to assess and minimize risk to the lowest possible level. These can be categorized into, among others, objective risk, subjective risk, pure risk, speculative risk, static risk, dynamic risk, fundamental risk, specific risk, individual risk, and collective risk (Ergonomia i ochrona..., 2009). Risk is closely tied to Occupational Health and Safety (OHS), as it involves identifying, evaluating, and managing potential hazards and risks in the workplace. The overarching goal of any OHS program is to create the safest possible work environment and to reduce the risk of accidents, injuries, and fatalities in the workplace. Proper adherence to OHS procedures can aid in preventing accidents, reducing the risk of employee injuries and illnesses, and mitigating costs such as sick leave, medical care, and disability benefits (Alli, 2008). There are two main components to the OHS system in Poland: the legal system and the organizational system. These together form the framework of occupational protection in the country. The legal system pertains to labor laws, applicable legal norms, and their placement within the appropriate hierarchy of health and safety laws. On the other hand, the organizational OHS system focuses on controlling workplace safety and health at a national level, within establishments, and among organizations involved in its creation (System BHP w Polsce, 2021). In Poland, the organizational OHS system outlines the institutions and associations responsible for formulating and executing tasks related to safety and health. The organizational system can be classified into two levels: national and establishment-specific. Two main standards define the occupational health and safety management system in Poland:

- PN-N-18001:2004 "Occupational Health and Safety Management Systems - Requirements".
- PN-N-18004:2001 "Occupational Health and Safety Management Systems - Guidelines" (Model systemu zarządzania BHP…, 2021).

Every enterprise should adhere to all OHS principles to prevent unwanted accidents in the workplace. Many companies set specific goals and principles and implement them. The model for such management and workplace safety is presented in Figure 1.

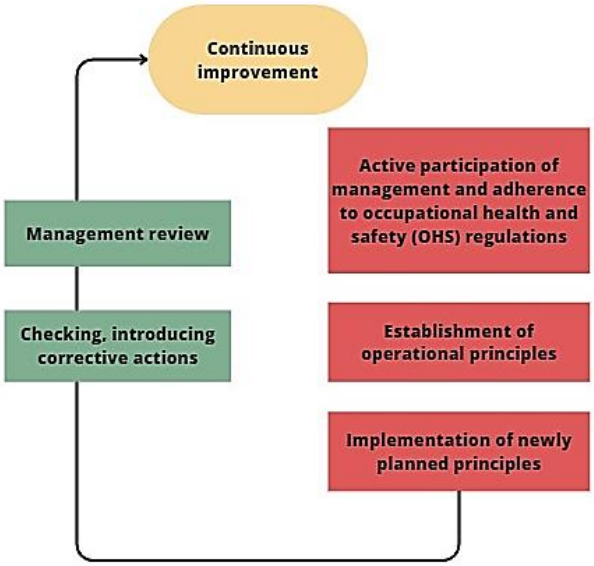

Figure 1. Deming Cycle in the management and occupational safety system.
Source: Model systemu zarządzania BHP…, 2021.

The Deming Cycle describes the various elements of continuous improvement. It begins with the active participation of management and adherence to safety and health principles. The next steps involve establishing operating procedures, and goals, and preparing specific plans for the future. Risk assessment and familiarization with the applicable laws for the enterprise to follow. The next stage is the implementation of the planned new rules, which involves aligning the entire organization, ensuring the necessary capital for the system to function properly, maintaining documentation for the occupational health and safety management system, effective communication, and providing special training to educate employees. Checking and implementing corrective actions is the subsequent step. The final element of the Deming Cycle is the review of management and continuous improvement of the company (Model systemu zarządzania BHP…, 2021).

Occupational health and safety (OHS) are closely linked to ergonomics, creating a comprehensive system for safeguarding the health and safety of employees in the workplace. Ergonomics is the science focused on adapting work to human physical and psychological requirements. It combines technical, biological, medical, psychological, sociological, and physiological aspects related to work, hygiene, law, and environmental protection. The main focus of ergonomics is the employee, ensuring that equipment, tools, and machinery are selected in a way that meets all their needs while causing moderate biological losses but maintaining high productivity and efficiency. These conditions have a positive impact on safety during work (Identifying and Addressing…, 2021). The primary goal of ergonomics is to eliminate discomfort and the risk of injuries during work, specifically reducing fatigue and injuries while increasing comfort, productivity, job satisfaction, and safety. Workplace injuries are not inevitable, and well-designed work should not lead to any harm. The employee is a priority in the workplace analysis (Ergonomia i ochrona..., 2009). Ergonomics can be divided into three categories: conceptual, corrective, and product ergonomics. Conceptual ergonomics

focuses on the creation of appropriate devices, machines, tools, and entire industrial halls. It is the most important of all categories because allowing errors at this stage can lead to long-term adverse effects affecting a large number of people. An example could be construction that is not adapted for disabled individuals, due to a lack of ramps. This way, a portion of society is excluded from social and professional life (Szlązak, Szlązak, 2010). Product ergonomics mainly deals with selecting machinery, tools, and devices to match human profiles, and the operation of these objects, including productivity, repair, regulation, and ensuring the safety of the person working with the given object. An example could be a car seat specially designed to match human dimensions (Szlązak, Szlązak, 2010). Corrective ergonomics focuses on fixing technical objects that have been incorrectly realized and designed. However, the feasibility of such corrections is sometimes limited, and in such cases, an analysis of the entire equipment and its fixtures is conducted (Szlązak, Szlązak, 2010). Asimplified diagram of the concept of ergonomics is shown in Figure 2.

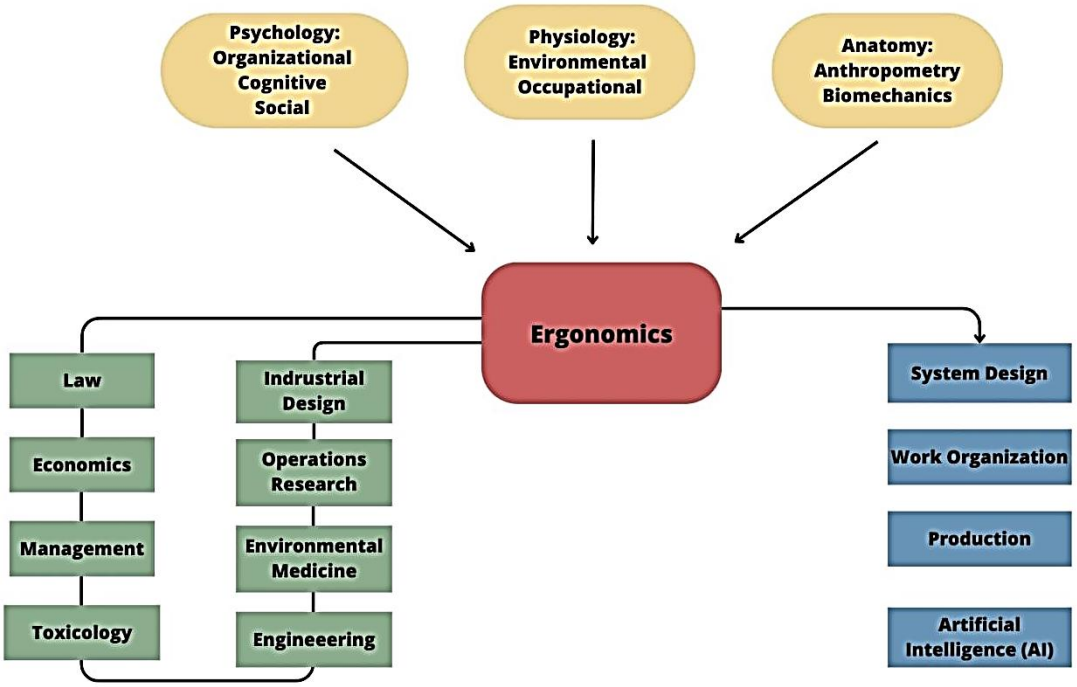

Figure 2. Simplified diagram of the concept of ergonomics.

Source: Own work.

It's also worth noting that ergonomics encompasses concepts such as law, economics, management, toxicology, industrial design, operations research, environmental medicine, and engineering, which, when combined, enable the creation of a safe work organization, appropriate system designs, production, and artificial intelligence while adhering to ergonomic principles. There are many definitions related to ergonomics created by different institutions, including the Polish Ergonomics Society, the International Ergonomics Association, and the International Labour Organization (ILO), which, along with their member groups, have created theirconcepts (Wykowska, 1994).

One of the main principles of ergonomics is to maintain a neutral posture, where the body is in a straight position, both while sitting and standing, with minimal pressure on the body and keeping the joints and spine on the correct axis. A neutral posture minimizes the strain on muscles, tendons, nerves, and bones, allowing for maximum control and energy production, working in the power/comfort zone, movement, and stretching - reducing excess energy expenditure, limiting excessive movements, contact stress, minimizing excessive vibrations, and providing appropriate lighting (https://ergo-plus.com/…, 2021).

Transitioning from OHS and ergonomics to risk management involves identifying potential hazards and implementing preventive actions to minimize risks. Risk, which accompanies every activity, is usually associated with negative consequences (Wykowska, 1994). It represents the possibility of a specific event occurring that could lead to the emergence of a threat and have specific consequences (Romanowska-Słomka, Słomka, 2014). Occupational risk involves examining the possibility of unwanted events occurring while performing work. The loss of health is an undesirable effect that can result from occupational hazards (Norma PN-N-18001:2004…). Risk assessment involves identifying hazards and harmful factors that have the potential to cause harm. Risk analysis focuses on three key tasks: risk assessment, risk management, and risk communication (Norma PN-N-18002:2000…). It involves recognizing potential obstacles and assessing risk by identifying risk that encompasses specific objects (Romanowska-Słomka, Słomka, 2014). A hazard is a potential harm that, in practice, is often associated with a condition or action that, in the absence of control, could result in injury or illness (Hazard, 2002). Hazard identification is the process of recognizing the existence of hazards and determining their characteristics (Norma PN-N-18001:2004…). Occupational exposure is a state in which employees are subject to the influence of hazardous, harmful, or burdensome factors related to their work (Hazard, 2002). Protective measures can be collective, individual, technical, or organizational and aim to minimize occupational risks (Pietrzak, 2007). "The primary goal of risk assessment is to determine the measures required by the organization to maintain and ensure the safety of employees, protect their health, and eliminate hazards leading to accidents at specific workplaces". It should also be noted that if there is no possibility of providing a 100% guarantee of eliminating risk in practice, the employer should reduce it to a minimum. "Risk assessment is intended, among other things, to prevent the effects of occupational hazards". The aim of writing method descriptions and risk assessments is to encourage the employer to plan occupational health and safety management, minimize and control risk appropriately, adhere to OHS principles, and protect employees and those who may be exposed. It is also important to present to employees and relevant authorities that the conditions at specific positions have been thoroughly considered. The goal is to demonstrate the appropriate selection of materials, workstation equipment, cleanliness during work, and a guarantee of continuous improvement in work sterility and safety (Romanowska-Słomka, Słomka, 2014). The result of the assessment should be a decision on whether the occupational risk can be acceptable in the specific position through appropriate monitoring. It may turn out that the occupational risk is high, in which case

one of the assessment outcomes will indicate the safety measures to be taken to eliminate or reduce the risk (Pietrzak, 2007).

Occupational risk assessment should be conducted by the employer for each workstation, especially when dealing with a new job position or when the assessment has never been carried out before (Romanowska-Słomka, Słomka, 2014). In chemical plants, laboratories, etc., where the main work factors involve biological, chemical, carcinogenic, mutagenic substances, and various types of preparations, risk assessment is mandatory. It's also required during the setup of a workplace, changes in protective measures, and in case of an accident at work. If there is any change in workplace conditions, an occupational risk assessment must be conducted (Pietrzak, 2007). Risk assessment can be divided into five stages. The first step is hazard identification. It's important to consider possibilities that could negatively impact the employees' health or cause harm. Conducting interviews with employees aids in risk analysis. Reviewing accident documentation and health records contributes to identifying less obvious hazards. The next step is assessing the likelihood, i.e., which employees are more or less exposed to harm. This involves selecting employees divided into different job positions. Each position has specific associated hazards. This way, injuries, and health issues associated with a particular job position can be predicted. The third step is risk assessment and deciding on precautionary measures. Controlling risk in an enterprise is crucial; access to hazards must be prevented, personal protective equipment must be provided, work should be organized to reduce exposure to hazards, and first aid equipment should be organized. Then, all steps need to be documented and implemented, providing better peace of mind for employees. The final and equally important step is updating the risk assessment. Every enterprise introduces various changes, and with them, hazards change too.

There are various methods available for occupational risk assessment that allow for accurate estimation of potential work-related hazards. Some of the most commonly used methods include Preliminary Hazard Analysis (PHA), the Five Steps Method, the Risk Matrix, quantitative methods of occupational risk assessment, and the Gibson Method. The choice of an appropriate risk assessment method depends on the specific work environment and the analysis objectives. Among these methods, Preliminary Hazard Analysis allows for a precise determination of risk level at a given job position and an assessment of whether the risk is acceptable. If the analysis indicates unacceptable risk, immediate actions to minimize the hazard are necessary. This method is applicable both in service facilities and the manufacturing sector. Its simplicity allows for a quick assessment of accident likelihood or other dangerous events during work and for determining their potential consequences. The Five Steps Method, while based on different assumptions, is also a useful tool, enabling a quantitative assessment of occupational risk and considering additional parameters that influence the assessment outcome.

The article aims is to analyze occupational risk using the Preliminary Hazard Analysis (PHA) and Five Steps Method for an operational employee performing a selected repair operation on a car within a chosen research facility.

2. Methods

The research subject is an automobile service center. Throughout the year, they repair between 700 and 1000 vehicles. The technological process, in terms of continuous improvement, depicted in Figure 3, concerns specific tasks performed by an automotive panel beater during their work. Each procedure requires the correct body posture, adherence to occupational health and safety (OHS) rules, as well as caution when using the provided tools and equipment.

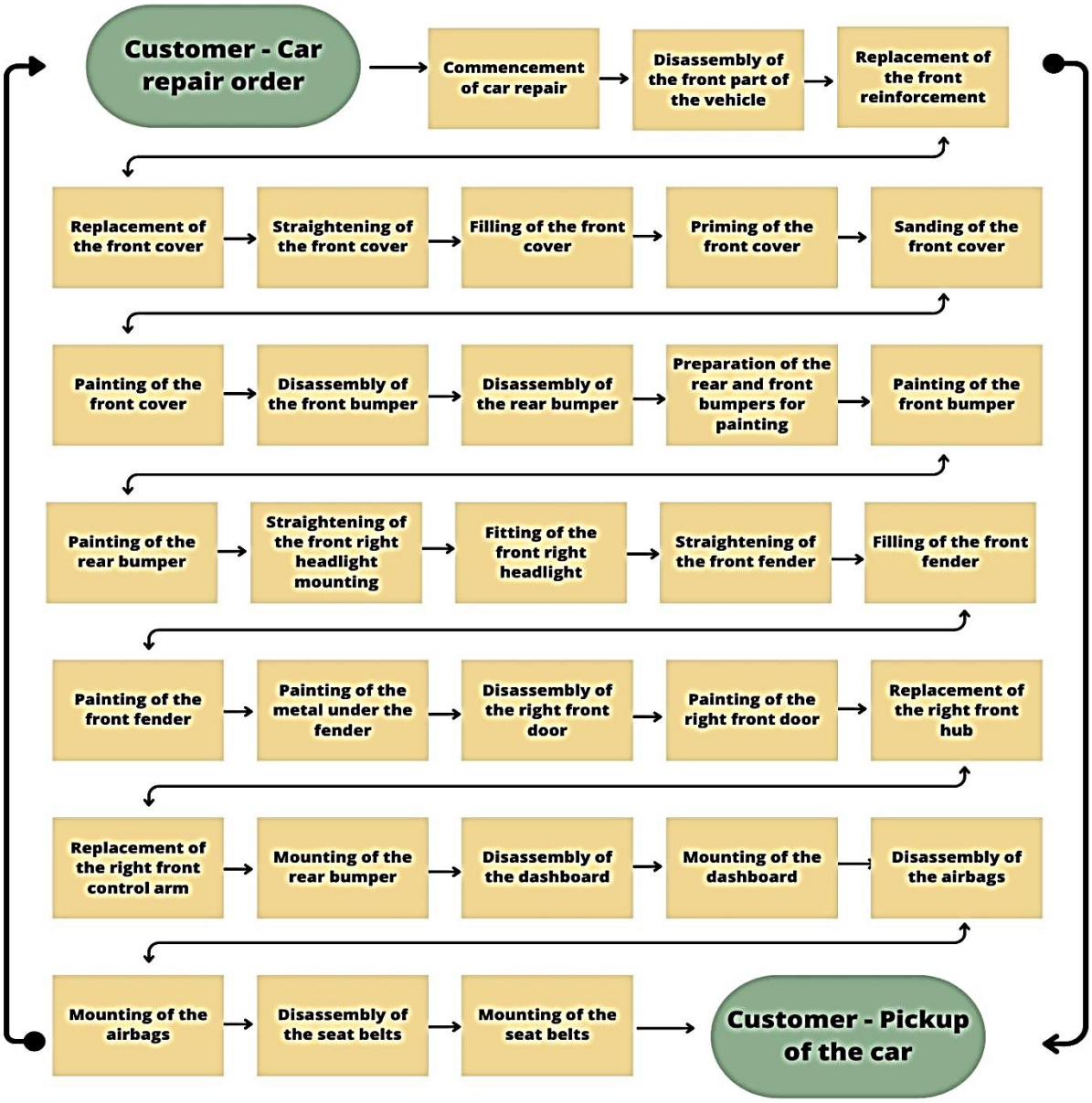

Figure 3. Simplified diagram of Deming Cycle about the technological process.

Source: Own work.

The technological process consists of various repair operations on the vehicle, starting from the customer's request and repair order to the final handover. During the execution of each task, the employee faces multiple hazards, making it crucial to adhere to OHS and ergonomic principles. The car repair process begins with disassembling the front part of the vehicle, followed by the replacement of the front reinforcement and hood. The hood undergoes operations like straightening, puttying, priming, sanding, and painting. It is essential to use proper protective clothing and paint masks during sanding and painting to prevent inhalation of harmful substances contained in the dust. Subsequent steps involve disassembling and painting the front and rear bumpers, straightening the right front headlight mount, and fitting the headlight. Straightening operations are also performed on the fender, followed by puttying and painting. The right front door is disassembled and painted. The repair process then continues with the replacement of the right front wheel hub and suspension arm, as well as the installation of the rear bumper. Afterward, the dashboard, airbags, and seat belts are disassembled and reinstalled, all within a continuous improvement cycle.

An automotive panel beater performs various production, repair, modernization, and prototype tasks involving shaping and processing sheet metal and profile sections for the automotive industry. They use specialized machinery, tools, and equipment, both manually and mechanically operated, often with control mechanisms and measurement devices (Kopańska, Chmieliński, Wierczuk, 2002).

Physical Hazards:

- Poor lighting can lead to deteriorated vision, fatigue, and headaches.
- Noise from using electric and pneumatic tools, such as a pneumatic sander.
- Infrared and ultraviolet radiation during the finishing process, particularly during drying and curing.
- Vibrations are generated by using sheet metal equipment, like a mechanical compressor.
- Electric current poses a risk of shock when using electric tools.

Chemical Hazards:

- Chemical substances present in paints, solvents, and mixtures can negatively affect health, leading to poisoning, allergies, and potentially severe conditions like cancer or skin diseases.
- Dust, including hydrochloric acid fumes and zinc oxide, is produced during sheet metal processing, depending on the materials used.

Ergonomic Hazards:

- Work posture is often forced into a bent position due to the nature of tasks, such as welding.
- Musculature strains from lifting heavy vehicle parts.

Hazards Leading to Accidents:

- Malfunctioning electric hand tools, lack of concentration on routine tasks, or using defective electrical equipment.
- Welding fragments without protective eyewear and gloves.

- Crushing risks due to faulty car frame pulling equipment.
- Burns caused by inappropriate protective clothing while using electric welders and grinders (Centralny Instytut Ochrony Pracy, 2021).

The analysis focuses on specific workstations within the automotive repair process, as depicted in Figures 4 and 5.

Figure 4. Paint Booth.

Source: Own work.

Figure 5. Car Preparation Zone for Painting.

Source: Own work.

In Figures 6-9, devices used during the repair of motor vehicles are presented. Before using any of them, it is important to ensure that the respective machine is in working order, as even a minor malfunction can lead to undesirable consequences.

Figure 6. Car Frame Straightening Machine.

Source: Own work.

Figure 7. Computer Operating the Car Frame Straightening Machine.

Source: Own work.

Figure 8. Sheet Metal Welder.

Source: Own work.

Figure 9. Welding Machine.

Source: Own work.

3. Results

Preliminary Hazard Analysis (PHA) - A semi-quantitative analysis conducted to identify all potential hazards and dangerous incidents that could lead to an accident. Subsequently, these hazards are prioritized according to their severity, and follow-up actions are developed. During this analysis, several variations of PHA are employed, including Rapid Risk Ranking and Hazard Identification (HAZID) (Ergonomia i ochrona..., 2009). PHA is a matrix-based method aimed at qualitatively determining risk associated with serious events, unforeseen situations, and hazards. This method allows for assessing the possibility of an accident occurring during a specific task and the consequences of an undesirable event. PHA results are used to compare major concepts, focus on critical risk issues, and provide input for more detailed risk analyses.

The magnitude of risk in the PHA method can be determined using the formula:

$$R = S \cdot P \tag{1}$$

where:

R - the magnitude of risk,

S - determining the magnitude of possible starts and damages,

P - determining the probability of damage or loss occurring as a result of an accident (https://ergo-plus.com/…).

The characteristics of damages and probabilities in the PHA method can be determined using six levels as described in Table 1.

Table 1.
Determination of Damage Magnitude (S) (Alli, 2008)

Level	Description of Damage
1.	Minor damage, minor injuries
2.	Severe injuries, measurable damage
3.	Severe injuries, significant damage
4.	Individual fatal accidents, severe damage
5.	Mass fatal accidents, extensive damage on the facility premises
6.	Mass fatal accidents, extensive damage on a large scale off-site

Table 2 presents the probability of damage occurrence.

Table 2.
Probability of Damage Occurrence (P) (Alli, 2008)

Level	Description of the Probability of Damage Occurrence
1.	Very unlikely
2.	Unlikely, occurring once every 10 years
3.	Occasional events, happening once a year
4.	Fairly frequent events, happening once a month
5.	Frequent, regular events happening once a week
6.	High likelihood of occurrence

Table 3 presents the risk assessment matrix using the PHA method.

Table 3.
Risk Assessment Matrix using the PHA Method (Alli, 2008)

P - Probability of Damage Occurrence							
S - Damage	**Level**	**1**	**2**	**3**	**4**	**5**	**6**
	1	1	2	3	4	5	6
	2	2	4	6	8	10	12
	3	3	6	9	12	15	18
	4	4	8	12	16	20	24
	5	5	10	15	20	25	30
	6	6	12	18	24	30	36

Values 1-3 - Acceptable - only actions based on the regulation and management principles of critical and safety-related systems are considered. Values 4-9 - Acceptable - the application of regulation and management principles of critical and safety-related systems and consideration of further research. Values 10-25 and higher - Unacceptable - risk-reduction measures are required. Risk assessment using the PHA method for an automotive sheet metal worker during the process of pulling the car onto the repaired frame involves the potential threat of chain breakage.

1. Calculating the risk magnitude using formula (Alli, 2008), using data from tables (Identifying and Addressing…, 2021) and (Szlązak, Szlązak, 2010).

   $R = S \cdot P$

   S = 4 (Individual fatal accidents, severe damage).

   P = 3 (Occasional events, happening once a year).

   Risk Magnitude:

   $R = S \cdot P = 4 \cdot 2 = 8$
2. Evaluation of Risk Level.

   The risk assessment yielded a score of 8, indicating an acceptable level of risk.

If the risk were to exceed the acceptable threshold in this case (9<), additional training for the workers would be necessary. Operating such equipment is one of the fundamental tasks in sheet metal work, so considerations extend to interns and those who are new to the profession.

Five-Step Method

The five-step method is a qualitative and index-based risk assessment approach.

Using formula 2, it is possible to calculate risk in the Five-Step Method:

$$R = P \cdot S \cdot F \cdot L \quad (2)$$

where:

R – risk magnitude,

S – determination of the magnitude of potential losses and damages,

P – probability of occurrence of damage or loss following an accident,

F – frequency of exposure,

L – number of exposed individuals.

The data provided in Tables 4-8 allow for the determination of risk magnitude.

Table 4.
Determination of the Probability of Damage or Loss Occurrence (Alli, 2008)

Value	Characteristic
0,033	Almost impossible
1,0	Very unlikely but possible
1,5	Very unlikely but possible
2,0	Possible but uncommon
5,0	Even chance
8,0	Likely
10,0	Occurs
15,0	Certain

Table 5.
Determining the magnitude of potential losses and damages (S) (Alli, 2008)

Value	Characteristic
0,1	Scratches, bruises
0,5	Cuts, minor injuries
2,0	Simple fractures, mild illness
4,0	Complicated fractures, serious illness
6,0	Loss of one limb, loss of an eye, permanent hearing loss
10,0	Loss of two limbs, loss of both eyes
15,0	Death

Table 6.
Exposure Frequency (F) (Alli, 2008)

Value	Characteristic
0,5	Once a year
1,0	Once a month
1,5	Once a week
2,5	Once a day
4,0	Hourly
6,0	Continuous

Table 7.
Number of Exposed Individuals (L) (Alli, 2008)

Value	Characteristic
1	1-2 individuals
2	3-7 individuals
4	8-15 individuals
12	16-50 individuals

By utilizing the data provided in the tables and appropriately assigning them to the formula, one can determine the magnitude of risk.

Table 8.
Risk Magnitude (R) (Alli, 2008).

Value	Characteristic
0-5	Negligible
5-50	Low, but negligible
50-500	High
Above 500	Unacceptable

Risk Assessment Using the Five-Step Method for an Automotive Sheet Metal Worker During Welding of Components That May Lead to Battery Short-Circuiting. The Potential Hazard Is a Vehicle Fire.

1. Calculating the risk magnitude using formula (2), taking data from tables 4-8.

$$R = P \cdot S \cdot F \cdot L \quad (2)$$

where:

P = 1 (Event possible but not daily),

S = 15 (Battery short-circuit could lead to an explosion and result in death),

F = 1.5 (Welding might be performed several times a week but not daily due to the nature of the damage),

L = 2 (Applies to all individuals in the service area).

2. Risk Magnitude.

$R = 1 \cdot 15 \cdot 1{,}5 \cdot 2 = 45$

4. Assessment of Risk Level

The risk assessment yielded a score of 45, indicating that the risk is negligible.

In this case, the risk falls below the threshold, signifying that the risk is negligible. However, it's important to remember that during each welding operation, protective devices must be connected to shield the vehicle's electronics from localized power surges.

All of these tasks involve various hazards, including poisoning, joint stress, injury, or even crushing of body parts. Therefore, it's crucial to exercise extreme caution and remain focused while performing each of these operations.

5. Discussion & Summary

This work focused on a detailed analysis of occupational risk using two methods: Preliminary Hazard Analysis (PHA) and the Five-Step Method. These methods were used to assess the risk levels for selected operations in the role of an automotive panel beater. Based on

the results, the risk level was determined to be acceptable in both cases, with a risk score of 8 in the first example and 45 in the second. If the risk level were to exceed the acceptable threshold, immediate risk reduction measures, including the implementation of new safeguards and protective measures, would be necessary.

Every employer should prioritize occupational risk assessment, as they bear the highest responsibility for human lives. Adhering to workplace safety and hygiene principles, as well as ergonomic principles, is crucial and the responsibility of the employer. If the risk during a job reaches a high level, employees have the right to refuse to perform their assigned tasks and to leave the workplace without facing any consequences. It's also essential to remember that while the employer is responsible for workplace safety and hygiene, employees must follow all regulations for their well-being. Therefore, reminding employees of all applicable rules at each step in the workplace is essential.

Preliminary Hazard Analysis (PHA) allows for precise result development and risk level determination, making it one of the most frequently used methods for occupational risk assessment, well-documented in the literature.

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DETERMINANTS OF RESTRUCTURING PROCESS IN DEEP DECARBONIZATION OF STEEL INDUSTRY IN POLAND

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Reasons and purpose: Decarbonizing economies is the primary goal of EU climate policy. The European Union has committed member states to achieving climate neutrality by 2050. The industry's transformation to "net zero" will require changes in many industries, including the steel industry. Decarbonization is necessary to stop global warming. Its main challenge is investment in new zero-carbon technologies. Approaching the strategic goal of 'zero emissions' of greenhouse gases by the world's economies by 2050 will require restructuring activities of economic processes, which, due to the scope of the subject matter, has been called decarbonization restructuring. The purpose of this paper is to present the determinants of steel industry restructuring in the process of climate transition.
Design/methodology/approach: The article is a conceptual analysis of the determinants of decarbonization of the Polish steel industry.
Findings: Based on decarbonization approaches, key restructuring issues were presented and framed as questions. These questions can be used to further discuss industrial restructuring in the implementation of the Net zero strategy.
Originality/value: Decarbonization is a very current industry issue. In Poland, the main source of electricity is coal (about 70% of energy is generated from the natural raw material). Deep changes are driven by the need to move completely away from steel produced from fossil fuels to sustainable steel (the term sustainable steel refers to steel produced with low-carbon and, in the future, zero-carbon technologies). The policy of moving away from coal will radically change technological processes in many industries. Among the industries included in the decarbonization program is the steel industry (coal is a reducer in the metallurgical process of the blast furnace). Global capital groups in the steel market have already initiated research and testing of new technologies for producing zero-carbon steel.

Keywords: decarbonization, steel industry, restructuring process.

Type of paper: Viewpoint.

1. Introduction

Decarbonizing the economy is a key objective of EU climate policy. Implementing the Paris Agreement of 2015, the European Union committed in December 2019 to achieving climate neutrality by 2050. This means that all economies must radically reduce greenhouse gas emissions according to the "Net Zero" strategy proposed in the European Green Deal. Achieving "net zero" is a challenge for many industries in the European market. The announced policy, which is called "Deep Decarbonization", has left no blank space on the map of transformation of the economies of the member states. Deep decarbonization is be achieved across all energy-intensive industries, as well as transport, energy, agriculture, construction and other carbon footprint industries. All economies that are described as "Green Economy", must be free of greenhouse gas emissions. The changes will be radical and profound, due to the amount of investment and the level of innovation. Carbon-neutral technologies and technologies to capture carbon dioxide from the atmosphere (CCU) have to be developed. In the coming years, CO_2 emission reductions will accelerate strongly. The adopted direction of environmental policy will force radical restructuring changes at many companies in the industrial markets.

Industrial restructuring is not a new concept in the Polish economy. In the 1990s, many sectors of industry that were strategic for the country's economy were undergoing radical restructuring process, which was a necessity to reform the economic system. That restructuring process that was enshrined in the government's recovery programs and was based on internal recovery measures. Restructuring, at that time, had a wide scope because it concerned both the company's assets and their sources of financing (Gajdzik, 2009). The form of restructuring, dating from the 1990s, was mandatory, i.e. imposed on companies by statutory provisions. Recovery programs were instruments for implementing the government's policy in the transformation of the economic system. After the completion of the radical restructuring, the companies embarked on a development restructuring, in which the existing quantitative restrictions (staff reduction, expenditure reduction, outsourcing, asset sale, production volume reduction, withdrawal of uneconomic technology) were replaced by qualitative measures (staff development, production assortment development, process optimization, insourcing, etc.) (Gajdzik, Ocieczek, 2015). That industrial restructuring enabled companies to restore, through fundamental changes, fundamental internal and environmental equilibrium (with political, legal, economic, environmental, technological and social requirements) (Borowiecki, 1997; Bitkowska, 2010).

After three decades since the introduction of the free market economy, due to the very strong interference of regulation, in European climate policy, forcing technological changes that would have progressed much more slowly on their own, interference is probably necessary, companies in many industries will be forced to carry out a renewed remedial restructuring. What will be

the characteristics of decarbonization restructuring of industries? To answer this question, a case study of decarbonization of the steel industry in Poland was used. The conditions were used to formulate rhetorical questions about the extent of deep corporate restructuring in the transformation of Polish steel industry according to the European Climate Policy.

2. Decarbonization of the Polish steel industry in strategic directions

The policies of the European Union indicate the very difficult path of transformation that the Polish and European metallurgy (steel industry) must take. The inevitable need to produce "green" steel means abandoning steel smelting using coke. In Poland, steel is produced using two technologies: blast furnace and converters (abbreviation: BF+BOF) and electric-arc furnaces (abbreviation: EAF). In the country, more than 50% of steel per year is produced in integrated mills, i.e. mills with blast furnaces, and slightly less than 50% in electric steel mills. The steel mills with the largest production potential are owned by global capital groups (the result of the restructuring of the iron and steel industry and the privatization of steel mills in the 1990s and beyond) (Gajdzik, 2009; Gajdzik, Sroka, 2012). The Polish steel industry employs more than 20 thousand people, a significant part of them work in integrated steelworks, i.e. strongly emitting CO_2. The largest employer on the Polish steel market is a metallurgical company established on the basis of the Polish Steelworks (during the restructuring of the iron and steel industry in Poland) and currently owned by foreign capital. In recent years, the Polish steel market has been shaken by two events: 1) the COVID-19 pandemic, which resulted in the disruption of supply chains, 2) the war in Ukraine and the restriction of supplies from that country, as well as the blockade of supplies and trade with Russia. The pandemic period was not as difficult for steel mills as the war in Ukraine. At the end of the pandemic (the third and fourth quarters of 2020), steel production increased, and the pandemic crisis itself, in terms of the volume of steel produced in Poland, was milder than the economic crisis of 2009 (the aftermath of the U.S. real estate and banking crisis in 2008) (Gajdzik, Wolniak, 2021). The outbreak of war in Ukraine and the continuation of hostilities, caused a higher increase in material and energy prices than in the crisis, and as a result, a high increase in the cost of steel production (Podsiadło, 2023). Steel prices were reaching maximum levels and there was still a shortage of products. The market was unable to accept the new prices and the biggest problem was the implementation of long-term contracts, which had to be renegotiated. In conditions unfavorable to the development of the steel market in Poland, steel mills are beginning to decarbonize technological processes.

Steelmaking is expected to produce "green" steel. As of today, there is no universally accepted definition of the term, and it is most often used to describe steel products that are produced in sustainable production (e.g. high recycling rate - use of steel scrap or use of "green"

energy). In recent years, the term "green" steel refers primarily to the use of new steelmaking technologies that reduce the balance of CO_2 per ton of steel (current ratio: 2t CO_2/1t steel) (IEA, 2020). Steel production from iron ore is carried out using coke in a blast furnace. "Green" steel in this case means reducing the carbon footprint by implementing alternative production technologies based on "blue" hydrogen, and ultimately on "green". The reference point for "green" steel is the concept of “Carbon Footprint”. The Product Carbon Footprint (PCF) defines the total greenhouse gas emissions generated by a product, from raw material extraction to the end of product life. It is measured in carbon dioxide equivalents (CO2e). Unfortunately, today there is no market for green steel, which means it has to be created from scratch, especially in coal-based countries, of which Poland is one (Kawecka-Wyrzykowska, 2022). In Poland, coal is a major source of greenhouse gas emissions, largely due to its key role in various areas of economic activity, particularly in the production of electricity and heat. In 2020, installed coal-fired electricity capacity accounted for 66% of all electricity generation capacity (of which hard coal accounted for 48% of capacity and lignite for a further 18%), renewables for 27% of capacity and gas for 6% (IEA, 2022, p. 105). Thus, Poland's electricity comes mainly from coal, although between 2010 and 2020 the share of this fuel declined from 87% to 69% (IEA, 2022, p. 121). The steel industry is one of the most energy-intensive and carbon-intensive industries. The production of one ton of steel produces two tons of CO_2 (World Steel Report, 2022). In Poland, the high carbon intensity of steel mills, is a result of the economy's high dependence on fossil fuels, especially coal. It has a dominant share in the production of electricity and heat, and is the reductant used in blast furnace technology For smelters in Poland, the move away from coal-based blast furnace technology, whose reductant is coal, and replacing it with a new Direct Iron Reduction technology (DRI) (Gajdzik et al., 2023). The phasing out of blast furnace technology will cause the world's steel industry to convert to electric production. Smelting steel in an electric furnace means building at least several such furnaces in Europe. In addition, electric furnace steelmaking technology is based on steel scrap, so the question: Will scrap suppliers be able to provide steel mills with a steady supply of this raw material? Scrap metal is becoming a strategic raw material, and it is doing so on a global scale, as trade in it has become global. The global nature of the raw material has caused scrap prices to soar in recent years. Currently, the price of scrap metal is able to exceed 2 thousand PLN, for comparison, in the 1990s, 100 PLN were paid for a ton of scrap metal. In addition to scrap in recent years, energy prices have risen from 0.3 euro/kWh to 0.6 euro/kWh, variable gas prices as a result of the deliberate actions of Gazprom artificially limiting supply in the Union market (gas quotes for TTF oscillated in the spring of 2021 in the range of $250-300 per thousand cubic meters, at the end of the summer of 2021 they exceeded $600, and in the autumn already $1,000 as well as CO_2 prices (in April 2020 they were at 20 euros per ton, in February 2022 it was almost 100 euros, in September they fall to approx. 65 euros per ton, and the average for 2022 is about 84 euros per ton (Gajdzik et al., 2023).

Decarbonization is a process of moving away from coal, which means that the Polish steel industry will have to consume more electricity, gradually abandoning the use of coal and coke. The production of green steel requires gigantic amounts of electricity, both to melt the raw material in the furnaces and to produce hydrogen. In deep decarbonization, coal cannot be the source of energy because it emits CO_2. Poland need green energy to change the industry but diversification of energy sources in Poland is poor. Poland does not have a nuclear power plant capable of supplying energy-intensive industries. So far, the investments are still at the project stage. Will nuclear power solve the problem of energy supply for energy-intensive industries in Poland?

The target direction of decarbonization of metallurgy is the use of "green" hydrogen in steel manufacturing but to obtain hydrogen (hydrogen as a reducer in steel processes) is needed "green" energy. Experts estimate that the decarbonization of metallurgy could cause an almost double increase in energy demand (Dzienniak, Zagórska, 2021). The rapid increase in energy demand will occur during the first stage of decarbonization of steel production, the transition from blast furnace technology to electric technology. The new DRI-EAF technology needs an energy supply. The development of DRI-EAF technology is a key strategy for the steel industry's participation in a climate-neutral Europe, and this strategy needs renewable energy to achieve the Green Deal goal of "net zero" (Eurofer, 2022).

In addition to investments directly related to the replacement of steelmaking technology, the steelworks will also be involved in the process of capturing carbon dioxide from the atmosphere. Carbon Removal (CDR), Carbon Capture and Storage (CCS) and Carbon Capture and Utilization (CCU) technologies will help industry achieve climate neutrality. Decarbonization also requires improved energy efficiency in this industrial sector. While this is not enough to decarbonize industry, energy efficiency will significantly reduce energy-related emissions (Gajdzik, Sroka, Vveinhardt, 2021).

3. Restructuring in deep industrial decarbonization strategy

Restructuring is a complex, interdisciplinary phenomenon of interest to many researchers. In the Polish literature, restructuring issues are dealt with, among others, by: R. Borowiecki, A. Bitkowska, S. Lachiewicz, A. Nalepka, B. Pełka, C. Suszyński, Z. Sapijaszka, Z. Malara, I. Durlik. In foreign literature we can mention such authors as: E.H. Bowman, H. Singh. Modern restructuring is a part of the Green Growth assumptions, as restructuring reforms leading to development in line with the Green Economy assumptions (macroeconomic perspective). European studies are available on this subject, e.g. Cevik and Jalles (2023) and international (Wiese et al., 2023). In addition, individual sectors of the world's economies adopt detailed rules for sectoral restructuring, e.g. the publication on the restructuring of the energy sector in

Japan (Jonesi, Kimi, 2013), as well as individual regions (Jakobsen et al., 2021), Isaksen et al., 2019). The growing popularity of restructuring process in recent years relates to the development of so-called green technologies and green conomies (Fløysand, Jakobsen, 2017). The word "green" in the last two decades has been a determinant of the development strategies of economies, industries and companies (Grillitsch, Hansen, 2019). In companies, the restructuring process involves a range of activities, from rescue (which is the most common application), to adjustment and development. The restructuring process can be implemented in selected areas of activity (e.g. human resources, the sphere of management and organization, the structure of fixed assets or operating costs), as well as it can cover all areas of the company's activity. It can be of the following nature: ad hoc, or adaptive, related to the preservation of the company's existence; or prospective, or anticipatory, related to the creation of conditions for the long-term development of the company. The main objective of the restructuring process is to obtain a better strategic position of the enterprise in the market and achieve more favorable economic results (Suszynski, 1999). The determinant of restructuring is the business environment, which has recently been very turbulent (Reilly et al., 1993). In the very dynamic environment, restructuring process is constantly the company's response to signals coming from the environment (Gajdzik, 2012). In restructuring process, companies undertake radical measures enabling them to maintain their strategic position on the market while ensuring competitiveness against other market participants (Spiżyk, 2017). If the process is carried out effectively, companies can reverse unfavorable trends and improve their economic situation. Once the restructuring process is completed, the enterprise again has a foundation and opportunities for growth. Restructuring changes can involve a single enterprise, be related to the continued development of business or the failure of previous investments. It can also involve the entire sector or certain segments of it. In the process of decarbonization, there are clear differences between sectors, with some more susceptible than others to the pressures of decarbonization (such sectors include the iron and steel, cement, chemical and petrochemical, pulp and paper, fertilizer, glass, ceramics, oil refineries and non-ferrous metals (mainly aluminum) industries (Opinion of the European Economic and Social Committee, 2022). An analysis of the industry's decarbonization force field can be implemented using these industries as an example. Such analyses will influence their internal restructuring course.

In decarbonizing industries, the scope of restructuring will be broad. According to the scope, micro-, macro- and sectoral restructuring were distinguished. The division was proposed by B. Pełka in the 1990s (Pełka, 1992) in the restructuring process of the Polish economy. Decarbonization at the micro level is implemented at specific power plants, steel mills, mines and other plants (factories) that use coal, either as a source of energy supply or in technological processes. Macro-restructuring is aimed at achieving long-term climate policy goals of zero CO_2 emissions by 2050. The domain of this restructuring will be profound transformations in individual divisions of the national economy, not only in industry, but also in agriculture, transportation, services, such as tourism. Energy transformation is inevitable for climatic,

economic, health, national security reasons, also the rapidly aging current coal-based infrastructure. Sectoral restructuring is positioned between micro- and macro-restructuring. One of the key scopes of sectoral restructuring is the (already happening) decarbonization of the steel industry, decommissioning of mines, ways and sources of energy supply (distributed grids, green energy), and in the future construction of micro nuclear power plants in Poland.

The restructuring process in the decarbonization strategy is strongly linked to technological change. The deep decarbonization of industry is a complete shift away from carbon-emitting technologies to "green" technologies, i.e. low- and zero-emission technologies. Poland is one of the most energy-intensive and high-emission EU Member States (15% of total EU greenhouse gas emissions come from Poland) (Kawecka-Wyrzykowska, 2022). For Polish companies, adaptive or corrective restructuring must be carried out in the process of decarbonization. Failure to carry out structural changes in a timely manner, or to carry them out only piecemeal, will be the main cause of transformational delays in the Polish economy.

The restructuring process at the company level (steel mills, mines, power plants, thermal power plants, cement plants, chemical plants, etc.) must be implemented at all operational levels. C. Suszynski (1999), in a former division, points to financial and ownership restructuring in addition to operational restructuring. Operational restructuring is implemented at the level of production, trade, procurement, distribution. Operational changes are related to the company's processes and resources (people, physical assets, organization). Decarbonization forces changes in manufacturing and/or power technologies in the production process. In broad terms, the restructuring process requires changes in entire supply chains, e.g. coal (mine), energy (thermal power plant), steel mill (steel producers), cars (automotive plants).

During technological restructuring, high-emission technologies will be phased out and new, high-tech, green and energy-efficient technologies will be introduced. Within it, the modernized - radically changed - machine park will be. Technological investments will be accompanied by changes in the production profile (new raw materials, new materials and products). Additive manufacturing already makes it possible to manufacture products with high functional and quality parameters. As decarbonization intensifies, investment in technological innovation will be very high, which may result in financial and ownership restructuring. SMEs will find it more difficult to invest in new technologies than strong capital groups, which is why the SME sector needs government support during the decarbonization period.

Entering companies into deep decarbonization already requires changes in their strategies. Deep decarbonization is geared towards achieving long-term effects and is a complex process involving the transformation of entire economies, with relevant provisions appearing in business strategies. Due to the seriousness of the problem, deep decarbonization must not take place under conditions of uncertainty and pressure of time, but must be a planned action structured and implemented in many areas of business activity of companies and institutions, concentrating the organizational effort on researching new technologies and their commercialization. A technology audit will be a helpful tool for companies on their way to

a net zero strategy (Gajdzik, 2022). However, in order for companies to be able to achieve deep decarbonization at home, they need to be given the opportunity to achieve zero-emission technology. In Europe's climate policy, it is assumed that deep decarbonization will be implemented comprehensively over the next decades. New manufacturing technologies, new energy sources, new energy infrastructure, etc. In companies, decarbonization will be based on the concept of reengineering (Durlik, 1998) , i.e. creating companies from scratch, but this time taking into account new principles of "deep" engineering aimed at rapidly reducing CO_2 emissions.

Technological restructuring should be supported by organizational and personnel changes. Green restructuring needs new competencies of employees and even new professions. Green employment is an opportunity for the development of the human factor (COM2014). The expansion of "green" jobs is considered in relation to the prospects of combining concern for growth, equity and sustainability with proactive urban and regional policies (Stilwell, Primrose, 2010). Green jobs are defined as direct employment created in economic sectors and activities that reduce environmental impacts and ultimately bring them down to levels that are sustainable (Poschen, 2008).

During the transition of the industry to "net zero" in the market, there will be companies that will be successful i.e. their restructuring will be active. The second group will be formed by companies that will block or postpone the implementation of changes. In such companies, restructuring will be passive, especially during the initial period of transition. The third group will be companies that actively participate in the transformation, but do not achieve economic or social efficiency (ambiguous restructuring) (Wawrzyniak, 1999). Deep decarbonization is inductive, that is, it is forced on companies by superior policies, so restructuring is also inductive - the company is forced to change. Autonomy of restructuring is strongly subordinated to inductiveness, which means that restructuring processes must have (and some already have) the support of superior institutions, in the form of funding for research and testing of new technologies, participation in technological projects and work of expert teams according to EU program initiatives (H2020, Eureka, SPIRE and others).

4. Key problems of industrial decarbonization on the example of steel industry in Poland

The steel industry is currently one of the major emitters of CO_2 (7% of global emissions). CO_2 emission indices for Polish steelworks are currently among the lowest in the world, regardless of the geographical location of the plant (REASteel). In the context of the phase-out of coal, steelworks will have to radically change their technological processes in the coming years. The radical changes are due to the need to completely move away from blast furnace

technology (more than 50% of steel in Poland is produced using blast furnace and converter technology, i.e. integrated smelters), towards electric furnace technology. On the European market, projects of key importance for the steel industry are being implemented based on direct reduction using hydrogen.

The main challenges of the energy transition are the very high costs of carrying it out. Businesses may experience a lack of a long-term implementation concept and legal loopholes that make it difficult to implement. Access to external financing for investment is particularly important for economic activity in the process of deep decarbonization, as the necessary adjustments involving investment may be delayed or hindered by limited access to external funds. Such access to finance is affected not only by capital markets or public financial support, but also by other regulatory factors, e. g. job creation for restructured steelworks, mines, power plants, etc. About 10% of people in Poland are employed in sectors that will undergo radical decarbonization changes. Poland is at the forefront of EU countries in this respect, ahead only of Slovakia, Czech Republic, Slovenia and Romania (Spotdata, 2019).

However, the European Commission's experience to date on the course of restructuring processes in Europe shows that practices in this area are reactive rather than anticipatory and proactive; they may take place too late in the decision-making process and do not involve external actors at a stage early enough to enable them to carry out restructuring effectively (KOM, 2012). J.E. Bethel, J. Liebeskind (1993) see the main reason for passivity as the intensification of radical changes in a short period of time, based mainly on assumptions of theory without practical solutions. Changes based on the conflict of interests of the principal and the agent do not bring the expected results. As part of the social dialogue, the Commission wants to hear the views of all stakeholders on good practices for decarbonizing specific industries. The restructuring process must be based on (1) anticipation of decarbonization trends, (2) preparation and management of restructuring processes based on the latest methods and techniques, including simulation and computer models (digital twin), (3) evaluation and reporting; (4) the role of social dialogue and (5) review of the situation and activity of decarbonization efforts.

With regard to the adopted directions of transformation, questions arise concerning the steel industry in Poland (based on: spotdata.pl/blog/2019).

1. Will the capital groups – owners of steel mills in Poland, be investing in new technologies in Polish steel mills?
2. Will steel mills be able, in a carbon-based economy, to realize of decarbonization with the success?
3. Will steel mills receive strong support from governmental institutions during the deep decarbonization?
4. How many workers, so far employed in the largest steelworks in Poland, will lose their jobs?
5. How will the steel market in Poland change?

6. Will decarbonization not cause a sharp increase in the costs of operating on the Polish steel producer market?
7. How will the decarbonization of industry affect the increase in prices of raw materials, energy and final products?
8. What will be the risk of the investment, or are companies able to estimate it, by having access to information on the costs of decarbonizing industry?
9. Does the chosen direction of investment in steelmaking technologies using steel scrap and the switch to steel production based on scrap mean a reduction in the demand for iron ore-based steel?
10. With the increase in demand for steel scrap, will the demand by far exceed the supply, and will the mills be able to ensure the continuity of production?
11. Will the raw materials and energy markets not shake?
12. Will the energy industry be able to supply renewable energy to steelworks?

Production of green steel requires additional energy capacity. In smelters for smelting the raw material in furnaces and (finally) hydrogen production. A further question is therefore justified as to whether excessive political interference in the structure of the energy transition will not make it very costly. The questions formulated may initiate a discussion about the course of deep decarbonization in Poland. How will decarbonization take place in industries and enterprises?

The steel industry is a strategic industry of the Polish economy. Decisions on changes in steelmaking technology in accordance with the guidelines of climate policy must find economic justification. The questions formulated in the publication should be considered in the restructuring of the industry. We should add that moving away from coal and basing the economy on non-carbon sources is not only a high cost, but also an opportunity for Polish companies arising from the need to produce many new products and provide services. The steel sector can produce structures for energy-efficient installations based on new technologies. A significant increase in the role of clean energy sources would also enable employment growth in new areas of production and services related to the operation of new facilities, their programming, monitoring, etc. Renewable sources of energy will not provide all the energy, controllable sources of energy will be needed, and after the elimination of fossil fuels, nuclear energy will appear in Poland for the first time and the nuclear power market will develop.

5. Conclusion

Restructuring, as a process of change and one of the many methods of maintaining the competitiveness of companies in a dynamic environment, is an opportunity for companies to activate corrective, adaptive, or development activities. It is characterized by such features as: the need to adapt the activities of the enterprise (core business) to changing conditions in the environment (especially when the effectiveness and efficiency of the enterprise are at a low level). In decarbonization restructuring, the fundamental changes will be in power supply production technologies, as well as in zero-carbon technologies and CO_2 capture (CCU). The decarbonization of industry will result in permanent changes in the economies of EU countries with a very broad impact on other economies. A peculiar feature of the restructuring changes determining the essence of the decarbonization process is the external driving factor (the European Climate Policy guidelines). Another feature is radical - the state of industries and businesses after a decade (the sub-goal by 2030, referred to as Fit 55) of major restructuring will be significantly different from the state before restructuring. The next decades will intensify the move toward zero greenhouse gas emissions by users. The deep decarbonization enshrined in the net zero strategic goal will be a revolution for many industries - the result of the changes introduced as part of the restructuring process will be the use of entirely new solutions (technologies) that break with the past. The EU's climate neutrality is being implemented comprehensively and multidimensional - restructuring changes will involve all areas of the functioning of economies (restructuring of energy-intensive industries will entail changes in dependent industries and product user markets). Decarbonization of industry is a long-term process - the effects of comprehensive restructuring will be visible over the next three decades. New investments, due to their scope and high level of innovation, are costly - the feature of costliness - restructuring changes are characterized by high costliness and not only in strictly financial terms, but also in social terms (loss of jobs for some employees, the need for retraining, a decline in real wages). The deep decarbonization of the industry leaves no enterprise unchanged, whether directly or indirectly, so its feature is its universality (massiveness) - it will affect virtually every enterprise. Restructuring must be well prepared, and its introduction must be preceded by thorough analysis. Planning - effective introduction of restructuring changes requires careful planning of activities in advance. The above-mentioned characteristics are a conceptual result based on the classification prepared by Innam (2002).

Decarbonization and restructuring will be a symbiosis of remedial changes to the environment, which must be "for us and for future generations" (quoted in the Brundtland Report).

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UNETHICAL NEGOTIATOR BEHAVIOR DURING NEGOTIATION PROCESS

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Purpose: The main objective of the study is to identify the causes of unethical negotiator behavior during negotiations.
Project/methodology/approach: An interview questionnaire was used in the survey. The survey was conducted through a random selection of a sample. The electronic survey was conducted in April 2023. The questionnaire was completed by 100 people, who use negotiation techniques in their professional work. The study is of a pilot nature.
Results: The analysis of the survey results shows that there are at least several reasons why negotiators choose unethical practices. Respondents' attitudes toward unethical behavior ranged from immediate reactions to wait-and-see attitudes.
Originality/value: The analysis of the literature leads to the conclusion that there is not much research on the reasons for unethical behavior in negotiations. The article is addressed to researchers dealing with the topic as well as negotiators - practitioners interested in this issue.

Keywords: negotiation, ethics, unethical behavior, tactics.

Category of the paper: Research paper.

1. Introduction

Negotiations are understood as talks aimed at reaching an agreement between the parties, resulting in the conclusion of a contract. Parties involved in negotiations seek agreement when they have common interests, some of which are shared by the parties, while others are opposing interests (Fisher, Ury, Patton, 2023). Negotiations, are also a sequence of mutual actions through which the parties seek to obtain a favorable solution to a partial conflict (Nęcki, 2013). The guarantee of achieving mutual satisfaction is an honest and reliable exchange of information. Negotiations play an important role in the operations of organizations. The ability to conduct talks often determines the establishment of new contacts and further cooperation between companies. A variety of tactics are used in negotiation practice to help achieve the desired goal. However, many of these raise ethical concerns. The purpose of this article is to

present negotiation tactics with particular focus on unethical tactics and to identify the reasons for using behavior that does not comply with the principles of the negotiation process.

2. Negotiation ethics

Ethics is understood as a set of moral assessments and norms adopted by a given society (Lewicki, Barry, Saunders, Minton, 2008). To be ethical is to act in accordance with prevailing norms, accepted principles, to follow recognized moral guidelines and to be guided by good intentions and good faith. The philosophical doctrine on morality distinguishes between theoretical, normative, applied and descriptive ethics.

Theoretical ethics deals, i.a., with defining moral value and determining which values can be called moral.

Normative ethics states what is morally right and what is morally wrong and, on this basis, generates directives or norms of positive behavior.

Descriptive ethics concerns people's actual behavior and moral beliefs.

Applied ethics deals with tools through which to influence the formation of moral attitudes.

Negotiation ethics refers to business ethics. During negotiations, it is worth paying attention to the dialogic ethics, understood as the general principles by which negotiation talks should be conducted. Negotiations always occur whenever a conflict of interest occurs. Competitive perceptions of participants in a negotiation situation are quite normal. Opposing interests consequently enforce a sense of competitiveness. Competitiveness results in a mutual rivalry between the parties. It should be noted that the more competitive are found in negotiations, the stronger the tendency towards unethical behavior.

Negotiation ethics consist of the ethics of process, the ethics of division, the ethics of representation and the ethics of intervention. Process ethics deals with the course of negotiations in three stages: preparatory, primary and finalizing (Kałążna-Drewińska, 2006).

The ethics of the process include the ethics of lies, or false statements, and the ethics of tactics.

The ethics of division answers the question of what criteria for division will be fair, that is, it concerns the ethical evaluation of the results of negotiations.

Ethics of representation deals with issues of fairness to those being represented, such as the attitudes of attorneys toward clients.

The ethics of intervention concerns fairness to those who are helped to reach an agreement, such as mediators involved in resolving a negotiation impasse.

It is worth noting that the first stage of negotiations covers a number of aspects and in fact ethical issues can be raised in any of them. These include defining the main and secondary objectives of negotiations, obtaining information on individuals and companies. Moral dilemmas can arise in any of the situations mentioned. One of them is that negotiators set goals that consider only their own interests. The next step is to gain knowledge about the negotiators so that in the future you know what tactics to use against them. A number of them are manipulative and often serve to win their sympathy. This is because the positive emotions of negotiators influence their perception and interpretation of the offer presented to them.

According to J. Kaminski (Kamiński, 2009) we can divide unethical behavior into three areas:

1. The area of dishonest information exchange:
   - using unauthorized methods to obtain information regarding the other party to the negotiation, such as stealing documents, using wiretapping, spy cameras, etc.,
   - dishonest self-presentation - falsifying information about the negotiator's competences, skills and credibility,
   - bluffing - falsifying true intentions,
   - falsification - creating incorrect conclusions,
   - fraud,
   - selective disclosure of information and data,
   - acting to the detriment of the represented party,
   - the pretense of impartiality.
2. An area of dishonest persuasion:
   - giving gifts and bribes,
   - undercutting the credibility of the other party by using slander,
   - exerting psychological pressure - time-pressure tactics, using threats,
   - inducement to adopt a position detrimental to the interests of the other party,
   - making decisions without agreement - in the case of unfair mediation.
3. The area of application of unfair criteria for evaluating the negotiation situation:
   - abusing one's position - demanding concessions for oneself, making demands under threat of abandoning negotiations,
   - failure to adhere to the negotiation rules established in the negotiations,
   - using different evaluation criteria with reference to one's own position and that of the other party,
   - manipulating the criteria for division.

3. Typology of manipulative negotiation tactics in light of research

Unethical behavior in the negotiation process is a fairly common practice. Analyzing the literature and empirical studies, R.J. Lewicki and R.J. Robinson proposed a typology of manipulative negotiation tactics, on which they based the construction of a scale to measure their perception SINS (Self-reported Inappropriate Negotiation Strategies). In his considerations, Levitsky assumed that these tactics are based on lies, i.e., "conveying intentionally deceptive information" aimed at gaining negotiating advantage. The classification of lie-based tactics proposed by the aforementioned authors is as follows (Lewicki, Barry, Saunders, Minton, 2008):

1. Camouflaging one's position - e.g., giving a false point of resistance in negotiations, below which one cannot go. In studies conducted back in the early 1970s, it was also established that inflated demands are an effective means of winning greater concessions from the other side.
2. Bluffing - is making false assurances or threats, i.e., making promises that conditional on the other party behaving in the way expected by the bluffer. In fact, the bluffer has no intention of making good on the conditional promise.
3. Falsification - for example, by knowingly providing financial analysis based on falsified data that puts the company in a more favorable light, presenting falsified evidence and certificates, and false guarantees, which consequently changes the opponent's position.
4. Distortion - involves the manipulation of the negotiator's rational thinking and inference, leading the interlocutor to draw erroneous conclusions. This may include, e.g., omission of certain unfavorable issues, selectively citing arguments that cause an unfavorable decision made by the other party.
5. Selective disclosure of information or misleading parties to negotiation. By exerting influence on those indirectly involved in the negotiations, the aim is to make them resist or favor a given form of arrangements (e.g., negotiations of trade unions with representatives of company managements or public administration involve members of a given professional group, who with their reactions shoot down some proposals of the other side).

R.J. Anton stated that camouflaging one's position is seen as most ethical, bluffing is seen as neutral, with fraud and finally forgery seen as extremely unethical (Kowalczyk, 2017).

Different perceptions of the degree of unethicalness of manipulative tactics are influenced by, i.a.:

- profession,
- age,
- gender,
- cultural differences.

R.J. Anton found that differences in perceptions of the ethicalness of these behaviors depend on the professional group. He said that people associated with business are more liberal in their views than other professions.

The same study concluded that bluffing was perceived as less ethical by younger and older people compared to middle-aged people, and by those with 3 to 5 years of work experience compared to those with shorter or longer work experience. In contrast, older respondents rated fraud as significantly less ethical than younger respondents.

Research by R.J. Anton also showed that bluffing and fraud were perceived as less ethical by women compared to men.

There are also cross-cultural differences in the perception of unethical negotiation tactics. For example, Chinese negotiators are significantly more tolerant than North American ones. The cultural dimension also influences the assessment of negotiation process according to the rival strategy and its characteristic methods of manipulation, making it more acceptable in Middle Eastern countries than in Asia, Western Europe or Latin America. There was also greater acceptance of them in the United States than in Europe. Similarly, bluffing was more accepted among Americans and Asian negotiators than European ones (Lewicki, Barry, Saunders, Minton, 2008). The ethical aspects of negotiating are strongly culturally conditioned, and when going from country to country, negotiators may doubt whether their behavior is acceptable to the other side. Sometimes they are forced to use methods that are seen as unethical in their cultural circle, but when they reach for them, the intended goal can be achieved. What hinders cross-cultural negotiations is the adoption of one's own perspective as the dominant one and the desire to subordinate the conduct of the other party to one's own ethical standards (Kowalczyk, 2017). Such a course of action is doomed to failure, as negotiations need to develop a common model, sometimes deviating from culturally ingrained principles or even abandoning the talks. Thus, the evaluation of the ethical side of negotiations varies by method as well as by profession, gender, age and seniority, and national culture. However, the cited studies show that there no situations occur in which any of the groups surveyed completely condemn all types of manipulation equally.

4. Reasons for unethical behavior of negotiators

4.1. Research sample characteristics

An interview questionnaire was used in the paper. The electronic survey was conducted in March 2023. The questionnaire was completed by 100 people. The selection of the test sample was deliberate. The survey aimed to answer the question of whether negotiators behave unethically during negotiations, and if so, what are the reasons behind such behavior. The study is of a pilot nature.

The survey included 29 women and 71 men who are responsible for negotiating with contractors in their companies. They were, for example, sales representatives, lawyers and salesmen. All respondents hold a university degree and have more than one year of work experience.

4.2. Results of own studies

When asked: "Do you behave unethically in your negotiations?", 55 people confirmed, 33 — denied, 12 had difficulty answering (Figure 1).

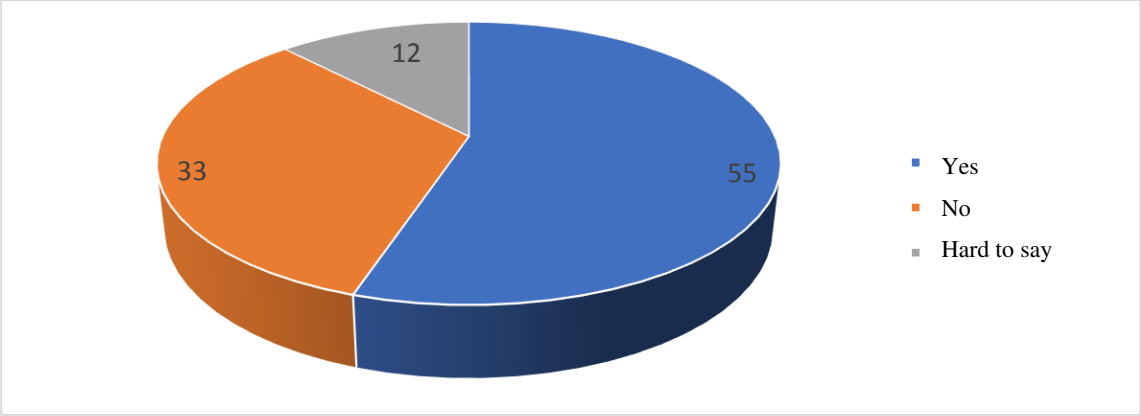

Figure 1. Number of respondents behaving unethically.

Source: Own elaboration.

Why did negotiators behave unethically in negotiations? Nine answers were available (Figure 2).

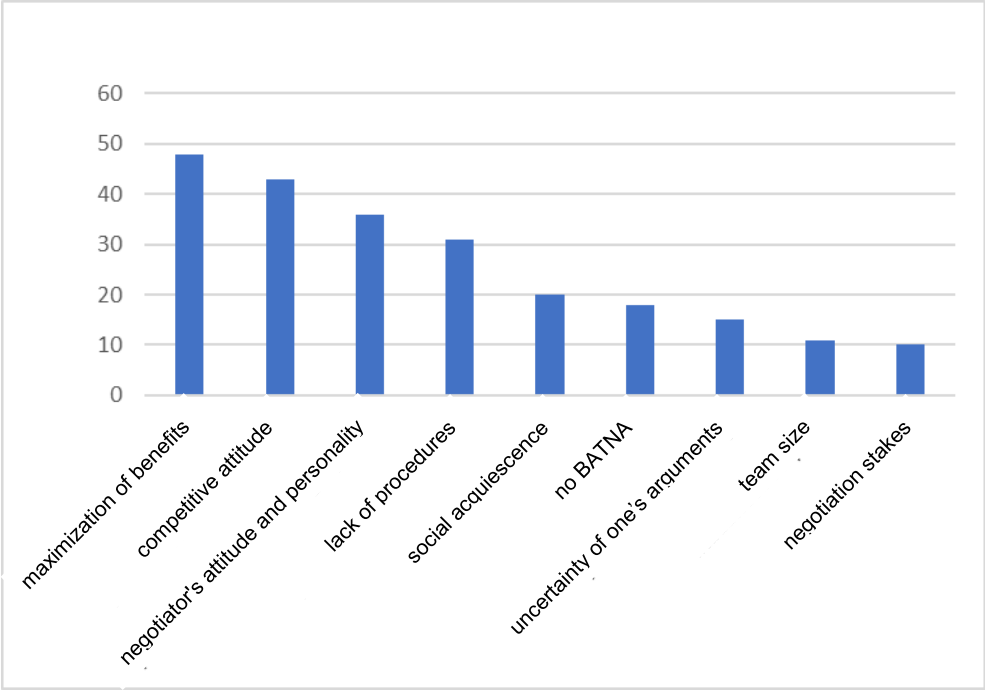

Figure 2. Most common reasons for unethical behavior.

Source: Own elaboration.

The first reason, most often chosen by respondents, is the desire to obtain maximum benefits. The negotiators' adoption of such an assumption makes them at least partially blind to many aspects of the negotiation situation. The more a negotiating party pursues profit, the stronger the tendency for unethical behavior to emerge.

The second reason is to conceive of negotiations as a win-lose situation. Competitiveness results in a mutual rivalry between the parties. The two parties compete with each other, and to win, they are even capable of reaching for foul play. Researchers of the problem say that the greater the focus on achieving self-interest, the greater the desensitization to unethical behavior. J. Kaminski (Kamiński, 2009) distinguishes two types of rivalry: incidental and essential. Incidental rivalry is that which occurs with respect to certain negotiating issues, the result of which is at least a partial alignment of the interests of both parties. Essential rivalry completely excludes the possibility of pursuing the interests of the opposing party. There is the following relationship: the more the negotiation has features of essential rivalry, the stronger the tendency towards unethical behavior.

The third reason is the attitudes and personalities of the negotiators. The following are distinguished:

- absolutists - guided by universal ethical principles,
- situationists - who profess the lack of universal rules; each situation requires a different approach,
- subjectivists - who approach situations from the perspective of their own interests,
- pragmatists - recognizing the existence of moral principles, but accepting the admission of unethical behavior when necessary to achieve an objective (Figure 3).

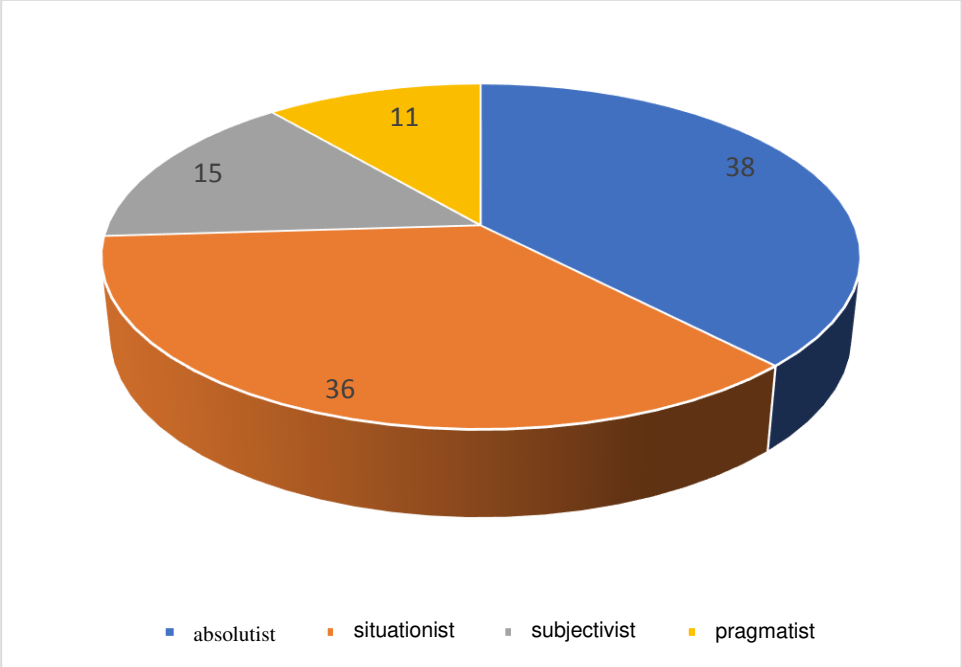

Figure 3. Negotiating attitudes.

Source: Own elaboration.

Among those surveyed, 38 declared themselves absolutists. Analysis of the survey results shows that these were all people who denied behaving unethically during negotiations. The high percentage (36%) of situationists is not surprising. People who do not adhere to universal principles in negotiation usually act unethically.

In addition, a personality factor is important, which seems to be important in terms of the tendency to behave unethically. For example, the so-called Machiavellian personality is characterized by a strong tendency toward unethical behavior. Machiavellians are individuals who share the set of beliefs of N. Machiavelli regarding tactics, manipulation of people and the relativity of moral norms (Zimbardo, Ruch, 1998). In the negotiation process, there is often the thought that the goal is so important that the means to achieve it may not be entirely honest, e.g., fighting for a contract that will keep jobs for a large number of people justifies falsifying information. In the context of respondents' fairly high approval of unethical actions, there was no high percentage of those who would describe their personality as Machiavellian (33%). Perhaps in the opinion of the negotiators taking part in the survey, this personality has such pejorative overtones that it is difficult to admit. It should be added at this point that all those who declared unethical behavior were consistent in their answers and answered the question in the affirmative: "Do you have a Machiavellian personality?" (Figure 4).

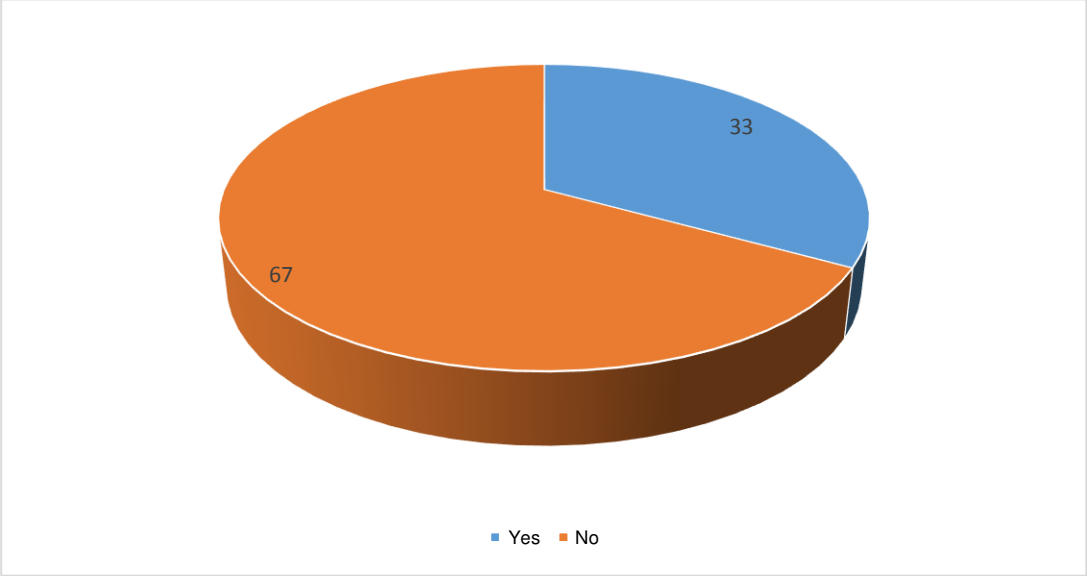

Figure 4. Machiavellian personality among the respondents.

Source: Own elaboration.

The fourth selected reason for unethical behavior in the negotiation process is the lack of procedures for handling negotiations. If procedures and rules have not been established at the beginning of the negotiation talks, arbitrary behavior very often leads to unethical actions, both in terms of how negotiations are conducted and in terms of the substantive context. Procedures in negotiations have an organizing function. For a given negotiation process, it is determined what is allowed and not allowed during what is known as metanegotiation, or negotiation about how to negotiate.

The fifth reason is social acquiescence, or lack thereof, to disregard ethical norms. This applies, for example, to such phenomena as social acquiescence to corruption, nepotism, lying. Agreeing to these behaviors is, in fact, allowing unethical behavior. R. Gesteland (Gesteland, 2000), as a result of his research, found that cultures in which a high degree of acquiescence to corrupt behavior occurs are pro-partner cultures in which personal contacts are central to contracts signed. In addition, the same author stated that these are polychronic cultures, that is, without schedules or time restrictions. In addition, they are characterized by a hierarchical society. The mere fact that someone is a representative of a certain type of culture does not determine the propensity for unethical behavior. Rather, it is a matter of pointing out certain conditions that increase the likelihood of such behavior occurring. At this point, it should be noted that Poles belong to moderately pro-partner and moderately polychronic cultures.

The sixth reason is the lack of BATNA, i.e., Best Alternative To a Negotiated Agreement. Having a BATNA proves really helpful in negotiations. This is because it adds confidence and allows for a flexible approach to the issues at hand. It also allows you to walk away from the negotiating table if the situation after the negotiation talks were to be worse than it was before the talks began. The lack of alternative options increases negotiators' tendency to cheat. Their bargaining power is less than that of having BATNA.

The seventh reason is uncertainty. This is the conclusion of a study by Roy J. Levitsky (Lewicki, Barry, Saunders, Minton, 2008). Unconfident negotiators provide more aggressive arguments and less honest information than opponents who are confident in their position.

The eighth reason is the size of the negotiator teams. When negotiating with one person, we are less likely to lie than when negotiating with a group of people or with new people at later stages of the negotiation process. In one-on-one communication, a kind of bond, a certain lasting interpersonal relationship, is established between negotiators. It makes it more difficult to behave unethically toward another person. However, if you are negotiating with a group of people or in the next stages of negotiations with new partners, it is definitely easier to lie. People perceive interactions with groups as less personal than interactions with individuals.

The ninth reason is the negotiations stakes. Whether negotiators behave unethically also depends on how big the possible benefits are, how profitable the gains made if negotiations are won. The higher the stakes in a negotiation, the greater the tolerance for unethical behavior. Higher profits and greater benefits “justify” ethically questionable actions.

5. Attitudes towards unethical action

The survey results showed that the majority (68 negotiators) were able to detect manipulation from the opposing side (Figure 5).

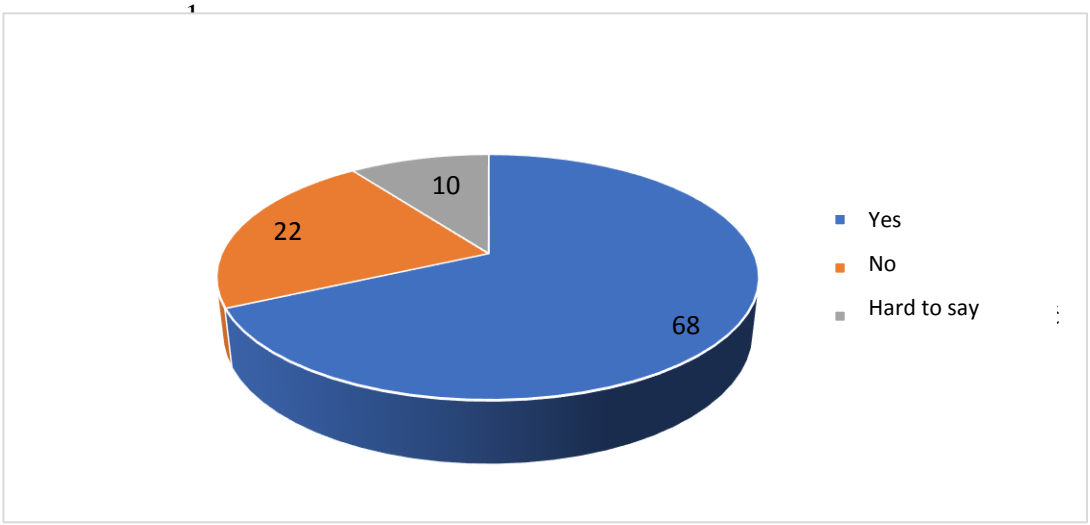

Figure 5. The ability to detect manipulation during negotiations.

Source: Own elaboration.

All women answered this question in the affirmative. In addition, those respondents had at least 5 years of work experience. Thus, experience, participation in many negotiations and the gender of the respondents determined the affirmative answer. Respondents were characterized by different attitudes toward unethical behavior. The highest percentage (42%) declared an immediate response. Only 6% of respondents indicated that when they observe unethical attitudes on the part of their opponent, they pretend not to see these behaviors (Figure 6).

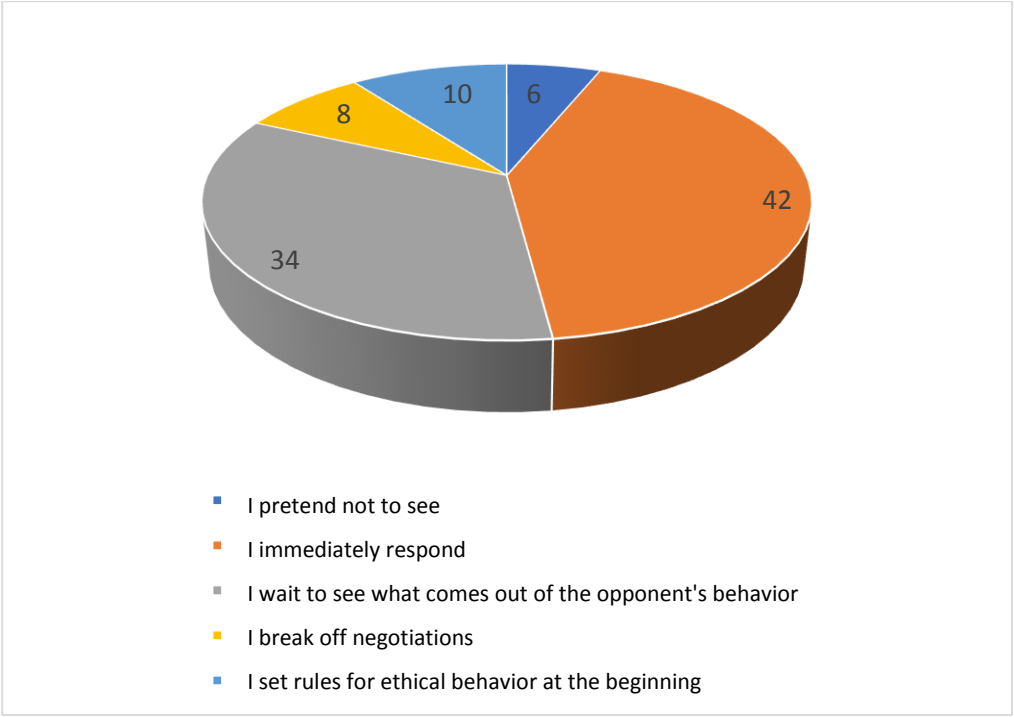

Figure 6. Behavior towards unethical attitudes of negotiators.

Source: Own elaboration.

At this point, it is worth noting the different approaches to unethical behavior. Interesting is the concept of Richard Shell, who distinguished three different approaches: the so-called poker players, idealists and pragmatists (Shell, 2006).

In the poker player approach, negotiations are a game based on certain rules. The precursor of this approach was President Harry Truman's advisor, Albert Z. Carr (Gasparski, Deitl, 2001). In his book "Business as a Game", he stated that bluffing and misleading are acceptable tactics in negotiations, and that negotiators who do not use them will never gain huge money or power. Carr's believed that good negotiators should ignore tips on building a friendly atmosphere and mutual trust, and focus on concealment and deception, and take full advantage of their craftiness.

In the idealist school, negotiations are seen as one aspect of coexistence in society. As cheating is morally reprehensible in normal life, it is not acceptable in negotiations either. This approach draws inspiration from religion and philosophy, especially from the ethical principles propounded by Immanuel Kant.

The pragmatic approach shows the influence of the above two concepts. It recognizes fraud as acceptable, however, it is not used if there are other honest alternatives. Credibility in negotiations is very important, as it builds mutual trust between parties and helps to reach an agreement. Dishonesty is not advisable, as it can badly affect both the negotiations and the reputation of the negotiator, not only at the negotiating table, but also future cooperation.

For example: A seller of used motorcycles, knowing that a particular motorbike is technically defective, when asked by a customer *What is the technical condition of this motorcycle?* will answer: *Excellent. It has just passed a technical inspection* - poker player approach; *I don't have detailed information about the technical condition of this motorcycle* - pragmatic approach; *Not the best. That's why we have an attractive price offer for it - idealistic approach*.

70% of the respondents called themselves pragmatists. Thus, they chose an immediate approach, recognizing the possibility of unethical actions when there is no ethical alternative (Figure 7).

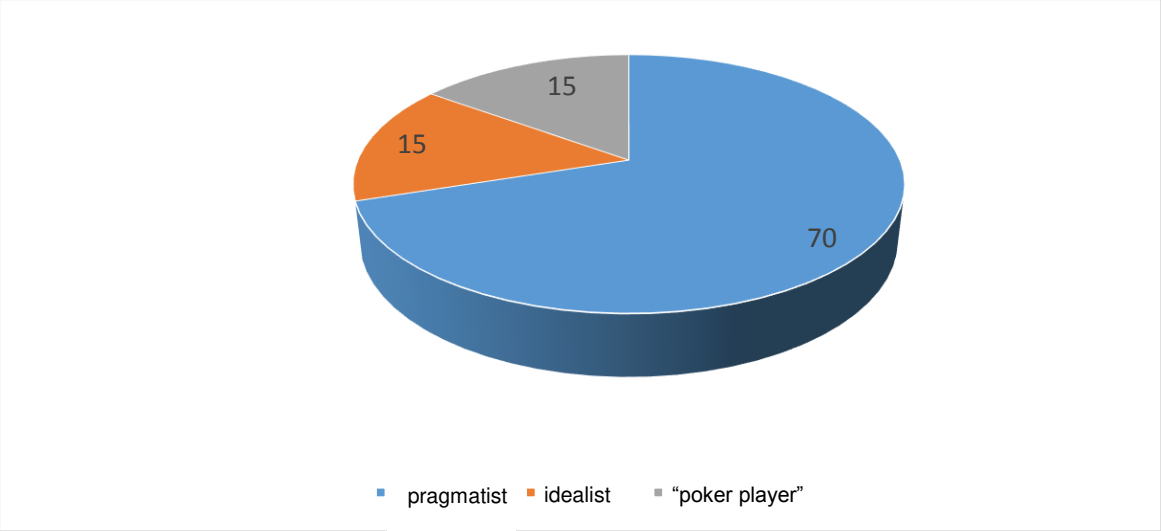

Figure 7. Supporters of positions against unethical behavior.

Source: Own elaboration.

"Poker players" were those respondents who had previously recognized that it was possible to behave unethically in negotiations and declared a Machiavellian personality. They were consistent in their responses. Only 15% of respondents said they were "idealists". As with "poker players", the connection between the earlier responses is quite noticeable. All respondents who did not support unethical behavior in the negotiation process previously described themselves as idealists.

6. Final thoughts

Ethics in negotiation involves acting with integrity. Sometimes, however, despite the best intentions, unethical behavior occurs. It is usually caused by a number of the factors mentioned above. The lack of respect for ethics in negotiations stems primarily from the belief that one must fight for one's interests at all costs. Rivalry is then placed over relationship building and the pursuit of agreement. To this end, opponents use a number of tactics considered unethical. Knowing them makes it easier to defend against their consequences. The ability to recognize underhanded tactics and counter them is an essential part of the negotiation process. It allows the negotiator to defend against incurring large costs and losses during the negotiations. Moreover, it strengthens the negotiator's bargaining power.

A number of authors, when discussing the negotiation process, provide universal, general ethical principles that should be applied during discussions (Kamiński, 2009). Thus, it is worth proceeding in such a way that the negotiator's behavior - if it were to become public - would not stain the negotiator's image and that of the organization represented. Lack of integrity, even if it enables them to win that one time, in the long run it will make the negotiator perceived as untrustworthy. Thus, the negotiations should be conducted in good faith and the goal should be to reach a mutual agreement, satisfying both sides. It is necessary to recognize the opponent's rights to their own beliefs and try to understand their point of view. It is important to treat each other with respect and honor previous agreements. On the other hand, the possibility of including issues proposed by the other side in the negotiations cannot be denied, especially during the initial phase of the negotiations. Untruth should not be stated, but not revealing everything is not lying. It is also not advisable to interfere in the internal affairs of the opposing party (Fisher, Ury, Patton, 2016). Ethical behavior in negotiations manifests itself in, i.a., following accepted procedures, not using manipulative and aggressive techniques or not pressuring the opponent. It is also very important to be honest in the exchange and acquisition of information and not to conceal inconvenient facts.

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COMPETENCIES IN THE FACE OF CHANGES BROUGHT ABOUT BY INDUSTRY 4.0

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Purpose: The purpose of this article is to identify trends and interests of researchers in the area of employee competencies in the face of changes brought about by Industry 4.0.
Design/methodology/approach: The achievements and results presented in the article were obtained from bibliometric studies conducted in Web of Science and Scopus databases. The study used dynamic literature analysis and knowledge visualization. Semantic maps of keywords were created to identify topics and contexts in which the research addresses competencies. VoSviewer software (version 1.6.16) was used to create the semantic maps.
Findings: The results obtained in the bibliometric survey confirm that the interest of researchers from all over the world in Industry 4.0 is constantly growing. In the Web of science and Scopus databases, publications on this topic continue to increase, but the vast majority of them are devoted to technology, digitization and digitalization, i.e. topics relevant to building the technical architecture of the business model. A clear research gap was identified in the area of social architecture of the business model, of which employee competency management is a component. Semantic keyword maps were created to identify topics and contexts where research is concerned with employee competency in the era of Industry 4.0.
Research limitations/implications: The literature analysis was narrowed to peer-reviewed articles published in English, indexed in the Web of Science and Scopus databases, which is a limitation of the study.
Originality/value: Original achievements obtained during the research include obtaining valuable research results on key areas linking competencies and Industry 4.0.

Keywords: competencies, Industry 4.0, Industry 5.0.

Category of the paper: research paper.

1. Introduction

The world is currently facing many changes in technological, economic and social areas. Industry 4.0 is challenging the economy and society. Academic circles are discussing the nature of these changes. Specialized research centers, universities and consulting firms are conducting studies on various aspects of the implementation of Industry 4.0 technologies and the pillars of Industry 5.0 and their consequences not only for consumers and society as a whole, but also for the future labor market, sustainable development, reducing energy consumption, increasing the resilience of the economy, etc. (Goti-Elordi et al., 2018; Zoubek et al., 2021; Vane et al., 2021).

The progressive process of digitization of all areas of the economy, which is a result of the industrial changes currently taking place, implies the need to analyze the consequences that relate to changes in the economy and society. These changes are affecting all areas of human life to an unprecedented extent. Industry 4.0 is distinguished by unlimited access to data and information, which is a competitive advantage (Bartosik-Purgat, Ratajczak-Mrozek, 2018; Birkel et al., 2019; Napoleone et al., 2020). Data providers are emerging smart factories, smart cities and smart homes, which use open socio-technological systems that connect smart machines and devices with human users in so-called cyber-physical systems (CPS). CPSs use increasingly sophisticated artificial intelligence algorithms that operate on large data sets that are collected and processed in real time, affecting physical processes across the network of relationships. In addition, the application of widespread digitization of processes in the economy brings changes in terms of increasing resource efficiency, increasing production flexibility. It also provides the opportunity to achieve a high level of sustainability, sustainable production and consumption (SPC) and reduce energy consumption. Industry 4.0 leads to changes in the structure of employment, there is a demand for new employee competencies and managers (Chaka, 2020; Arcadio, 2023; Ghassoul, Messaadia, 2023). Therefore, the main purpose of the article is to identify trends and interests of researchers in the area of workforce competencies in the face of changes brought about by Industry 4.0.

2. Materials and methods

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

methodology adopted in the study, the following research stages were carried out: planning, implementation and reporting.

The subject of the analysis was to identify trends and research interests in the area of competence in the era of the Industry 4.0. Identification of topic/research areas is a critical step in the analysis. Its results may change if different search phrases and criteria are used. The search was conducted on January 15, 2023 in the Web of Science and Scopus databases. All results obtained were exported to .ods, .bib, .txt files for further use using VOSviewer software. The defined research area was converted into phrases:

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

The above phrases, in the Web of Science database, were searched in the "Topic" category, including title, abstract, keywords defined by the author(s) and keywords plus (so-called "KeyWords Plus" - words and phrases extracted from the titles of cited articles, as defined in the Web of Science database). The Scopus database was searched for title, abstract and keywords defined by the author(s). The time range of the search from January 01, 2011 to December 31, 2022 was adopted. 2011 was set as the beginning of the search, this was dictated by the fact that it was in 2011 that a group of German experts introduced a strategy for industrial development based on smart technology called Industry 4.0, while the term Industry 5.0 officially began to be used in 2021. Thus, the search timeframe 2011-2022 includes works in the field of the fourth industrial revolution, which is formed by Industry 4.0 and Industry 5.0. The results obtained were further narrowed down to scientific, peer-reviewed articles published in English.

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

3. Results and discussion

The topic competence in connection with Industry 4.0 were covered by 200 researchers in the WoS database and 160 in the Scopus database. Researchers from 60 countries, representing 217 research centers, published 216 papers, which are published 159 source titles and indexed in the WoS database. On the other hand, in the Scopus database, researchers from 49 countries, representing 172 research centers, have published 1181 papers, which are published in 98 source titles.

Among the most active researchers in the WoS database are F. Ansari (3), L. B. Liboni (3), L. O. Cezarino (3), A. Adamik (3); among the most popular titles are Sustainability (19), Technological Forecasting and Social Change (5), Journal of Technical Education and Training (4), Sensors (4); The countries from which the largest number of researchers come are Silesian University of Technology (7), University of Bergamo (5), Technical University of Lodz (4), Ministry of Science Education of Ukraine (4), Technical University of Vienna (4), Tecnológico de Monterrey (4), University de Sao Paulo (4), University of Ljubljana (4), University of Maribor (4).

Among the most active researchers in the Scopus database are V. Dwiyanti (3); among the most popular titles are Sustainability (15), Procedia Manufacturing (6), Technological Forecasting And Social Change (4), Sensors (4), Journal of Technical Education and Training (4), International Journal of Innovation Creativity and Change (4); The countries from which the largest number of researchers come are Indonesia (24), Poland (23), Germany (22), Italy (21), Spain (13), England (10), Malaysia (10); the research centers to which the most papers are affiliated are the University of Education in Indonesia (6), Silesian University of Technology (5), University of Maribor (4), University of Negeri Padang (4).

The topics of competence in connection with Industry 5.0 were covered by 54 researchers in the WoS database and 44 in the Scopus database. Researchers from 7 countries, representing 32 research centers, published 14 papers, which were published in 16 source titles and indexed in the WoS database. And in the Scopus database, researchers from 10 countries, representing 22 research centers, published 12 papers that were published in 10 source titles.

Among the most active researchers in the WoS and Scopus databases are F. Aguayo-Gonzalez (2), M. J. A. Gutiérrez (2); among the most popular titles are Industrial Crops And Products (2), Sustainability (2); the countries from which the largest number of researchers come are Mexico (3), India (2), Spain (2); the research center to which the most papers are affiliated is the University of Seville (2).

The above-described results are shown in Table 1.

Table 1.
Basic bibliometric indicators of scientific articles from the research area "Competence"

Scientific articles from 2011 to 2022 from the field of research - Competence	**Base Wos**	**Base Scopus**
(TS=("industry 4.0")) AND TS=(competence)		
Number of records	216	181
Number of researchers	200	160
Most active researchers	F. Ansari (3), L.B. Liboni (3), L.O. Cezarino (3), A. Adamik (3)	V. Dwiyanti (3)
Number of source titles	159	98

Cont table 1.

Most popular source titles	Sustainability (19), Technological Forecasting and Social Change (5), Journal of Technical Education and Training (4), Sensors (4)	Sustainability (15), Procedia Manufacturing (6), Technological Forecasting And Social Change (4), Sensors (4), Journal of Technical Education and Training (4), International Journal of Innovation Creativity and Change (4)
Number of countries	60	49
Countries from which the largest number of researchers come	Italy (27), Germany (26), Poland (25), India (16), England (14), Spain (12), Brazil (11), Mexico (10)	Indonesia (24), Poland (23), Germany (22), Italy (21), Spain (13), England (10), Malaysia (10)
Number of research centers	217	172
Research centers to which most papers are affiliated	Silesian University of Technology (7), University of Bergamo (5), Technical University of Lodz (4), Ministry of Science Education of Ukraine (4), Technical University of Vienna (4), Tecnológico de Monterrey (4), University de Sao Paulo (4), University of Ljubljana (4), University of Maribor (4)	University of Education in Indonesia (6), Silesian University of Technology (5), University of Maribor (4), University of Negeri Padang (4)
(TS=("industry 5.0")) AND TS=(competence)		
Number of records	14	12
Number of researchers	54	44
Most active researchers	F. Aguayo-Gonzalez (2), M. J. A. Gutiérrez (2)	
Number of source titles	16	10
Most popular source titles	Industrial Crops And Products (2), Sustainability (2)	
Number of countries	7	10
Countries from which the largest number of researchers come	Mexico (3), India (2), Spain (2)	
Number of research centers	32	22
Research centers to which most papers are affiliated	University of Seville (2)	

Source: own study.

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

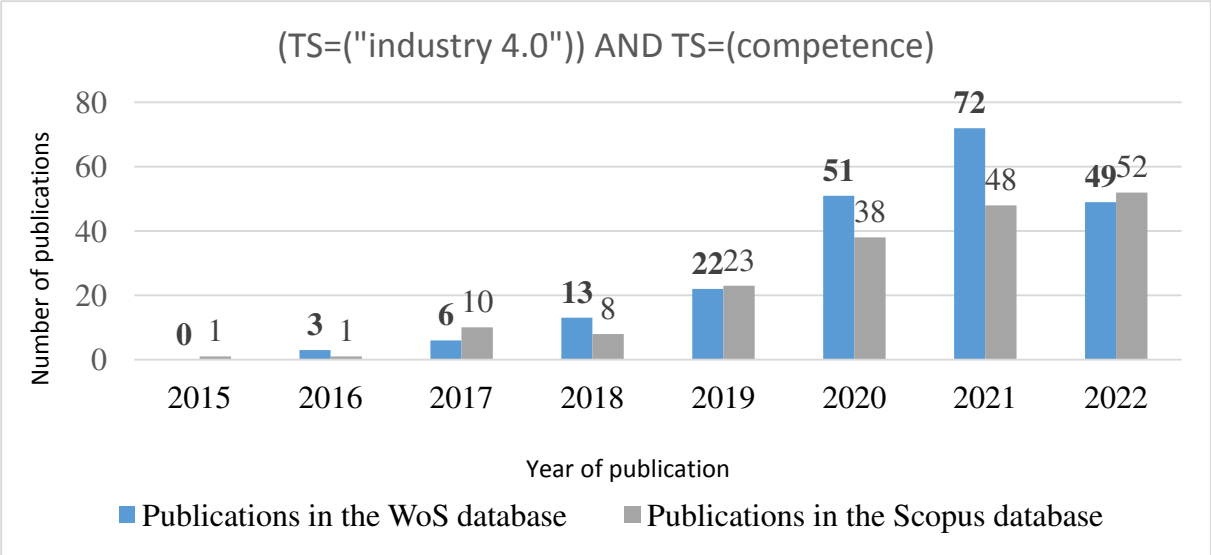

Figure 1. Growth rate of published articles in WoS and Scopus database from 2011 to 2022 for the phrase (TS=("industry 4.0")) AND TS=(competence).

Source: own study.

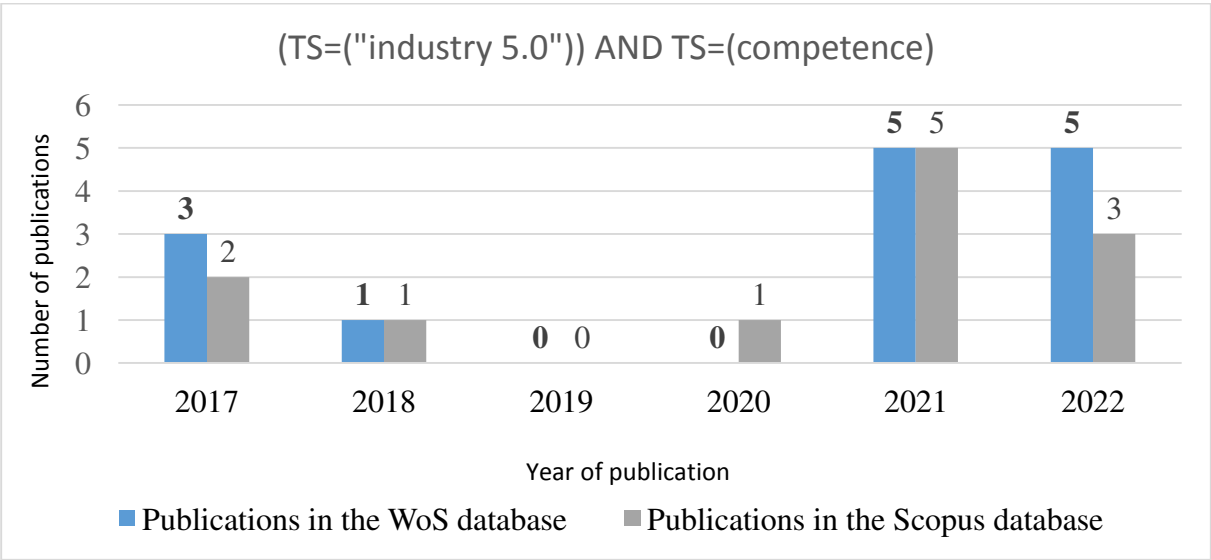

Figure 2. Growth rate of published articles in WoS and Scopus database from 2011 to 2022 for the phrase (TS=("industry 5.0")) AND TS=(competence).

Source: own study.

A review of the dynamics of the number of published scientific papers in the study area indicates that these are new topics, the interest in them is as follows:

- Competence + Industry 4.0 (TS=("industry 4.0")) AND TS=(competence) - the first publication from this area in the Scopus database appeared in 2015. In 2016, 3 publications were indexed in the WoS database and one in the Scopus database. The following year, 2017, already saw 6 publications in WoS and 10 in Scopus. The number of publications from year to year, from this area gradually increased in both databases, but it can be noted that the upward trend in the number of publications continued until 2021, and in 2022 it began to decrease. In 2021, there were

72 publications indexed in Wos and 48 in Scopus, while in 2022 it was 49 in Wos and 52 in Scopus. This situation is most likely due to the fact that in 2021 people started talking about Industry 5.0, in which a lot of attention is paid to the person/employee, so it becomes reasonable to associate competencies precisely with Industry, 5.0, and not Industry 4.0.

- Competence + Industry 5.0 (TS=("industry 5.0")) AND TS=(competence) - despite the fact that the concept of Industry 5.0 appeared in 2021, researchers had already started writing about it in conjunction with competence in 2017, at which time 3 articles were indexed in the Web of Science database, while 2 articles were indexed in the Scopus database. In the following year, 2018, one article each appeared in both databases. In 2019, no articles from the area of competence and Industry 5.0 were indexed in the databases. In 2021, when the concept of Industry 5.0 was already officially talked about, 5 articles each were indexed in the databases, while in 2022, 5 articles were of interest in the WoS database and 3 articles in the Scopus database.

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

Table 2.
WoS fields of study to which retrieved works were assigned for the phrases Competence + Industry 4.0

Place in the ranking	Fields of science defined in the Web of Science database	Search results (number of documents)
(TS=("industry 4.0")) AND TS=(competence)		
I	Management	43
II	Education Educational Research	35
III	Environmental Studies	26
IV	Business	24
V	Environmental Sciences	22
(TS=("industry 5.0")) AND TS=(competence)		
I	Agricultural Engineering	2
	Agronomy	
	Computer Science Interdisciplinary Applications	
	Environmental Sciences	
	Environmental Studies	
	Green Sustainable Science Technology	
	Multidisciplinary Sciences	

Source: own study.

Analyzing the data in Table 2, it can be seen that publications with the phrase (TS=("industry 4.0")) AND TS=(competence) were assigned to the following WoS scientific fields: management (43), education and educational research (35), environmental research (26), business (24), environmental science (22). On the other hand, publications in the phrase (TS=("industry 5.0")) AND TS=(competence) were assigned to agricultural engineering, interdisciplinary applications of computer science, environmental science, environmental research, sustainable science technology and multidisciplinary science (2).

Table 3.
Scopus knowledge areas to which the retrieved works were assigned for the phrases competency + Industry 4.0/ 5.0

Place in the ranking	Fields of science defined in the Scopus database	Search results (number of documents)
(TS=("industry 4.0")) AND TS=(competence)		
I	Engineering	74
II	Social Science	73
III	Business, Management and Accounting	55
IV	Computer Science	50
V	Energy	21
(TS=("industry 5.0")) AND TS=(competence)		
I	Computer Science	4
	Engineering	
	Social Science	
II	Environmental Science	2
	Energy	
	Agricultural and Biological Sciences	

Source: own study.

As can be seen from the data in Table 3, publications in the phrase (TS=("industry 4.0")) AND TS=(competence) were assigned to the following Scopus knowledge areas: engineering (74), social sciences (73), business, management and accounting (55), computer science (50), energy (21). On the other hand, publications in the phrase (TS=("industry 5.0")) AND TS=(competence) were assigned to: computer science, engineering, social sciences (4), environmental science, energy, agricultural and biological sciences (2).

Analyzing the keywords from all the searched publications in the WoS and Scopus database in the field of competence and Industry 4.0 (Figure 3) and in the field of competence and Industry 5.0 (Figure 4), one can see similar correlations as in the articles dealing with skills. However, it should be added that here there are new areas such as managerial competencies, leadership, technological competencies, the learning organization, empowerment, educational innovation, higher education. With the development of research towards Industry 5.0, emerging new research areas correlated with competencies are: competency-based education, engineers, sustainability competencies, personal competency development programs, affective work environment. It is noteworthy that the topic of process resilience is already appearing in publications in the area of competencies and Industry 5.0.

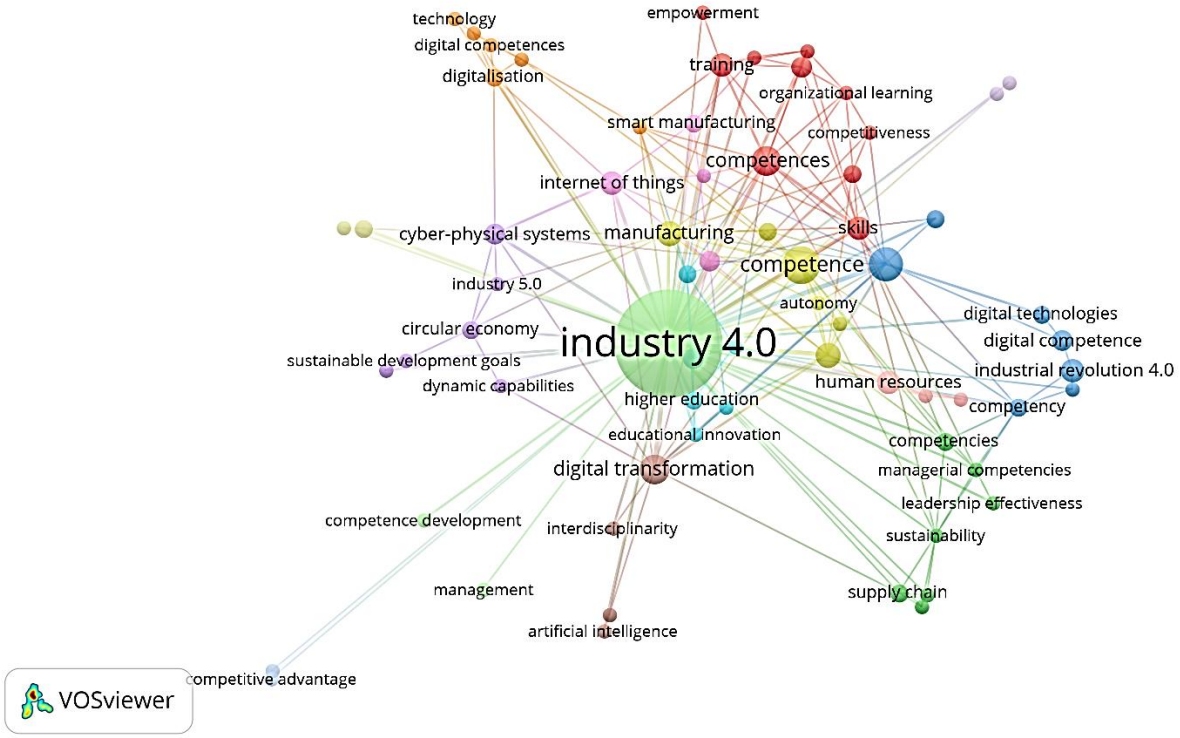

Figure 3. Keyword map for the phrase (TS=("industry 4.0")) AND TS=(competence).

Source: own study.

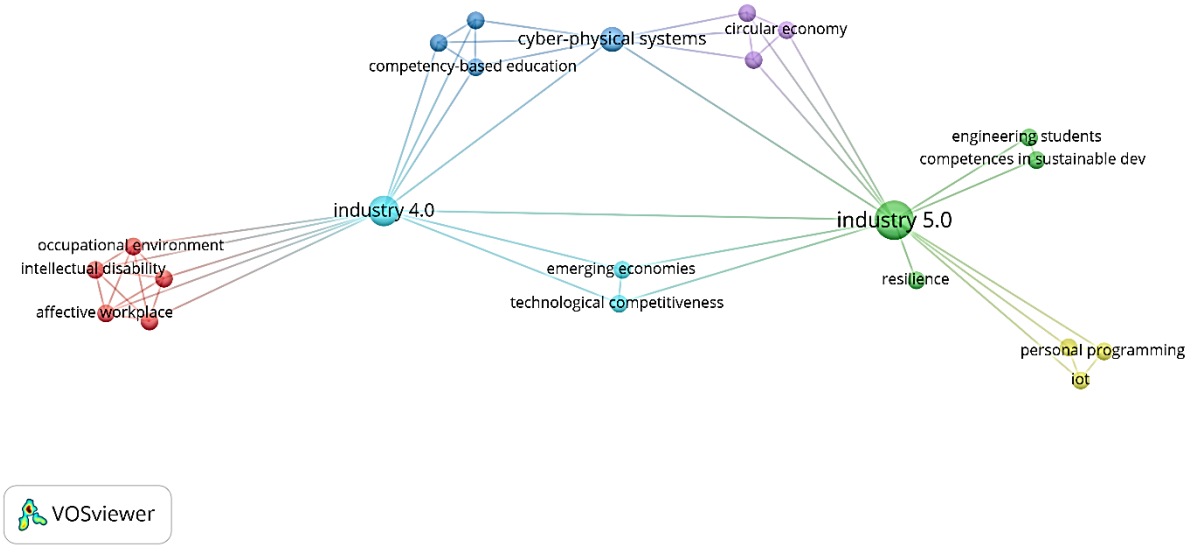

Figure 4. Keyword map for the phrase (TS=("industry 5.0")) AND TS=(competence).

Source: own study.

From the set of publications in the subject area of Competence and Industry 4.0/5.0 indexed in the WoS database, articles marked as Highly Cited Papers were selected, while ten articles with the highest number of citations were selected from the Scopus database and their content analyzed to identify what research issues they address. Several articles were duplicated in both databases, so fifteen articles were finally selected:

1. Bertola, P., & Teunissen, J. (2018). Fashion 4.0. Innovating fashion industry through digital transformation. Research Journal of Textile and Apparel, 22(4), 352-369. This article aims to provide insights into the current state of knowledge and major trends of the "fourth industrial revolution".
2. Cezarino, L.O., Liboni, L.B., Oliveira Stefanelli, N., Oliveira, B.G., Stocco, L.C. (2021). Diving into emerging economies bottleneck: Industry 4.0 and implications for circular economy. Management Decision, 59(8), 1841-1862. In this article, the authors seek to explore the relationship between the concepts of Industry 4.0 and the circular economy (GOZ) as an input to management decision-making in emerging countries. Analyzing trends in scientific production to determine the interface of the two constructs, the purpose of this article is to identify constraints to the implementation of Industry 4.0 and the circular economy in Brazil, as well as to present original frameworks and strategic paths to overcome constraints for emerging countries.
3. Chatterjee, S., Rana, N.P., Dwivedi, Y.K., Baabdullah, A.M. (2021). Understanding AI adoption in manufacturing and production firms using an integrated TAM-TOE model. Technological Forecasting and Social Change, 170, 120880 - The study aimed to identify how environmental, technological and social factors influence the adoption of Industry 4.0 in the context of digital manufacturing. The study attempted to identify the socio-environmental and technological factors that influence the adoption of embedded artificial intelligence technology by digital manufacturing and production organizations.
4. Cimini, C., Boffelli, A., Lagorio, A., Kalchschmidt, M., Pinto, R. (2020). How do industry 4.0 technologies influence organizational change? An empirical analysis of Italian SMEs. Journal of Manufacturing Technology Management, 32(3), 695-721. This article aims to explore the organizational implications of implementing Industry 4.0 technologies, with a particular focus on operations. The article discusses these implications in two directions: organizational prerequisites and consequences of technology implementation. The results of the multiple case study show that the introduction of Industry 4.0 technology is linked to the development of a new type of job profile (i.e., "Autonomous Operative Job Profile") and higher levels of technology implementation create a greater need for non-technical competencies.
5. Dwivedi, A., Moktadir, M.A., Jabbour, C.J.C., de Carvalho, D.E. (2022). Integrating the circular economy and industry 4.0 for sustainable development: Implications for responsible footwear production in a big data-driven world. Technological Forecasting

and Social Change, 175, 121335 - The purpose of this study is to provide an original analysis of the key challenges associated with the interaction of Industry 4.0 and the circular economy for sustainable footwear production. A comprehensive literature review was conducted to identify challenges to 14.0-CE for SFP in the context of emerging economies. It was shown that a lack of competence in the concepts of Industry 4.0 and the closed loop economy hinders the goal of sustainable footwear production.

6. Fareri, S., Fantoni, G., Chiarello, F., Coli, E., Binda, A. (2020). Estimating Industry 4.0 impact on job profiles and skills using text mining. Computers in Industry, 118, 103222. The purpose of this research was to develop a quantitative measure of the readiness of employees belonging to a large company in relation to the Industry 4.0 paradigm.
7. Flores, E., Xu, X., Lu, Y. (2020). Human Capital 4.0: a workforce competence typology for Industry 4.0. Journal of Manufacturing Technology Management, 31(4), 687-703. The purpose of this article is twofold: to raise and address an important change for human capital in the future of Industry 4.0 and to propose a human-centered perspective for companies in the new industrial revolution.
8. Jiménez López, E., Cuenca Jiménez, F., Luna Sandoval, G., Ochoa Estrella, F.J., Maciel Monteón, M.A., Muñoz, F., Limón Leyva, P.A. (2022). Technical Considerations for the Conformation of Specific Competences in Mechatronic Engineers in the Context of Industry 4.0 and 5.0. Processes, 10(8), 1445 - The article proposes 15 technical considerations related to general industrial needs and disruptive technologies that serve to define the specific competencies required by mechatronic engineers to meet the challenges of Industry 4.0 and 5.0.
9. Kaasinen, E., Schmalfuß, F., Özturk, C., Aromaa, S., Boubekeur, M., Heilala, J., ... & Walter, T. (2020). Empowering and engaging industrial workers with Operator 4.0 solutions. Computers & Industrial Engineering, 139, 105678. In the article, Industry 4.0 and human-centered development, referred to as Operator 4.0, is central. The authors' vision of Operator 4.0 includes smart factories of the future that are ideally suited to workers with different skills, abilities and preferences. The vision is realized through solutions that empower workers and engage the labor community. Employee empowerment is based on tailoring the shop floor to the employee's skills, abilities and needs, and supporting the employee to understand and develop their competencies. Engaging the labor community is based on tools that allow workers to participate in the design of their work and training and share their knowledge.
10. Mazur, B., Walczyna, A. (2022). Sustainable Development Competencies of Engineering Students in Light of the Industry 5.0 Concept. Sustainability, 14(12), 7233. The purpose of this article is to examine the level and nature of sustainability competencies among students of two Lublin universities: Lublin University of Technology and Lublin University of Life Sciences. This is to make it possible to assess the students' preparedness to implement the principles of sustainable development in

their future professional activities. The research aimed to determine the relationship between the type of university and students' competencies, through a self-assessment of competencies. The conceptualization and operationalization of sustainability competencies were based on the de Haan and Cebrian models, respectively.

11. Rachmawati, I., Multisari, W., Triyono, T., Simon, I.M., da Costa, A. (2021). Prevalence of Academic Resilience of Social Science Students in Facing the Industry 5.0 Era. International Journal of Evaluation and Research in Education, 10(2), 676-683 - The purpose of the article was to prevalence of academic resilience of social science students in facing the Industry 5.0 era.
12. Simons, S., Abé, P., Neser, S. (2017). Learning in the AutFab-the fully automated Industrie 4.0 learning factory of the University of Applied Sciences Darmstadt. Procedia Manufacturing, 9, 81-88. The article describes the challenges for manufacturing and the technologies proposed by Industry 4.0. It presents a fully automated Industry 4.0 learning factory and a dedicated learning path in this manufacturing facility as a problem-based laboratory space for students and project-based courses.
13. Suarez-Fernandez de Miranda, S., Aguayo-González, F., Ávila-Gutiérrez, M.J., Córdoba-Roldán, A. (2021). Neuro-competence approach for sustainable engineering. Sustainability, 13(8), 4389 - The purpose of this article was to identify factors on which to base the neurocompetence design of an instructional engineering environment and the tendency to develop curricula within dual training models.
14. Uhlemann, T.H.J., Schock, C., Lehmann, C., Freiberger, S., Steinhilper, R. (2017). The digital twin: demonstrating the potential of real time data acquisition in production systems. Procedia Manufacturing, 9, 113-120. This paper introduces a concept based on the learning factory to demonstrate the potential and advantages of real-time data acquisition followed by simulation-based data processing.
15. Zangiacomi, A., Pessot, E., Fornasiero, R., Bertetti, M., Sacco, M. (2020). Moving toward digitalization: a multiple case study in manufacturing. Production Planning & Control, 31(2-3), 143-157 - This paper presents an analysis of multiple case studies to provide a managerial perspective for implementing a transformation path towards Industry 4.0 in the manufacturing value chain. The proposed results in terms of key challenges, typical mistakes and best practices according to the level of digital implementation, provide an overview of references that can help companies understand what are the most important issues to address in the face of adopting digital and innovative technologies.

4. Conclusion

The bibliometric analysis of global scientific works in the area of competence in conjunction with Industry 4.0 and Industry 5.0 represents an effort to rationalize and systematize existing knowledge in the field of employee competency management of smart enterprises. The analysis made it possible to show in terms of time the reconstruction of scientific productivity effects in the studied area.

The results obtained in the bibliometric study confirm that the interest of researchers, from all over the world, regarding Industry 4.0 is constantly growing. The Web of science and Scopus databases continue to increase the number of publications on the subject, but the vast majority of them are devoted to technology, digitization and digitalization. Authors pay a great deal of attention to the technological aspects and digitization in the context of challenges for businesses.

The largest number of researchers working on this issue of competence in the era of Industry 4.0 come from Italy, Germany, Poland, India, England, Spain, Brazil, Mexico, Indonesia and Malaysia. A review of the dynamics of the number of published scientific papers in this area showed that from 2017 to 2021 there was an upward trend of articles related to competency and Industry 4 0, in 2022 the number of publications began to decrease most likely because scientific articles in the field of competency and Industry 5.0 began to appear in the lanes. Published articles in this area, attributed to management, education, environmental studies, business, environmental sciences, information technology applications, sustainable science technology and multidisciplinary sciences. As indicated by the keywords defined by the authors of the publications, the articles in this area are, on the one hand, about education, soft skills, smart society, work design, and on the other hand, about the technologies of Industry 4.0 (big data, artificial intelligence, data analytics) and the pillars of Industry 5.0 (focus on the human being, the worker and his continuous development). It can also be seen that sustainability topics are gaining momentum. New areas are emerging, such as managerial competence, leadership, technological competence, the learning organization, empowerment, educational innovation, higher education. With the development of research towards Industry 5.0, emerging research areas correlated with competencies are: competency-based education, engineers, sustainability competencies, personal competency development programs, affective work environment. It is noteworthy that the topic of process resilience is already appearing in publications in the area of competencies and Industry 5.0.

In articles from the research area of Competence and Industry 4.0/5.0, the topics covered are:

- Major trends of the fourth industrial revolution;
- The relationship between the concepts of: industry 4.0 and the circular economy;

- Identification of how environmental, technological and social factors influence the adoption of Industry 4.0 in the context of digital manufacturing;
- Organizational implications of the implementation of Industry 4.0 technologies, with a focus on operations and the consequences of technology implementation;
- Development of a new type of job profile, i.e. "autonomous operative job profile";
- The lack of competence in Industry 4.0 and the circular economy, which consequently hinders the goal of sustainable production;
- The development of a quantitative measure of the readiness of employees belonging to a large company in relation to the Industry 4.0 paradigm;
- Changing human capital for the needs of Industry .4.0;
- 15 technical solutions related to general industrial needs and disruptive technologies that serve to define the specific competencies required by mechatronics engineers to meet the challenges of Industry 4.0 and 5.0;
- The human focus, referred to as the development towards operator 4.0. This includes smart factories of the future that are ideally suited to workers with different skills, abilities and preferences;
- The level and nature of sustainability competence among students at two Lublin universities: the Lublin University of Technology and the Lublin University of Life Sciences;
- The academic resilience of social science students in the face of the Industry 5.0 era;
- A fully automated learning factory and a dedicated learning path in this manufacturing plant as a problem-based laboratory space for students;
- A managerial perspective for implementing a transformation path toward Industry 4.0 in the manufacturing value chain.

An in-depth analysis of the content of publications retrieved from WoS and Scopus databases indicates that the subject matter studied is characterized by multidisciplinary specificity. This approach makes it possible to obtain a comprehensive approach to research. The analyzed areas are also characterized by a wide range of studies; they draw knowledge of research methodology, methods and tools from many sciences. In theoretical terms, the research conducted contributes to the identification of the current state of knowledge on competencies in relation to Industry 4.0 and Industry 5.0, by analyzing the evolution of the state of knowledge and trends. The main limitation of the study is based on the number of citations and popularity of publications, which cannot determine the actual contribution of scientific work to the area under study. An interesting direction for future research may be to consider the problem of adapting the education system and preparing government instruments to support today's society in rapidly adapting to widespread digitization. An important issue is the adaptation of older workers to changing jobs. Moreover, the older generation will increasingly use e-health, e-patient, e-government or e-banking, e-commerce, etc.

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14. Kaasinen, E., Schmalfuß, F., Özturk, C., Aromaa, S., Boubekeur, M., Heilala, J., ... & Walter, T. (2020). Empowering and engaging industrial workers with Operator 4.0 solutions. *Computers & Industrial Engineering*, *139*, 105678.
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VR-AIDED TRAINING TO COPE WITH HAZARDS IN COAL MINES

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Purpose: Ability to take proper actions and decisions when a hazardous situation occurs is crucial for safety of employees affected by this situation. In a coal mine, this regards both miners and mine rescuers. Providing them with effective training on hazards is a challenge, as these are difficult or impossible to simulate or recreate for training purposes, at real working sites or at training facilities. Application of VR seems to be a solution, as it enables to develop a virtual representation of working environments as well as actions and phenomena happening there. The paper focuses on the use of VR in the training of mine rescuers and concept of such training is proposed. Applicable possibilities, limitations and recommendations are also presented and taken into account in the concept.
Design/methodology/approach: Literature studies were carried out: 1) to identify possibilities to VR integration in the training of mine rescuers resulting from legal regulations, 2) to identify applicable methods, recommendations and findings presented in scientific publications. The proposal for use of virtual reality in the training of mine rescuers was described taking into account: the training procedure, observation in the VR-aided training, the training materials.
Findings: Researches presented in scientific publications support the idea to VR integration in the training, however – to make it more effective - the trainee should be accompanied by a trainer. Analysis of Polish legal regulations regarding training of mine rescuers reveals that there is no formal barrier for VR integration in the training, however carrying out actions in virtual reality cannot replace the mandatory practical exercises.
Research limitations/implications: The concept of VR integration in the training of mine rescuers takes into account possibilities and limitations established by Polish legislation.
Practical implications: It is allowed to integrate VR in mandatory training of mine rescues.
Originality/value: VR integration in mandatory training of Polish mine rescuers has not been described so far in scientific papers. The paper is addressed to: 1) persons managing mining plants, 2) managers of mining rescue stations, 3) managers of mining supervision authorities.

Keywords: training, virtual reality (VR), mining industry, mine rescue, occupational safety and health (OSH).

Category of the paper: research paper, general preview.

1. Introduction

Application of Virtual Reality (VR) for training purposes becomes more and more common. There are at least two reasons for that: 1) VR gives exceptional opportunities comparing to other ICT solutions, 2) VR hardware and software affordability - and thus popularity of and familiarity with this technology - is growing.

Virtual reality is a computer-generated representation of objects, places and related phenomena and processes. In context of training, this is particularly advantageous when conducting training in real conditions - at real machines, real workplaces, locations etc. is impossible (e.g. you cannot carry out particular activities as a learning task), problematic or accompanied with risks, like e.g. injury of a trainee, causing hazard to persons or objects the trainee interacts with etc. However, the extent to which VR-based materials reflect real working conditions, depends on the type of VR employed.

VR solutions range from non-immersive VR to fully immersive VR (Azarby, Rice, 2022; Mandal, 2013; Martirosov et al., 2022; Pedram et al., 2021). Depending on the type, there are different possibilities as regards sense of presence and immersion (Wilkinson et al., 2021) in the VR world, and taking actions there. Non-immersive VR, called also desktop VR, provides a computer-generated environment, but the user stays aware of and keeps control of their physical environment. High-resolution screens are used for displaying the virtual environment and the user interacts with it with use of input devices likes keyboard, mouse, joystick etc. In semi-immersive VR the user is partially immersed in a virtual environment, where they can move but cannot directly interact with objects there. The user has a sense of being in a different reality – when they focus on the digital image, but they also remain connected to their actual surroundings. A flight simulator is an example. In high immersive VR, a user gets impression of being fully immersed in the virtual world. This is a first-person, multisensory experience comprising a deep ‘sense of presence’. Observers’ perception is that they are inside the virtual world and interact directly with the environment. This is obtained with use of head-mounted displays (HMD) and haptic controllers. Applicability and suitability of particular types of VR for learning purposes depends on a number of factors, like e.g. subject of training, costs, access to hardware and software, possibilities and limitations of trainees.

Application of VR for teaching (including a variety of related aspects), covering all the types of VR mentioned above, is a subject of many research publications (e.g.: Beck et al., 2020; Cail et al., 2021; Omlor et al., 2022; Ogrizović et al., 2021; Zhou et al., 2018). In addition to research activities on the subject - focused among others on development the most appropriate approaches and solutions - the growing interest and appreciation for VR-aided training is also manifested by constantly increasing offer of commercial VR-based training solutions.

The publication concerns the problems of training and virtual reality on the example of the concept of VR integration in the training of mine rescuers. The scope of the work includes: analysis of specialist publications on the use of virtual reality for training purposes and current regulations on the training of mine rescuers (shaping safety with use of VR, legal background regarding training on hazards - in Polish coal mines), proposal to use of virtual reality in the training of mine rescuers (the training procedure, observation in the VR-aided training, the training materials).

2. Shaping safety with use of VR

Safety of workers is related with and conditioned among others by: the way in which working activities are carried out; hazards at the working environment (constantly present and these possible ones); taking proper actions and behaviors in emergency situations, e.g. once a hazard occurs or an accident happens; effective rescue action, if it is realized. Training to provide employees as well as rescuers with relevant knowledge and skills is crucial, and use of VR for that purpose becomes more and more common. Dedicated VR-based training materials are created (both as commercial products and as versions for research purposes), and their development as well as their use in training process are a subject of researches. However, it should be underlined that when highly immersive VR is mentioned in scientific papers, typically VR serious games are considered.

Review of publications on application of VR for occupational safety and health training in high-risk engineering industries, published in years 2011-2021, has been done by authors of (Toyoda et al., 2022). Based on selection criteria used for the literature search, there were 45 publications identified as relevant: 25 related with construction, 8 – with manufacturing and assembly, 7 – with chemical process/laboratory, 2 – with mining, 2 – with electric power and electronic and 1 – with agriculture. The findings of the review covered the following issues regarding VR-aided OSH training in the considered industries: topics investigated by researchers; types of VR applied (non-immersive/desktop, semi-immersive, or fully immersive); assessment of the training effectiveness (outcomes measured, techniques used); comparison of training methods applied in terms of improvement of training effectiveness (comparison between particular types of VR and comparison of VR-aided training with other/traditional methods). Extensive elaboration with a thorough and detailed discussion and implications is presented in the paper. Some of the findings are as follows:

- Two main topics learnt within VR-aided OSH training are: 1) risk assessment, 2) machinery or process operation.
- There is a continuous and noticeable increase in use of fully immersive VR for training in OSH in high-risk engineering industries, which is also reflected by the increasing number of studies and publications. The increase is related among others with: 1) continuous improvement of HMD and related software, and – at the same time - decreasing costs of VR integration in the training, 2) benefits provided by the high degree presence and immersion. Application of semi-immersive VR has been least covered by the publications. The main reason for that was that use of this type of VR is related with high costs and efforts both at building stage and operation phase (including maintenance). Another reason is limited access to facilities that actually have integrated semi-immersive VR solutions in their training processes. As regards application of low-immersive VR, its coverage by publications declined during the period covered, however it did not disappear as the semi-immersive. There are two main reasons indicated for that: 1) accessibility due to relative low cost of development and application of the desktop VR, 2) benefits provided comparing to traditional training methods (e.g. in terms of trainee's engagement, considered attractiveness etc.).
- Results of majority of the studies indicate that application of VR for training enables to obtain better learning effects than use of traditional methods, like e.g. video-based training. This applies to all VR types.
- Referring to the 4-level Kirkpatrick's training evaluation model (Kirkpatrick, 2006):
  - in the studies regarding VR-aided training, the focus is mainly on: i) Level 1, i.e. the reaction level, at which opinions of trainees on the training (if it is engaging, relevant etc.) are identified, ii) Level 2, i.e. training level, at which it is verified whether the intended competencies (knowledge, skills, attitudes etc.) have been acquired,
  - Level 3, i.e. application of the competences (acquired/improved at VR-based training) during actual work has been little investigated,
  - no study covered Level 4, i.e. measuring of the training results in terms of its impact on an organization,
  - as regards including Level 3 and Level 4 in the studies – little and non, respectively – it is caused by limited time and funds, insufficient for wider research.

The further discussion will be carried out in context of VR-aided training to prepare workers to cope with hazardous situations in coal mines, addressed for miners or rescuers.

Researches presented in scientific papers provide guidelines and recommendations to be taken into account during: 1) organization and realization of training with use of high immersive VR training materials, and 2) development of this type of materials. The following examples can be mentioned:

- factors that should be taken into account during preparing and carrying out VR-aided training (including development and/or selection of VR materials) discussed in (Liang et al., 2019; Pedram et al., 2020),
- a methodology for creation of VR materials proposed in (Isleyen, Duzgun, 2019),
- an approach to composing of VR materials for training: 1) a 2-stage building of familiarity with carrying out actions in case of hazard occurrence followed by assessment task proposed in (Tan et al., 2015); 2) 2-stage learning within a VR serious game - practical session preceded by instruction session proposed in (Liang et al., 2019),
- organization of VR training site to enable direct (physical) participation of the trainer during VR training session proposed in (Liang et al., 2019).

Examples of high-immersive VR materials are described in (Isleyen, Duzgun, 2019; Liang et al., 2019; Pedram et al., 2020; Tan et al., 2015).

Below, more details regarding the abovementioned papers are presented.

In (Pedram et al., 2020) a study regarding application of immersive VR for training of mine rescuers is presented along with findings as regards factors that directly or indirectly affect this mode of training. In the research, 284 rescuers participated in a VR-aided training session. In the VR scene, the task of the rescue brigade was to carry out rescue action to find a missing miner, in conditions of fire (galleries and roadways contaminated with toxic gases, visibility highly reduced etc.). Before and a month after the training session, the trainees filled in a test, which revealed that 52% of them improved their competencies, and the rest of participants maintained them on the same level. However, the authors underline being aware of shortcomings of this kind of measurement of effectiveness of VR-training of mine rescuers, but at the same time they raise that the nature of rescue actions makes it difficult to verify the learning effect in the real conditions. Additionally, in the paper a research on factors affecting effectiveness of VR-aided training and its consideration by the trainees is presented. A thorough literature review on this subject is followed by the authors' own study carried out with the participants of the VR training sessions mentioned above. The rescuers' opinions and attitudes before and after the training were identified with use of specially prepared questionnaires. There were a number of conclusions drawn from the whole study (i.e. the literature review and own practical study). Some of them are as follows: 1) a trainee should feel comfortable with use of the VR environment, therefore a proper instruction should be provided, 2) the VR material used has to be easy-to-use, 3) the content of the VR material has to be considered as useful and the activities to be carried out in the VR scene must be considered as consistent with real-life working activities, 4) there must be high realism of the VR scene, 5) follow-up discussion with a trainer after the training session, obtaining feedback (comment on the performance in the VR scene, explanations etc.) is essential for the training effectiveness, and expected by the trainees.

VR-based training material addressed for miners to improve their capability to evacuate when coal and gas outburst takes place is a subject of (Tan et al., 2015). The system has been built with use of Virtools – a platform dedicated for development of interactive 3D materials. The authors describe both the very training material and its development process. In the VR training material, there are 3 modules representing 3 stages of the training: 1) building trainees' familiarity with the process of coal and gas outburst – its occurrence and consequences; 2) building trainees' familiarity with carrying out evacuation (the module is a kind of serious game in which a trainee, helped with additional guidance – e.g. prompt windows, arrows displayed on a road etc., carries out an escape task); 3) verification of trainees' knowledge on evacuation (the module is a kind of serious game in which a trainee carries out evacuation task with no additional guidance). The creation of the VR training material conducted by the developers includes: 1) collecting material to properly visualize – in a VR scene – occurrence of coal and gas outburst, damage it causes to roadway(s) and miners; 2) collecting information to define the best evacuation methods and routes; 3) design of the VR scene; 4) development of scenario; 5) development of input materials: 3D models and animations, and other materials, like e.g. sounds, map to be displayed to the trainee etc.; 6) integration of input materials in Virtools scene, taking into account the scene design and scenario.

A methodology to follow to develop VR-based materials for training regarding hazards in underground operations is presented also in (Isleyen, Duzgun, 2019). Identification of potential hazards and taking proper actions to mitigate them was the competence to be acquired or improved. The focus was on hazards occurrence in a tunnel after blasting. The proposed and practically implemented (during the development of the VR training material) methodology includes: 1) development of 3D models of the underground location; 2) development of scenario of the training to be carried out in VR scene; 3) creation of VR material in a dedicated tool – a game engine (adding real-life appearance to the 3D models, defining interactions etc.); 4) implementation of the VR material in a VR system (a dedicated VR space or room); 5) testing by several experts in the given domain (here: mining), including both fresh and experienced VR users. In the VR training material developed, a trainee's tasks included: inspection of the tunnel and identification of potential hazard (one of 3 options is correct); carrying out activities to mitigate the hazards (a trainee is asked to use rock bolts for supporting the tunnel taking into account additional information provided); verifying whether the work has been carried out in a correct way and taking corrective actions if necessary. In the testing stage experts from the domain, with high and with no VR familiarity, took part. Their feedback has been obtained in a follow-up interview. Although some remarks regarding improvement of the material were given, the possibilities to carry out inspections in virtual representations of underground locations as well as to conduct actions to mitigate potential hazards there and observe effects were found highly useful and giving exceptional training opportunities.

In (Liang et al., 2019) development, content and evaluation of a VR serious game for training regarding rock fall hazards in coal mines is presented. A detailed description of the creation process including integration of engineering knowledge on the loose rock and rock fall is provided. As regards the content, the competences intended to be acquired or improved with the VR material are: 1) scaling of loose rock, 2) abilities to identify loose rock and unstable ground. This is reflected by two modules of the VR serious game – one is addressed for novice scalers, to build their familiarity with the scaling process, and the other one is for all other employees carrying out work underground – to build their abilities to recognize hazards related with rock falls. In each module, two phase learning mode is applied. First, there is an instruction session – to obtain relevant knowledge to carry out the task. Then, a practical session in which trainees carry out the actual task (and obtain feedback in case of errors) takes place. In the authors' concept for the game (that was implemented, next) and learning process, particular attention was put to two aspects: 1) support for a trainee – presence of a 'virtual instructor' and a 'real instructor', 2) adapting of difficulty level to a trainee. The virtual instructor operates as a tutor within the game, who provides a trainee with guidelines and information regarding the task. As regards the 'real instructor', according to the authors' concept, both a trainee and a trainer participate in the a VR training session. The trainee who operates in the VR scene with use of HMD and controllers is accompanied by a trainer who – simultaneously - observes view of the VR scene and the trainee's actions on a screen and can give some instructions. Additionally, in the game an algorithm to adapt the content to a particular trainee based on their performance in the game is integrated – to make the training most effective and avoid situations in which a trainee abandons the training due to too high difficulty. The VR serious game underwent evaluation to compare it with video-based training on the same subject. Two testing groups participated: VR-Group and Video-Group. An instruction on use of VR equipment and VR materials was provided as necessary. Each group – after learning with the training material – conducted two tests with use of the serious game - one immediately after the learning sessions and one a week later (to check the long-term effect of the training). The evaluation revealed that use of VR serious game provided better learning effects – in each test the VR-Group obtained higher scores than the Video-Group, and in case of the VR-Group the decrease in scores obtained in the first and in the second test was lower. However – as interviews with participants of VR-Group revealed - time of the VR-aided training session has to be established taking into account dizziness being the side effect. The authors of the paper recommend 15 minutes.

3. Legal background regarding training on hazards - in Polish coal mines

Working in coal mines is accompanied by a number of hazards. To avoid them (if possible) or to cope with them once they take place, all the parties involved have to have proper competencies, and these are acquired through – among others – training (Stańczak, Kaniak, 2021). This regards employees from a coal mine (including miners with qualifications of a mine rescuer) and professional mine rescuers from specialized rescue units.

The main legal act, provisions of which set out the rules regarding employee training in Poland is the Labor Code (Ustawa z dnia 26 czerwca 1974 r. …). In particular:

- article 94 states that an employer has to conduct systematic employees' training in occupational safety and health (OSH),
- articles 237^3 and 237^4 state that it is forbidden to allow an employee to perform work for which they do not have sufficient knowledge on occupational safety and health, and it is mandatory that an employee undergoes relevant OSH training.

Detailed provisions regarding OSH training are provided in the regulation on training in occupational safety and health (Rozporządzenie Ministra Gospodarki i Pracy z dnia 27 lipca 2004 r. …). The following issues are included in the regulation: training objectives; rules; scope; framework training programs (for different groups of trainees, like e.g.: management staff, workers in blue-collar jobs, employees in engineering and technical positions) and their implementation. The following learning objectives as regards the trained workers are indicated: 1) acquaintance with hazards and risks at work and with appropriate preventive measures and activities; 2) learning the regulations and principles regarding OSH at the trainee's work; 3) acquiring the ability to perform work in a manner that is safe for oneself and others, to deal with emergency situations, and to provide assistance to a person who has suffered an accident.

For some jobs there are separate regulations regarding required qualifications and training. This applies, in particular, to jobs related with high risk as well as jobs in selected services. Examples of the later ones are:

- water rescue: WOPR - Water Volunteer Rescue Service and MOPR - Masurian Voluntary Rescue Service (water rescuers); the applicable regulations are act on the safety of people staying in water areas (Ustawa z dnia 18 sierpnia 2011 r. …) and the regulation on training in water rescue (Rozporządzenie Ministra Spraw Wewnętrznych z dnia 21 czerwca 2012 r. …),
- mountain rescue: GOPR - Mountain Volunteer Rescue Service and TOPR – Tatra Volunteer Rescue Service (mountain rescuers); the applicable regulation is act on safety in the mountains and rescue in the mountains and on organized ski areas (Ustawa z dnia 18 sierpnia 2011 r. …).

Coal mining is an example of high-risk industry. In case of hazards occurrence in a coal mine, mining rescue stations (CSRG – Central Mining Rescue Station, OSRG – Regional Mining Rescue Station, KSRG – Factory Mining Rescue Station) are units involved in rescue actions, if necessary. A legal act that establishes the legal basis for the mining industry, which includes, among others, general regulations on mining and mine rescue qualifications and general regulations on the organization of mine rescue services is the act establishing the Geological and Mining Law (Ustawa z dnia 9 czerwca 2011 r. …), in particular Articles 53-60 and 122-124. Training of all parties involved in rescue actions in mines (not only these excavating coal) is regulated by provisions of the regulation on mine rescue (Rozporządzenie Ministra Energii z dnia 16 marca 2017 r. …). The further discussion will focus on mine rescuers. Undergoing a specialist training and passing the exam is mandatory to become a mine rescuer. Courses for candidates for mine rescuers include a theoretical and a practical part, and are delivered by the relevant rescue unit. The course curricula include the following topics: the organization of mine rescue services; mine rescue regulations; the organization of rescue operations; natural and technical hazards; respiratory protection equipment; rescue equipment; first aid; and the psychology of behavior of mine rescuers and persons in charge of rescue operations. The practical part includes exercises in use and control of self-rescue equipment (breathing apparatus, escape apparatus etc.) and rescue equipment. Depending on the competencies to acquire, practical training includes activities conducted in conditions similar to those occurring during rescue operations, with a simulated hazard, especially in an exercise chamber. There are also exercises conducted under conditions of full smoke and limited visibility. Mine rescuers are obligated to undergo a dedicated periodic course every five years. The scope of the course is provided in the regulation.

Based on the analysis of regulations, the following can be stated in the context of this paper:

- Topics regarding hazards at workplace are a subject of occupational safety and health training. Related regulation defines scope of this training but does not establish mandatory types of training materials and methods. Therefore, there is possibility to integrate VR in this type of training.
- As regards training of coal miners with mine rescuer qualifications and training of professional rescuers, legal acts establish topics to be covered by theoretical training and by practical training. This does not exclude VR integration for learning of knowledge and skills related with hazards in undergrounds of coal mines. However, it cannot replace or reduce the mandatory practical exercises.

4. Concept of VR integration in the training of mine rescuers

The prerequisite assumption while development of the concept of VR integration in the training of mine rescuers is that getting familiar with hazards and acquisition of knowledge on relevant behaviors once the hazards occur contributes to safety – both of the rescuers and the rescued miner(s).

Effective training about hazards possible to occur in a coal mine and proper behaviors to take is a challenge. However, use of ICT makes it easier to achieve. Actual occurrence of a hazard, e.g. a fire, can be presented with use of computer-generated animations. This applies also to presenting of taking proper actions in case of a hazard occurrence. Such materials can be complementary to a practical training, and the later one covers some of the activities and situations that take place when a hazard occurs, e.g. rescuing an injured miner in conditions of full smoke and limited visibility. VR-based materials are a solution that combines computer-generated representation with a practical experience of hazards occurrence and taking related actions. They should be considered and used as supplementary (not 'substitute') to the other training materials and activities carried out so far.

4.1. The training procedure

A framework plan of the proposed VR-enhanced training aimed for absorption of proper behaviors in case of hazard is presented in the figure below (Figure 1). In the blocks, the parties or items involved in realization of particular activities are provided in the square brackets.

There are three prerequisite conditions for carrying out the training:

- a trainee already obtained a training that provided them with knowledge on hazards and behaviors once they occur,
- a trainee is willing to undergo this type of training, i.e. VR-aided training (no 'forced participation'),
- there are no contraindications or other reasons for excluding a trainee from this type of training; these can be not known at this stage, but should be clear after exercises in VR, carried out before the actual training.

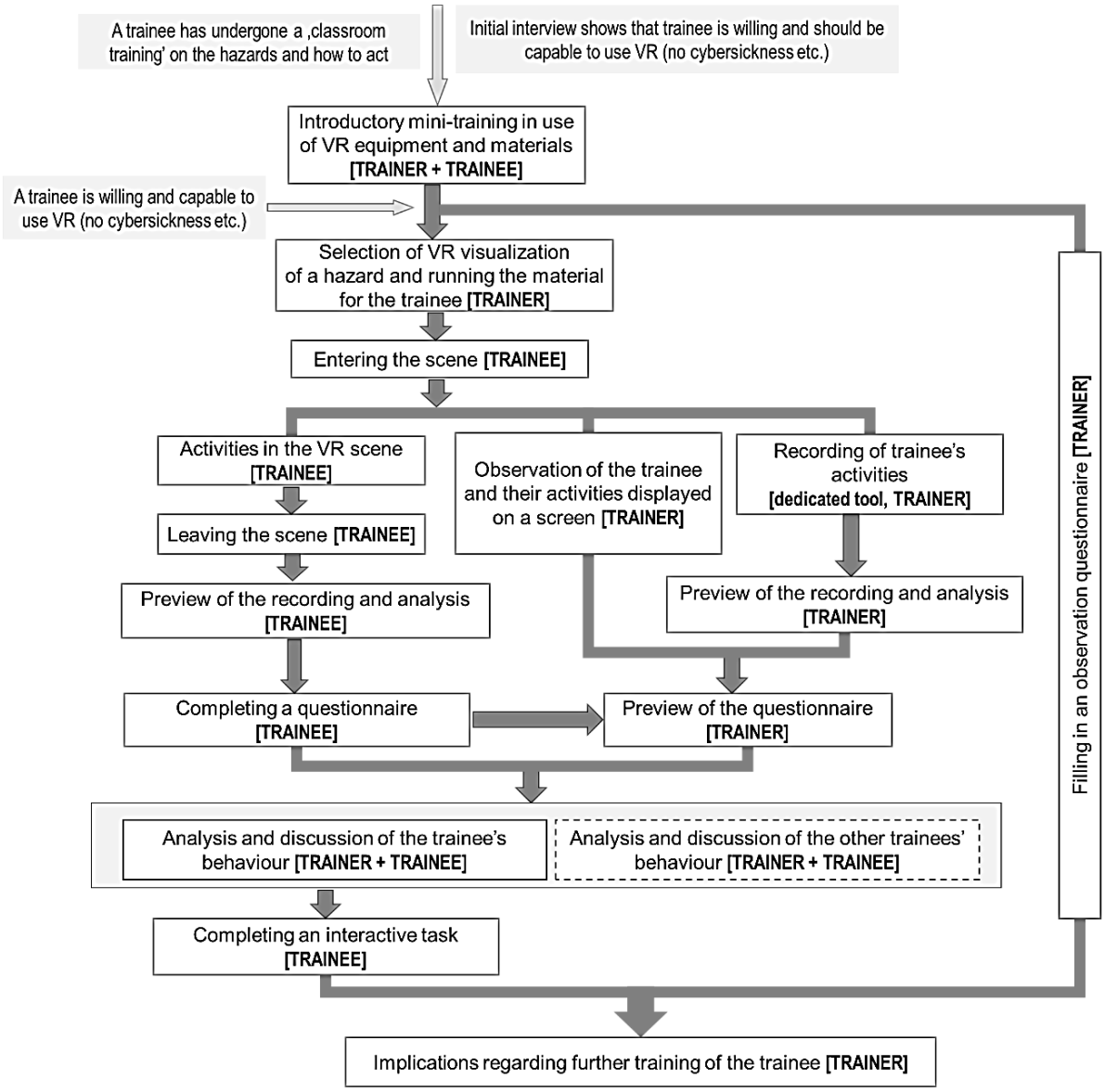

Figure 1. VR-enhanced training on behaviors in hazardous situations.

To make VR-based training effective, a trainee has to feel confident in use of the equipment and VR materials. A separate VR material for that purpose should be prepared, and the trainee should be provided with relevant instruction. The VR scene used should include representation of some location in a coal mine undergrounds with typical, ordinary circumstances there (no extraordinary situations, hazards etc.). The exercises should include basic movements and actions (use of controllers). The trainee should be instructed how to operate inside the scene of the VR material they are to enter (e.g. ‘you can move around in the location, you can move your head in each direction and…’). The introductory mini-training should be tailored to the trainee’s current abilities to use of VR. In case of novice users, the preparatory training should start with basic introductory information and very elementary actions in the VR scene. In case of trainees who already undergone training with this type of materials (e.g. regarding other hazards), this instruction can be relevantly adapted. After this preparatory stage of the VR-enhanced training, it should be clear whether the training can be continued by the trainee.

Once the decision to continue training is made, before running the VR material, the trainee should be also informed about the aim of the training. For the trainee the message conveyed should be that they will have opportunity to experience hazard via immersion in a VR scene where the hazardous situation is simulated, and that the trainee should react as if in real-life. The other reason for this - i.e. observation of the trainee's behavior, its analysis and giving feedback to the trainee - shouldn't be provided to the trainee, not to affect their attitude before and actions after entering the VR scene.

The assumption is that - for the training purposes - there is a repository of VR materials in which occurrence of hazards is simulated. After preparing of a trainee for the VR-aided training, a trainer selects one of the available training materials and the trainee enters the scene and operates there. All the trainee's actions are simultaneously displayed on a dedicated screen and recorded for later use. The trainer – being next to the trainee – observes them as well as the view of their actions displayed on the screen. As regards the observation of the trainee, the aim is twofold:

- to see their behavior and reactions to what is happening in the scene (this is complementary to the view on the screen),
- to stop the training in case of negative impact of the VR material on the user, or accident (e.g. falling over).

After the trainee finishes activities and leaves the VR scene, they are instructed to preview the recording and analyze their behavior (if it was appropriate etc.). This is done by the trainee on their own, and the resulting thoughts are expressed by completing a questionnaire.

Both the recording and the questionnaire are browsed and analyzed by the trainer, who gets view of: i) the trainee's abilities to behave in a correct way when a given type of hazard occurs, and ii) needs to improve these abilities. Then, the trainer starts with the trainee a session, during which they discuss and analyze the trainee's behavior. The objective is to provide the trainee with appropriate explanations and knowledge that should contribute to their proper behavior in the future. Optionally, also recordings from other trainees' VR sessions can be viewed and used for further discussions regarding behaviors during a given type of hazard – to enhance the training effectiveness.

During the whole training, the trainer fills in an observation questionnaire. It should be composed of the following main parts:

- introductory section - identification of a trainee and of a scene used for the VR training session,
- VR session – the main part is a checklist in which possible (both proper and improper) activities are listed. There is also space for additional characteristics; for each VR training material from the repository a separate, adequate checklist is used,
- VR session follow-up – reporting on: 1) the trainee's feedback on their actions in the VR scene expressed in the questionnaire, and 2) discussion with the trainee.

After a week's time, a trainee completes an interactive task to assess their knowledge on behavior when the particular hazard occurs. However, regardless the scores obtained, if the performance of the trainee during the VR-aided training was poor, it is recommended to repeat the training on this particular hazard but with use of other scene, in the future.

4.2. Observation in the VR-aided training

In the concept, observation is the method used for gathering information about the trainees' behaviors. Observation is the most elementary method of empirical cognition that is a part of other social research methods, including pedagogical research. Observation is understood, among others, as a purposeful, i.e. directed and intentional and systematic perception of the object, process or phenomenon under study. An object of observation can be e.g.: the conditions in which the observed persons are currently present; the situations in which they participate as active or passive members of them; the reactions (also the psychological ones) of the observed persons to these conditions and situations. In pedagogical research, the following classification criteria and types of observation can be distinguished, among others: the contact of the observer with the observed persons or persons (direct and indirect observation, including participatory observation), the degree of structuring of observation (structured and unstructured observation), the degree of openness of observation (overt – when it is know that observation takes place or covert – when happening of observation is concealed) (Ciesielska et al., 2018; Kumar, 2022; Łobocki, 2000; Sztumski, 2010).

In the VR-aided training, the actions of a trainee in the VR scene - viewed on the screen - are the main object of observation. This observation is carried out two times: 1) during the VR session, 2) after the VR session – via preview of the recording made during the VR session. In the first situation, a direct observation is carried out, and in the second situation – an indirect observation. The observation is overt. The trainer is present in the room where the VR session takes place, and the view from HMD is being displayed on the screen. The observation is also structured. Each VR-based training material has been developed based on a scenario. Additionally the trainer has an observation.

4.3. The training materials

Each VR material should be developed taking into account realistic scenarios as regards the hazard (or several hazards) occurrence. But at the same time, the realism and thus affecting on a trainee's senses should be softened because the ultimate goal is not to shock or scare but to make them familiar with particular hazard and thus making them more capable to behave in a correct way when the hazard occurs.

In the figure below (Figure 2), screenshots from VR material regarding fire occurrence are shown. In this scene, first, the trainee is placed in a gallery, where he walks around. After several seconds he hears the sound of sparks and notices them (if he turned towards the sound). Next, smoke appears and starts spreading. Another stage is appearing of open fire and its spreading.

Figure 2. Screenshots from VR scene in which fire occurrence take place.

5. Conclusions

During occupational safety and health training, there are limited possibilities to encounter hazards - to see and/or experience them, and to react to them by proper decisions, actions, behaviors. This applies in particular to high-risk industries. To some extent, hazards and their effects can be used for training purposes. Exercises of mine rescuers in a training gallery where the task is to evacuate a victim, in dusty conditions and reduced visibility is an example. Application of VR seems to be a good solution to mitigate shortcomings of theoretical and practical training as means to provide employees with knowledge and skills for identification of hazards and taking proper reactions.

VR enables to recreate any work environment and phenomena there, including hazards. However, there are different possibilities as regards learning, depending on the immersion level of VR applied. This mainly regards presence, interactions and taking actions (as in real life workplace etc.) in the VR environment (VR scene). Opportunities offered to learning by fully

immersive VR are a subject of growing interest and appreciation, which is followed by growing implementation for training purposes, including OSH training. There is also a growing number of commercial VR solutions (e.g. VR serious games) for training of particular groups of users, information on which is highly disseminated, which contributes to growing awareness on VR as means for training and its popularity This is accompanied by decreasing costs of necessary hardware and software, and growing improvement of software tools to make them appropriate and friendly for ordinary users.

Possibilities and limitations regarding application of VR for training purposes, also as alternative or supplementary to traditional training methods, are a subject of many researches, findings of which are presented in scientific papers. The studies support consideration of VR as technology highly useful and giving exceptional opportunities for training. Recommendations and guidelines on carrying out VR-aided training and development of VR-based training materials are provided as well, in scientific papers. Analysis of legal regulations regarding training of coal mine employees and mine rescuers reveals that there is no formal barrier for VR integration in the training, however – in case of mine rescuers – this cannot replace the mandatory practical exercises.

The concept of VR integration in the training of mine rescuers takes into account possibilities and limitations established by Polish legislation, it is allowed to integrate VR in mandatory training of mine rescues. VR integration in mandatory training of Polish mine rescuers has not been described so far in scientific papers. The paper is addressed to persons managing mining plants as well as to managers of mining rescue stations and managers of mining supervision authorities.

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BRAND-RELATED USER-GENERATED CONTENT IN NEW MEDIA – SYSTEMATIC LITERATURE REVIEW

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Purpose: In new media age, growing ranks of consumers generate reviews, opinions, pictures and other types of content regarding brands (BR-UGC). The objective of the present paper is recognition of current knowledge about individual motives of users' engagement in and factors that condition generating brand-related content.
Methodology: The author conducted a systematic literature review and tried to apply PRISMA statement as much as possible. For searching articles across reputable business journals the Scopus database was used. Only top tier journal form AJG 2018 list was included into analysis. As procedure require, study eligibility criteria and report eligibility criteria were used.
Findings: Users' motivation to create a BR-UGC can be divided on: motivation to build self-image and be proud of own work, motivation to belong to a community, hedonic motivation, motivation to improve branded products or services, motivation to help other people, revenge motivation, motivation to express negative feelings or emotions, motivation to get compensation or benefits from the company, motivation by habits. Users are motivated to use BR-UGC by: a need to keep in touch with friends and family, a need for information, brand loyalty, emotional attachment to the brand, a need to avert boredom. Current literature allowed also to identified a factors of BR-UGC creation (e.g. the portal use intensity, perceived usefulness of content creation) and BR-UGC using (e.g. visual appearance, informational content and objective evidence).
Research limitations: Only Scopus database was chosen because it allowed to select a papers in top tier journals. It could omit some important studies but the use of one database led to including a large number of papers. The use of ABS list as criterion, some publication in journals could be missed. In future research an analysis can be expanded with other databases and other journals.
Originality/value: Based on conducted analysis, the author made an attempt to group individual motives and factors investigated by scholars, and propose a typology.

Keywords: user-generated, brand-related, content, individual motives, new media, co-creation.

Category of the paper: Literature review.

1. Introduction

Nowadays, every organization wants to have a brand. Organizations from the sector of high technologies, industrial goods, intermediates, services, B2B, pharmaceutical laboratories, non-governmental organizations as well as non-profit organizations (Kapferer, 2012). The brand is perceived as an asset and a source of competitive advantage (Chinomona, 2016), attracts a loyal group of buyers and enables companies to achieve a leading position in the market (Kall, 2001). Some approaches treat a brand as a set of abstract associations which consist of information's such as key benefits, values, product attributes, images and emotional associations (Rokka, Canniford, 2016). A brand is no longer what marketers tell the customers it is. It is rather what consumers tell each other it is. In recent years, there are growing ranks of consumers talking about brand in virtual space, especially in social media. The number of reviews, opinions, comments, stories about brands and other types of user-generated content (UGC) regarding companies, brands and products has increased significantly (Colicev, Kumar, O'Connor, 2019; Roma, Aloini, 2019). Users make an unpaid labor (Crowston, Fagnot, 2018) by sharing their branded experience and contribute to the content of brand narrative and the process of brand storytelling. They voluntarily co-create brand meaning amongst firms and other brand's stakeholders (Pentina, Guilloux, Micu, 2018).

With the use of brand-related user-generated content (brand-related UGC, BR-UGC), consumers declare their love for a brand as well as complain when a brand does not meet their expectations. From the point of view of the brand, UGC can provide an opportunity to learn more about its consumers. Firms are able to gather information to help in customer segmentation and hence advertisement targeting. UGC can be an inspiration for the creation of new products based on the needs of the target group (Nanne, Antheunis, Van Der Lee, Postma, Wubben, Van Noort, 2020). Brand-related UGC shared in new media may have been treated more trustworthy by consumers than other sources because it is transmitted in a consumer's personal network (Kim, Johnson, 2016). Literature pertaining to source effects proved that the influence of a message communicated by a peer or similar source on consumer behavior is greater than message communicated by an expert or corporate source (Hautz, Füller, Hutter, Thürridl, 2014). In marketing research, scholars frequently investigated the performance consequences of BR-UGC on company sales and stock market performance (Colicev, Kumar, O'Connor, 2019; Tirunillai, Tellis, 2012; Wang, Guo, Susarla, Sambamurthy, 2021). Brand-related UGC influence on consumers' emotional and cognitive responses. Consecutively, emotional and cognitive responses exert impact on behavioral responses toward the brand, such as information pass-along, impulse buying, future purchase intention and brand engagement (Kim, Johnson, 2016).

Taking into consideration an important role of brand related UGC from brand strategy perspective, the primary objectives of present research is recognition of current knowledge about individual motives of users' engagement in brand-related content in new media and determination of the factors that condition engagement in brand-related content. New media in

current marketing contexts refer to digital technologies such as the Internet and mobile devices. These digital technologies are highly interactive, virtual, global, and base on the many-to-many model of communication (Kelly, Vandevijvere, Freeman, Jenkin, 2015). The author asked following research questions:

Why people engage in generating branded content in new media?

Why people use brand-related content generated by others in new media?

Which factors has positive impact on users' engagement in generating brand-related content in new media?

Which factors have positive impact on users' engagement in using brand-related content generated by others in new media?

The author also proposed a typology of investigated individual motives and factors of creating and using brand-related UGC. Present paper also contribute to the practice. The results could help managers to encourage consumers to engage in branded content. Moreover, the knowledge about users' motivation and factors is also important from the point of view of Internet portals which exist because are co-created by it users (e.g. TripAdvisor or Facebook).

In order to meet the assumed goal the author conducted a systematic literature review and tried to apply PRISMA statement as much as possible. The presented study is a part of the research project titled "Brand introduction into virtual worlds of computer game as a form of customer engagement," which received funding from Poland's National Science Centre (Preludium 17, 2019/33/N/HS4/01530). The paper is organized as followed. The first section presents research strategy, study eligibility criteria and report eligibility criteria. Second section contains results of the systematic literature review. The paper ends with discussion and conclusions.

2. Research strategy

2.1. Study and report eligibility criteria

In order to reach an assumed goals of present research a systematic literature review was applied. Systematic review of the existing literature in a specific area allows for an in-depth understanding of the scope of research work carried out and identifying research gaps (Xiao, Watson, 2017). It leads to planning future research, formulating research questions and explaining the choice made (Torres-Carrión, González-González, Aciar, Rodríguez-Morales, 2018).

Systematic literature review is based on replicable and transparent steps. According to PRISMA checklist, the procedure required use of study eligibility and report eligibility criteria (Voorberg, Bekkers, Tummers, 2015).

Study eligibility criteria

1) Type of studies – The papers should focus on content generated by user in new media. The term "new media" can be defined as content available on-demand through digital devices, which provide the opportunity to participate and be actively involved, reply to other users and give feedback. New media are manipulated, networkable and interactive (Odone, Ferrari, Spagnoli, Visciarelli, Shefer, Pasquarella, Signorelli, 2015). What is important, new media is outside managerial control (Onishi, Manchanda, 2012). User-generated content should take form not only word-of-mouth communication. UGC definition requires publication of content in some public sphere and consequently excludes private online communications such as e-mail or instant messaging (Wu, Lirn, Dong, 2014). Many researchers indicated that the concept of UGC is broader than eWOM (e.g. Smith, Fischer, Yongjian, 2012; Hautz, Füller, Hutter, Thürridl, 2014). UGC is related to media content created by users to disseminate information and opinions amongst other users (Wang, Guo, Susarla, Sambamurthy, 2021). Moreover, the content need to be related to the brand. According American Marketing Association, brand is a name, a term, mark, symbol, design or a combination, which identifies a vendor's goods or services and differentiates its offering from its competitors. In accordance with the definition, when an entrepreneur or manager creates a name, logotype or symbol for a new product, he creates also a new brand (Keller, 2011). Initially, the term "brand" was associated with a physical product or service. Nowadays, the term brand also refers to various types of entities such as companies, geographic places, political parties as well as movies and celebrities (Muzellec, Lynn, Lambkin, 2012). Therefore, the study treated the concept of a brand very broadly. Moreover, UGC should be placed in broadly available portals, not manage by the brand owner such as firm's websites or online shops. When firm or brand is a web administrator, brand unfavorable content may be removed or modified. The author afraid it may influence the results of the literature research. The main characteristic of UGC is the lack of commercial biasness (Ray, Bala, Rana, 2021). UGC on branded pages on portals that are not owned by the brand (e.g. Facebook, Twitter) are included in the analysis.
2) Type of participants – The content should be generated by ordinary users of new media such as new media consumers or brand customers but users not related to the brand through formal ties like employers of company (brand) or employers of advertising agency working for brand. UGC must be published outside of "professional routines and practices" (Wu, Lirn, Dong, 2014).
3) Study design – only empirical studies are eligible. The author included all types of research conducted in the field of branded UGC in new media.

Report eligibility criteria

1) Language – only English written papers were selected. The choice of the English language allowed for the inclusion in the analysis of works that have been internationally assessed and function in the international scientific circulation (Czakon, Klimas, Kawa, 2019).
2) Publication status – peer-reviewed journals article from well-established publishers form AJG 2018 list with 4*, 3 and 2 ranks was considered.
3) Year of publication – literature review was made at the beginning of 2022 so paper publish by the end of 2021 were included.

2.2. Search strategy and record selection

The first step in a systematic review was the selection of the subject of research, i.e. determination of the set of publications that would be the subject of the analysis. The definition of the research subject began with the selection of the database and determination of keywords (Czakon, 2011). To find articles across reputable business journals the Scopus database was used. In order to avoid searching for articles from a different scientific field and too many texts not related to the topic, keywords were created in the form of word associations, not individual words (Czakon, 2011). The author chose following key words. Key words related to user creation: "user-generated", "consumer-generated", "customer-generated", prosumption, co-creation, modding. User may be named interchangeably "consumer" or "customer". Content can be generated by user of new media or consumer of brand or customer of brand. Prosumption is the increase involvement of customers in the process of production (Alderete, 2017). UGC is described as digital prosumption online were user produce what he or others consume (e.g. Comor, 2015; Fuchs, 2014; Ritzer, Jurgenson, 2010). UGC can be also associated with the concept of value co-creation. It plays an important role from a marketing perspective and refers to creation a value in-use by consumers and continuous cooperation with organization. This concept also assumes that consumers play an active role in producing an object of their own consumption (Pongsakornrungsilp, Schroeder, 2011). Users also generate content in computer games and virtual worlds (Hofman-Kohlmeyer, 2021). In the case of games, value co-creation pertain to cooperation between players and game developers (Ranjan, Read, 2016). User-generated content takes form of so called "mods", unofficial add-on placed in some virtual world by its own end users (Luca, 2015). The act of changing the game, usually through programming and tools that are not part of the game, is defined as "game modding" (Poor, 2014). The author used a few key words emphasizing the relationship to the brand: brand, company, firm, business. These words could be used interchangeably by scholars. The last set of key words contain terms related to new media: "new media", internet, online, "social media", game, mobile, interactive, virtual. According to definition, the new media is a new digital communication's technologies that include the internet and broadband networks, advanced telecommunications networks (also includes digital mobile phones) and digital broadcasting

(with digital television) (Goggin, Newell, 2003; Mei, Bansal, Pang, 2010). Due to the proliferation of UGC on social media platforms, the author includes the "social media" key word into the analysis. A significant part of the global population exchanges consumption experiences via social media. Yet in 2019, social networking sites were a part of the daily life of over 2.8 billion people (Sabermajidi, Valaei, Balaji, Goh, 2020). Mobile devices are a part of consumers' everyday life and create a space in which the virtual is part of reality and reality is part of the virtual. Consumers flexibly move between online and offline realms (Presi, Maehle, Kleppe, 2016). Thus the author included keywords "mobile" and "virtual".

The texts were searched by titles, abstracts and keywords. It allows to omit searching anywhere in the text where key words may appear accidentally or accessory (Czakon, Klimas, Kawa, 2019). The analysis covered publications that were published by the end of 2021. The lower threshold has not been established because the UGC is a relatively new phenomenon and there are no publications from the period before the year 2000 to appear in the searched results.

As a result of the search carried out, 2919 articles were obtained. After that, the result was limited to articles in peer-reviewed journals (1729 papers). Figure 1 shows the number of publications over the years. The growing trend, especially last 6 years, indicate the growing interest of scholars in user-generated content.

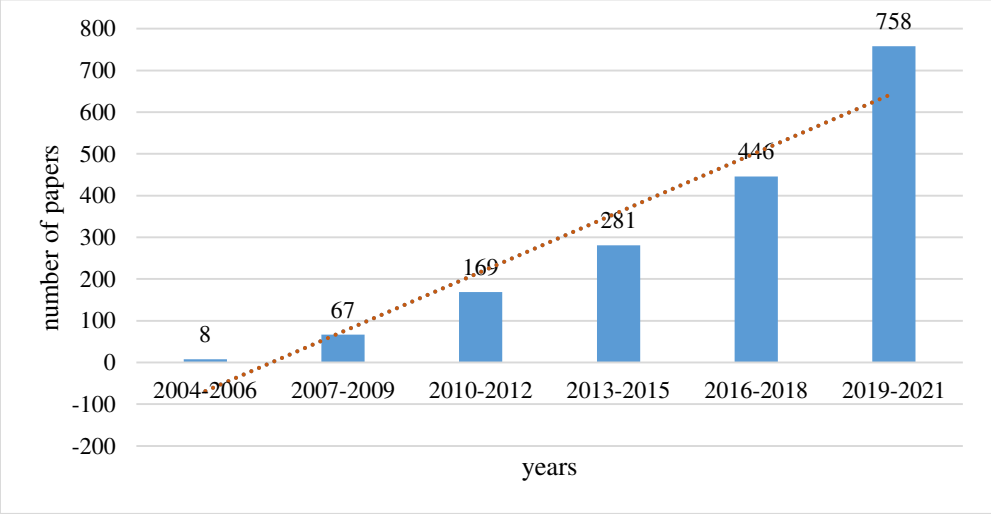

Figure 1. Number of articles published in journals.

Source: Own elaboration.

Next, the search was limited to quality journals within the business and managerial literature fields by use the Chartered Association of Business Schools Academic Journal Guide (ABS journal list) (Akter et al., 2021; Leonidou et al., 2020; Mitrega et al., 2022; Pereira et al., 2021). The author include top tier journal form AJG 2018 list with 4*, 3 and 2 ranks. Finally, it were obtained 412 papers from journals such as Information Systems Research, Journal of Marketing, Journal of Marketing Research, Management Science, Information Systems Research, Journal of Product Innovation Management or Tourism Management.

After that, the author analyzed abstracts of gathered articles and according to screening criteria removed all irrelevant papers. The author established following screening inclusion criteria. An article needs to focus on user-generated content, brand-related content and present only empirical studies. The author employs also screening exclusion criteria. Papers which focus on content generated by users connected with the brand and the papers dealing exclusively with word of mouth communication only were excluded. Additionally, duplicated papers were also removed. The screening of all articles allows to receive 125 papers. Figure 2 shows the process of searching appropriate research papers.

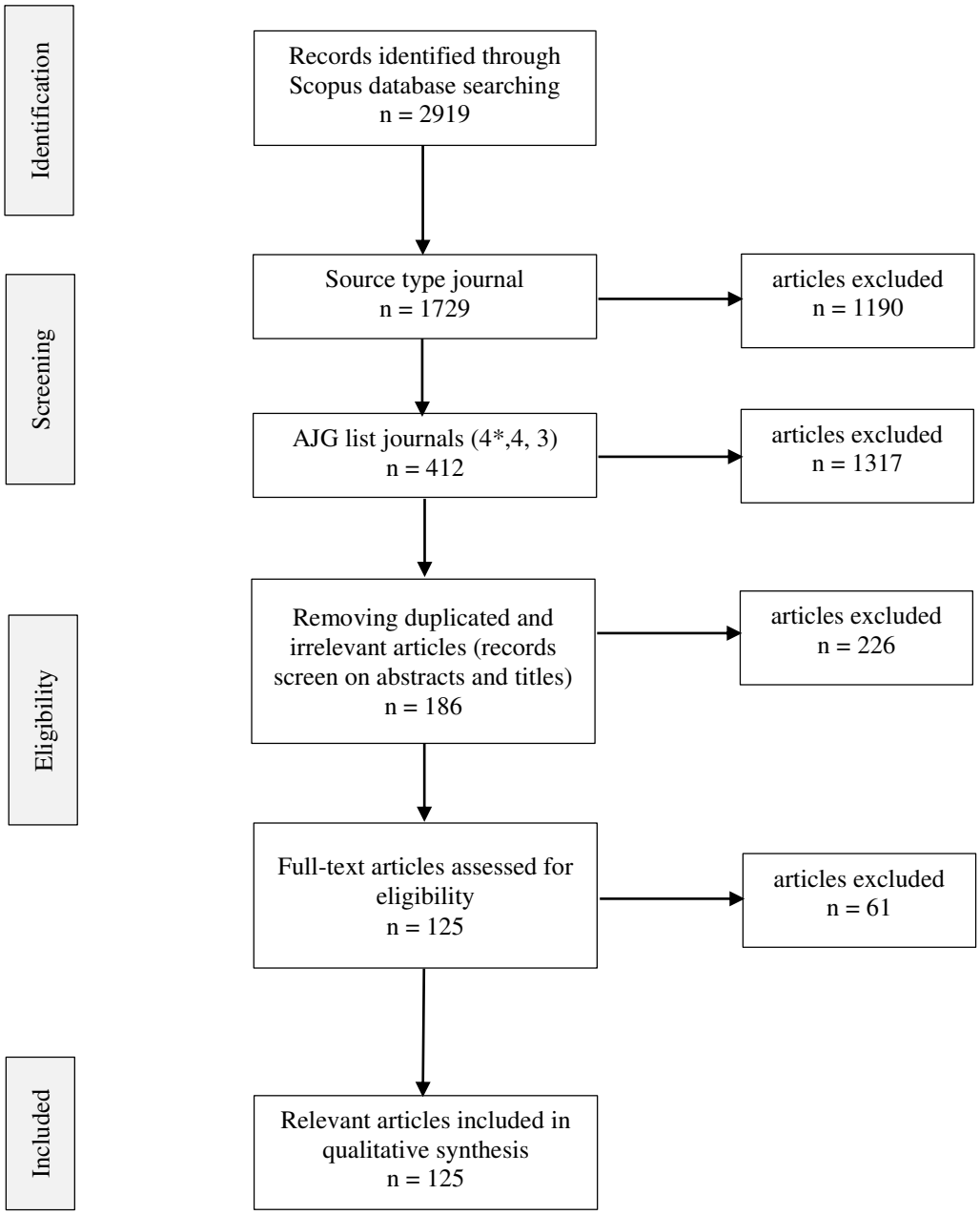

Figure 2. Literature search process.

Source: Based on Moher, Liberati, Tetzlaff, Altman, & PRISMA Group*, 2009.

3. Results of the systematic literature review

3.1. Definitions

User generated content (UGC) can be defined as a media content created by members of the general public and includes any form of online content created, initiated, circulated, and consumed by users (Kim, Johnson, 2016). UGC may be individually or collaboratively produced, modified, shared and consumed (Smith, Fischer, Yongjian, 2012). UGC is online published and differ from online word-of-mouth. UGC is generated by users and not just conveyed like WoM (Roma, Aloini, 2019). The content needs to meet three requirements to be defined as user-generated: a publication requirement, creative effort, and creation outside of professional routines and practices. The requirement of publication excludes private online communications such as e-mail or instant messaging. UGC must exist in some public sphere. The creative effort is related to the unique value added by users to the work, creating original work, modifying or adapting as well as assembling existing works. Moreover, the creation be made outside the confines of professional environments and routines (Wu, Lirn, Dong, 2014). According to Singh, Hillmer and Wang (2011) consumer-generated media have three following characteristics. First, the content is not controlled by marketers. Second, the sheer volume of information is staggering. Third, consumer-generated media influence buyer behavior (Singh, Hillmer, Wang, 2011).

Brand-related user-generated content is a form of consumer engagement that happens when consumers generate or share content related to the brand. Consumers may share brand experiences for example by tagging posts concerning the brand, participating in contests launched by the brand, or placing online ads or "like ads" to network members. They generate content e.g. by writing brand-related experiences, responding to advices or queries on the brand. Content generating requires creation or production of brand-related message by users and is more engaging end effortful (Sabermajidi, Valaei, Balaji, Goh, 2020). UGC is broader in its scope than eWOM however frequently takes the form of eWOM messages, especially in social media (Kim, Johnson, 2016). Consumers are active generators and distributors of product information in a range of forms e.g., videos, text, and audio (Kim, Johnson, 2016).

3.2. Types of BR-UGC

In available literature, there are different types of branded UGC. Amongst these types can be listed: liking and commenting the brand, publishing photos of the brand's products, making a brand selfies, writing articles on blogs, writing customer reviews, video sharing and online curation.

Customers engage in generating content simply by liking and commenting the brand on social networking sites (Kitirattarkarn, Araujo, Neijens, 2019). Although these behaviors represent the lowest amount of customer effort but show a certain level of commitment and are visible to other (Pentina, Guilloux, Micu, 2018).

Users often publish photos of the brand's products on their personal social media accounts (Pentina, Guilloux, Micu, 2018). A particular type of photograph is brand selfie which shows an everyday consumption activity involving a brand. It consists of four elements, namely a person, a brand logo or physical product, different types of physical surroundings and technology (Presi, Maehle, Kleppe, 2016). Consumers make branded selfies and share these selfies via various media platforms such as Instagram (Rokka, Canniford, 2016).

Internet users also write about products or suppliers on blogs (Halliday, 2016). Blogs are usually maintained by individual users with regular entries of commentary in the form of text, graphics or video. Content is commonly displayed in reverse-chronological order (Onishi, Manchanda, 2012). There are research in current literature investigating the influence of blogs on brand performance (e.g. Gopinath, Chintagunta, Venkataraman, 2013).

Customers frequently search for information on the website about various services or products, read the online reviews or social media posts, and then decide to use a service or product or not. Online customer reviews are considered as one of the most reliable information source (Ray, Bala, Rana, 2021).

The other case of user-generated content is placing corporate advertisement videos or other materials of firms on social networking sites like YouTube by its users. These videos have the potential to spread rapidly (Wu, Lirn, Dong, 2014).

Consumers engage in online curation using branded items on social shopping sites. Consumers curate, select, organize and present, product images on themed lists or boards. For example, on Indian LimeRoad, a popular social shopping site, active users combine images of fashion merchandise available on the site into stylish looks and present their designs to other users (Weeks, Smith, Hulland, 2021).

Most often scholars investigate UGC in social media platforms e.g. Instagram, blogs, Pinterest, Facebook (Presi, Maehle, Kleppe, 2016), Twitter (Hill, Benton, Panniello, 2019). Frequently they study communities on the TripAdvisor travel forum (Colladon, Guardabascio, Innarella, 2019) or users of other customer review portals such as online airlines review website airlinequality.com (Chatterjee, 2019; Siering, Deokar, Janze, 2018). Popularity gain also UGC on merchandise website, in various forms like online ratings, posts and feedback (Ray, Bala, Rana, 2021). In gathered papers there were no research which pertain brand related UGC in computer games.

3.3. Research methods

The current research on brand-related user-generated content are differentiated in terms of applied methods (figure 3). The largest group constitutes quantitative approach. Researchers conducted analysis of some content such as customer reviews and then define variables and perform statistical calculations. For example Ye, Law and Gu (2009) used a crawler to download a text of consumer reviews and developed a fixed effect log-linear regression model to assess the influence of online reviews on the number of hotel room bookings. Vast majority of these researchers (32 papers) accurately reported this procedures, little less declared application of text mining method (22 papers), a few (4 papers) used a machine learning. The second group of methods represents a survey study with internet users (25 papers). The third is experiment (16 papers) and quasi-experiment (2 papers) method. The large group of research constitutes also qualitative content analysis (14 papers) with netnography study (7 papers). There were also used a method such as interviews (10 papers), original methods proposed by authors (4 papers), analysis of UGC in form of graphic (4 papers), case study (3 papers), N-gram method (1 papers) and analysis of participant's diaries (1 papers). Scholars frequently combine methods to gained assumed research goals, e.g. Herrero, San Martín and Hernández (2015) conducted in-depth interviews with hotel managers and personal surveys to a sample of 830 users. The authors also include different data into analysis, data from UGC and data describing some company's performance. Torres, Singh and Robertson-Ring (2015) used a customer reviews from TripAdvisor, relevant information from these hotels included the number of online booking transactions and the total revenue derived from online booking. You and Joshi (2020) collected the UGC volume and valence data for consumer reviews and blog posts about particular car models and annual sales volume of these car models in chosen years.

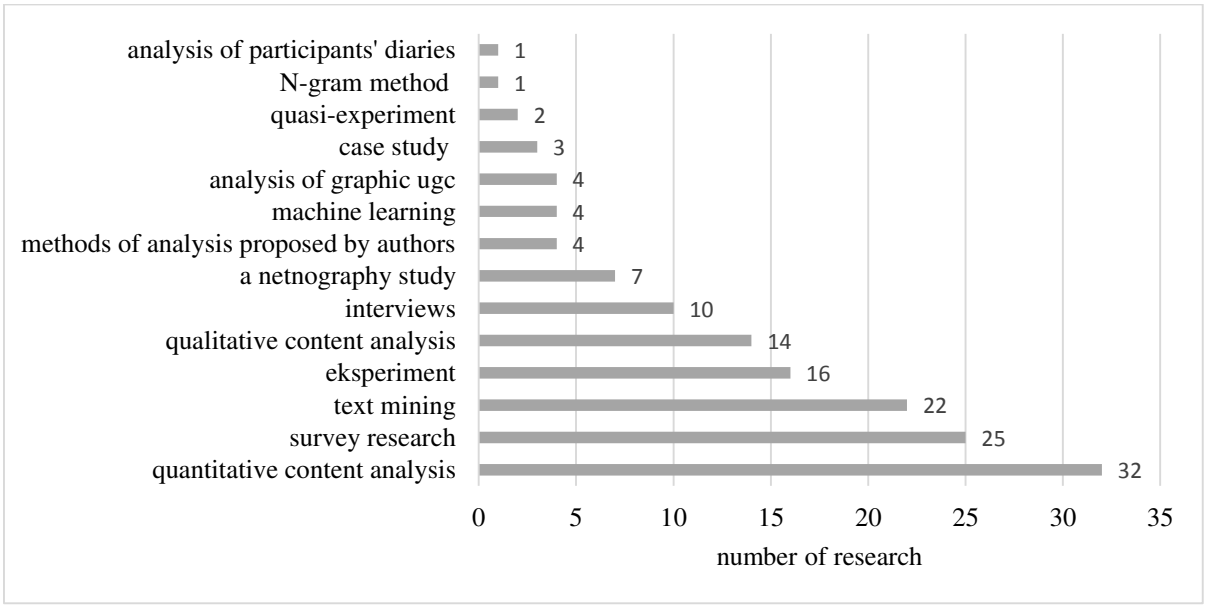

Figure 3. Research on brand-related user-generated content.

Source: Own elaboration.

3.4. Concepts relevant to the creation of branded UGC

There are a few concepts relevant to the creation of branded UGC. The most often used by scholars are: service-dominant logic, consumer culture theory, consumer socialization theory, uses and gratifications theories.

Value co-creation

Value co-creation is the collaboration between consumers and producers in the area of new ideas, design and development of new products (Tajvidi, Richard, Wang, Hajli, 2020). Value is some kind of an improvement in system well-being (Quach, Thaichon, 2017). From a marketing perspective, values are created when customers move from passive receivers to an active partners co-working with suppliers (Tajvidi, Richard, Wang, Hajli, 2020) through interaction and dialogue. The value is co-create through the exchange of knowledge and skills and co-producing unique experiences (Quach, Thaichon, 2017). In online brand communities, customers communicate with each other through postings, instant messaging and chat and discuss about company's products and brands. Consumers in brand communities take part in shaping brand meaning (Rossolatos, 2019). They co- create a value through various marketing activities, especially new product development, new promotions, consumer insights and also cultural and lifestyle aspects (You, Joshi, 2020).

Service-dominant logic

Early marketing focus on building competitive advantage by operand resources, namely tangible traits of a product's offer. In 1990s, marketers moved to operant resources (Halliday, 2016). The value of services is not in their the technical quality or in their delivery processes. Service value is embedded in consumer experiences and in interactions between service provider and consumer (Mitrega, Spacil, Pfajfar, 2020). UGC is an operant resource, generated outside the organization and outside its direct control. In the virtual environment consumers are co-creators of knowledge (Halliday, 2016).

Consumer culture theory

Similarly like in service- dominant logic, in consumer culture theory brand meanings are interpreted and culturally produced by many authors, often during identity construction (Healy, McDonagh, 2013). Consumer's social skills (their ability to acquire, consolidate and apply learning about organizations) makes an important contribution to the brand (Halliday, 2016).

Consumer socialization theory

Socialization is the process in which an individual develops, through interaction with other people, his specific patterns of socially relevant behavior and experience. Consequently, consumer socialization is a process of consumers learning about the consumption environment

from advertisement observation and interaction with others. After that, this knowledge shapes their purchase behavior and consumer experiences. Peers, mass media, social networking sites and the Internet play the role of socialization agents. In the socialization process, these agents shape an individual's knowledge, skills and attitudes that lead to purchase decisions. BR-UGC is treated also as a socialization agent (Sabermajidi, Valaei, Balaji, Goh, 2020).

Uses and gratifications theories

The theory assumes that people select and use a particular media because they want to satisfy specific needs and achieve gratification. People engage in BR-UGC to attain the desired values (Huang, Chen, 2018).

3.5. Individual motives of creating and using BR-UGC

In the presented paper the author makes an attempt to answer four research questions. First and second research questions are related to individual motives of creating and using brand related UGC in new media:

RQ1: Why people engage in generating branded content in new media?

RQ2: Why people use brand-related content generated by others in new media?

Systematic literature review allow to identify a few research contributing to knowledge about individual motives.

Huang and Chen (2018) conducted interviews and an online survey to identify the values that drive consumers to use a brand fan page. They indicated following values: self-respect, being well respected, security, warm relationship with others, a sense of accomplishment, self-fulfillment, a sense of belonging, fun and enjoyment of life, convenience, and better service.

Self-respect value appears when one feels like behaving with honor and dignity or has pride in oneself. Being well respected is a feeling of being treated fairly and sincerely, which requires the cooperation of others. Security is related to someone's feeling of safety and free of danger. He feels protected from physical and financial harm, and having people in life whom he/she can count on for support. Warm relationships with others refers to experience having warm friendships and congenial friends. A sense of accomplishment takes place when one feels like he has achieved something great, e.g., intrinsic rewards received from work. Someone feels self-fulfillment when he's potential is actualized. It can be conceptualized as high self-esteem via altruism and the accomplishment of goals. A sense of belonging is a feeling of acceptance as a natural member of something. Fun and enjoyment of life can be described as a feeling of pleasure, increased happiness, and enjoyment of life. Convenience is related to time savings, the quality of being convenient or efficient. Better service is a value derived when the company continues to improve the products or services provided. The authors also confirmed that these values drive consumers to engage in a fan page by liking and commenting (Huang, Chen, 2018).

Presi, Saridakis and Hartmans (2014) conducted a survey study focused on the motivation of service customers to create brand-related user-generated content (BR-UGC) after a negative service experience. They consider the following motivations: altruistic motivation, vengeance motivation, venting negative feelings motivation, self-enhancement motivation, and economic motivation. Altruism is a motivation based on wanting to help others. Vengeance motivation is a customer desire to exert some harm on the firm, typically as a result of an extremely negative purchase experience. Venting involves expressing negative feelings or emotions, such as anger. Venting negative feelings as an emotional release that helps reduce tension, frustration or anger. Self-enhancement motivation can takes many forms. It allows consumer to gain attention and have a constant positive view of oneself as connoisseurship and intelligent shoppers. Economic motivation appears when customer create UGC in the form of a complaint on the organization's on some Internet services in the hope of gaining compensation for their negative experience. Research show that altruistic, vengeance and economic motivations are strong drivers for UGC creation as a result of a negative service experience (Presi, Saridakis, Hartmans, 2014).

Sabermajidi, Valaei, Balaji and Goh (2020) examined self-enhancement and self-affirmation as individual motivations on generating and sharing BR-UGC on Facebook. They carried out interviews and surveys to study amongst Facebook users.

According to the results generating and sharing BR-UGC are affected by self-enhancement. Individuals who create and transmit content are motivated by their intention to disseminate their self-image. From a self-enhancement perspective, self-image can be improved by activities such as writing publicly opinions about consumption experience, and tagging others (e.g. friends) while sharing that experience.

Self-affirmation has no significant influence on generating and sharing BR-UGC (Sabermajidi, Valaei, Balaji, Goh, 2020). The basic premise of self-affirmation theory is that people have a strong need to see themselves as valuable, worthy, and good. It is an important motivator of behavior because people need to show a positive self-image. They routinely dismiss, distort, or avoid information that threatens their self-worth (Toma, Hancock, 2013).

Halliday (2016) used a student's diaries with reflection of their interactions with branded website and creation of and/or commentary UGC. He identified a few motivations for engaging in Br-UGC: a need to keep in touch with friends and family, a need to keep updated on products and news, information and pictures, a need to keep updated with news (notifications), self-affirmation, motivations for shopping (information needed at the various stages of buying from e.g. browsing product reviews), to pursue personal interests, and tantalizingly, to avert boredom (Halliday, 2016).

Herrero and San Martín (2017) carried out a survey amongst tourists visiting a Spanish destination who have a personal profile on social networking site, specifically on Facebook. They were asked about potentially publishing content related to their destination experiences. Research shows that there are three main drivers of users' intentions to use social network sites

to publish content about their experiences: performance expectancy, hedonic motivation, and habit. The influence of two potential drivers, price value and effort expectancy, were not found.

Performance expectancy is "the degree to which using a technology will provide benefits to consumers in performing certain activities" Hedonic motivation is defined as the "fun or pleasure derived from using a technology". Habit is defined as "the extent to which people tend to perform behaviors automatically because of learning". Price value is defined as "consumers' cognitive tradeoff between the perceived benefits of the applications and the monetary cost for using them". Effort expectancy is the degree of ease of use of technology by consumers (Herrero, San Martín, 2017).

Yang, Ren and Adomavicius (2019) conducted an online survey to establish users motivations to post and engage with others on Facebook business pages and explain why users visit Facebook business pages. The users motivations to post on business pages include: sharing their experiences with others, asking the company questions and making suggestions regarding the companies' products, services, or other issues. The motivations for liking and commenting are different. Users often like posts because they agree with the posts or they share similar experiences with the posters. Users comment on posts because they want to join the discussions, share their own experiences and to answer other users' questions.

Users visit Facebook business pages and read user posts to get information about the companies' products and services, to learn about other users' experiences, for social reasons such as being part of the user communities (Yang, Ren, Adomavicius, 2019).

Healy and McDonagh (2013) used a netnographic grounded theory to investigate a users' motivations to value co-creation in the virtual brand community. They stated that users engage in value co-creation for brand success (consumers are loyal to the brand), community identity (emotional attachment to the brand, fans see themselves as part of what brand creates), control (to exert influence on the brand), community membership and co-production (fans believe that at least they are together, as a group, they want to co-produce this community identity by posting to or reading the forum) (Healy, McDonagh, 2013).

Brodie, Ilic, Juric and Hollebeek (2013) using netnographic methodology they explores the proposed conceptualization of customer engagement in virtual communities.

The analysis was aimed on identifying a consequences of the consumer engagement process in BR-UGC but also shows that the consumer engagement process is initiated largely by consumers' need for information (Brodie, Ilic, Juric, Hollebeek, 2013).

Individual motives of brand-related UGC creation and using proposed by authors are presented in appendix table A1.

3.6. Factors influencing creation and using brand related UGC

The third research question pertain to factors influencing brand related UGC creation:

RQ3: Which factors has positive impact on users' engagement in generating brand-related content in new media?

Sabermajidi, Valaei, Balaji and Goh (2020) considered following factors which can have an influence on generating and sharing BR-UGC on Facebook: age, gender, race, the number of Facebook friends (network strength), the amount of time on Facebook and Facebook use intensity (refers to an engagement in use of Facebook in daily routine). They confirmed that age, time on Facebook, number of Facebook friends, and Facebook usage intensity are significantly related to generating and sharing brand-related user-generated content (Sabermajidi, Valaei, Balaji, Goh, 2020).

Cheung and To (2016) proposed: attitudes toward co-creation in social media, involvement with social media, subjective norms, perceived behavioral control, and perceived usefulness.

Attitudes toward co-creation in social media is consumer's evaluation of co-creation in social media as positive or negative phenomenon. Involvement with social media is perceived importance of the use of social media content. Subjective norms are related to perceived pressure from significant others to participate in co-creation a content in social media. When consumers feel more control over service co-creation in social media, they can be more willing to co-create. Perceived usefulness is the degree to which a consumer is convinced that using social media to share experiences and opinions on products or services is useful (Cheung, To, 2016).

Lin, Sarker and Featherman (2019) proposed a few factors which can have an influence on sharing brand-relate information in social media: social presence, commitment, subjective norms, social ties, outcome expectations and privacy risk. Social presence is the sense of presence on social media. Commitment refers to the degree of which a user feels that he/she belongs and is involved in a community. Subjective norms are related to the degree to which a user perceives that other people approve his/her information sharing activity on social media platform. Social ties described the strength of social relationships with a participants of particular community. Outcome expectations are users' beliefs that information sharing behavior can lead to accomplished personal as well as community-related outcomes. Privacy risk refers to the need of maintaining anonymity and protection of personal information (Lin, Sarker, Featherman, 2019). Similarly Tajvidi, Richard, Wang and Hajli (2020) stated that generating content about brand can depends on the level of privacy concerns. They defined privacy concerns as users fear about disclosing their personal information and sharing their shopping experience (Tajvidi, Richard, Wang, Hajli, 2020).

Three of the factors studied by Herrero and San Martín (2017), i.e., facilitating conditions, social influence and privacy concerns, do not have any influence on the intention to use social network sites to share content.

Facilitating conditions refer to the resources and support available to perform a behavior seen by users. Social influence can be defined as the extent to which consumers believe that some important people like family or friends expect they should use a particular technology. Privacy concerns is associated with potential cost of publishing user-generated content in terms of self-disclosure (Herrero, San Martín, 2017).

Shih, Lai and Cheng (2017) assumed that cognitive trust and affective trust influence online self-disclosure in social media. According to definition trust is "a generalized expectancy held by an individual that the word, promise, or statement of another individual can be relied on". Cognitive trust is related to interpersonal trust based on rational thinking. Affective trust is an interpersonal trust based on emotional feelings. Research confirmed only influence of cognitive trust on online self-disclosure intentions (Shih, Lai, Cheng, 2017).

An important factor could also be the size of population of audience and an increase in the network size (size of Internet portal) (Wang, Goes, Wei, Zeng, 2019), product satisfaction or lack of product satisfaction (Chen, Zheng, Ceran, 2016), consumers' personal openness trait. As a personality trait, openness is defined as a tendency to be broad-minded, imaginative, curious, flexible, and interested in new ideas (Shulga, Busser, Bai, Kim, 2021). Presi, Saridakis and Hartmans (2014) indicated that also extraversion and attitudes towards service recovery strategies influence some motivation to create BR-UGC. In literature, extroverts are described as talkative and sociable, goal-oriented, and having larger social networks. They are more assertive and are more likely to want to help others. Extraversion is one of the factors in the big-five factor model of personality. Service recovery encompass all the actions that an organization may take to compensate for losses (Presi, Saridakis, Hartmans, 2014).

Factors influencing brand-related UGC creation proposed by authors are presented in appendix table B1.

The fourth research question pertain to factors influencing using brand related UGC:

RQ4: Which factors has positive impact on users' engagement in using brand-related content generated by others in new media?

Yu and Sun (2019) listed following factors: vividness, interactivity, informational content, entertaining content, position, and valence of comment.

Vividness describes how dynamic a post is. Posts can take a form of text, image or video. Interactivity on the post refers to interactive traits of posts such as the link embedded inside the text. Informational content allows to meet the need of information-seeking. Entertaining content is perceived as fun and exciting and improve positive consumers' attitude. Position is related to some traits of placing posts. For example posts published in the early morning are less popular comparing to posts published during peak hours of consumer activity. To frequently publishing post is less effective. The valence of content show how positive or negative the brand message is (Yu, Sun, 2019).

Pérez-Vega, Taheri, Farrington and O'Gorman (2018) pointed out fan page cues that can influence consumer engagement in brand fan pages: social interactive value, visual appearance and identity attractiveness. Social interaction value is benefit from the growth, maintenance and broadening of relationships with other people. Visual appearance of fan pages pertain to website layout, images, and look. Identity attractiveness is the degree to which individuals show preference for an object (brand). Consumers are attracted to brands because they perceived

distinctive traits of brand or see a brand as prestigious (Pérez-Vega, Taheri, Farrington, O'Gorman, 2018).

Eslami, Ghasemaghaei, Hassanein (2021) consider factors influencing customer engagement in BR-UGC social media: popularity, discourse logic, argument frame, and product's lifecycle stages. Engaged customers can like, comment or share BR-UGC.

The popularity of some content in social media is measured by the number of it followers. Discourse logic is an information whether an influencer in her/his post, provide an opinion about product using objective evidence instead of subjective opinion. Argument frame refers to positivity, negativity or neutrality of the influencer's message regarding a product. UGC effectively endorse a product when the shape of messages is appropriate with the products' lifecycle stage (introduction, growth, maturity and decline). From proposed factors, only argument frame does not correlate with customer engagement in BR-UGC (Eslami, Ghasemaghaei, Hassanein, 2021).

Kitirattarkarn, Araujo and Neijens (2019) investigate factors that influence a consumer response to BR-UGC in social media. They considered: informative the branded-UGC, entertaining the Br-UGC, social the Br-UGC, tie, individualistic cultures, collectivistic cultures.

Informative the branded-UGC is the extent to which the content provides valuable information about product or brand (e.g. economic, performance information).

Entertaining the Br-UGC is the extent to which the content consist of funny elements, provide relaxation and enjoyment. Social the Br-UGC is the extent to which the content requires social interactivity and collaboration. Tie is the extent to which consumers feel close to the source of content creator. People in individualistic cultures are autonomous and independent from their social groups. Their personal goals are usually more important than the goals of their groups. People in collectivistic culture feel a strong belonging to the group. They generally adhere to the norms of their groups. Their priority is consistent with the goals of social groups (Kitirattarkarn, Araujo, Neijens, 2019). Cultural factors like collectivism and individualism are also indicated in 2020 by other authors, namely Leonhardt, Pezzuti, Namkoong.

Busser and Shulga (2019) focused on two factors that influence involvement in video brand consumer-generated advertising, namely organizational transparency, and brand authenticity. Transparency is related to message clarity. Authenticity is the consumer perception of brand consistency and continuity, originality and uniqueness (Busser, Shulga, 2019).

Weeks, Smith, Hulland (2021) focused on online curation. According to them the popularity of collections created by users depends on two factors. One factor is the number of different categories on which the curation is published. A second factor is curation age, namely the length of time a curation exposure. Research showed that the larger the number of other categories to which A set is posted as a positive impact on liking the curation is greater. Conversely, the longer the curation time was found to have a negative impact on likes (Weeks, Smith, Hulland, 2021).

Factors influencing brand-related UGC using proposed by authors are presented in appendix table B2.

Based on gathered research during present analysis, the author made an attempt to group individual motives and factors investigated by scholars, and propose a typology. Users' motivation to create a BR-UGC can be divided on:

1) motivation to build self-image and be proud of own work,
2) motivation to belong to a community,
3) hedonic motivation (fun and enjoyment from BR-UGC creation),
4) motivation to improve branded products or services,
5) motivation to help other people,
6) motivation do revenge (a customer's desire to exert some harm on the firm),
7) motivation to express negative feelings or emotions,
8) motivation to get compensation or benefits from the company,
9) motivation by habits (people tend to perform behaviors automatically because of learning).

People are motivated to use Br-UGC by:

1) a need to keep in touch with friends and family,
2) a need for information (about branded products at the various stages of buying),
3) brand loyalty,
4) emotional attachment to the brand (fans see themselves as part of what the brand creates),
5) a need to avert boredom.

Current literature allowed also to identified a factors of BR-UGC creation:

1) demographic factors (e.g. age, gender, race),
2) the size of the population of the audience (e.g. number of Facebook friends),
3) the portal use intensity (amount of time on the portal in daily routine),
4) attitudes toward BR-UGC creation,
5) subjective norms (perceived pressure from others to participate in the co-creation of content),
6) perceived usefulness of content creation,
7) perceived behavioral control on co-creation process in particular service,
8) facilitating conditions (available resources and support),
9) sense of social presence,
10) privacy concerns,
11) consumers' personal traits (e.g. openness traits, extraversion).

There are also several factors for BR-UGC using:

1) demographic factors (e. g. age, gender, race),
2) portal use intensity (the amount of time on the Internet portal),
3) visual appearance (e.g. website layout, images, interactivity),
4) informational content and objective evidence,

5) entertaining content,
6) position (e.g. display time of day),
7) valence of comment,
8) brand attractiveness, products' lifecycle stage,
9) the popularity of some content,
10) requirement for social interactivity and collaboration,
11) cultural factors (individualism, collectivism).

When it comes to factors of creating and using of BR-UGC indicated by scholars, the significance of all were not confirmed in previous research. However in other media or in case of other type of content these factors can exert influence on creation and/or using BR-UGC.

4. Discussion and conclusion

With the rapid expansion of new media in the last decade, users became not only passive recipients of branded messages but also became amateur authors of various types of content. In present paper the author represents a result of conducted systematic literature review aimed on identifying users' motivations to engage and factors that influence engagement in brand-related user-generated content in new media. The author tried to apply as much as possible the procedures of PRISMA statement.

Taking into account an important role in shaping brand communication, UGC attracted the attention of many scholars. Scholars applied a diversified research method. The largest group represents quantitative approach. Most often researchers conducted content analysis and then defined variables and performed statistical calculations. Frequently an online survey was made.

Conducted research focused on consumer responses to branded UGC, for example interplay between online product reviews and firm strategies (Feng, Li, Zhang, 2019), the influence of UGC on product sales (Goh, Heng, Lin, 2013; Wang, Guo, Susarla, Sambamurthy, 2021), the relationship between UGC and stock market performance (Tirunillai, Tellis, 2012). Research also explores what customers write about the branded product and their competitors (Netzer, Feldman, Goldenberg, Fresko, 2012) and investigates BR-UGC as a source of information that helps companies improve their products and services (Singh, Hillmer, Wang, 2011). A few scholars made a research on users' motivation to engage and factors influencing BR-UGC creation and using.

4.1. Contribution

Presented study contribute to theory on consumer behavior. The author identified a research on brand-related user-generated content. Based on literature review, the author proposed a definition of BR-UGC and indicated a criterion to content can be defined as user-generated.

What is important, literature allows to differ BR-UGC from electronic word-of-mouth communication (eWoM). UGC is broader in its scope than eWOM. The author also listed a types of BR-UGC mentioned in extant literature. The main contribution of the present paper is determining an individual's motives of creating and using BR-UGC as well as factors influencing creation and using brand-related UGC. The author proposed a typology of investigated individual motives and factors. With regards to the methodology, A review of applied methods was made. The most popular methods were indicated. The last but not the least, directions of future research were outlined. The author took the approach connecting insights formulated by other authors and own identification of research gap during literature review (Mitrega, Klézl, Spáčil, 2022; Schilke, Hu, Helfat, 2018).

Present paper also contribute to the practice. Consumers are willing to cooperate with companies when they can meet some needs through this cooperation. The knowledge about consumers' motivation to create and use BR-UGC as well as what factors facilitate managers developing marketing strategies in virtual environment. It could help them encourage consumers to engage in branded content. For example a user motivated by self-enhancement want to gain attention and become popular in online community. Companies can support activity of users who spread positive message about brand, e.g. in the form of brand selfies, through sharing, liking or commenting these pictures. Probably users will be pleased that company help them to disseminate their self-image. A need of accomplishment can be met when users feels like he has achieved something great. Managers can organize an online contest and reward the best works. Consumers often generate a content because of a need of better product or service. Producer should ask people about preferences when work on new product and show people that their voice matters and they consider suggestion. Venting negative feelings and vengeance motivations are strong drivers for BR-UGC creation as a result of a negative service or product experience. It requires from companies to maintain continuous dialogue with unsatisfied customers e.g. by answering the questions and commenting negative posts with explanation and offering some compensation. Companies should control BR-UGC all the time to prevent transforming negative feelings into vengeance motivations. Because some users generate or use brand related content to attain fun and enjoyment, marketing managers should encourage users for example by fun topic of contest.

An understanding of users' motivation and factors is also important from the point of view of Internet portals. Some portals exist because they are co-created by it users, for example TripAdvisor or Facebook. Their primary objective is probably to encourage content generation, making it easier, convenient, and enjoyable. Marketers should also consider what factors could be important from users' perspective, for example visual appearance of Internet portals, especially website layouts, images, interactivity.

4.2. Limitations and future research

The Presented research has several limitations, which constitute an opportunity for the undertaking of further research in the area of brand-related UGC. First, only Scopus database was used. Scopus database was chosen because it allowed to select a papers in top tier journals. It could omit some important studies but the use of one database led to including a large number of papers. Similarly, the use of ABS list as criterion, some publication in journals could be missed. In future research an analysis can be expanded with other databases and other journals.

Based on the results of conducted studies, the searching paper can be continued by adding more precise key words that describe branded user-generated content such as "customer review" or "brand selfie". Finally, the text were searched by titles, abstracts and keywords. It can be suspected that there were some papers in which key words appear only in full text. Nevertheless, this procedure allows to omit searching anywhere in the text where key words which may appear accidentally or accessory (Czakon, Klimas, Kawa, 2019).

Despite of the significant progress made, there still is a need of further research. In previous work, the authors investigated different types of branded UGC but the contents most often were placed in social media. There is no prove that motivation for and factors influencing generating and using BR-UGC are the same in different online platform. Future research should also determine which attributes or advantages of platforms lead to higher performance and cause more fun in the use or creation of BR-UGC (Herrero, San Martín, Garcia-De los Salmones, 2017). Some comparison study can lead to interesting findings. For example media with lower and higher levels of social presence such as blogs and virtual social worlds (Perez-Vega, Taheri, Farrington, O'Gorman, 2018). Probably firms need to have different strategies for various platforms to enhance their customer engagement (Eslami, Ghasemaghaei, Hassanein, 2021). Parallelly, the generalizability of findings across different platforms needs attention (Eslami, Ghasemaghaei, Hassanein, 2021; Shih, Lai, Cheng, 2017).

In addition, vast majority of research consider BR-UGC on social networking sites such as Facebook, subsequently little less pertain BR-UGC on customer review portals. In the future, scholars could investigate other media types. There is a lack of research in current literature regarding branded content creation in computer games. Passioned gamers have fun working voluntarily on something like amateur software development. They are gradually extending or changing already existing games which is called game modding (Pereira, Silva Bernardes, 2021). Research made amongst computer game users showed that a number of game mods (unofficial game modifications) contain branded element. In some cases, the brand play a leading role in game mods such as branded clothes and accessories to avatar or branded car which player can drive inside a virtual environment (Hofman-Kohlmeyer, 2021). Nevertheless, there were no papers focus on BR-UGC in computer games in present literature review.

It is also worth to pay attention on to the factors that influence publishing (or using) content on particular platform. The other words, how people choose particular platform to engage in branded content (Herrero, San Martín, Garcia-De los Salmones, 2017). An interesting issue to explore is also how different individual motivations influence the content and formats of postings across platforms (Presi, Saridakis, Hartmans, 2014).

Future research should also take into account motivations and factors across different BR-UGC types. According to literature, users are engage in liking and commenting the brand, publishing photos of the brand's products, making a brand selfies, writing articles on blogs, writing a customer reviews, video sharing and online curation. Perhaps users are guided by other motives to placed branded photos and other motives to write a customer review. It can be questioned, what types of BR-UGC obtain the most likes or shares (Tajvidi, Richard, Wang, Hajli, 2018). Future research should also explore what actions can a company take to increase generating and using positive BR-UGC amongst consumers.

Moreover, previous research should be expanded on other industries. For example in the case of customer review, majority of papers focus on tourism services. It would be interesting to replicate a research for different goods or services and conduct a comparative analysis. Consumers' motivations for engaging with brands can differ according to different product categories (Kitirattarkarn, Araujo, Neijens, 2019).

An interesting issue is also cultural factors influencing BR-UGC but present literature refers only to two factors, collectivism and individualism. Maybe there are other cultural factors worth paying attention to. There is also a lack of research on different generations, in which consumers will have different orientations and group behavior (Cheung, To, 2016).

It is worth to expand knowledge about social motivations (e.g. desire for social reciprocation and maintenance of relationships), the role of social bond strength with network members as well as loyalty to the brand and brand community (Sabermajidi, Valaei, Balaji, Goh, 2019). It will be interesting to study relation between users' online activity and his or her positions in a community (Wang, Goes, Wei, Zeng, 2019). In previous research, little is known about the role of personal traits in branded content creation. Presi, Saridakis and Hartmans (2014) considered extraversion, one of the traits in the big-five model of personality. Future research could take into account other personality traits described in this model. There is also lack of knowledge about the role of other users' content (especially online friends) on individuals' content creation and sharing (Chen, Zheng, Ceran, 2016).

Further research can be also expanded on long-term actions of users engaged in continuous communication with brand through UGC. What motivates consumers after a firm's response to create next content, especially when they are unsatisfied. Customers who do not obtain their desired firm's response may undertake further actions (Presi, Saridakis, Hartmans, 2014).

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Appendix A. Individual motives of brand-related UGC creation and using

Table A1.
Individual motives of brand-related UGC creation and using

Authors	Year	Individual motives
Healy, McDonagh	2013	for brand success, community identity, control, community membership and co-production
Brodie, Ilic, Juric, Hollebeek	2013	consumers' need for information
Presi, Saridakis, Hartmans	2014	altruistic motivation, vengeance motivation, venting negative feelings motivation, self-enhancement motivation, economic motivation
Halliday	2016	a need to keep in touch with friends and family, a need to keep updated on products and news, information and pictures, a need to keep updated with news (notifications), self-affirmation, motivations for shopping, to pursue personal interests and tantalizingly, to avert boredom
Herrero, San Martín	2017	performance expectancy, hedonic motivation, habit, price value, effort expectancy
Huang, Chen	2018	self-respect, being well respected, security, warm relationship with others, a sense of accomplishment, self-fulfillment, a sense of belonging, fun and enjoyment of life, convenience, better service
Yang, Ren, Adomavicius	2019	sharing their experiences with others, asking the company questions and making suggestions regarding the companies' products, services, or other issues
Sabermajidi, Valaei, Balaji, Goh	2020	self-enhancement, self-affirmation

Appendix B. Factors influencing brand related UGC creation and using

Table B1.
Factors influencing brand-related UGC creation proposed by authors

Authors	Year	Factors
Presi, Saridakis, Hartmans	2014	Extraversion, attitudes towards service recovery
Cheung, To	2016	attitudes toward co-creation in social media, involvement with social media, subjective norms, perceived behavioral control, perceived usefulness
Chen, Zheng, Ceran	2016	product satisfaction, lack of product satisfaction
Herrero, San Martín	2017	facilitating conditions, social influence, privacy concerns
Shih, Lai, Cheng	2017	cognitive trust, affective trust
Lin, Sarker, Featherman	2019	social presence, commitment, subjective norms, social ties, outcome expectations, privacy risk
Wang, Goes, Wei, Zeng	2019	size of population of audience, size of Internet portal
Sabermajidi, Valaei, Balaji, Goh	2020	age, gender, race, the number of Facebook friends, the amount of time on Facebook, Facebook use intensity
Similarly Tajvidi, Richard, Wang, Hajli	2020	privacy concerns
Shulga, Busser, Bai, Kim	2021	consumers' personal openness trait

Table B2.
Factors influencing brand-related UGC using proposed by authors

Authors	Year	Factors
Pérez-Vega, Taheri, Farrington, O'Gorman	2018	social interactive value, visual appearance, identity attractiveness
Yu, Sun	2019	vividness, interactivity, informational content, entertaining content, position, valence of comment
Kitirattarkarn, Araujo, Neijens	2019	informative the branded-UGC, entertaining the Br-UGC, social the Br-UGC, tie, individualistic cultures, collectivistic cultures
Busser, Shulga	2019	organizational transparency, brand authenticity
Eslami, Ghasemaghaei, Hassanein	2021	popularity, discourse logic, argument frame, product lifecycle stages
Weeks, Smith, Hulland	2021	the number of different categories on which the curation is published, curation age

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BARRIERS TO TECHNOLOGY TRANSFER AND COMMERCIALIZATION OF RESEARCH FINDINGS: CASE STUDY

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Purpose: Effective technology transfer and the commercialization of research results are vital components for bridging the gap between academia and industry. The aim of the work is to identify barriers to technology transfer and commercialization, as well as to assess them in terms of their importance for the both management staff and research workers at the research institute of the Łukasiewicz network.
Design/methodology/approach: This article delves into the realm of technology transfer and commercialization barriers, focusing on a case study conducted within the Łukasiewicz network's research institute. The study not only identifies these barriers but also assesses their significance from the perspectives of both management staff and research workers.
Findings: The study underscores the importance of understanding and addressing these barriers to enhance the efficiency and impact of technology transfer efforts. This investigation classifies the identified barriers into distinct categories, shedding light on potential variations in perception and prioritization between management and research personnel. By comparing and contrasting the viewpoints of these two key stakeholder groups, this study offers a nuanced view of the obstacles that can impede the problems in transformation of research innovations into tangible market solutions.
Originality/value: The study attempting to identify barriers to technology transfer and commercialization from the point of view of the management staff and researchers workers at the Łukasiewicz network's research institute is a new study that has not been conducted before. This proves the originality of the presented work.

Keywords: Commercialization, Barriers, Research institute, Knowledge transfer, Research-to-market transition.

Category of the paper: Case study.

1. Introduction

Innovation is a dynamic and intricate sequence of events. It commences with the exploratory phase, primarily rooted in the expansive realm of Research and Development (R&D) (Akis, 2015; Dziallas, Blind, 2019; Edwards-Schachter, 2018; Grebski, Mazur, 2022; Varadarajan, 2018). This initial phase is further augmented by insights gleaned from market dynamics and the strategic maneuvers of competitors, collectively shaping the innovation commences with a search phase, mainly within the expansive domain of Research and Development (R&D), as well as through the discernment of market signals and competitor behaviors.

Government expenditure on research and development across all the European Union (EU) has shown significant growth (How much money does your government allocate for R&D, 2002). In 2021, total government investments in research and development reached EUR 109.25 billion, accounting for 0.8% of GDP, marking a 6% increase from 2020 and a substantial 35% surge compared to 2011. Among EU member states, Luxembourg (EUR 689 per capita) and Denmark (EUR 530 per capita) lead in research and development investments, while Romania (EUR 19 per capita) and Bulgaria (EUR 24 per capita) allocate the least. Unfortunately, Poland also ranks really low, with a government expenditure of EUR 62 per capita. Only four EU countries exhibit lower investments than Poland, and some nations allocate up to ten times more funds to research and development.

Heightened investments in research and development positively influence economic growth (Minviel, Bouheni, 2022; Pessoa, 2010) and amplify productivity, consequently impacting wage levels. The cultivation of a robust innovation ecosystem is essential in the digital era, as it not only fosters competitive products but also facilitates innovative technologies.

Collaborations between academia and industry drive both competitiveness and quality of life improvements (Nyemba et al., 2021). Central to economic growth and innovation is the commercialization of research results (Slotfeldt-Ellingsen, 2023). This encompasses knowledge and technology transfer, research and development project creation, and collaborations between research institutions and businesses (Clarke, 2016; Madsen et al., 2017), all driving economic advancement. Commercialization involves the transfer of knowledge, ideas, and research outcomes from laboratories to the market, contributing to innovation dissemination (Jagusiak-Kocik, Janasik, 2023). As defined by the National Centre for Research and Development, commercialization encompasses the transfer and sale of research outcomes to the economic and social realm, enriching businesses with technical and organizational expertise. It involves building business models around technologies and new products, shaped by technological and innovative policies. The process generates added value for ideas, research outcomes, technologies, and new products, fostering innovation across economies and industries. Commercialization, like any phenomenon, has both positive and negative facets (Barski et al., 2010; Flisiuk, Gołąbek, 2015; Kilian-Kowerko, 2013; Orłowski,

Tylżanowski, Leoński, 2017). While it activates various domains, it can yield specific economic benefits. However, barriers and obstacles can hinder the efficacy of the commercialization process, impeding economic growth and strategy implementation anchored in knowledge dissemination.

In summary, innovation's journey begins with exploration within R&D and the interpretation of market cues, propelling investments in research and development across the EU. Despite progress, barriers to effective commercialization persist, negatively influencing economic development and innovation dissemination.

2. Functionality of the Scientific Research Market

The notably low level of private expenditures on Research and Development (R&D) in Poland underscores the core issue of an underperforming or inadequately functional scientific research market. In economic terms, a market is an amalgamation of voluntary transactions aimed at optimizing income and utility for all participants.

Modelled as such, the scientific research market (Dömeová, 2008; Kalcheva et al., 2018; Liu, Li, 2017) can be schematically presented as follows, encompassing four distinct areas:

1. Supply-side (Generation of Knowledge):
   - Inventor: their pivotal role is inventing (scientific work), with their primary resource being knowledge.
   - University/Research Institute: primarily tasked with providing research infrastructure and aiding in research organization, their main resource is infrastructure.
2. Demand-side (Demand for Knowledge):
   - Entrepreneur: their primary function is the application of inventions, with managerial skills and market/production insights being their main resources. The other, not less important function is giving signals to inventors, what solutions are/will be required by the market.
   - Investor: their central role is financing the application of inventions, with capital as their main resource aiming in gaining positive financial outcome from those investitions.
3. Transmittal Mechanism (Matching Demand and Supply):
   - Science Broker: facilitating the connection between demand for knowledge and the supply of knowledge (mediating between academia and entrepreneurs), their key resource is managerial skills.

4. Market Regulation Policy: Ensuring that the commercializational activities being performed on the market will be aligned with governmental strategies regarding that market:
    - Government/Local Government Institutions: principally encouraging the creation/utilization of knowledge through the execution of scientific/development policies and appropriate regulations for the research market, their main resources are public funds and regulatory authority.
    - Entrepreneurship Support Institutions: mainly encouraging entrepreneurship and innovation through state economic policies, their main resources are public funds.
    - Science Funding Institutions: incentivizing research in line with scientific policy, their primary resource is public funding.
5. The principal actors within the scientific research market belong to spheres:
    - Institute Sphere: comprising Inventors and Research Institutes. Their actions are driven by scientific ambitions and financial interests. Business Sphere: Encompassing Entrepreneurs, Investors, and Science Brokers. Profit serves as their primary motivation.
    - Government Sphere: encompassing Government/Local Government Institutions, Entrepreneurship Support Institutions, and Science Funding Institutions. Their actions are motivated by the execution of scientific/developmental policies and legal regulations.

Research institutes play a pivotal role in fostering innovation among their employees through several strategic mechanisms (Dahm et al., 2021). These mechanisms encompass the cultivation of an environment that not only ensures a high degree of intellectual and organizational freedom but also should offer strong financial incentives for commercialization efforts. The intricate interplay of these factors creates an ecosystem that empowers researchers to channel their innovative endeavors toward impactful outcomes. A central element in stimulating innovation is the provision of a considerable level of intellectual and organizational freedom. Research institutes need to afford researchers the autonomy to explore uncharted territories, experiment with novel ideas, and collaborate across disciplinary boundaries. This freedom fosters a culture of creativity and curiosity, laying the groundwork for innovative breakthroughs. Financial incentives also play a crucial role in driving innovation. While there exists an evident conflict of interest between individual researchers and the institution regarding the allocation of direct revenues from commercialization, the alignment of interests through direct, understandable and sustained incentives can yield sustainable benefits. Encouraging researchers to focus on long-term gains, where the institution benefits from the collective efforts of active researchers, ensures a healthier collaboration between individual goals and institutional objectives. Another dynamic incentive is the enforcement of mechanisms that necessitate active pursuit of long-term benefits from research commercialization. This financial compulsion encourages researchers to engage proactively in exploring avenues for generating

value from their research findings. This motivation is particularly relevant in a time when innovation is at the heart of economic growth and technological advancement. Furthermore, creating the right incentives within the regulatory framework enhances activities in the scientific research market. Regulatory bodies can stimulate interest and participation by facilitating a conducive environment for research market engagement. These incentives can range from streamlined intellectual property policies to supportive mechanisms for innovation-driven activities.

Despite these stimulants, research institutes may exhibit limited interest in maximizing the sale of research outcomes for various reasons. Challenges stemming from resource constraints, either in terms of human capital and technological infrastructure. Complicated and ineffective commercialization remuneration systems and or insufficiently qualified and demotivated managing personnel can easily hinder the effective offering of research outputs to meet the economy's demands. Additionally, a scarcity of skills and experiences in commercialization efforts, coupled with a reluctance to acquire them (with unavoidable presence of factors mentioned above), can dampen the potential for successful knowledge transfer. Institutional disinterest in commercialization can also stem from an overreliance on easily accessible "soft" funding sources which are much more easier to get and then to process and settle. When readily available sources fulfill an institution's operational needs without necessitating robust commercialization efforts, there usually is less incentive to actively engage in knowledge transfer to the market which requires much more of scarce available skills and organizational effort. Institutes may encounter structural barriers impeding the commercialization process. Administrative hurdles that seem essential on the surface can obscure or hinder the exploration of commercialization opportunities. Moreover, an apparent concern for safeguarding the quality of fundamental research may mask the reluctance of passive stakeholders to embrace commercialization efforts. In some instances, there might be an inclination towards rapid profit realization through maximum cost imposition on inventors for infrastructure utilization, aiming to maximize direct income from commercialization. Research institutes serve as catalysts for innovation by nurturing an environment of intellectual freedom, providing financial incentives, and facilitating the alignment of researcher and institutional interests. However, challenges such as resource constraints, outdated and unmotivating remuneration systems, skill gaps (especially in the area of sales, marketing and customer relations management), reluctance to commercialize, and lack of institutional dynamics can act as barriers. Addressing those challenges is pivotal to creating a thriving ecosystem that efficiently translates research outcomes into real-world impact.

3. Barriers to the commercialization of research results

Barriers to commercialization encompass a spectrum of constraints and characteristics that hinder the smooth and efficient operation of the innovation system, leading to an impasse in the collaboration between academic institutions and businesses (Matusiak, Guliński, 2010). These barriers are encountered both externally, within the business environment, and internally, within the enterprise itself (Panek, 2009).

In existing literature, four distinct categories of barriers have been identified (Barski, Bartosik, 2010; Matusiak, Guliński, 2010):

1. Structural Barriers.
2. Systemic Barriers.
3. Awareness and Cultural Barriers.
4. Competency Barriers in Technology Transfer.

To surmount these barriers, fostering effective collaboration between academic institutions and businesses is essential. Overcoming structural barriers necessitates the formulation of comprehensive strategies and policies that align the goals of both sectors. Addressing systemic barriers calls for streamlining regulatory frameworks to ensure they nurture innovation rather than inhibit it.

Structural barriers (Barski, Bartosik, 2010; Matusiak, Guliński, 2010) manifest when well-defined strategies and executed policies are absent due to the limitations imposed by the business environment. Examples of structural barriers include:

- Stringent Formalization of Procedures.
  A highly formalized procedure for accessing EU funds can hamper innovation initiatives. Excessive bureaucracy and procedural rigidity within administrative support mechanisms can diminish efficiency by adhering to administrative formulas. This leads to the allocation of funds without achieving developmental goals and a preference for safe and conventional projects, bypassing innovative and risky endeavors, which contradicts the essence of innovation.
- Implementation Discrepancy.
  Gaps between program implementation and design can disrupt the seamless execution of supportive instruments and programs. This disparity impedes the effective realization of the intended objectives.
- Outdated Institutional Frameworks.
  Some academic institutions and research centers retain legal foundations, organizational structures, remuneration systems, managing culture and characteristics from the 1970s and 1980s. Taking into account the fact that those were the times of totally different political and economic regime, adhering to extremely different economic goals and

values. This hinders the adaptation of research and development infrastructure to contemporary market conditions, thwarting innovation.

- Inflexible High-Budget Projects.
  Funding high-budget projects without considering economic trends or business environment needs can lead to investments that lack relevance and potential growth trajectories, limiting the effectiveness of innovation initiatives.
- Limited Support for Academic Entrepreneurship.
  Inadequate support for bridging academic innovation and entrepreneurship hinders engagement in self-employment-based strategies. This limits the potential for simplified forms of innovation within academic environments.
- Inadequate Impact of Implementations and Patents.
  The limited impact of technology implementations and commercialized patents on the career trajectory of scientific professionals dampens the motivation for research commercialization.
- Low Adaptability and Commercial Readiness.
  Reduced flexibility among academic institutions to adapt to changing market conditions and a lack of preparedness for commercial activities restricts innovation.
- Restricted Investment Grant Opportunities.
  Limited options for academic community members to access investment grants hinder the advancement of research and development initiatives.
- Emphasis on Pedagogy Over Research.
  Prioritizing pedagogical tasks over research, collaboration with the business sector, technology transfer, and knowledge commercialization diminishes the overall research environment's potential for innovation.
- Reluctance Toward Innovation.
  The inclination of most modern businesses to merely adapt proven solutions from more developed countries, influenced by customer conservatism and limited market size, impedes the demand for innovative products.

Systemic barriers (Barski, Bartosik, 2010; Matusiak, Guliński, 2010) are closely linked to the excessive number of legal acts and regulatory overload within the business environment. Moreover, they stem from the absence of legal measures that could mobilize the economy towards innovative development and enable adaptation to changing economic circumstances. Systemic barriers encompass challenges such as:

- Challenges in Handling EU Procedures. Difficulties in managing EU contest procedures due to unclear rules, errors in application forms, varied interpretations of regulations, and delayed payments by government and regional administrations.

- Lack of Familiarity with EU Aid Principles: Insufficient awareness of EU rules governing public assistance within both public administration and innovation centers. Ambiguities in these regulations can further exacerbate the issue.
- Complex Legal Frameworks: Complicated and numerous legal acts regulating various facets of business activity and growth deter interest in entrepreneurship and business development.
- Absence of Comprehensive Innovation Policy: The absence of a holistic and cohesive innovation policy aligned with sectoral policies results in an inability to coordinate and define strategic directions for technological advancement and economic modernization.
- Imperfect Financial Support Mechanisms: The existing system of exemptions, reliefs and subsidies remains controversial and imperfect.
- Lack of Methodological Foundations: Insufficient methodological frameworks that leverage scientific accomplishments to formulate policies that support innovative entrepreneurship.
- Limited Information Flow and Collaboration: Weak information sharing and collaboration between regional government bodies and central authorities in innovation policy formulation.
- Internal Academic Barriers: Obstacles within academic institutions that hinder or sometimes prevent engagement in research and implementation tasks for commercial clients.
- Incompatibility of Legal Provisions: Certain clauses of the "Higher Education Law" conflict with other legal acts.
- Absence of Institutional Regulations: The absence of university regulations and contractual templates for intellectual property rights transfer, service activities, research contracts, profit-sharing from commercialization, etc.
- Conflicting Laws and Funding Evaluation: Laws that contradict each other in terms of evaluating academic staff and research funding.
- Deterioration of Research-Oriented Units: The existence of research institutions that have lost their scientific-research character, relying on revenue streams unrelated to research activities.
- Limited Intellectual Property (IP) Benefits: Often, intellectual property protection in scientific institutions does not aim to generate benefits from future commercialization.
- Complex Decision-Making Processes: Decision-making processes concerning contributing IP as equity to a company are often beyond the scope of ordinary academic management. This significantly elongates the commercialization process.
- Barriers in Financial Pro-Innovation Actions: Regulations concerning public financial pro-innovation actions, posing obstacles in the form of public assistance regulations.

- Inflexible Organizational Structure: Inertia in embracing organizational changes and bureaucracy within academic institutions.
- Regulatory Transformation Challenges: Issues related to the speed of adjusting regulations concerning the offering and transformation of certain financial instruments tied to technology commercialization.
- Fragmented Approach to Support: A predominant focus on perfecting individual forms of support for innovation and entrepreneurship at the expense of creating effective synergy between them (lacking a systemic approach).
- Organizational Constraints in Institutions: The internal organizational structure of Institutes may hinder the development and implementation of entrepreneurship programs.

Cultural and awareness barriers (Barski, Bartosik, 2010; Matusiak, Guliński, 2010) revolve around the lack of trust, awareness, and societal acceptance of innovative attitudes, juxtaposed with the participants' high self-esteem in the science-business relationship. These barriers encompass:

- Risk Avoidance Mindset. Entrepreneurs and individuals in academia often lack the motivation to undertake risks associated with technology transfer, research result commercialization, establishing enterprises, and fostering innovation.
- Absence of Partnership and Low Trust. Insufficient partnership and a low level of societal trust hinder collaboration and actions in the economic sphere, as well as within the science-business relationship.
- Trust Deficiency Affecting Business Utilization. Low societal trust leads to reduced utilization of pro-innovation services by businesses, even when these services are non-commercial or partially subsidized.
- Regional Authorities' Traditional Focus. Regional authorities' emphasis on traditional policy tools and support areas is often distant from contemporary economic needs.
- Undervaluation of Innovation Support Institutions. Regional authorities might overlook innovation support institutions and fail to recognize their significant role in regional innovative development and capacity-building.
- Weak SME-Academic Collaboration. Limited cooperation between SMEs and national science and technology institutions.
- Insufficient Qualifications for Advanced Collaboration. Inadequate qualifications for engaging in advanced collaboration formats within EU countries.
- Ineffective Adoption of Foreign Practices. Inability to effectively adopt technologies, organizational solutions, and best practices from more developed countries.
- Lack of Entrepreneur Trust in Academic Knowledge. Entrepreneurs often lack trust in knowledge from Polish universities and apprehensions about collaborating with academic institutions. They believe these institutions are not adequately prepared

organizationally for collaboration with industry, even when possessing modern and enticing technologies.

- Ignorance of IP's Competitive Advantage. Entrepreneurs lack understanding of the role of intellectual property (IP) in building competitive positions and adding value to companies.
- Academic-Business Cooperation Hesitance. Academic reluctance to collaborate with business, sometimes viewed as profit-oriented and at odds with the ethos of scholarly activities.
- Perception of Universities and Research Centers. Universities and Research Centers are often perceived as entities fundamentally uninterested in promoting entrepreneurial activities.
- Risk Aversion among Academics. Academic staff and doctoral candidates are hesitant to embrace entrepreneurial activities as part of their career plans.
- Vulnerability of Entrepreneurial Staff. Despite their competencies and task completion, those engaged in business activities are often the first to face redundancy during reorganization or downsizing. That happens because either the more entrepreneurial workers cannot stand the organizational culture and they leave or their superiors fire them first hoping they easier find a new job.
- Undervaluation of Applied Research. Applied research is often considered less prestigious within academic circles, where "true science" pertains to fundamental research, while developmental work and business-related services are considered inferior.
- Misplaced Role of Universities and Research Centers. The belief that universities and Research Centers should focus on benevolent knowledge sharing rather than seeking mechanisms for profitable commercialization.
- Financial Self-Sufficiency Expectations. Imposing financial self-sufficiency on academic innovation centres compels them to generate short-term revenues, restricting their long-term potential.
- Weak R&D-Industry Ties Restrict Service Growth. Weak connections between research and development and innovation centers impede pro-innovation service development, innovative idea creation, and their translation into the SME sector.
- Being passive in innovation Offerings and IP Protection. Academic institutions and Research centers show passivity in developing innovative solutions and protecting them legally.
- Limited Commercialization Efforts by Research Institutes. Research institutions usually remain passive in commercializing intellectual property by contributing inventions to companies in exchange for shares or stocks.

Competency barriers (Barski, Bartosik, 2010; Matusiak, Guliński, 2010) are frequently linked to the incompetence of local government bodies, research institutes authorities and administrations, and novice (as well as experienced) entrepreneurs. Within these barriers, the following can be identified:

- Regional Authorities' Limited Industry Awareness. Lack of regional authorities' knowledge about growth industries and creative sectors.
- Scarcity of Expertise for Market Analysis and Strategy. Absence of skilled specialists capable of conducting market analysis and devising effective marketing strategies.
- Inadequate Legal Understanding among Entrepreneurs. Lack of awareness about legal regulations concerning intellectual property (IP) usage among entrepreneurs, leading to erroneous decisions such as neglecting IP protection or selecting inappropriate protection forms.
- Inefficient Utilization of Time for Patent Approval. Ineffectual use of time between filing an application and patent approval by nascent entrepreneurs.
- Research institute Administration's Collaboration Inefficacy. Institute administrations struggling to formalize business collaboration and equitable distribution of resultant benefits.
- Resource Insufficiency for Microenterprises' IP Management. Microenterprises lacking the necessary personnel and resources for effective intellectual property management.
- Institute Staff's Limited Technology Transfer Knowledge. Institute staff's inadequate understanding of technology transfer mechanisms and intellectual property protection principles. And the institutes' management are not adequately remunerated and motivated to be ready to carry and solve much bigger managemental problems in commercialization than those which are to encounter when managing the staff in realization the basic research.
- Lack of Entrepreneurial Knowledge and Entrepreneurial Skills among employees of the institute. Insufficient knowledge of innovative enterprise functioning, technology management, technology transfer, legal matters, accounting, and marketing.
- Institut Staff's Limited Industry Interaction and Experience: Low engagement and limited experience of institute staff in business collaboration and engagement with the institute environment.
- Limited Commercialization Support from Institutions. General failure of research institutions to develop comprehensive offerings for intellectual property commercialization, where protected solutions are often under-promoted and their implementation is inadequately described.
- High Personnel Turnover in Innovation Centers and research institutes. High staff turnover, low practical business knowledge, and lack of substantial business experiences among a significant portion of innovation center staff and collaborators.

- Weaknesses in Protective and Claim Procedures. Weaknesses in the specialist group responsible for preparing and executing protective and claim procedures.
- Overemphasis on Formal IP Protection. Excessive focus on formal industrial property protection methods, often undervaluing the wide array of informal solutions that can prove more effective in specific scenarios.
- HR Challenges in Innovation Centers. Difficulty in recruiting and retaining skilled employees within academic innovation centers due to unattractive financial offers and limited time-bound project positions. Similar situation in research institutes, whilst realizing fundamental research usually cannot provide them with good remuneration conditions.
- Lack of Performance Monitoring in Innovation Centers. Many innovation centers exhibit low activity in monitoring and evaluating their operations and outcomes.
- Competency Gaps in Public Support in Innovation Centers. Substantial competency deficits within innovation centers related to public assistance. Analogical situation among the researchers in research institutes.
- Outdated and inadequate remuneration systems, completely not motivating researchers in institutes to bear the hardships of implementation activities, which are much more difficult and demanding than basic research.

4. Research methodology

The research was conducted in the first quarter of 2023 at one of the institutes within the Łukasiewicz network. A total of 102 individuals participated in the study, comprising 42 members of the management team and 60 scientific employees, accounting for nearly one-third of all institute personnel. The research was structured into three phases. During the initial phase, a selection was made of the 10 most frequently identified barriers to commercializing research results by the institute's employees. Preliminary selection was based on interviews conducted with the employees, as well as a voluntary survey form designed to highlight the most significant barriers faced by employees in the context of research outcome commercialization. To facilitate this, the survey form included a guide with explanations of the most commonly encountered barriers, as described in Section 3 of this article.

Utilizing the 10 most frequently mentioned barriers that emerged from the selection process, a structured form was created, and respondents were asked to position specific barriers within a hierarchy of importance. The analysis of the results was facilitated by the Importance Index (W) (Karaszewski, 2001), calculated using formula (1):

$$W = \frac{\sum_{i=1}^{k} n_i w_i}{k \cdot N} \quad (1)$$

where:
W - importance index,
i - indication of the place of the barrier,
k - maximum weight (indicating the order of the instrument meant assigning the weights in reverse order,
n_i - the number of indications of a given method (technique) on the *i*-th place,
w_i - weight corresponding to the site of the technique *I*,
N - number of respondents.

In the third phase, a comparison was made between the prioritization of barriers from the perspective of the management team and the scientific staff. Additionally, an analysis was conducted to uncover disparities in the perception of the competency-related barrier.

This phase involved a comprehensive examination of the identified barriers, considering how their importance was perceived differently by the management personnel and the scientific researchers. The aim was to explore potential variations in viewpoints and priorities between these two distinct groups within the institute.

The analysis also focused specifically on the competency-related barrier, aiming to delve deeper into any divergences between the management and scientific staff regarding their understanding, assessment, and significance of this particular obstacle. By scrutinizing the discrepancies, the research aimed to identify potential areas for targeted improvement strategies and interventions related to competency-building activities.

5. Result and Discussion

Based on the conducted analysis, the 10 most frequently mentioned barriers to research outcome commercialization by institute employees were selected. These include:

1. Lack of awareness of commercialization.
2. Lack of cooperation with the private sector.
3. Difficulties in protecting intellectual property.
4. Lack of financing at the stage of commercialization.
5. Academic and publishing culture.
6. Complex administrative procedures.
7. Lack of commercialization project management skills.
8. Investment risk.

9. International competition.
10. Lack of entrepreneurial culture.

The compilation of obtained responses for the importance rankings (W importance index) for individual barriers from the perspective of the management team is presented in Fig. 1, while from the perspective of the employees in Fig. 2.

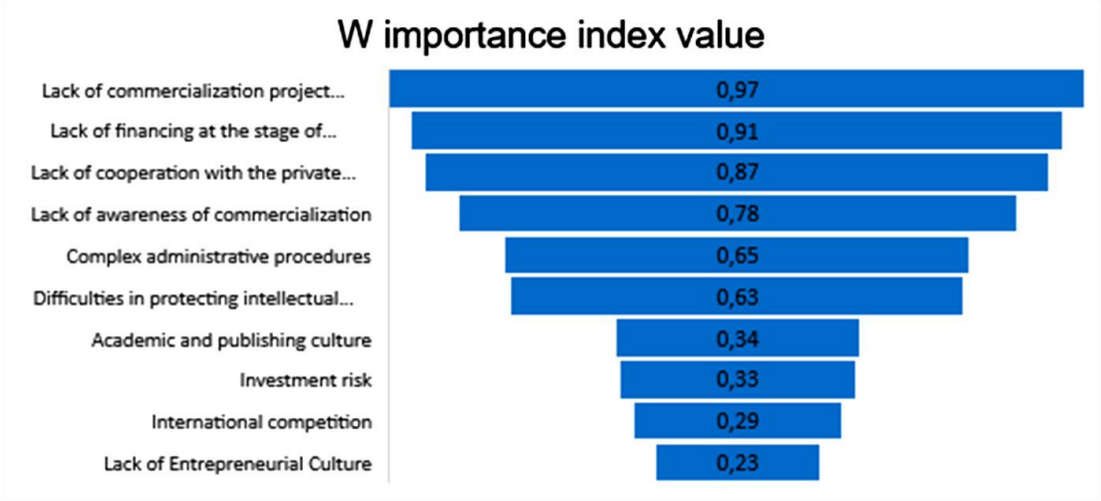

Figure 1. List of importance index W for selected barriers to the commercialization of research results - the management's team perspective.

Source: own study.

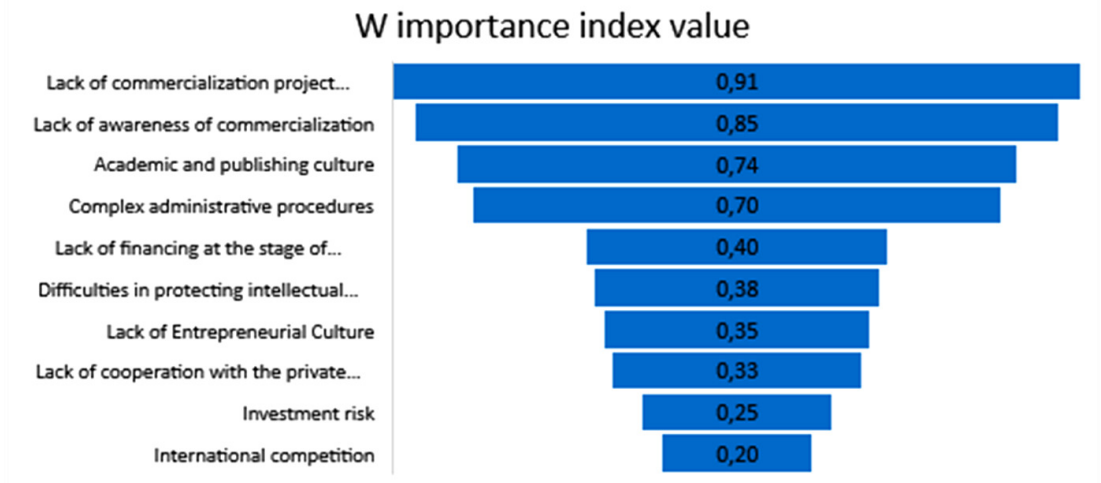

Figure 2. List of importance coefficients W for selected barriers to the commercialization of research results – employees' perspective.

Source: own study.

In the assessment provided by the management's team, the most significant barriers include:

1. Lack of commercialization project management skills: managers may perceive this as a pivotal barrier due to their awareness of the necessity for effective management throughout the commercialization process to attain success and secure funding.
2. Lack of financing at the stage of commercialization: managers generally possess a comprehensive understanding that insufficient funds could potentially lead to delays

or even hinder the commercialization process, subsequently impacting the institute's overall development.

3. Lack of cooperation with the private sector: from a business perspective, institute managers can view collaboration as a key factor, recognizing its potential to bring about funding, resources, and a market-oriented perspective.

From the employees' perspective, the most critical barriers are:

1. Lack of commercialization project management skills: scientific staff might not perceive this barrier as prominently as the managers do, as their focus tends to lean more towards the scientific aspects of their work.
2. Lack of awareness of commercialization: scientific personnel could concentrate primarily on scientific research and publications, possibly not fully grasping the significance of transforming their research into viable products or services.
3. Academic and publishing culture: researchers may encounter considerable pressure related to scientific publications, which could potentially conflict with the necessity to maintain secrecy for the purpose of successful commercialization.

The disparities in perceiving these barriers across different domains arise from:

1. Lack of financing at the stage of commercialization: both managers and scientific staff might recognize this barrier as pivotal, as it directly impacts the feasibility of executing commercialization projects.
2. Lack of cooperation with the private sector: both teams might acknowledge the value of private sector collaboration, albeit from distinct viewpoints managers view it as a source of funding, while scientific staff see it as an avenue to access resources and market insight.
3. Lack of commercialization project management skills: while this issue holds more significance for managers, scientific staff might also appreciate that a lack of management skills can potentially delay or complicate the success of the commercialization process.

In summary, the study highlights differing perspectives between institute managers and scientific employees concerning the most notable barriers to successful commercialization. While management emphasizes project management skills, funding, and private sector collaboration, scientific employees underscore their need for improved awareness, a shift from pure research to commercial products, and a balance between academic and commercial priorities. These disparities underscore the complexity of the commercialization landscape, affected by diverse perspectives within research units and fields. Both groups of employees identified the competency barrier as the most significant. It refers to the lack or insufficient skills and knowledge needed for effective management of a commercialization project or the process of transforming scientific research into products or services.

Differences were identified in how the leadership and employees of research institutes may approach this barrier:

- Perspective of Research Institute Leadership: recognizing competency gaps: Institute leadership recognizes the need for possessing project management skills in commercialization and identifies it as a key element for achieving success in commercialization. Encouraging competency development: Leadership initiates and supports training programs and invests in developing project management skills among employees. Considering hiring experts: Leadership considers hiring specialists with experience in managing commercialization projects to fill competency gaps.
- Perspective of Scientific Employees: Lack of experience: Scientific employees may not realize the role that project management plays, leading to a lack of skills in this area. Time concerns: Scientific employees, focused on research, may worry that learning project management will take up a lot of their time and divert them from their research work. Resistance to change: Scientific employees accustomed to research work might resist acquiring new skills, especially if it's beyond their comfort zone.

In the area of competency gaps, there are also differences in the perception of barriers that stem from:

- Differences in priorities: Management may view the development of competencies as crucial for effective institute management, while scientific staff may see it as an additional responsibility.
- Understanding the necessity: Institute management typically possesses a deeper understanding of why possessing commercialization management skills is essential, whereas scientific employees may require education in this domain.
- Role transition: Scientific employees may harbor concerns that the need to acquire management skills will change their roles from researchers to project managers.

Competency gaps can lead to variations in the perception of barriers by both institute management and scientific staff. These differences arise from distinct perspectives, priorities, as well as understanding of needs and consequences related to managing commercialization projects.

6. Conclusion

The case study has shed light on the multifaceted nature of barriers that impede the successful transfer and commercialization of research findings. Recognizing and addressing these barriers is of paramount importance for maximizing the societal and economic impact of academic research.

The findings underscore the need for institutions and stakeholders involved in research and technology transfer to develop comprehensive strategies. These strategies should encompass skill development, improved collaboration with industry, and effective management of intellectual property rights to overcome the identified barriers. The diverse perspectives of management and scientific staff regarding barriers highlight the necessity of tailoring approaches for different stakeholders. Management needs to foster a culture that encourages skill development, while addressing the concerns of scientific staff regarding role transitions. The dynamic nature of the barriers suggests that strategies for technology transfer and commercialization should be continuously monitored and adapted. Regular assessments can help institutions stay responsive to emerging challenges and changing stakeholder perceptions.

The case study has provided valuable insights, yet there is room for further investigation into specific strategies that effectively mitigate the identified barriers. Future research could focus on evaluating the long-term impact of tailored interventions and examining successful case studies that have overcome similar challenges.

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MANAGEMENT STRATEGIES AND ECONOMIC PERSPECTIVES: UNPACKING THE PARALLELS AND CONTRASTS BETWEEN POLAND AND THE CZECH REPUBLIC

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Purpose: The article aims to elucidate management and economic divergences between Poland and the Czech Republic, providing valuable insights for Central European policymakers and entrepreneurs.
Design/methodology/approach: The research employs literature analysis, tabular comparisons, and surveys conducted in both countries.
Findings: Parallels exist in governance and policy alignment, while disparities are evident in economic development and sectoral priorities. These findings offer a nuanced understanding of shared traits and distinct differences shaping the business landscapes and economic paths of these Central European nations.
Research limitations/implications: The research has limitations, such as its specific timeframe and omitted variables. It underscores the importance of comparative analysis for comprehending unique and common features in both economies.
Practical implications: Practical implications extend to policymakers, managers, and entrepreneurs in Poland and the Czech Republic, providing insights for informed decision-making and collaboration. Understanding both similarities and differences enables stakeholders to leverage strengths and address specific challenges, promoting growth and cooperation within the Central European region.
Social implications: The study suggests potential enhanced collaboration and mutual understanding between the societies of Poland and the Czech Republic, facilitated by aligned management strategies and economic policies. These insights may foster a shared sense of identity and purpose in the Central European region, contributing to social cohesion and mutual growth.
Originality/value: This research's uniqueness lies in its comparative analysis of management strategies and economic prospects between Poland and the Czech Republic, an underexplored area in existing literature. Its value extends to both academic discourse and practical applications, offering distinct insights to drive collaboration and development within the Central European context.

Keywords: Management, comparative analysis, organizational culture, centralization, business practices, regional economics, cooperation, innovation, Poland, Czech Republic.

Category of the paper: research paper.

1. Introduction

In the evolving landscape of global business, the understanding and evaluation of management strategies and economic perspectives is critical. As two prominent Central European economies, Poland and the Czech Republic present a rich tapestry of similarities and differences worth exploring. This research delves into the various facets of business conduct, economic conditions, and organizational behavior that shape the two nations.

The comparison of management structure between Poland and the Czech Republic forms a core part of this investigation. A detailed look at the hierarchy, authority, decision-making processes, and their impact on employees and business results unveils the underlying organizational principles guiding enterprises in these countries. This inquiry helps in discerning how different or similar these concepts are in the two contexts.

Furthermore, the article offers a comparative analysis of industry focus and employee experience between Poland and the Czech Republic. This analysis shines a light on the sectors that dominate the economies of both nations and how employees perceive their professional environment. The connection between industrial concentration and workforce dynamics is a thread that runs through this comparative study.

An overview of management and economic perspectives between Poland and the Czech Republic lends a macroscopic view to this comparative endeavor. Examining the policies, regulations, market forces, and economic indicators provides a complete picture of the business ecosystem. The parallels and contrasts in these areas hold valuable insights into how each country has tailored its economic strategies.

The aspect of decision-making processes and transparency forms another significant angle of comparison. A thorough comparative analysis of how decisions are made, who makes them, and how transparent these processes are in Poland and the Czech Republic can uncover variations in leadership and governance in the corporate landscape of both nations.

The study also covers internal communication and organizational culture in a comparative analysis between Poland and the Czech Republic. Understanding how companies in these countries communicate internally, foster organizational culture, and its impact on productivity and innovation is key to this analysis. This section provides a nuanced view of how businesses nurture their internal environment and the consequent effect on overall performance.

Lastly, the comparative analysis of results on the example of Poland and the Czech Republic ties together all the previous sections. It brings coherence to the various strands of comparison, synthesizing the insights gathered from each angle. This part offers a summative view that places the detailed comparisons in a broader context, emphasizing the relevance and implications of the findings.

Overall, this article offers a comprehensive and nuanced view of management strategies and economic perspectives, painting a vivid picture of business in Poland and the Czech Republic. By weaving together varied threads of comparison, it provides an in-depth understanding of how these two Central European economies navigate their unique and shared challenges. The learnings from this research can inform policymakers, business leaders, academics, and anyone interested in the intricate dynamics of business management and economy in the region.

It is worth pointing out that the similarities between Poland and the Czech Republic are:

Both are members of the European Union and the Visegrad Group, a regional alliance of four Central European countries. Both sides are characterized by a high level of mutual trade, exceeding EUR 20 billion per year. They mainly export and import similar products such as food, machinery, electrical equipment, base metals, cars and aircraft (Garlick, 2019, pp. 1390-1414; Nowak et al., 2022, p. 1599; Svejnar, 2002, pp. 3-28; Roland, 2002, pp. 29-50; Tung, Havlovic, 2003, pp. 289-306; Business ties between Poland and the Czech Republic, Economic forecast for Poland).

They both participate in a cross-border cooperation program financed by the European Regional Development Fund, which aims to strengthen ties and increase the attractiveness and accessibility of areas near the Polish-Czech border.

Here are some contrasts between Poland and the Czech Republic:

Poland has a much larger population (38 million) and GDP ($595 billion) than the Czech Republic ($10.7 million and $262 billion, respectively). Poland recorded stronger economic growth in 2022 (4.9%) than the Czech Republic (3.6%), but according to forecasts it will face a sharper slowdown in 2023 (0.7%) than the Czech Republic (1.8%) with due to increased inflation, tighter financing conditions and low consumer and business confidence.

Poland is characterized by higher inflation (13.2% in 2022) than the Czech Republic (9.5% in 2022), which is mainly due to the growing increase in prices of energy, food and services. In both countries, inflation is expected to peak in early 2023 and decline gradually thereafter.

2. Selected theoretical aspects of the management structure on the example of Poland and the Czech Republic

Differences in the distribution of positions between Poland and the Czech Republic suggest a different approach to the management structure. This may indicate differences in hierarchy, authority and decision-making processes. It is important to consider whether these differences are the result of different business traditions or whether they may be a response to specific business challenges and goals.

Table 2. Comparison of Governmental Policies, Goals, Regulations, Support, Challenges and Strategies for the Implementation of Hydrogen Technologies in Poland and Germany presents a detailed analysis broken down by Poland and Germany, taking into account various aspects related to the implementation of hydrogen technologies. This comprehensive table can serve as a reference for further research and analysis in this field. A detailed analysis broken down by Poland and Germany is presented in Table 1 below.

Table 1.
Comparison of the management structure between Poland and the Czech Republic: hierarchy, authority, decision-making processes and impact on employees and business results

HIERARCHY	
Poland	A more hierarchical management structure may prevail, where decisions are taken at higher levels and lower-level employees have limited autonomy.
Czech Republic	A flatter structure is possible, where employees at different levels have more influence on decisions.
AUTHORITY	
Poland	Authority can be more focused, with a clear line of command and more emphasis on obedience and compliance.
Czech Republic	A more decentralized authority is possible where employees are encouraged to think for themselves and take initiatives.
DECISION PROCESSES	
Poland	The decision-making process can be more formalized, with clear procedures and regulations that must be followed.
Czech Republic	The decision-making process can be made more flexible and participatory, with more emphasis on cooperation and consensus.
IMPACT ON EMPLOYEES AND BUSINESS RESULTS	
Poland	A hierarchical structure can lead to greater efficiency and control, but it can also reduce employee initiative and satisfaction.
Czech Republic	A flat structure can increase employee engagement and satisfaction, but it may also require stronger leadership and coordination.

Source: (Authors own work on the basis of: Skuza, Scullion, McDonnell, 2013; Ladner, 2017; Grobelna, 2019; Knippschild, 2011; Kabus, 2019; Grzelczak et al., 2017; Goetz, Wollmann, 2001).

In Poland, the management structure tends to be more hierarchical. This means that decisions are made at higher levels of the organization and employees at lower levels have limited autonomy (Cichoń et al., 2021). This centralization can lead to faster and more decisive decision-making, but at the same time it can discourage individual initiatives and innovation at lower levels.

In the Czech Republic, the management structure is flatter, which means that employees at different levels have more influence on decisions. This decentralization can promote creativity and innovation, but it can also lead to problems with coordination and uniformity.

The authority in Poland is more focused and concentrated, with a clear line of command. This can lead to a more organized and coherent structure, but also to potential inflexibility and bureaucracy (Hąbek, Wolniak, 2016).

In the Czech Republic, authority is more decentralized, which encourages independent thinking and initiative on the part of employees. This can lead to increased adaptability and response to changing market conditions.

Decision-making processes in Poland are often more formalized, with clear procedures and regulations. This can lead to consistency and transparency, but it can also slow down the decision-making process.

In the Czech Republic, decision-making processes are more flexible and participatory, which can lead to greater cooperation and consensus. However, this may require stronger leadership and coordination to ensure effective implementation of the decision.

The hierarchical structure in Poland can lead to greater efficiency and control. Nevertheless, it can also discourage employees from taking initiatives and affect their satisfaction. The flat structure in the Czech Republic can increase employee engagement and satisfaction, but may require stronger leadership and coordination.

While Poland and the Czech Republic are neighboring countries with many common characteristics, differences in governance structure can affect the way organizations operate in these countries. Poland seems to prefer a more hierarchical and centralized structure, while the Czech Republic tends towards a flatter and decentralized model. These differences can have different implications for both employees and business outcomes, with distinct advantages and disadvantages for each approach. The choice of the appropriate structure depends on the specificity of a given organization, its goals and culture as well as on the market environment in which it operates (Tikhonova, Dvornikova, 2018). Differences in the governance structure between Poland and the Czech Republic are multidimensional and may have various causes and consequences. The final interpretation may require further research and analysis, which takes into account the specificity of various industries, history, culture and economic environment of both countries.

3. Comparative Analysis of Industry focus and employee experience between Poland and the Czech Republic

This table 2 provides an insightful comparison between Poland and the Czech Republic, focusing on the differences in industry specialization and employee experience. It highlights

how each country may prioritize various sectors and how their approach to employee retention and development may differ. Such a comparative analysis can be vital for stakeholders seeking to understand the unique business landscapes of both countries, informing decisions in investment, management practices, and market entry strategies.

Table 2.
Comparative Analysis of industry focus and employee experience between Poland and the Czech Republic

INDUSTRY DIFFERENCES	
Poland	IT sector: As previously mentioned, Poland may focus on technology and innovation, which suggests a stronger emphasis on the development of this field.
Czech Republic	Other Industries: The Czech Republic may focus on other sectors, such as engineering, automotive and tourism, reflecting the country's unique resources, traditions and strategies. Diversification: There may also be more diversification in the Czech Republic, which indicates flexibility and adaptability to different markets and trends.
EMPLOYEE EXPERIENCE	
Poland	Stability: As previously indicated, a longer seniority may indicate the stability and attractiveness of employers in Poland. Employee development: Polish companies may put more emphasis on employee development and training, which can affect loyalty and satisfaction.
Czech Republic	Worker Mobility: There may be greater worker mobility in the Czech Republic, indicating a dynamic labor market where workers often change employers in search of new opportunities. Flexibility: The Czech Republic can promote more flexible career paths and a variety of experiences, which can attract different talents and skills. Recruitment strategy: Differences in seniority may also reflect different recruitment and employment strategies, such as greater openness to international workers or different approaches to employment contracts.

Source: Authors own work on the basis of: (Koubek, Brewster, 1995; Wolniak, Sułkowski, 2016; Clark, Soulsby, 1998).

The distribution of industries and the experience of employees in Poland and the Czech Republic reflect the different strategies, values and cultures in both countries. Both Poland and the Czech Republic have their own unique characteristics that can provide valuable insights for entrepreneurs, investors and managers. Analyzing these differences can lead to a deeper understanding of both markets and enable you to plan and execute your business strategies more effectively.

4. Comparative Overview of management and economic Perspectives: Poland and the Czech Republic

As part of globalization and an increasingly complex business world, understanding the cultural and economic differences between countries becomes crucial to international success. Poland and the Czech Republic, two dynamically developing economies in Central Europe, present unique approaches to both management and investment in new technologies.

Table 3 is an attempt to illustrate these differences. It analyzes and compares key aspects of management, such as hierarchical management style and employer-employee relations, as well as some specific economic perspectives, such as investments in hydrogen technology.

By juxtaposing these diverse elements, the table provides valuable insight into how different cultures and management strategies can influence the business and economic dynamics in these two countries. Such analysis can prove to be an invaluable tool for investors, managers and policy makers who seek to understand and act effectively in these unique market contexts.

Table 3.
Comparative Overview of management and economic Perspectives: Poland and the Czech Republic

POLAND	
Hierarchical Management	In Poland, a more hierarchical management style may prevail. Managers often make key decisions, and lower-level employees may have limited autonomy. This may reflect traditional social values and norms that emphasize the importance of authority and structure.
Organizational Culture	Polish companies can put more emphasis on procedures and regulations, promoting a culture that values consistency and compliance with set standards.
Employer-Employee Relations	In Poland, employer-employee relationships can be more formal, with clear lines of communication and expectations towards employees.
CZECH REPUBLIC	
Democratic Governance	The Czech Republic is a parliamentary representative democracy with a president as head of state and a prime minister as head of government. Introduced in 1993 after the dissolution of Czechoslovakia, it defines the rules and structure of governance. It operates on the principle of separation of powers into three independent branches: executive, legislative and judiciary.
Organizational Culture	Czechs are often recognized for their strong work ethic, valuing hard work, precision, and responsibility. This manifests in organizations as a focus on goals, efficiency, and quality.
Employer-Employee Relations	In the Czech Republic, these relationships may be more relaxed and collegial, reflecting openness and a desire for cooperation at different levels of the organization.

Source: (Authors own work on the basis of: Skuza, Scullion, McDonnell, 2013; Ladner, 2017; Grobelna, 2019, Knippschild, 2011; Grzelczak et al., 2017; Goetz, Wollmann, 2001).

A comparison of management styles in Poland and the Czech Republic brings to light differences that are not only superficial, but also deeply rooted in the culture and tradition of both countries. A higher percentage of democratic governance in the Czech Republic, for example, may indicate a more collegial and participatory working style, while Poland may lean towards a more organized and hierarchical structure. These differences can have a significant impact on how business is conducted, how employees are motivated and how organizations achieve their goals in both countries.

5. Innovations and Management Styles: A Comparative Analysis of Poland and the Czech Republic

In today's rapidly changing world of technology and globalization, innovation and management style are becoming key elements of success for any economy. Poland and the Czech Republic, two important countries in Central and Eastern Europe, are known for their unique approaches to science, technology and management (Wojtaszek, Miciuła, 2019).

Table 4 gives an overview of these two different perspectives. On the one hand, it shows the commitment of both countries to invest in research and development and innovation, with Poland focusing on supporting startups and the Czech Republic on engineering and new technological products. On the other hand, it analyzes differences in management styles, emphasizing a hierarchical but increasingly flexible approach in Poland and a more consensus- and cooperation-oriented structure in the Czech Republic (Potluka, Liddle, 2014).

These differences in management and innovation can have a significant impact on the ways of doing business, organizational culture and the ability to adapt to new challenges and opportunities in both countries. This table provides a valuable overview of these key aspects that can serve as a tool for investors, entrepreneurs and business leaders who wish to understand and take advantage of these unique features of Poland and the Czech Republic.

Table 4.
Innovations and Management Styles: A Comparative Analysis of Poland and the Czech Republic

INNOVATIONS	
Poland	Poland is one of the largest economies in Central and Eastern Europe, and its market is attractive to external investors. In recent years, Poland has invested in scientific and technological development, focusing on modern technologies and innovations. Examples include support for startups and research and development programs.
Czech republic	The Czech Republic is known for its engineering and technical tradition. In the field of science and technology, there is a strong emphasis on research and development, which translates into innovation. There are many high-tech companies in the Czech Republic that focus on the development of new products and technologies.
MANAGEMENT STYLE	
Poland	The management style in Poland is characterized by a combination of traditional hierarchies with elements of a modern, more flexible approach. The approach to employees is changing, focusing more and more on autonomy, motivation and creativity. This approach can foster innovation because it gives employees more freedom to create and implement new ideas.
Czech republic	The Czech style of management is more oriented towards consensus and cooperation. Companies often use a flatter organizational structure, which can foster communication and the exchange of ideas. Such a structure can foster innovation as it allows thoughts and ideas to flow more easily across the different levels of the organization.

Source: Authors own work on the basis of: (Costa et al., 2023; Špaček, 2018; De Blick et al., 2023; Savitt, 1998, Wojtaszek, Miciuła, 2019; Koubek, Brewster, 1995; Cerciello et al., 2023).

Differences in management styles and approaches to innovation in Poland and the Czech Republic can be seen as a reflection of cultural and historical differences. Both countries have their own unique features that can foster innovation, but in different ways.

Poland, with its increasingly flexible approach and support for startups, can create an environment conducive to experimentation and risky projects. In turn, the Czech Republic, with its emphasis on consensus and cooperation, can foster innovation through effective communication and cooperation between departments.

Ultimately, management style can have a significant impact on how organizations in Poland and the Czech Republic approach innovation. Adjusting the management style to the organizational culture and market specificity may be the key to success in the field of innovation (Heyden et al., 2019).

6. Decision-making Processes and Transparency: A Comparative Analysis of Poland and the Czech Republic

In today's business world, decision-making processes and the level of transparency in organizations are essential to the effectiveness, trust and satisfaction of employees. Different approaches to these key aspects of management can have a profound impact on a company's culture and performance.

Table 5 presents an analysis of these two important areas in Poland and the Czech Republic. It provides a detailed look at the different styles of decision-making in traditional and modern organizations in both countries and the importance of transparency in decision-making. In Poland, we observe both hierarchical decision-making structures and a growing tendency towards more decentralized and democratic approaches, especially in modern companies and startups. Similarly, in the Czech Republic, these differences are reflected in conservative companies compared to those that promote innovation and collaboration.

Table 5.
Decision-making Processes and Transparency: A Comparative Analysis of Poland and the Czech Republic

POLAND	
Making a decision	
In Poland, decision-making processes in organizations may differ depending on the type of company and organizational culture.	
Traditional Organizations	In some of the more traditional Polish companies, decisions are made at higher levels of management. This means that lower-level employees have less influence on decision-making processes.
Modern Organizations	In companies that promote a more open and flexible culture, decision-making processes are more decentralized. In such cases, teams and individuals have more freedom and responsibility to make decisions.
Power Structure	In Poland, there is a trend towards flat organizational structures, especially in modern companies and startups. Greater employee participation in decision-making may indicate a more decentralized and democratic power structure.
CZECH REPUBLIC	
Making a decision	
As in Poland, in the Czech Republic there are also differences in decision-making processes depending on the type of company and organizational culture.	
Traditional Organizations	In more conservative and hierarchical companies, decisions are made primarily by senior management.
Modern Organizations	Innovative and collaborative companies often take a more decentralized approach to decision-making, where employees at various levels have an influence on decision-making processes.
Power Structure	In the Czech Republic, a culture of collaboration and consensus can lead to a flatter organizational structure where employees are more involved in decision-making. It could also mean a more decentralized and flexible power structure.

Cont. table 5.

POLAND	
Transparency level	
In Poland, the transparency of the decision-making process may vary from organization to organization. In modern companies, especially those focused on innovation and agility, transparency is often highly valued.	
Benefits of Transparency	Transparency in Poland is seen as a way to build trust among employees, improve communication and promote accountability.
Exceptions and Challenges	Some companies, especially more traditional ones, may not promote full transparency. This may be the result of fears of disclosing sensitive information or the complexity of decision-making processes.
Organizational Culture and Values	
In Poland, values such as honesty and ethics are important in shaping organizational culture. Transparency of the decision-making process is often associated with these values and can be a key element in building a positive image of the company.	
CZECH REPUBLIC	
Transparency Level	
The Czech Republic, like Poland, has a varied level of transparency in the decision-making process in different companies.	
Benefits of Transparency	In the Czech Republic, transparency is also considered an important factor in building trust and cooperation. Companies that promote openness and clarity in their decision-making processes may experience higher employee engagement.
Exceptions and Challenges	As in Poland, not all companies in the Czech Republic adhere to full transparency. The reasons may be similar, such as fear of disclosure or lack of understanding of the benefits of full transparency.
Organizational Culture and Values	In the Czech Republic, a culture of cooperation and consensus can foster transparency. Pursuing a common goal and mutual trust are often important values, and transparency in decision-making processes can be crucial to achieving these goals.

Source: Authors own work on the basis of: (Kohnová et al., 2023; Wolniak, 2023; De Blick et al., 2023; Savitt, 1998, Tung, Havlovic, 1996; Plaček et al., 2023; Claessens, Djankov, 1999; Bejtkovský, 2016).

Transparency of the decision-making process in Poland and the Czech Republic is a complex issue that reflects differences in organizational culture and company values. Both countries tend to promote transparency as a means of building trust and honesty, although the implementation of this goal may differ. Introducing and maintaining transparency requires proper management and understanding of the organization's specifics. This may include clear communication of decision-making processes, regular updates, and promoting a culture of openness and honesty (Abdallah, 2023). There is still room for improvement in both countries in terms of fully implementing transparency, and further research and adaptation to local conditions and values are crucial for the successful implementation of this important element in governance.

7. Internal Communication and Its Relationship with Organizational Culture in Poland and the Czech Republic

Internal communication and organizational culture are key elements of company management and strategy, affecting productivity, employee satisfaction and the overall working atmosphere. Collaboration, innovation and hierarchy are values that can shape both

communication and organizational culture differently in different countries and different types of companies (Khosravi et al., 2019).

The table 6 outlines the unique features and challenges of internal communication and organizational culture in Poland and the Czech Republic. In Poland, many companies strive to promote clear and effective communication, using modern tools and strategies, as well as emphasizing the importance of cooperation and innovation. However, in some larger, more hierarchical companies there can be communication problems. Similarly, in the Czech Republic, especially in small and medium-sized enterprises, communication can be more direct and open. Both Poland and the Czech Republic pay attention to innovation, especially in dynamically developing sectors, but they can show different degrees of formality and hierarchy depending on the industry and company tradition. The table 6 provides valuable insights for leaders and managers who seek to understand and adapt effective internal communication practices and organizational culture. It serves as a guide for those who want to understand how these key elements function in different cultural and organizational contexts, and how they can be adapted to the individual needs and goals of companies.

Table 6.
Internal Communication and Organizational Culture: A Comparative Analysis of Poland and the Czech Republic

POLAND	
Assessment of internal communication	
Strengths	In Poland, many companies strive for clear and effective communication, promoting openness and regular meetings between teams.
Weaknesses	There may be problems in large, hierarchical companies where communication can be more formal and complex.
Tools and Strategies	The use of modern communication tools, such as online collaboration platforms, can support internal communication.
Key elements of organizational culture	
Collaboration	In Poland, many leaders promote teamwork and collaboration.
Innovation	In some sectors, especially in technology, innovation is the key to success.
Hierarchy	In more traditional companies, hierarchy and structure may be more prominent.
CZECH REPUBLIC	
Assessment of internal communication	
Strengths	In the Czech Republic, especially in small and medium-sized enterprises, communication can be more direct and open.
Weaknesses	In some larger companies there may be communication barriers related to hierarchy and structure.
Tools and Strategies	The Czech Republic also uses modern tools and strategies to promote effective internal communication.
Key elements of organizational culture	
Cooperation	In the Czech Republic, cooperation and consensus are often key values.
Innovativeness	As in Poland, innovativeness can be valued, especially in dynamically developing sectors.
Hierarchy	Czech companies may exhibit varying degrees of formality and hierarchy depending on the industry and company tradition.

Source: Authors own work on the basis of: (Soukopová et al., 2023; Wolniak, 2023; De Blick et al., 2023; Savitt, 1998, Tung, Havlovic, 1996; Plaček et al., 2023; Claessens, Djankov, 1999; Bejtkovský, 2016).

In both Poland and the Czech Republic, there is a focus on effective communication, especially through the use of modern tools and online collaboration platforms. Larger, more hierarchical companies in both countries may face challenges in internal communication, where the structure can cause complexity and barriers. Teamwork, collaboration, and innovation are highlighted as key elements of organizational culture in Poland. In contrast, cooperation and consensus appear more emphasized in the Czech Republic (Afonina, 2015). The importance of hierarchy varies between traditional and modern sectors in both countries. More traditional companies in Poland and the Czech Republic may prioritize structure, while innovation is more common in technology and dynamically developing sectors (Soukopová, 2017). Overall, the two countries share similarities in their approach to internal communication and organizational culture, with some differences in emphasis and implementation reflecting local business traditions and industry characteristics.

8. Comparative analysis of results on the example of Poland and the Czech Republic

In the study on management strategies and economic perspectives in Poland and the Czech Republic, proper examination and comparative analysis of 384 respondents in Poland and 328 respondents in the Czech Republic are key to unpacking the parallels and contrasts between these two nations. Here is how these aspects were applied and why they are relevant in the context of this study:

Poland (384 respondents): The analysis in Poland was conducted to reflect the diversity of management strategies and economic perspectives, taking into account factors such as governance, economic development, and sectoral priorities.

Czech Republic (328 respondents): Similarly, the Czech analysis was structured to highlight the corresponding features and differences within the country. It covered various management practices, economic policies, and regional economic aspects that are unique to or shared with Poland.

Representativeness in a survey study refers to the extent to which the research sample reflects the general population from which it was drawn. This is a key aspect that determines whether survey results can be generalized to the entire population. In the context of the study on management strategies and economic perspectives in Poland (384 respondents) and the Czech Republic (328 respondents), representativeness can be understood by applying the following formulas and concepts:

Sample size (n): This is the number of units in the sample, i.e., 384 for Poland and 328 for the Czech Republic.

Population Size (N): This is the total number of units in the population from which the sample was drawn. It could be the total number of adult citizens in both countries, for example.

- Margin of Error (e): The margin of error expresses how far the results of a sample may differ from the actual results of the population as a whole. The standard margin of error is often 5% or 3%.
- Confidence Level (Z): This is the Z-score corresponding to the desired confidence level, often 95% or 99%.
- Standard Deviation (σ): This is a measure of the dispersion of results in the sample.
- Sample Size Calculation Formula:

sample size - Z-score value - standard deviation - population size - margin of error

$$n = \frac{Z^2 \cdot \sigma^2 \cdot (N - n)}{e^2 \cdot (N - 1) + Z^2 \cdot \sigma^2}$$

where:
n - sample size,
Z - Z-score value,
σ - standard deviation,
N - population size,
e - margin of error.

For this particular study, the appropriate values for: N, e, Z, and σ should be selected based on the purpose of the study and the characteristics of the population to achieve adequate representativeness. The selection of 384 and 328 respondents for Poland and the Czech Republic must comply with these parameters to ensure that the results are reliable and can be generalized to the wider population in both countries.

In both countries, the sample was structured to include a variety of social groups, including industry experts, policy makers, academia, entrepreneurs, and the general public. Efforts were made to make the sample demographically balanced, in line with national statistics, so that the results could be generalized to a wider population. Although the number of respondents in Poland and the Czech Republic was slightly different, this difference is not significant and does not affect the ability to compare results between the two countries.

Figure 1 provides an analysis of job positions within limited liability companies in both Poland and the Czech Republic. This analysis, sourced from the authors' own research, aims to uncover potential differences and similarities in the organizational structure of businesses within these two countries. The focus on job positions across various levels of the organization, including senior management, department managers, regular employees, and other roles, offers a window into the management culture and priorities of businesses in Poland and the Czech Republic. By examining these aspects, the figure 1 sets the stage for a deeper understanding of how organizational hierarchies are constructed and what this reveals about the broader business environment in each country.

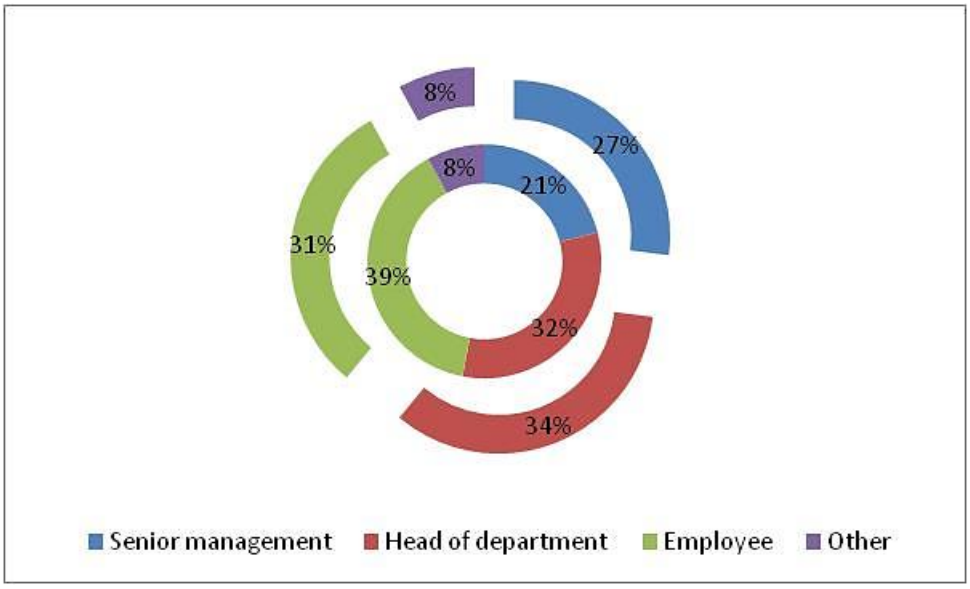

Figure 1. Analysis of the job position based on employees from Poland and the Czech Republic. Source: Authors' own research.

The interpretation of the results regarding positions in the company in Poland and the Czech Republic shows some differences in the organizational structure of limited liability companies in both countries. In Poland, senior management accounts for 21% of the structure, while in the Czech Republic this ratio is higher, at 27%. This may suggest that there is a slightly greater focus on higher-level management in the Czech Republic. A similar difference occurs in managerial positions, where in Poland department managers account for 32%, and in the Czech Republic 34%. Although the difference is small, it may indicate a slightly greater role of middle management in the Czech Republic. As regards employees, in Poland they constitute a larger part of the structure, at the level of 39%, compared to 31% in the Czech Republic. This may indicate that in Poland there is a greater emphasis on teamwork and involvement of lower-level employees. The "Other" category is the same in both countries, at 8%, indicating a similarity with regard to other positions and roles in the organization. In conclusion, these results may indicate some differences in the organization and management structure between Poland and the Czech Republic, with a greater emphasis on senior management and middle management in the Czech Republic, and a greater role of lower-level employees in Poland.

Figure 2 presents an industry analysis for Poland and the Czech Republic, derived from the authors' own research. This analysis aims to shed light on the distribution of employees across different sectors such as IT, manufacturing, services, trade, and others in both countries. By exploring the landscape of industries, the figure intends to highlight the underlying economic dynamics and potential differences and similarities between Poland and the Czech Republic. Such insights can provide valuable context for understanding the broader economic trends, preferences, and strategic directions that characterize the business environments in these two nations. Whether there are variations in the concentration of industries or alignment in certain sectors.

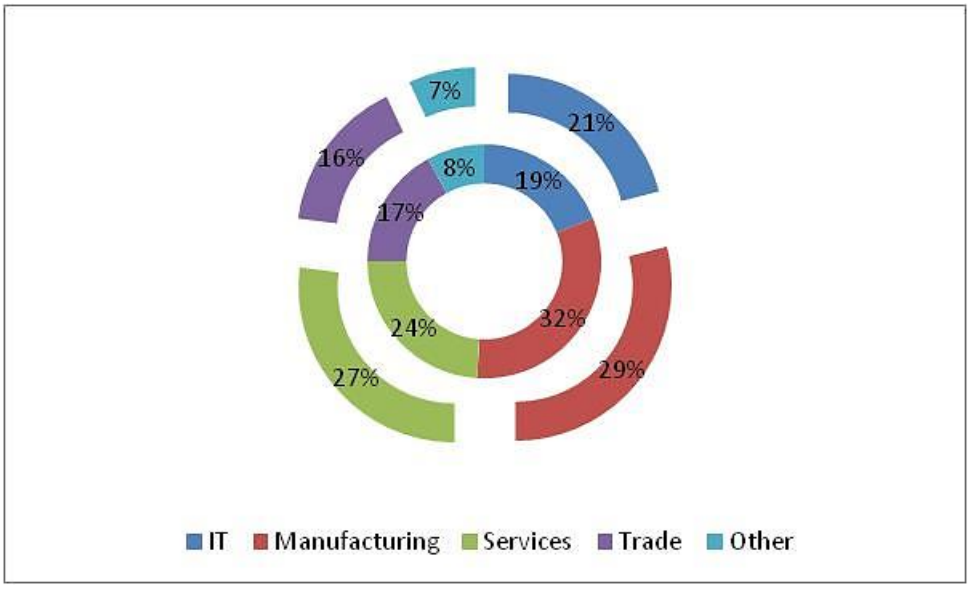

Figure 2. Industry analysis based on employees from Poland and the Czech Republic.
Source: Authors' own research.

The results of the survey on industries in Poland and the Czech Republic reveal interesting differences and similarities between the two countries. In Poland, the IT industry accounts for 19% of the answers, while in the Czech Republic it is 21%, which may suggest a slightly greater involvement in technology in the Czech Republic. Manufacturing is more significant in Poland, accounting for 32%, compared to 29% in the Czech Republic, indicating a stronger focus on the manufacturing industry in Poland. Services are slightly more diverse, with 24% in Poland and 27% in the Czech Republic, which may reflect differences in service sector orientation. Trade is almost equal, with 17% in Poland and 16% in the Czech Republic, which indicates a similar importance of this industry in both countries. The "Other" categories are small and similar in both countries, with 8% in Poland and 7% in the Czech Republic, which may suggest a similarity in the distribution of other smaller industries. Taken together, these results show both differences and similarities in the economic structure of the two countries, with some exceptions in the IT, manufacturing and services industries.

Figure 3 provides an analysis of work experience, focusing on the number of years employees have worked in their current company in both Poland and the Czech Republic, based on the authors' own research. The figure seeks to explore the subtleties and nuances in the employment landscape of these two countries, considering various stages of career longevity, such as less than a year, 1-5 years, 6-10 years, and over 10 years. Without delving into specific percentages, Figure 3 aims to shed light on potential differences and similarities in employment stability, loyalty, and retention trends. Whether the results reveal a culture of staying with one company for longer periods or a tendency for more frequent job changes, the figure serves as an essential snapshot of how work experience and career paths are shaped in Poland and the Czech Republic. It offers a foundation for understanding broader workforce dynamics and organizational practices in these two European nations.

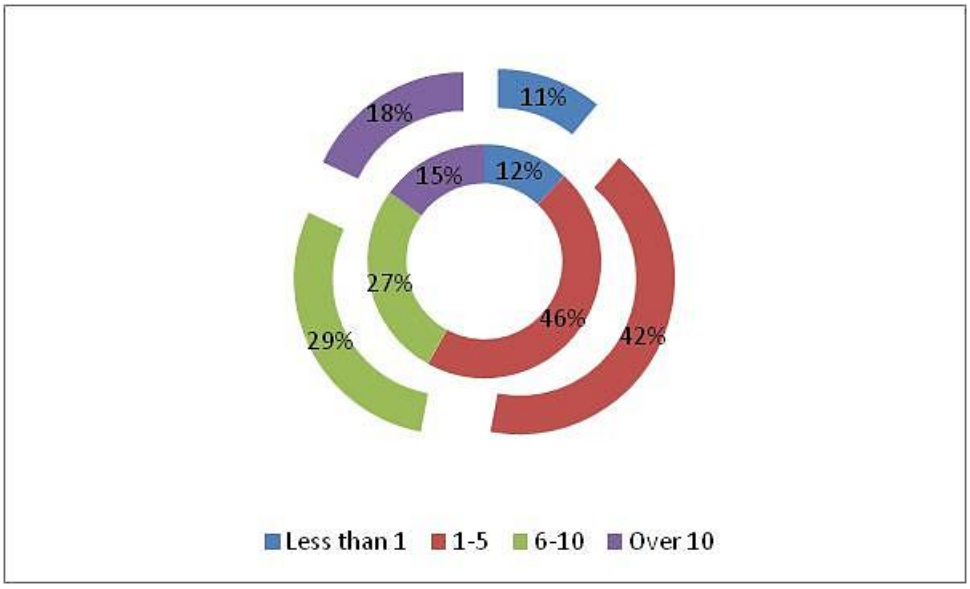

Figure 3. Work experience analysis based on employees from Poland and the Czech Republic.
Source: Authors' own research.

The results of the survey regarding the number of years of work in the current company in Poland and the Czech Republic show some subtle differences in both countries. In Poland, 12% of respondents have been working in their current company for less than a year, compared to 11% in the Czech Republic, which indicates a similar level of employment stability in the early stages of a career. In the category of 1-5 years of work, there are slightly more respondents in Poland, 46%, than in the Czech Republic, where the result is 42%, which may suggest that in Poland employees are more likely to stay with the company for the first few years. When it comes to employees with 6-10 years of experience, the Czech Republic has a slightly higher percentage, 29%, compared to 27% in Poland. This may indicate that employees in the Czech Republic are more likely to stay in their jobs for an average period of time. In the category over 10 years, the Czech Republic also has a higher percentage, 18%, compared to Poland, where the result is 15%, which may suggest a greater tendency to stay in one job in the Czech Republic for a long time.

Overall, these results may indicate slightly more stable employment in the Czech Republic in the medium to longer term, while Poland seems to have slightly more stable employment in the shorter period of 1-5 years.

Figure 4 presents an analysis of management styles in Poland and the Czech Republic, specifically focusing on the perception of how these styles foster innovation, as derived from the authors' own research. The figure attempts to uncover how employees in both countries perceive their management style, whether it supports or inhibits innovation within the organization. This examination includes the perspectives of those who believe management is conducive to innovation, those who do not, and those who have no opinion on the matter. By comparing these views between Poland and the Czech Republic, Figure 4 seeks to reveal not only the prevailing opinions but also subtle differences and nuances between the two

countries. Understanding the role of management in driving innovation is crucial for organizational success, and this figure provides valuable insights into the perceived alignment between management practices and innovative culture in these two European nations. It adds depth to the ongoing conversation about leadership and innovation, contributing to a broader understanding of the connection between management style and creativity in the workplace.

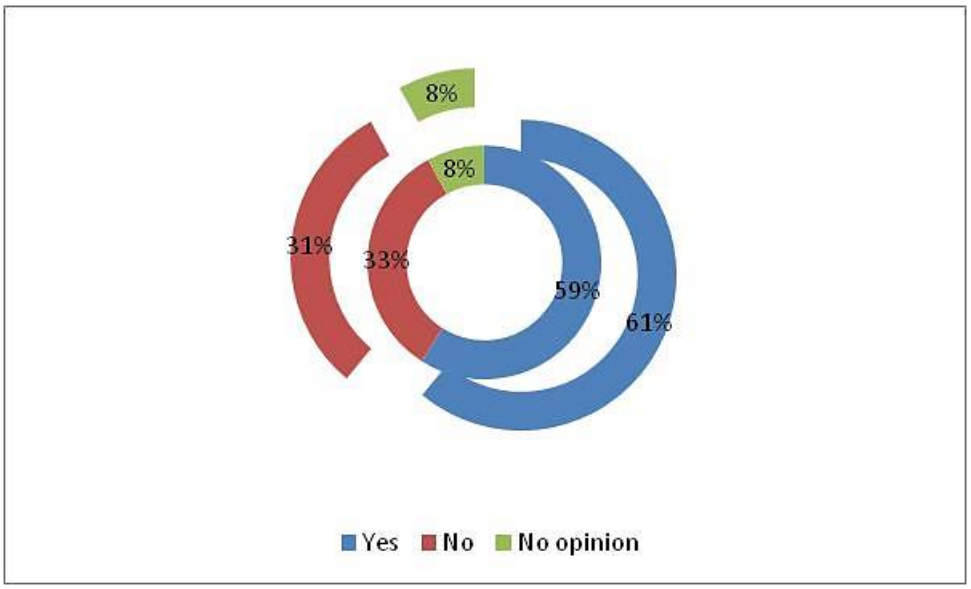

Figure 4. Management style analysis based on employees from Poland and the Czech Republic.
Source: Authors' own research.

The results of the survey regarding the innovation-friendly management style in Poland and the Czech Republic are similar, but show some differences. In Poland, 59% of respondents believe that there is a management style conducive to innovation, while in the Czech Republic the percentage is slightly higher at 61%. This may suggest that both in Poland and the Czech Republic there is a relatively strong belief that appropriate management practices can support innovation, but in the Czech Republic this belief is somewhat stronger.

On the other hand, 33% of respondents in Poland believe that the management style is not conducive to innovation, compared to a slightly lower percentage in the Czech Republic of 31%. This may indicate a slightly greater skepticism in Poland as to the possibility of supporting innovation through management practices. The percentage of respondents who have no opinion on this subject is the same in both countries and amounts to 8%. This may suggest that the issue is not yet fully understood by a certain group of respondents in both countries. Overall, these results may indicate that there is a general agreement in both Poland and the Czech Republic that management style can foster innovation, but there is some variation in the degree of this agreement and some degree of uncertainty as to how to achieve this.

Figure 5 illustrates an analysis of the decision-making processes in organizations within Poland and the Czech Republic, based on the authors' own research. By investigating how decisions are made and who is involved in the decision-making process, the figure aims to highlight the similarities and differences between the two countries in this crucial aspect of

organizational management. The analysis includes perspectives on the roles played by various levels within the organization, including upper management, middle management, employees, and even customers. The comparison between Poland and the Czech Republic may provide valuable insights into the broader trends in organizational culture, centralization, delegation of responsibility, and the influence of different stakeholders in the decision-making process. By examining these dynamics, Figure 5 contributes to a more nuanced understanding of organizational behavior, management practices, and business culture in the context of these two European nations. It adds to the discourse on how decisions are made within organizations and the underlying factors that shape these processes.

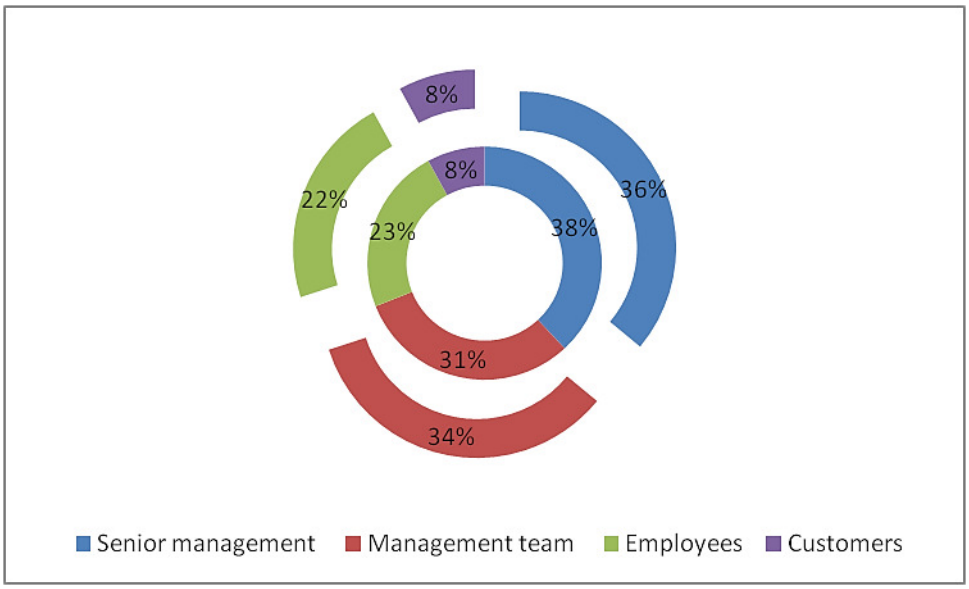

Figure 5. Analysis of the innovation-friendly management style based on employees from Poland and the Czech Republic.

Source: Authors' own research.

The interpretation of the results of the survey on decision-making processes in Poland and the Czech Republic shows some similarities and differences in the structure of decision-making in both countries. In Poland, the highest percentage of respondents, 38%, believe that the upper management makes decisions, while in the Czech Republic the figure is 36%. This is a minor difference, but it may suggest a bit more centralization in Poland. The answers regarding the management team are also similar, with 31% in Poland and 34% in the Czech Republic, which indicates some degree of delegation of responsibility for decisions to lower levels of management in both countries. However, a slightly higher percentage in the Czech Republic may suggest a slightly greater role of middle management in the decision-making process. When it comes to employees, the answers are again close, with 23% in Poland and 22% in the Czech Republic, indicating that in both countries employees have some but limited influence on decision-making processes. Customer responses are identical in both countries, with 8%, indicating that in both countries customers play a relatively minor role in business decision-making. Overall, these results suggest that both in Poland and the Czech

Republic decision-making processes are dominated by upper management, but there are some differences in the extent to which middle management and employees are involved in these processes. These results may also indicate a similarity in business culture and management practices between the two countries.

Figure 6 provides an analysis of the transparency of decision-making processes within organizations in Poland and the Czech Republic, based on the authors' own research. The analysis focuses on examining the perspectives of employees on whether the decision-making processes within their organizations are conducted openly and transparently. This analysis uncovers both the similarities and the subtle differences between the two countries in how transparent decision-making is perceived. The insights derived from this survey may have implications for understanding the organizational culture, trust in leadership, and effectiveness of communication within businesses in Poland and the Czech Republic. By exploring the views of those directly involved in or affected by decision-making processes, Figure 6 adds to the ongoing dialogue on how decisions are made, managed, and communicated within organizations. It also points to areas where there may be room for improvement or further investigation to enhance transparency and clarity in decision-making, which are key factors in building trust and collaboration within an organization.

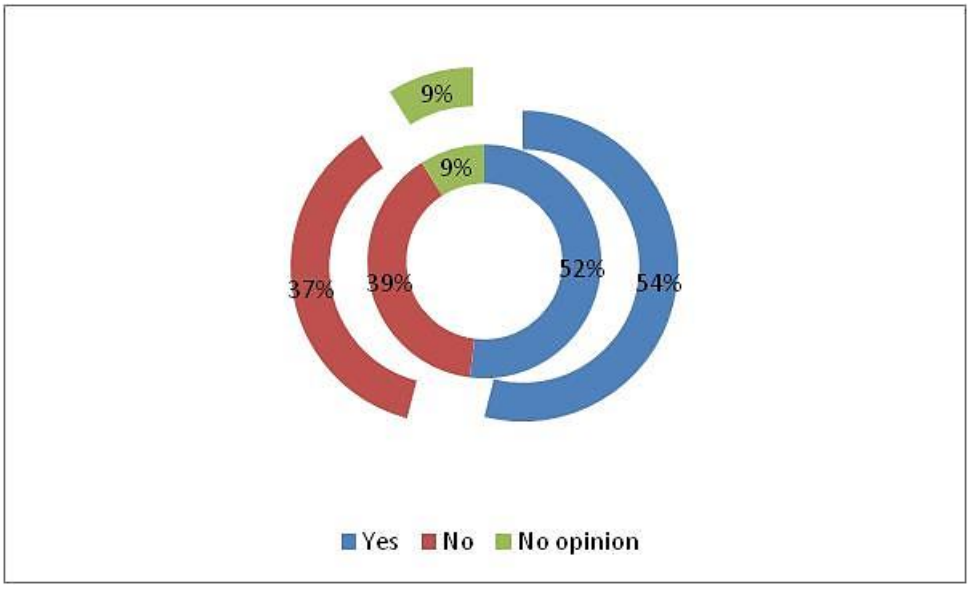

Figure 6. Analysis of decision-making in management based on employees from Poland and the Czech Republic.

Source: Authors' own research.

The interpretation of the results of the survey on the transparency of the decision-making process in Poland and the Czech Republic shows quite similar opinions in both countries. In Poland, 52% of respondents believe that the decision-making process is transparent, while in the Czech Republic this figure is 54%. This small difference may indicate a slightly greater openness in decision-making in the Czech Republic compared to Poland, although this difference is minimal. On the other hand, 39% of respondents in Poland believe that the decision-making process is not transparent, compared to a slightly lower percentage, 37%, in the Czech Republic. This difference may suggest that in Poland there is a bit more skepticism or uncertainty about the clarity and openness of decision-making processes in companies. The proportion of respondents who had no opinion on the subject was the same in both countries, at 9%. This may indicate that in both countries there is a certain group of people who do not have sufficient knowledge or experience to express their opinion on the transparency of the decision-making process. Overall, these results suggest that there is a relatively high level of transparency in decision-making in both Poland and the Czech Republic, with slightly more openness in the Czech Republic. However, there is also a significant proportion of people in both countries who feel that these processes are not clear enough, which may indicate the need for further research and possible improvement in this area.

Figure 7 presents an analysis of the perceptions of internal communication within limited liability companies in Poland and the Czech Republic, as derived from the authors' own research. The focus of the analysis is on understanding how employees in both countries evaluate the quality of internal communication within their organizations. While highlighting some disparities, it also uncovers common trends in how communication is perceived, assessed, and valued in these two countries.

The comparison between Poland and the Czech Republic adds a cross-cultural dimension to the study, shedding light on the nuances of communication within business environments. This analysis not only reveals insights into the effectiveness of internal communication but also hints at underlying cultural differences and expectations that may influence these perceptions.

By offering a detailed examination of positive and negative evaluations, Figure 7 contributes valuable information that could guide efforts to enhance communication strategies within organizations. The emphasis on both very good and unsatisfactory ratings provides a nuanced view that could inform management practices, potentially leading to more effective and satisfying communication within companies in both Poland and the Czech Republic.

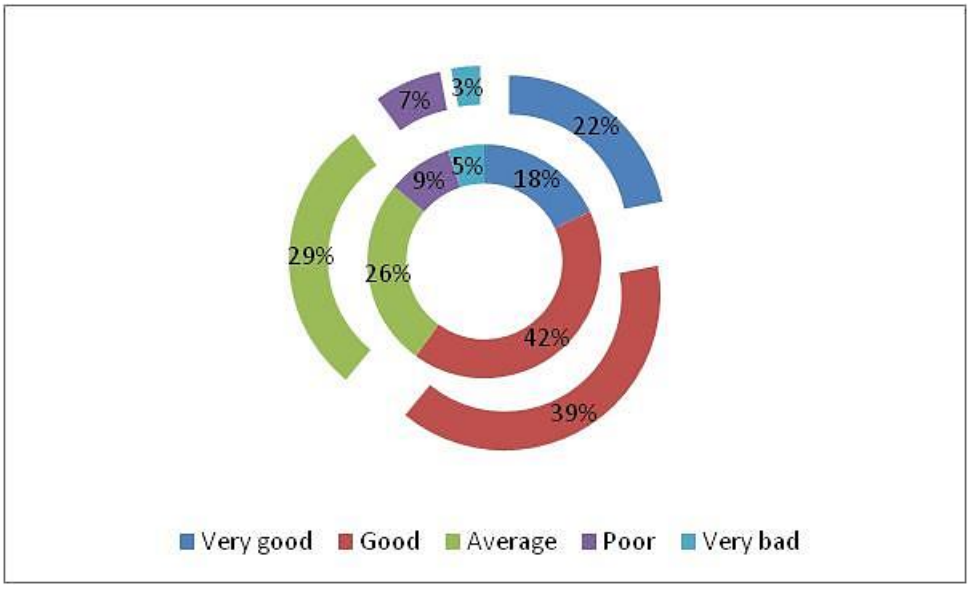

Figure 7. Analysis of the transparency of the decision-making process based on employees from Poland and the Czech Republic.

Source: Authors' own research.

Interpretation of the results regarding internal communication in limited liability companies in Poland and the Czech Republic shows some differences in the perception of the quality of communication in these two countries.

In Poland, the majority of respondents rated internal communication as good (42%) or very good (18%), which is 60% in total. In the Czech Republic, 39% and 22% of respondents gave these ratings, respectively, for a total of 61%. In both countries, the majority of respondents perceive internal communication in their companies as positive, although in the Czech Republic this percentage is slightly higher in the "very good" category. As for the average rating, in Poland it is 26%, while in the Czech Republic it is 29%. This indicates that a similar proportion of respondents in both countries consider internal communication to be average. In negative terms, 9% of respondents in Poland rated internal communication as bad and 5% as very bad. In the Czech Republic, these figures are slightly lower, with 7% and 3% respectively. This suggests that there is slightly less dissatisfaction with internal communication in the Czech Republic than in Poland.

Taken together, these results suggest that in both countries, the majority of respondents view internal communication in their organizations positively. However, in the Czech Republic there is a slightly greater tendency to rate communication as very good, while in Poland there is slightly more dissatisfaction in this area. This may indicate slightly higher standards or differences in communication practices between the two countries.

Figure 8 presents an analysis of the perceptions of key elements in organizational culture within limited liability companies in Poland and the Czech Republic, as sourced from the authors' own research. The study explores the values and principles considered essential by employees in both countries, offering a comparative view that highlights both shared

perspectives and distinct national differences. Categories such as cooperation, innovation, hierarchy, transparency, and social responsibility are analyzed, providing a multifaceted look into what defines organizational culture in these two contexts. The similarities in the emphasis on cooperation and hierarchy across Poland and the Czech Republic reveal a common ground in the understanding of organizational dynamics and interpersonal relationships. Differences in the importance assigned to innovation, though slight, offer insights into varying priorities and approaches to creativity and growth.

Figure 8 adds value to the broader discussion about organizational culture by emphasizing both commonalities and subtle distinctions between Poland and the Czech Republic. By focusing on the elements that employees consider essential, this analysis contributes to a more nuanced understanding of what shapes and drives organizational culture within the region. This information could guide companies in creating cultures that resonate with their employees' values, potentially fostering a more engaged and effective workforce.

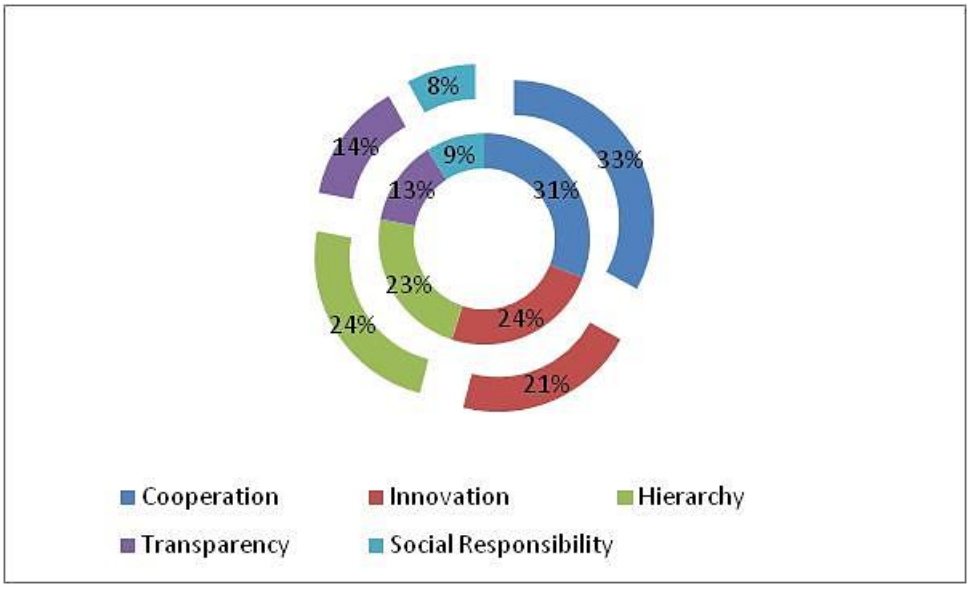

Figure 8. Analysis of the transparency of the decision-making process based on employees from Poland and the Czech Republic.

Source: Authors' own research.

Interpretation of the results regarding the key elements of organizational culture in limited liability companies in Poland and the Czech Republic reveals some similarities and differences between these two countries.

In both countries, cooperation is considered the most important element of organizational culture, accounting for 31% in Poland and 33% in the Czech Republic. This means that employees in both countries value working together and interacting with others. Innovation is also important, but differences in the perception of this element are visible, with 24% in Poland and 21% in the Czech Republic. This may suggest that in Poland there is a slightly greater emphasis on innovation as a key element of corporate culture. The hierarchy is equally important in both countries, with a slight difference in favor of the Czech Republic, where it

accounts for 24%, compared to 23% in Poland. This may indicate a similar perception of the role of structure and order in organizations in both countries.

Transparency and social responsibility are less important in both countries, but are still considered key elements of culture. Transparency is 13% in Poland and 14% in the Czech Republic, and social responsibility is 9% in Poland and 8% in the Czech Republic. These differences are minimal and may indicate a similar perception of these values in both countries. Taken together, these results suggest that the key elements of organizational culture are quite similar in Poland and the Czech Republic, with an emphasis on collaboration, innovation and hierarchy. The differences, although minor, may reflect slightly different priorities and values in the company cultures of the two countries.

9. Discussion

Poland has a more detailed structure of a centralized and hierarchical governance structure, where decisions are basic at a higher level and authority is more concentrated. In the Czech Republic, on the other hand, a flat structure prevails, where employees have an influence on decisions, and authority is more decentralized.

Decision-making processes in Poland are often higher formalized and categorized, while in the Czech Republic they are of a higher degree of cooperation and consensus. A hierarchical structure in Poland can display greater efficiency and control, but it can also create initiative and modules. In Czech, a flat structure can support employees, but it requires stronger leadership and channels. These differences are multidimensional and can have different effects and effects. They may result both from differences in the business industry and be a response to specific challenges and business goals in each country.

Poland tends to have a more centralized and hierarchical governance structure, where decisions are made at higher levels and authority is more concentrated. In the Czech Republic, on the other hand, a flat structure prevails, in which employees have more influence on decisions and authority is more decentralized.

Decision-making processes in Poland are often more formalized and organized, while in the Czech Republic they are more flexible and participatory, which can lead to greater cooperation and consensus. Poland can lead to greater efficiency and control, but it can also reduce employee initiative and satisfaction. In the Czech Republic, a flat structure can increase employee engagement, but requires stronger leadership and coordination.

These differences are multidimensional and can have various causes and consequences. They may result both from differences in business traditions and be a response to specific business challenges and goals in each country. In Poland, a more hierarchical style of management may prevail, where managers often make key decisions and lower-level

employees have limited autonomy. This may reflect traditional social values and norms that emphasize the importance of authority and structure. By contrast, the Czech Republic may have a higher proportion of democratic governance, which may indicate a more collegial and participatory working style. Polish companies can put more emphasis on procedures and regulations, promoting a culture that values consistency and adherence to established standards. Meanwhile, in the Czech Republic, investments in hydrogen technology can open up new economic opportunities, stimulating innovation. In Poland, these relationships can be more formal, with clear lines of communication and expectations towards employees. In the Czech Republic, these relationships may be more relaxed and collegial, reflecting openness and a desire for cooperation at different levels of the organization. Investments in hydrogen technology can open up new economic opportunities in the Czech Republic, creating jobs and stimulating innovation. This is an aspect that may differ from the Polish approach.

In Poland, a more hierarchical style of management may prevail, where managers often make key decisions and lower-level employees have limited autonomy. This may reflect traditional social values and norms that emphasize the importance of authority and structure. By contrast, the Czech Republic may have a higher proportion of democratic governance, which may indicate a more collegial and participatory working style. Known as one of the largest economies in Central and Eastern Europe, Poland focuses on investments in scientific and technological development. The focus on modern technologies and innovations, such as support for startups and research and development programs, makes Poland attractive to external investors. The Czech Republic is known for its engineering and technical tradition. A strong focus on research and development translates into innovation. There are many high-tech companies in the Czech Republic focused on developing new products and technologies. The Polish management style combines traditional hierarchies with elements of a modern, more flexible approach. The approach to employees is changing, focusing more and more on autonomy, motivation and creativity. This approach can foster innovation by giving employees more freedom to create and implement new ideas. The Czech style of management is more oriented towards consensus and cooperation. Companies often use a flat organizational structure, which can foster communication and the exchange of ideas. Such a structure can be conducive to innovation because it allows thoughts and ideas to flow more freely at different levels of the organization. Both countries have their own unique features that can foster innovation, but in different ways. Poland, with its increasingly flexible approach and support for startups, can create an environment conducive to experimentation and risky projects. By contrast, the Czech Republic, with its emphasis on consensus and collaboration, can foster innovation through effective communication and collaboration across departments. Ultimately, management style can significantly influence how organizations in Poland and the Czech Republic approach innovation. Adjusting the management style to the organizational culture and market specificity can be the key to success in the field of innovation. This comparison can serve as a valuable tool for investors, entrepreneurs and business leaders who want to understand and take advantage of these unique features of Poland and the Czech Republic.

In more traditional Polish companies, decisions are made at higher levels of management, which means less influence of employees at a lower level. Modern Organizations: In companies that promote a more open and flexible culture, decision-making processes are more decentralized, giving teams and individuals more freedom and responsibility. Power structure: In Poland, there is a tendency to flat organizational structures, especially in modern companies and startups. In more conservative companies, decisions are made mainly by senior management. Modern Organizations: Innovative and collaborative companies often adopt a more decentralized way of making decisions.

Power Structure: In the Czech Republic, a culture of collaboration and consensus can lead to a flat organizational structure with more employee involvement in the decision-making process. In Poland, transparency is seen as a way to build trust, improve communication and promote accountability. Exceptions and Challenges: Some companies, especially more traditional ones, may not promote full transparency for fear of disclosing sensitive information.

In Poland, values such as honesty and ethics are important in shaping organizational culture, and transparency is often associated with them. In the Czech Republic, transparency is also important in building trust and cooperation. As in Poland, not all companies in the Czech Republic are fully transparent. In the Czech Republic, a culture of cooperation and consensus can foster transparency.

The transparency of the decision-making process in Poland and the Czech Republic is a complex issue that reflects differences in organizational culture and company values. Both countries seem to promote transparency as a means of building trust and fairness, although the implementation of this objective may differ. Introducing and maintaining transparency requires proper management and understanding of the specifics of the organization. This may include clear communication of decision-making processes, regular updates, and promoting a culture of openness and honesty. There is still room for improvement in both countries with fully implemented transparency, and further research and adaptation to local conditions and values is crucial for the successful implementation of this important element of governance.

In Poland, many companies strive for clear and effective communication, promoting openness and regular meetings between teams. There may be problems in large, hierarchical companies where communication can be more formal and complex. The use of modern communication tools, such as online collaboration platforms, can support internal communication. In Poland, many leaders promote teamwork and cooperation. In some sectors, especially technology, innovation is the key to success. In more traditional companies, hierarchy and structure may be more apparent. In the Czech Republic, especially in small and medium-sized enterprises, communication can be more direct and open. Some larger companies may have communication barriers related to hierarchy and structure.

The Czech Republic also uses modern tools and strategies to promote effective internal communication. In the Czech Republic, cooperation and consensus are often key values. As in Poland, innovation can be valued, especially in dynamically developing sectors.

Czech companies can exhibit varying degrees of formality and hierarchy depending on the industry and company tradition. In both countries, there is an emphasis on effective communication, especially through the use of modern online collaboration tools and platforms. Larger, more hierarchical companies in both countries may face internal communication challenges where structure can create complexity and barriers. Teamwork, cooperation and innovation are emphasized as key elements of organizational culture in Poland. In the Czech Republic, cooperation and consensus are more emphasized. The meaning of the hierarchy varies between traditional and modern sectors in both countries.

Overall, the two countries show similarities in their approach to internal communication and organizational culture, with some differences in emphasis and implementation reflecting local business traditions and industry characteristics. In the Czech Republic, more emphasis on senior and middle management positions. In Poland, greater involvement of employees at lower levels. Some similarities in other roles. Slight differences in involvement in IT and services in the Czech Republic. Stronger focus on industry in Poland. Similarities in trade and other smaller industries. The analysis suggests differences and similarities in employment stability and loyalty between Poland and the Czech Republic. There are subtle differences in employment stability between Poland and the Czech Republic. In Poland, employees seem to be more stable in the period of 1-5 years, while in the Czech Republic there is more stability in the medium and longer term. In Poland and the Czech Republic, there is a similar belief that management style can be conducive to innovation, but in the Czech Republic this belief is slightly stronger. There is also some difference in skepticism about the ability of management practices to support innovation.

This analysis aims to highlight the similarities and differences in decision-making processes in Poland and the Czech Republic, but without specific data it is difficult to draw concrete conclusions about trends in organizational culture, centralization, delegation of responsibility and the impact of various stakeholders on the decision-making process. The results show that decision-making in both Poland and the Czech Republic is mainly centralized and involves senior management. Small differences in the involvement of middle management and employees suggest a slightly greater role for middle management in the Czech Republic. Both countries show little role for customers in decision-making. Similarities and slight differences may reflect shared business culture and management practices.

The results indicate a similar level of perceived transparency of decision-making processes in Poland and the Czech Republic. Slightly greater openness in the Czech Republic is offset by slightly greater skepticism in Poland. These results indicate a relatively high level of transparency, but also highlight the need for further research and potential improvements. Although no details are provided, the purpose of this analysis is to understand the assessment of the quality of internal communication in limited companies in both countries. Exploring common trends and differences, it aims to shed light on the effectiveness of communication, cultural differences and expectations.

The insights can guide efforts to improve communication strategies, potentially leading to more efficient and satisfying communication within organizations in both countries. Together, these analyzes provide a complex picture of organizational behavior, management practices and business culture in Poland and the Czech Republic. They underline the importance of understanding these aspects to foster innovation, trust and collaboration within companies, reflecting the subtleties of the European business environment. The study on internal communication in limited liability companies in Poland and the Czech Republic showed mostly positive perceptions in both nations. While the total percentage of good and very good ratings was almost identical, there was a slightly higher tendency in the Czech Republic to rate communication as very good, and slightly more dissatisfaction in Poland. The results may hint at different standards or practices in communication between the two countries. The interpretation of key elements in organizational culture revealed common ground in the emphasis on cooperation and hierarchy in both countries. Slight differences were noted in the perception of innovation, with Poland valuing it more. Transparency and social responsibility were considered less important but similar in both contexts. These findings indicate that the core elements of organizational culture are largely aligned in Poland and the Czech Republic, with minor variations possibly reflecting different corporate priorities and values.

10. Conclusion

The discussion should be enhanced by contextualizing these findings within the existing body of research. By conducting a comparative analysis with prior studies, a more comprehensive understanding of the presented findings can be achieved. This will provide a broader perspective and help establish the significance of the current research within the field.

Regarding the conclusions section, it is currently lengthy and detailed, spanning four pages. To improve its practical applicability in economic practice, it is advisable to condense this section. Retaining only the most crucial and pragmatic insights will make it more accessible and actionable for business practitioners.

The comparison of decision-making processes and organizational cultures between Poland and the Czech Republic has revealed nuanced differences. While both countries share similarities, such as centralized decision-making involving senior management, there are subtle distinctions, particularly in the roles of middle management and employee involvement. To strengthen the validity of these findings, references to existing research should be included for context.

Concerning internal communication, both nations perceive it positively, with slight variations indicating potential differences in communication standards or practices. The shared emphasis on cooperation and hierarchy in organizational culture is evident, with minor deviations such as Poland's higher valuation of innovation.

In summary, this analysis offers valuable insights into the organizational dynamics of Poland and the Czech Republic. It emphasizes the importance of comprehending these aspects to foster innovation, trust, and collaboration within companies. However, a more concise and referenced discussion and conclusions section would enhance the practical applicability of these insights in the realm of economic practice.

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ANALYSIS OF THE WORKING TIME OF THE SELECTED TECHNOLOGICAL PROCESS

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Purpose: The purpose of this paper is to analyze the impact of process reorganization and the application of the MTM-1 method on the production efficiency of selected operations in the manufacturing of screws. The study aims to assess the changes in production time, reduction of non-standard activities, and improvements in motion economy and management

Design/methodology/approach: The objectives of this research are achieved through a combination of empirical investigation and the application of the MTM-1 method. The study encompasses an analysis of pre-existing production processes and their respective timings. The practical implementation of the MTM-1 technique is employed to reevaluate the process and derive optimized time values. The theoretical scope of the paper lies in process optimization and industrial engineering methodologies.

Findings: The research findings indicate a significant reduction in production time after the reorganization and the application of the MTM-1 method. The time required for individual operations decreased from an average of 12.88 minutes to 9.46 minutes, marking an efficiency gain of approximately 30%. Moreover, non-standard activities and unnecessary movements, such as excessive body, leg, and eye motions, were reduced by nearly 40%. The most time-consuming motions identified were walking and positioning. This study confirms the positive impact of process optimization on production efficiency and ergonomic improvements.

Research limitations/implications: While this research provides valuable insights into process optimization using the MTM-1 method, the study is limited to a specific production context. Further research could explore the application of similar methodologies in diverse manufacturing environments. Additionally, a broader range of metrics could be considered to comprehensively evaluate the impact of process changes.

Practical implications: The findings of this study hold practical implications for manufacturing industries. Implementing the identified process improvements and considering the principles of motion economy can lead to enhanced production efficiency and reduced ergonomic strain on workers. Companies can adopt the optimized practices and methods discussed in this paper to improve overall operational performance.

Social implications: The research's social implications revolve around the potential improvement in worker well-being and safety. By reducing non-standard activities and minimizing excessive motions, companies can contribute to improved workplace ergonomics and employee satisfaction. Additionally, the promotion of efficient production practices aligns with principles of sustainable manufacturing and responsible corporate behavior.

Originality/value: (mandatory) This paper contributes to the field of industrial engineering by showcasing the tangible benefits of applying the MTM-1 method in the context of screw production. The study's value lies in its practical insights into process optimization and the subsequent enhancement of production efficiency and worker comfort. This paper is relevant to researchers, practitioners, and professionals seeking to streamline manufacturing processes and improve workplace ergonomics.

Keywords: MTM-Method-Time Measurement, Lean Management, ergonomic improvements, production management, WCM.

Category of the paper: Case study.

1. Introduction

In the literature, there is no unequivocal term "process," which is often confused with concepts such as procedure, activity, or task. Every activity or set of activities can be presented as a process, during which, starting from an initial state or input, we obtain a result, i.e., an output enriched with added value that is meaningful to the customer. The definition of the process can be found in the PN-ISO technological standards, where a process is defined as: "a set of interrelated resources and activities that transform input into output" and produce a result that has value for the customer (Ossowski, 2012).

Production, on the other hand, involves manufacturing products from raw materials using various processes. It is a study of the processes required for manufacturing parts and assembling them in machines. A production process is one carried out in a facility to transform semi-finished products or raw materials into finished products. The art of transforming raw materials into finished products using various tools, machinery, production settings, and production processes is known as manufacturing (Singh, 2006).

Manufacturing is the creation of products from raw materials through various processing methods and equipment in operations organized according to a developed plan for the appropriate use of resources such as materials, energy, capital, and people. Products can be defined as all the results of human work, both tangible and intangible. Products can include various types of services, activities, organizations, and technological or organizational ideas. Production management is the execution and delivery of finished products or services. A manufacturing facility is a separate process that consists of one or several production systems. The process of producing products must take place in a specially designed, complex manufacturing process. This process is a component of all activities aimed at applying human thought to transform raw materials, materials, and semi-finished products into a product of the required quality. The production process also includes a series of research and development activities, as well as distribution and customer service. The manufacturing process includes operations such as (Kubiński, 2008):

1. Technological operations - assembly or disassembly of a product, involving a permanent change in the relative positions of the product's components.
2. Control or measurement operations - visual inspection, inspection, measurement, testing objects, and comparing the results with requirements.
3. Transportation operations - moving a product, material, or part from a warehouse or to a warehouse, as planned in the production process.
4. Storage and warehousing (storage) operations - during this operation, items are at rest and await further processing, inspection, or transport. This operation does not change the product's characteristics but requires a place for storage in a warehouse.

The model of the manufacturing process can be used to analyze the production process (Dwiliński, 2002) The structure of the system is the complexity of the relevant production factors. The criteria for this include the diversity of technological operations, such as levels of system efficiency (Gawlik, Plichta, Swić, 2013):

- Organizational level: The most important are the relationships between the company and the market. Factors affecting efficiency include the overall goals of the company, methods of measurement, and so on.
- Process level: The level of interdepartmental processes related to the development of new products, procurement, production, sales, etc.
- Job level: Where the processes are supervised by workers performing various tasks.

Process planning involves selecting production resources (machines, cutting tools, presses, devices, fixtures, measuring tools, etc.), determining the efficient sequence of operations, specifying changes in the form, dimensions, or finish of the machines, and defining operator actions. It also establishes an efficient sequence of production steps to minimize material handling, ensuring that work is done at minimal costs and maximum efficiency (Singh, 2006).

A good understanding of the principles of designing and implementing a technological process is fundamental to the success of any project. The main elements that make up a technological process are operations, procedures, and actions. An operation is the basic element of a process that aims to change the dimensions, shape, and properties of a given object. The operation is performed at a specific workstation by one worker or one crew without interruptions for other tasks. It also allows for the calculation of execution costs. We distinguish between simple operations, where the number of procedures is small and complex operations, which consist of several procedures. A procedure is a part of an operation that we perform without changing the work tools, without changing the processing parameters, or with a single setting and mounting. The division of operations into procedures is not always clear and necessary, for example, when conventional machines are used in the process, the division must be clear. However, if the technological process is designed for CNC machines or numerically controlled machine systems, this division is not always clear (Karpiński, 2004).

The structure of a technological process refers to individual operations that make up the discontinuity of the process and the gradual shaping. The discontinuity of the process involves using various methods and types of processing. To obtain a finished product with the correct dimensions, surface roughness, or properties, each operation must be carried out gradually, taking into account different processing methods. The following points illustrate the structure of a technological process (Bieniok, 2004).

1. Preliminary Operations - These include cutting of bar materials, straightening, and tapping.
2. Creating the machining base for further operations - This includes surface and hole machining. This base is prepared at the beginning of the process to machine all remaining surfaces later.
3. Performing rough and shaping operations - This involves removing damaged layers of material and shaping the object according to the engineering drawing.
4. Performing heat treatment or thermo-chemical treatment operations - This process involves obtaining changes in the properties of the surface layer of products subjected to treatment due to temperature, time, and the technological environment.
5. Performing finishing and precision machining operations - These methods include grinding, turning, milling, and milling.
6. Performing quality control operations - This operation may also occur during the process, after major machining operations.

In the machine industry, time standardization is the necessary amount of time required to complete a specific scope of work under the appropriate technical and organizational conditions of the plant, by a specified number of workers with designated qualifications. The issue of time standardization is related to optimizing the time required for individual tasks at a given workstation. The result of the proposed actions should be the selection of appropriate methods for standardizing work time to streamline the execution of specific tasks by employees.

Analytical measurement techniques allow for the determination of unit time and preparatory and finishing times for technological operations (Bieniok, 2004). Analytical measurement techniques include methods such as time study, workday photography, and video analysis, including snapshot operations.

Time study is a fundamental method for determining the main time or auxiliary time, which is a fundamental component of the unit time of a technological operation (Bieniok, 2004). This method involves measuring time using a stopwatch to record the duration and pace of the activities in the technological process. The purpose of this study is to measure the current duration of a given activity and determine the optimal duration of a specific operation to ensure the overall process is efficient (Jędrzejewski, Kocjan, 2021). The following elements are involved in conducting this study (Bieniok, 2004):

- Identifying the workplace and selecting the employee.
- Getting acquainted with management and workers, the methods used, the work environment, and the product.
- Breaking down the operation into elements.
- Determining the number of measurements.

During the observation of a particular operation, the duration of the operation is recorded. This activity should be repeated several times. Then, the arithmetic mean or weighted average is calculated. The result obtained determines the actual duration of a given operation cycle and forms the basis for the time standard. This method allows for the precise determination of the labor intensity of a specific stage in the technological process (Bieniok, 2004).

Workday photography is one of the oldest time measurement methods. Data from observations using this method illustrate various ways of performing tasks and are used to formulate the correct sequence of operations and the likelihood of irregularities in the process. Workday photography involves measuring times throughout an entire work shift for a specific employee. The duration of a particular activity is observed and later subjected to analysis. Based on this data, defects that occur at a particular workstation are identified, and possible solutions to the problem are suggested. A report is then prepared (Bartnicka, 2016). There are four types of workday photography (Bieniok, 2004):

1. Individual Workday Photography - In this case, the work of a single employee is assessed during a specific time frame.
2. Team Workday Photography - A team of workers who perform the same task is observed.
3. Route Photography - Several or dozens of workers performing tasks at a specific time of day on a specified route are observed.
4. Self-Photography - This method is the most time-consuming because the performer must document their workday photography over an extended period. It is primarily used for studying the time organization of managerial and office work.

Workday photography allows for the determination of elements such as task preparation and completion, the execution of simple tasks, and workstation operation. This method helps identify the causes of breaks and downtime and develops organizational and technical objectives to address them (Grabowska, Matela, 2021).

Video analysis involves recording images with a phone or camera. This method allows observers to see how a particular process or task is performed as if they were present at the production site.

Snapshot operation is one of the most popular methods for collecting information about the current state of a process. This technique belongs to statistical methods. To ensure reliable results that align with reality, as many attempts as possible should be made. In this method, numerous observations are made regarding the workforce, processes, and machines over a certain period. The goal of such work is to identify the structure of work and breaks for

employees and machines (Mioduszewski, 2013). The application of snapshot operation methods requires meeting the following elements (Bieniok, 2004):

- Representativeness - Taking a sufficiently large sample of selected observations.
- Randomness - Randomly selecting observation moments.
- Causally Continuous - Making observations in situations considered routine.

The method of snapshot operations involves (Bieniok, 2004):

- Making random 2-second observations at appropriate times.
- Capturing observations within a specific work time frame.
- Recording the results of observations.
- Calculating the time utilization plan based on a predefined time classification.

The final results involve (Bieniok, 2004):

- Developing a time utilization plan expressed in percentages.
- Presenting the results in tables and diagrams.
- Confirming the credibility of the obtained results.
- Improving the specific element to minimize time losses.

The snapshot operation technique is one of the simpler methods of work time standardization. It allows for the simultaneous observation of several objects or dozens of them. The obtained results are representative when the correct research procedure is used.

Analytical and computational methods allow for the determination of execution time and preparatory-concluding time for a planned process (Katschenreiter-Praszkiewicz, 2015). Analytical-computational techniques are distinguished based on elementary movements and time standards. Time standards are understood as quantities of time needed to perform specific work operations the length of justified work breaks for an employee or the most favorable machine work conditions (Żukowski, Duczmal, 2007). The following standards are distinguished (Bieniok, 2004):

- Time standards establish the amount of time needed to complete a specific task.
- Efficiency standards specify the number of product units that must be produced in a specific time unit.
- Service standards set the number of machines allocated to an employee or an entire team working in a multi-station service system.
- Staffing standards determine the number of employees required to operate one or more machines.

Time standards are determined based on observations and measurements at individual workstations. This method involves developing separate time consumption categories, such as (Żukowski, Duczmal, 2007):

- Preparatory-concluding time standards (tpz).
- Main time standards (tg).
- Auxiliary time standards (tp).

- Technical and organizational service time standards (tto).
- Time standards for physiological breaks (tf).

The time standardization method aims to increase work efficiency and resource productivity. In manufacturing facilities, work standards have broad applications, and this research helps eliminate disruptions in the entire production process (Żukowski, Duczmal, 2007).

Method Time Measurement (MTM) is a tool for describing, structuring, configuring, and planning work systems through defined process modules, to be an efficient pattern for production systems. This method can be used wherever there is a need to plan, organize, and execute human tasks effectively. With this method, a planned process can be executed from start to finish without additional costs associated with process inefficiency (de Almeida, Ferreira, 2009).

The MTM methodology involves structuring sequences of movements into basic movements. Each basic movement is assigned a standard time value, which is determined as a function of factors influencing its composition. The MTM methodology can be applied to configure work methods and products (de Almeida, Ferreira, 2009). The assumptions of elementary movements are as follows (Ekonomika ruchów elementarnych…, 2021).

- Simultaneity of movements – performing work with both hands using general ergonomic principles.
- Simplifying movements – aiming to simplify elementary movements to make them as time-efficient as possible.

By applying these principles, the optimization process can yield increased work efficiency while reducing the burden of work. Considering these principles, a person can accomplish more work while becoming less fatigued.

The MTM method was first applied in the 1940s. The method breaks down work into smaller units of motion. It includes 17 basic movements, of which typically 5 are used, each with assigned elementary times. These movements include reaching, grasping, carrying, assembling, and releasing. Individual movements are combined based on tables with normative times.

The advantages of using the MTM method include:

- Determining the time for a specific activity broken down into smaller elements, taking into account the prevailing conditions and parameters affecting work pace.
- The ability to design a specific operation before the entire technological process is started.
- Streamlining the work process easily through straightforward analysis.
- The ability to determine the detailed duration of a specific activity and its elements.
- Establishing optimal work process improvements.

The MTM method is used by technologists at various stages of product production, work organizers, and when selecting the most appropriate work execution variant. Its biggest advantage is the ability to standardize workstations and establish time standards needed to calculate the duration of a specific task or overall company costs (Ekonomika ruchów elementarnych…, 2021).

Summative, comparative, and estimation methods allow for the determination of unit time for the planned process. These methods require planning a catalog of benchmark jobs, which can be used to determine labor intensiveness by estimating the differences between the benchmark object or process and the one currently being executed (Kutschenreiter-Praszkiewicz, 2015).

This article aims the working time for the production of fasteners in a selected technological process in a fastener production company. The pressing process was used for the study as one of the processes in fastener production.

2. Methods

Methods of data acquisition:

- Direct interviews conducted with employees of the company.
- Observation of the manufacturing process within the company.
- Participation in tasks and teamwork within the company.
- Analysis of the company's materials and system documents.

The company's primary area of operation is the production of connectors and screws. The facility offers connectors manufactured according to national and European standards, as well as custom-sized components with enhanced mechanical properties. The company's product range includes metric screws with hexagonal heads, inch screws with hexagonal heads, screws for caterpillar tracks, screws with twelve-sided heads, double-sided screws, cylindrical screws with hexagonal sockets, cup-head screws with collars, standard and crown nuts, self-locking nuts, plugs, and hydraulic connectors, pins, and rivets. Additionally, the company provides services related to the thermal and surface treatment of entrusted components, such as heat improvement, galvanic zinc coating, zinc or manganese phosphate treatment, and oxidization (blackening). The company possesses its own Materials Research Laboratory. The products manufactured find applications in construction, energy, petrochemicals, automotive, machinery, and defense industries, as well as in oil and gas extraction. The facility exports its products to countries including Germany, Sweden, Finland, Lithuania, and Hungary. The company's products are utilized by globally recognized manufacturers of machinery, equipment, and vehicles. The description of the integrated management system in the company is presented in Figure 1.

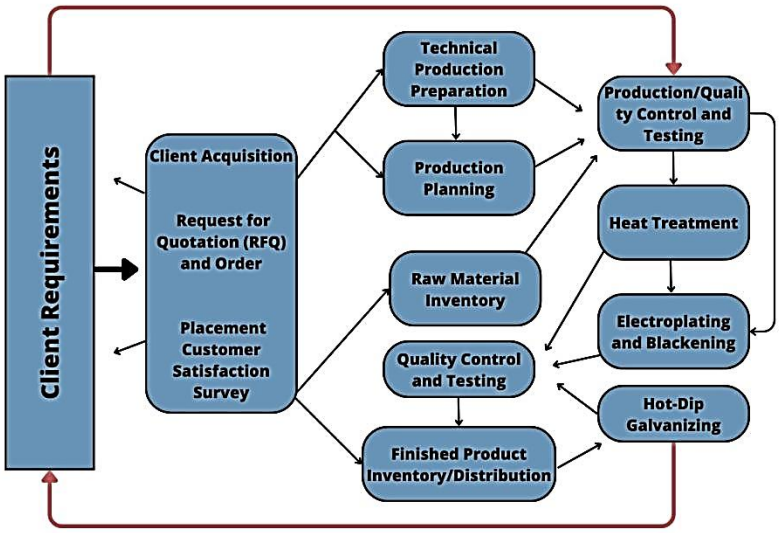

Figure 1. Diagram of the integrated management system in the company.

Source: Own elaboration (Company internal materials).

The process of fulfilling the entire order is crucial for the customer. It is important to keep it constantly moving in the supply chain management process, ensuring its efficiency. The relationship between a company and its interested customer is mutual consumption. The company acquires a customer through bidding interactions, followed by product orders, and finally conducts customer satisfaction surveys. When integrating into a company's production plan, their process can be divided into several stages. The implementation of the order includes elements such as: receiving an order from the customer, confirming the order, production planning, purchasing materials required for production, heat treatment or galvanization of products, conducting destructive or non-destructive testing, packaging finished products, assembling, and warehousing, and then transportation, which is the delivery of the order.

Screws and nuts are used in various applications, such as machinery construction, furniture production, hydraulics, and vehicles. Screws and nuts create a form of metric fasteners. Inside the nut is a thread that is placed on the screw, creating a reliable installation. The materials used for producing screws and nuts include stainless steel, carbon steel, chrome steel, or alloy steel; titanium, copper, and brass. Screws are made from very strong, thick wire or rod steel. After spending 30 hours in an oven, which softens the steel, enabling further processing, the wire is immersed in a tank of sulfuric acid, which removes rust. It is then rinsed with water and coated with zinc phosphate, a substance that acts as an anti-corrosive and lubricant, making screw forming easier. Screws are made by the cold forging method, shaping the steel using dies of various shapes. First, the machine straightens the wires and cuts them into sections slightly longer than the future screw. The excess is then transformed into the head. Each section is pressed into successive dies, which gradually shape the screw's head. The machine forges up to 300 heads per minute. The die forms a small flange. Then it is molded into a round head. Finally, it gives it a shape, such as a hexagon. The other end of the screw is

shaped by another machine. A large header forms a so-called "shoulder", an oblique cut to facilitate the nut application. Each screw must have a thread, which is also created by the cold forging method. Special heads extrude it. Samples are taken from each production batch and subjected to quality control. Quality controllers use various tools such as micrometer screws to measure diameters, calipers, and ring gauges for threads. Nuts are hot-forged. The machine produces billets by cutting a steel rod, heated to 1200°C, into short sections for malleability. Then hydraulic hammers give the billets a hexagonal shape while the die punches a hole. Then the tap cuts the thread in the hole. Black oil is used here, lubricating the tap to minimize wear. Screws and nuts are placed in an oven heated to 870°C for an hour. This gives them the desired hardness. Rapid, five-minute cooling in oil stabilizes the metal's internal structure. The steel is hard but brittle. To give it proper strength, screws and nuts are heated in an oven for another hour. Quality controllers conduct random strength tests by measuring the force required to break the screw. If it is greater than or equal to the allowable force, the batch passes inspection, provided that the fracture occurred on the threaded, weakest section. Finally, the finished products are ready for packaging. Labels provide information about product sizes and grades. In Figure 2, the stages of the screw manufacturing process are presented.

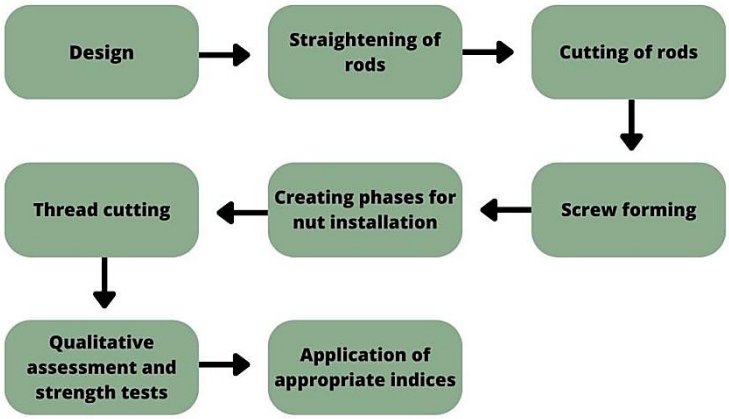

Figure 2. Stages of Screw Manufacturing Process.

Source: Own Compilation.

Throughout the entire process, the Method of Time Measurement (MTM) elemental motion analysis can be applied.

The choice of MTM variant depends on the level of integration of elements and the type of production. Three variants of the method are distinguished (Strzelecki, 1983):

- MTM-1 - for mass production and large-scale production, where operation times range from 0.1 to 0.5 minutes.
- MTM-2 - for medium and small-scale production, where operation times range from 0.5 to 3.0 minutes.
- MTM-3 - for custom production and specific tasks, where operation times range from 3.0 to 30.0 minutes.

In this work, an analysis of the working time of a selected production process was conducted using MTM-1.

The inventors of the MTM-1 method divided the motions performed by the worker in the assembly process into three groups. Each of the groups consists of several types of elementary movements (Drązkiewicz, 1972):

- Group 1 - Hand Movements.
- Group 2 - Eye Movements.
- Group 3 - Leg and Body Movements.

a) Group 1 consists of 9 elementary hand movements:

1. Reach (R).
2. Move (M).
3. Grasp (G).
4. Turn (T).
5. Position (P).
6. Apply Pressure (AP).
7. Disengage (D).
8. Release (RL).
9. Crank (C).

b) Group 2 consists of 2 elementary eye movements:

1. Eye Travel (ET).
2. Eye Focus (EF).

c) Group 3 consists of 15 elementary leg and body movements:

1. Foot Motion (FM).
2. Leg Motion (LM).
3. Walk (W).
4. Side Step (SS).
5. Turn Body (TB).
6. Stoop (B).
7. Return to Stoop (AB).
8. Stoop Down (S).
9. Return to Stoop Down (AS).
10. Kneel to One Knee (KK).
11. Return to Kneel to One Knee (AKK).
12. Kneel on Both Knees (KBK).
13. Return to Kneel on Both Knees (AKBK).
14. Sit (SIT).
15. Stand Up (STD).

In the original formulation of the MTM method, American units of length and weight were used, expressed in inches and pounds. In Europe, corresponding units of centimeters and kilograms were applied. However, when it comes to the unit of time in the MTM method, the situation is more complex. The standard recording speed was 16 frames per second, which translates to 0.0625 seconds per frame. Using such a time measurement unit would be cumbersome, so the authors decided to create a new unit of time called TMU (Time Measurement Unit). The time value for one TMU at a recording speed of 16 frames per second is 1.736 TMU. The formula for the MTM method unit looks as follows (Drązkiewicz, 1972):

$$1 \text{ TMU} = 0.036 \text{ seconds}, 1 \text{ hour} = 100{,}000 \text{ TMU} \quad (1)$$

The characteristics of elementary hand movements (which account for approximately 80% of all movements) are as follows (Strzelecki, 1983):

1. Reach R: The purpose of the reaching movement is to move an empty hand or an object weighing up to a maximum of 1.25 kg to a specified location. It can be performed with the hand or fingers. The movement is characterized by execution conditions, length, types of movement, and movement difficulties. The notation for this movement consists of the letter R indicating the movement, a number indicating the length of the movement, and the letters A, B, C, D, or E indicating the execution conditions.
2. Move M: The purpose of the moving movement is to change the position of an object in space. It can be performed with the hand or fingers. The movement is characterized by execution conditions, length, types of movement, and the weight of the moved object. The notation for this movement consists of the letter M indicating the movement, a number indicating the length of the movement, the letters A, B, C, D, or E indicating the execution conditions, and a number indicating the weight of the moved object.
3. Grasp G: The purpose of the grasping movement is to gain control over an object (or objects) with fingers and/or the hand to enable the next work element. This movement is classified into 5 categories and several classes. The notation for this movement consists of the letter G indicating the movement, a number indicating the category of the movement, optionally the letters A, B, C, or the letters A, B, C, and a number 1, 2, or 3.
4. Release RL: The purpose of the releasing movement is to release one or more objects from hand control by opening the fingers or breaking contact.
5. Position P: The purpose of the positioning movement is to correctly place one object relative to another. It is performed with fingers or a hand. There are only two types of positioning - in-a-hole and linear. It is characterized by the type of fit and pressure, as well as by the degree of symmetry and the difficulty of manipulating objects. The notation for this movement consists of the letter P1, P2, or P3 indicating the movement depending on the fit, the letters S, SS, or NS depending on the degree of fit symmetry, the letters E or D depending on the difficulty of manipulating the object, and a number indicating the weight of the moved object.

6. Disengage D: The purpose of the disengaging movement is to overcome resistance when disconnecting objects. During the execution of the movement, there is an involuntary recoil of the hand. It is characterized by the type of fit, manipulation difficulty, and care. The notation for this movement consists of the letter D1, D2, or D3 indicating the movement depending on the fit, and the letters E or D indicating the difficulty of manipulating the object.
7. Turn T: The purpose of the turning movement is to rotate the empty hand or an object around the axis of the forearm. It is characterized by the angle of rotation of the hand and the weight of the object. The notation for this movement consists of the letter T indicating the movement, a number indicating the angle of rotation, and the letters S, M, or L depending on the weight of the object.
8. Apply Pressure AP: The purpose of applying pressure movement is to overcome resistance by exerting controlled force. It can be performed by any part of the body.
9. Crank C: The purpose of the cranking movement is to move an object in a circular path. It is characterized by the diameter of the path, the number of turns, and the execution conditions (whether the elbow remains nearly immobile during the movement or performs circular movements). The notation for this movement consists of the letter C indicating the movement, a number indicating the diameter of the path, the letters A or B depending on the elbow movement, and a number indicating the number of turns.

3. Results

The time analysis was conducted during the pressing operation using tools such as workday photography and video analysis. This operation is a machining method involving the repetitive introduction of material into a closed forming die, often its plasticization, followed by melting, hardening, or solidification, and then the removal of the object, in this case called a press-out, from the socket. It can be carried out on presses or without their assistance, but always with the use of a tool, which is the forming die with a forming socket.

Based on the data, the times for individual operations were calculated according to the standards of elementary motions in the MTM method. Table 2 includes selected operations according to the MTM-1 methodology.

Table 1.
Selected Activities Described Using the MTM Method

Description of Activities	Code	Explanation of the Code
An employee walking 6 meters to the shelf	TB.C2	Rotating the body with the movement of one leg and bringing the other forward
	WM	Normal walking for every 1 meter
	TB.C2	Rotating the body with the movement of one leg and bringing the other forward
Retrieving a matrix from the shelf	EF	Careful examination
	S	The object can be placed in infinitely many positions around an axis aligned with the folding direction - symmetrically
	R40A	Reaching for an object located at a distance of 40 cm in a specific place
	G1C1	Grasping a roughly cylindrical object
	M40C	Moving the object a distance of 40 cm to an exact location
Placing the screws in a container	M30C	Moving the object a distance of 30 cm to an exact location
	RL1	Releasing the object by opening the fingers

Source: Own work.

After analyzing the elementary motions, calculations were made for all elementary motions of the upper limbs, elementary eye movements, body movements, and leg movements. The movements from the 2nd and 3rd groups of elementary motions were detailed along with the elementary movements from the 1st group. This compilation is presented in Figure 3. The total time for elementary motions performed during this operation was 12.88 minutes. The compilation also includes non-standard activities, which are those not subject to norms.

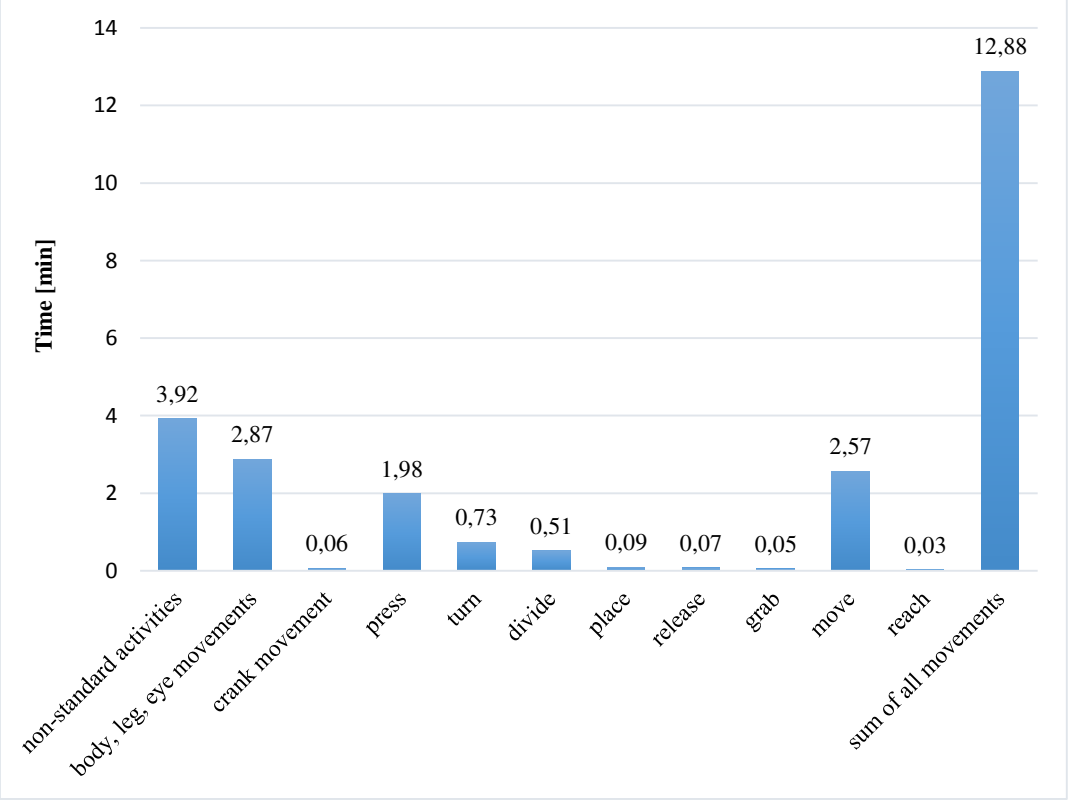

Figure 3. Values of time for individual movements performed during the pressing operation.

Next, the total time for movements from groups 2 and 3 was measured. Knowing that most of the movements in group 3 consist of walking, side steps, and turning the body, the total time for these specified movements was calculated and summed up. The results obtained are presented in Table 2.

Table 2.
Elementary movements from group 2. Comparison of the time of and group 3 during the pressing operation

Elementary movements from group 2	Elementary movements from group 3
27,30 TMU	4 989,1 TMU
0,99 s	179,6 s
0,02 min	2,99 min

Source: Own elaboration.

Figure 4 shows a Pareto Diagram, indicating the percentage contribution of movements about the total time expressed in minutes.

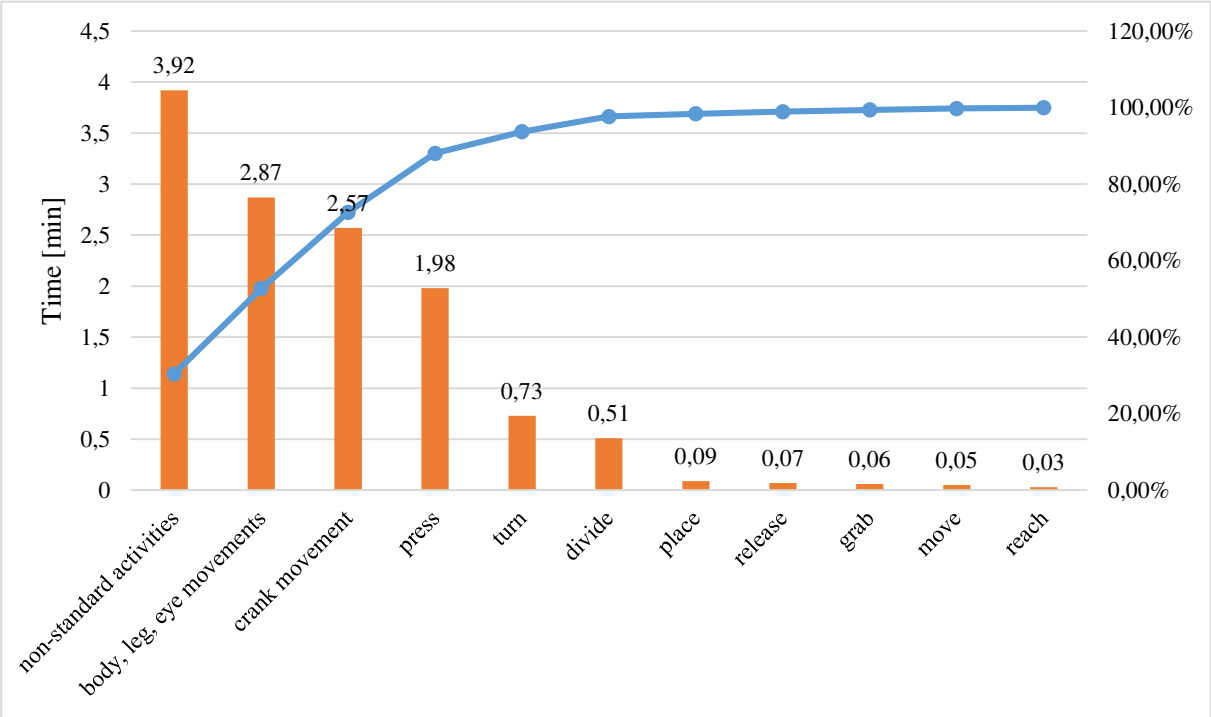

Figure 4. Pareto chart with the participation of individual movements during the pressing operation.

It can be observed that the most time-consuming activities are non-standard activities, body, leg, and eye movements, as well as the "bring" movement, which together account for slightly over 70% of the total operation time. Other moves such as place, release, grab, move and reach, while important, are a small part of the total.

Figure 5 presents the time (expressed in minutes) and the percentage contribution of elementary movements for which it was observed that their time values would change after the reorganization. By altering the organization of the workstation, a reduction in the time of elementary movements such as "reach," "grasp," and "move" was anticipated. Changing the sequence of these movements was expected to yield reliable results.

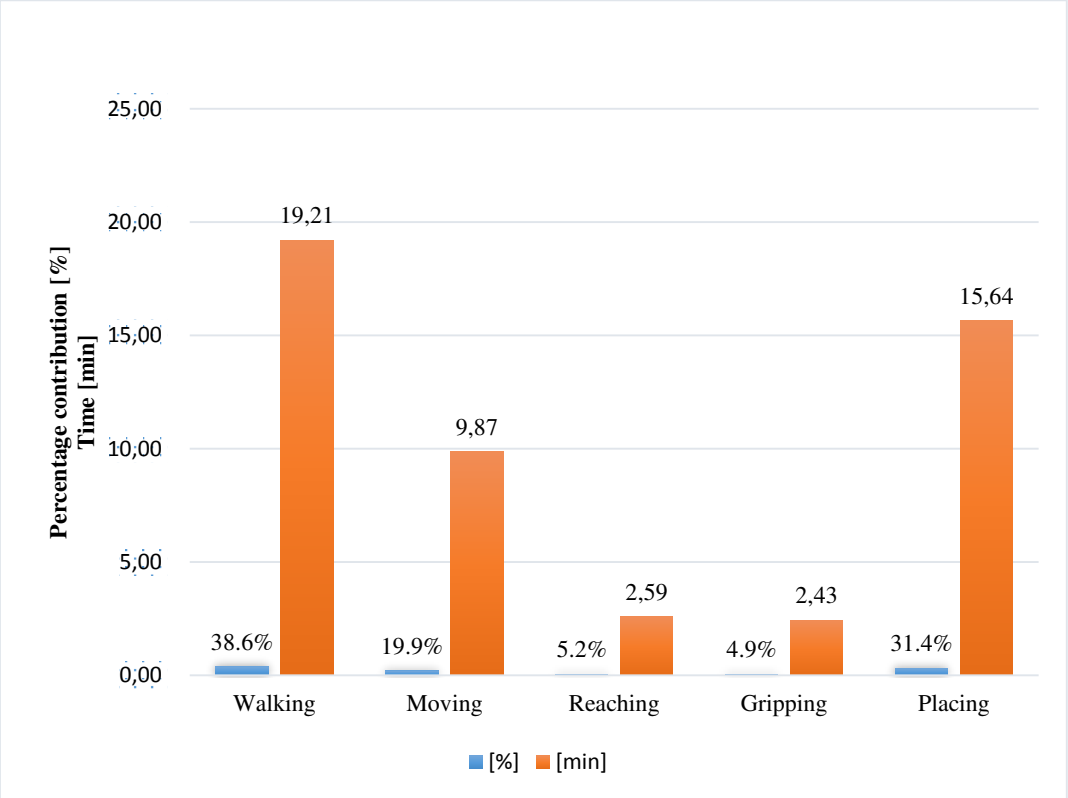

Figure 5. The participation of the most important movements during the pressing operation.

To reduce the operation time, after conducting the analysis, changes were proposed in the organization of the workplace and technology. It was assumed that each product produced would have its workstation. All materials needed for production should be placed on the production table within easy reach to avoid wasting a lot of time fetching them from the warehouse shelves.

After making changes in the workplace, a time analysis was conducted again using the MTM-1 method. Operations were recorded and assigned times. Based on this, individual elementary movements from group 1, group 2, and group 3, as well as non-standard activities, were recorded and presented in Figure 6.

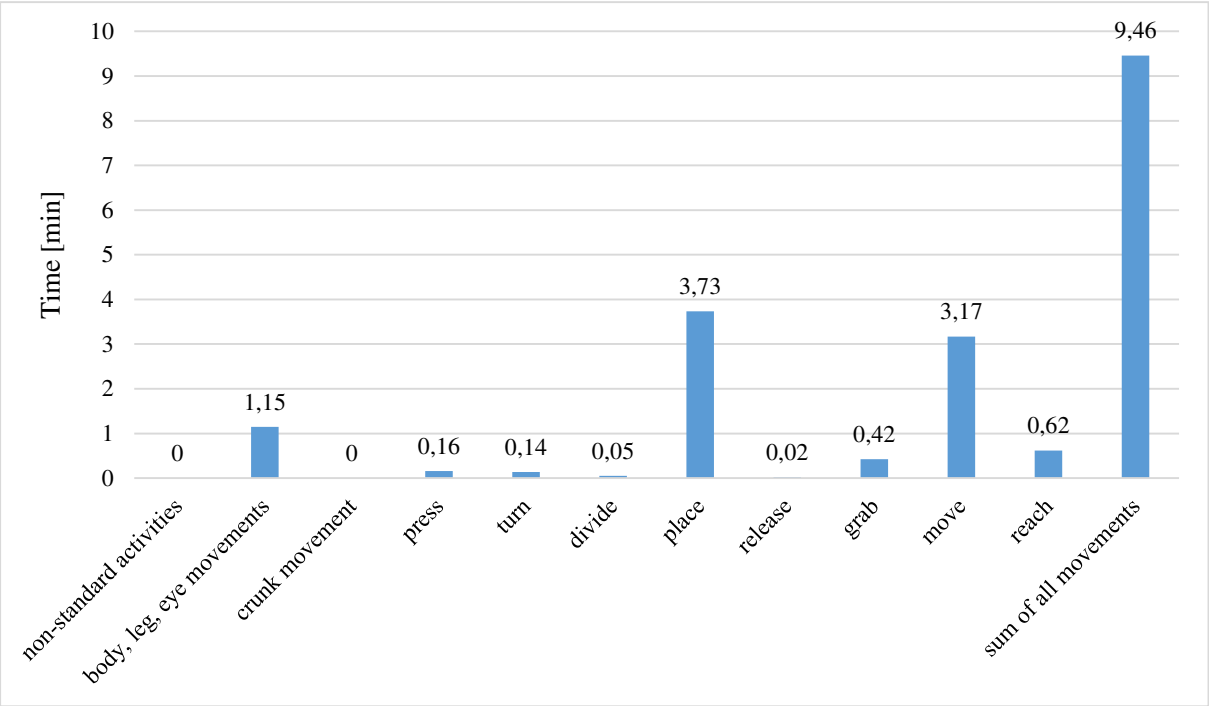

Figure 6. The time values of individual movements performed during the pressing operation are as follows.

When analyzing the cart, attention was drawn to the exceptional importance of certain movements, including: place (3,73 min), move (3,17 min) and body, leg, eye movements (1,15 min). The total time off all movements was 9,46 min.

The Pareto Diagram (Figure 7) created for the time values after the reorganization during the pressing operation shows that approximately 80% of all elementary movements are composed of elementary movements to position and transfer. Movements from group 1 constitute a significant majority compared to the values before the reorganization. Thanks to changes in technology, it was possible to eliminate movements referred to as non-standard activities.

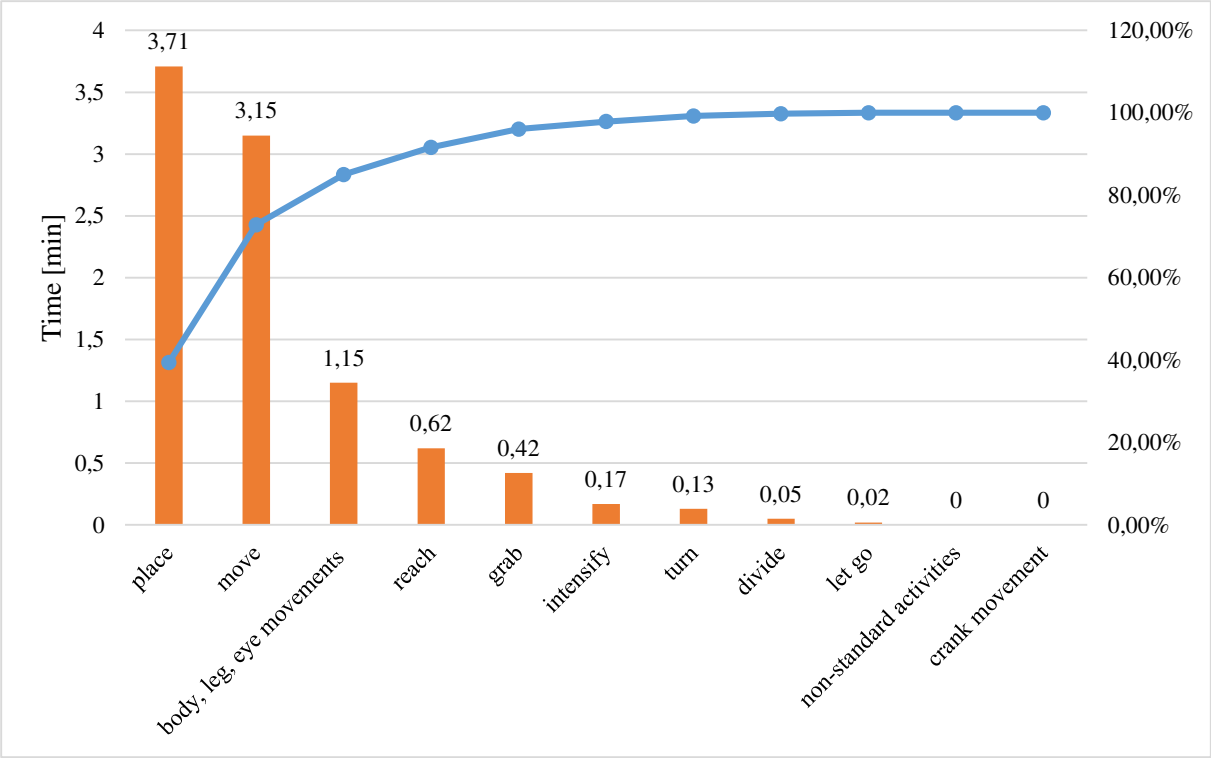

Figure 7. The Pareto Diagram depicting the participation of individual movements during the pressing operation after the workstation changes.

Of significant value are the movements: place, move and body, leg, eye movements. Non-standard activities and crank movement have been eliminated to zero.

When it comes to the movements of walking, moving, reaching, grasping, and positioning, it was possible to reduce their duration, as shown in Figure 8.

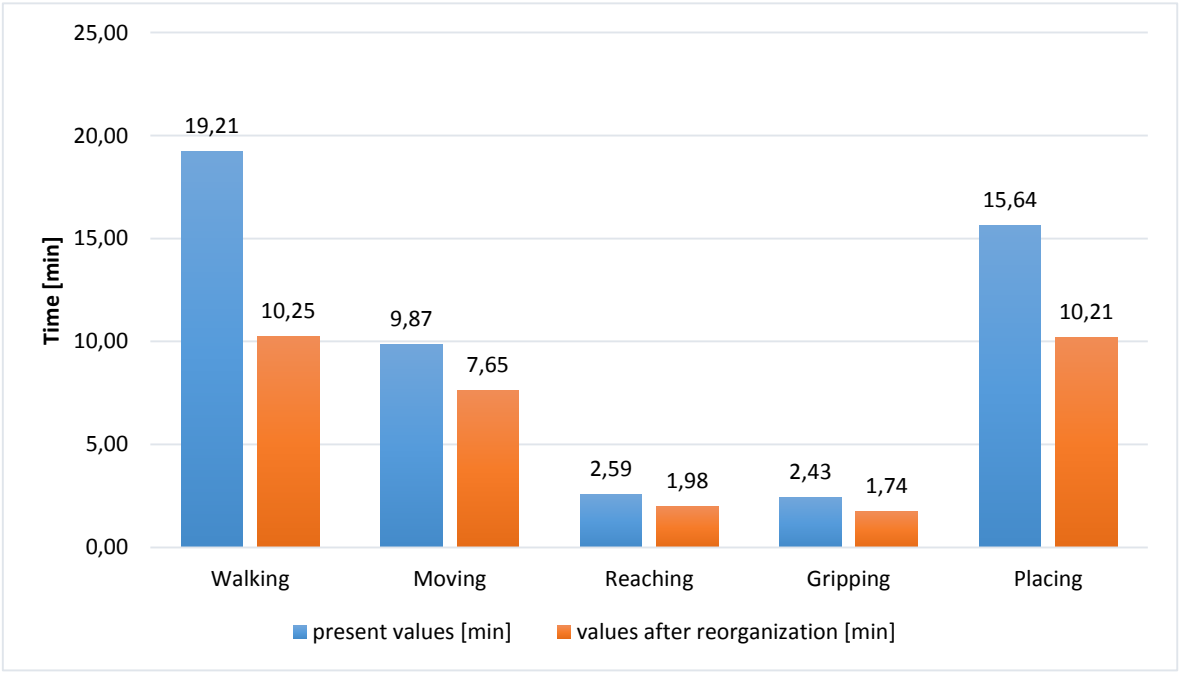

Figure 8. Comparison of the timeshare of the most important movements during the pressing operation before and after changes in the workstation organization and technology.

In each of the analyzed activities, a significant reduction in it's duration was achieved. The walking move was reduced to an impressive 10,25 minutes and the moving move to 7,65 minutes. The reaching move was reduced to just 1,98 minutes, and the gripping move was reduced to 1,74 minutes. Moreover, the placing time was reduced to 10,21 minutes. These significant achievements in time optimization of movements have significantly influenced the efficiency of the process.

The percentage share of the most important movements is presented in Figure 8. As can be observed, despite the shorter duration of individual movements, their percentage share has increased in most cases.

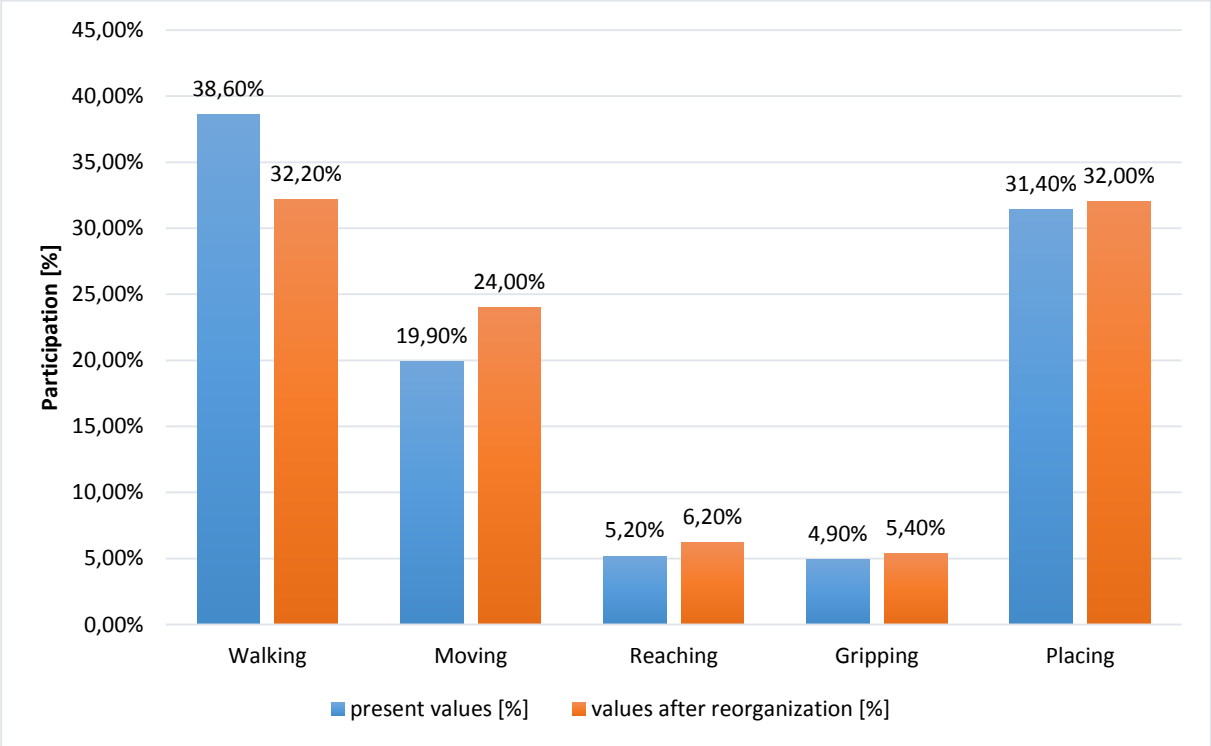

Figure 9. Comparison of the percentage share of the most important movements during the pressing operation before and after changes in workstation organization and technology.

The percentages showing the share of individual movements in the overall statement clearly reflect the changes made. Walking, which initially occupied a significant share, was effectively reduced to 32.2%. At the same time, other movements gained importance. Moving increased its share to 24%, which was a significant increase. The reaching traffic is currently 6.2%. Gripping now accounts for 5.4% of the total. On the other hand, placing traffic, despite a slight increase, remains at the level of 32%, still being an important part of the process. These changes in the percentage structure of movements are important for optimizing the process.

4. Summary

In screw production, the following technological operations are used: stamping, pressing, rolling, milling, and cutting. This article aimed to analyze the working time of manufacturing fasteners in a selected technological process in screw production.

Analyzing the research results, it can be observed that the time taken for individual operations in the process before the changes was 12.88 minutes. After the workstation reorganization and the application of the MTM-1 method, the time for performing all operations was reduced to 9.46 minutes. This represents a reduction in time by 3.42 minutes, which is nearly a 30% acceleration in production time at the given workstation. Non-standardized activities and the 'move' motion were significantly reduced. The time for body, leg, and eye movements was reduced by nearly 40%. The most time-consuming movements at the workstation are walking and positioning. The workstation should be designed so that all necessary materials are located at the workstation, and finished products do not need to be stored far away.

Through this analysis, the entire production process can be streamlined, and its optimal improvement can be determined, and this work also confirms it.

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ARE TRADE CREDIT AND BANK LOANS SUBSTITUTIONAL OR COMPLEMENTARY? A CROSS-SIZE STUDY OF EU FIRMS

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Purpose: This study investigates the interaction between trade credit and short-term bank loans among European Union (EU) firms, spanning small, medium, and large sizes. The research aims to determine whether these financing sources operate as substitutional alternatives or complementary resources within varying firm scales.
Design/methodology/approach: The research is based on yearly financial data from the BACH database for three size groups of firms in the period 2000-2020. Methods include panel data models estimated for total sample and for individual size groups to capture the indirect impact of size on the relationship between short-term institutional financing and trade credit. Additionally, the study distinguishes between the supply and demand of trade credit.
Findings: The research discovered complementary relationships between net trade credit and short-term bank loans for small and medium-sized firms, which contradicted the initial expectation of substitution, while large firms did exhibit the expected complementary effect. However, the impact of trade credit supplied and demanded varied across firm sizes, with small and large firms showing no significant effects while medium-sized firms displayed substitution effects.
Research limitations/implications: The dataset employed in the study contains aggregated data rather than individual firm-level financial information. This choice represents a compromise between information richness and the need for harmonization to ensure comparability.
Practical implications: The findings could be valuable for individuals engaged in the management of short-term corporate finances. Understanding the variations in managing receivables and payables, particularly influenced by firm size, can contribute to improved comprehension of business finance and its operational dynamics. This, in turn, can aid in effectively managing the trade-off between trade credit and short-term institutional financing.
Originality/value: This research adds to the current body of knowledge primarily by employing a multi-faceted approach that encompasses three size categories and explores trade credit from both the perspectives of supply and demand. This approach provides insights into corporate short-term financing strategies, encompassing the interplay between trade credit and bank loans.

Keywords: trade credit, short-term bank loan, complementary effect, substitution effect, firm size, panel data modelling

Category of the paper: Research paper.

1. Introduction

Trade credit and bank loans are integral components of a firm's financial toolkit, providing vital resources for sustaining operational efficiency and growth. In the pursuit of optimal financing strategies, businesses must navigate the complex interplay between these two funding sources. The nature of this relationship – whether trade credit and bank loans are substitutable or complementary – holds significant implications for the financial decisions of European Union (EU) firms, particularly when accounting for variations in firm sizes.

The European business landscape is diverse, encompassing a spectrum of enterprises ranging from small start-ups to large conglomerates. Such diversity requires a detailed understanding of how firms of different sizes leverage trade credit and bank loans to meet their short-term financing needs. The interaction between these financing sources becomes a critical factor influencing working capital management, growth opportunities, and overall financial stability.

This paper embarks on a comprehensive exploration of the trade credit and bank loan within the EU context, with a distinct focus on the impact of firm size. By undertaking a cross-sectional study that encompasses small, medium, and large enterprises, this research seeks to discern whether trade credit and bank loans operate as substitutes or complements across varying firm scales. The insights from this study may enrich our understanding of the financial decision-making processes undertaken by EU firms and contribute to the broader discourse on optimizing financing strategies.

The subsequent sections of this paper present a literature review encompassing key theories and prior research, outline the data collection and employed methodology, detail the empirical analysis, and discuss the implications of the findings. Ultimately, this research aims to provide a comprehensive perspective on the complex relationship between trade credit and bank loans, shedding light on the strategic choices made by EU firms in pursuit of financial sustainability and growth.

2. Substitution vs. Complementariness of Trade Credit and Bank Loan: Literature Review and Hypotheses Development

Understanding the interaction between trade credit and bank loans is essential for devising effective financial management strategies. This section reviews existing literature, drawing insights from the main theories and empirical studies that explore the substitution and complementarity effects of these financing sources.

The substitution effect in the context of bank loans and trade credit, involves a shift from one financing method to another due to changes in relative costs or terms, while the complementary effect suggests a simultaneous utilisation of both methods for enhanced financial management. The effects are manifested in the negative relationship between the use of institutional finance and trade credit in the case of substitutability, and a positive one in the case of complementarity.

The theoretical underpinnings of this study can be traced to well-established financial theories. The pecking order theory, as proposed by Myers (1984), suggests that firms prefer internal financing over external debt and prioritize lower-cost options such as trade credit before resorting to higher-cost options like bank loans. This theory implies a potential substitution effect, where firms utilize trade credit to fulfill their short-term financing needs, thus reducing reliance on bank loans.

Conversely, the trade-off theory, advocated by Frank and Goyal (2003), posits that firms aim to balance the benefits of debt financing against associated costs like interest payments and potential loss of control. This theory points towards the possibility of a complementary relationship, as firms strategically combine trade credit and bank loans to achieve optimal financing while minimizing costs and risks.

The dynamics of trade credit and bank loans are further influenced by agency costs (Jensen and Meckling, 1976) and information asymmetry (Smith, 1987). Suppliers, armed with intimate knowledge of their clients' financial health, may extend trade credit based on private information, thereby lessening the need for external bank loans. On the other hand, lenders, due to information asymmetry, might necessitate collateral or impose stricter terms, making bank loans less attractive. These considerations can result in either a substitution or complementarity effect between short-term bank loans and trade credit, depending on the specific contextual conditions.

The empirical landscape presents a mixed picture regarding the substitution vs. complementarity effects of trade credit and bank loans. Some studies suggest that these financing sources are substitutes, leading to an either/or choice between them (Petersen and Rajan, 1997). This behaviour could be attributed to firms prioritising the least costly financing option or managing information asymmetry through trade credit relationships. Conversely, other studies propose a complementary relationship between trade credit and bank loans, with firms using both sources to address distinct aspects of their financing needs (Deloof, 2003). This approach leverages the flexibility of trade credit and the scalability of bank loans to optimize financing strategies. Table 1 presents a synthesis of the complementary and substitution effects derived from an extensive literature review.

In addition to the mixed evidence reported in the table, one can also encounter inconclusive research items, such as the study by Elliehausen and Wolken (1993) who found the short-term credit-to-assets ratio insignificant in determining trade credit and thus providing no evidence as to the possible substitutability or complementarity of trade credit and institutional credit.

Table 1.
Complementary versus substitution effect between institutional finance and trade credit: summary of literature review

Effect	Supporting studies chronologically
Complementary (+)	Biais and Gollier (1997); McMillan and Woodruff (1999); Demirguc-Kunt and Maksimovic (2001); Ono (2001); Fisman and Raturi (2004); Cunningham (2005) for low wealth firms (i.e. firms whose investments are more likely to be finance constrained); Maksimovic and Frank (2005); Cuñat (2007); Uesugi and Yamashiro (2008); Bougheas, Mateut and Mizen (2009) for accounts receivable; Zawadzka (2009); Cole (2010); Alarcón (2011); Vaidya (2011); Yang (2011) for accounts receivable; Cai, Chen and Xiao (2014) if the retailer's internal capital is substantially low; Carvalho and Schiozer (2015); Lin and Chou (2015) for the supply of trade credit (i.e., accounts receivable); Białek-Jaworska and Nehrebecka (2016) in medium size and large companies; Andrieu, Staglianòa and van der Zwan (2018); Afrifa et al. (2023) for private firms that have limited access to alternative financing resources, such as financial markets
Substitution (–)	Meltzer (1960); Petersen and Rajan (1997); Deloof and Jegers (1999); Kohler, Britton and Yates (2000); Nilsen (2002); Burkart and Ellingsen (2004); Cunningham (2005) for medium wealth firms (i.e. firms whose investment is less likely to be constrained by availability of external funds); Beck, Demirgüç-Kunt and Maksimovic (2008); Bougheas et. al (2009) for accounts payable; García-Teruel and Martínez-Solano (2010); Hui, Xiaojun and Shunming (2011); Kling, Salima and Eleimon (2011); Yang (2011) for accounts payable; Molina and Preve (2012) for firms in financial distress; Bastos and Pindado (2013); Ogawa, Sterken and Tokutsu (2013); Cai, Chen and Xiao (2014) if the retailer's internal capital grows; Engemann, Eck and Schnitzer (2014); Santos and Silva (2014); Lin and Chou (2015) for the demand of trade credit (i.e., accounts payable); Białek-Jaworska and Nehrebecka (2016) for small companies; Levine, Lin and Xie (2018); Palacín-Sánchez, Canto-Cuevas and Di-Pietro (2019); Duliniec and Świda (2021); Pinto et al. (2023); Afrifa et al. (2023) for public firms that have easy access to cheap external finance;

Source: own elaboration based on the listed literature items.

The above review is certainly not exhaustive and covers only a limited portion of the extensive body of literature dedicated to trade credit management. Nevertheless, a characteristic pattern that emerges from the summary reported in Table 1 is the occurrence of a complementary effect in the context of trade credit supply, as pointed out by several studies. This manifests as a positive correlation between accounts receivable and bank loans. Conversely, for the demand of trade credit, a substitution effect is commonly identified, evidenced by a negative relationship between accounts payable and bank loans. Furthermore, certain scholars contend that the prevalence of complementarity should be anticipated in more developed economies and (or) among firms with facile access to institutional finance, as noted e.g. by Demirguc-Kunt and Maksimovic (2001). In contrast, in less mature financial markets, enterprises are compelled to explore alternate sources, including trade credit. Similarly, financially constrained companies are more inclined to resort to trade credit as a substitute of bank credit.

The absence of a unanimous consensus among scholars and the reliance on the prevalence of either complementarity or substitutability in specific circumstances renders the formulation of research hypotheses a non-trivial task. The divergent empirical outcomes encourage to delve into the underlying reasons for these conflicting findings. A plausible explanation resides in the contingent nature of the connection between trade credit and short-term bank financing, which may hinge on additional factors, such as firm size – central to the focus of this study,

wherein firm size serves as an indirect factor influencing the interplay between trade credit and bank loans. It is reasonably justifiable to anticipate that smaller enterprises, which often encounter greater challenges in securing institutional funding, will opt for trade credit as an alternative financial mechanism. Likewise, the formulation of research hypotheses is constructed in consideration of both the supply and demand facets of trade credit.

For all sizes of firms, a complementary effect between net trade credit and short-term bank loans is hypothesized (**H1a**). Specifically, a higher utilization of net trade credit is expected with an increase in short-term bank loans.

In the case of all firm sizes, the existence of a complementary effect between the trade credit supplied and short-term bank loans is proposed (**H1b**). As the utilization of short-term bank loans increases, a concurrent rise in the supply of trade credit is anticipated.

However, for all sizes of firms, a substitution effect between the trade credit demanded and short-term bank loans is expected (**H1c**). This suggests that when the reliance on short-term bank loans decreases, there will be an elevated demand for trade credit.

When considering firms categorised as small in size, a substitution effect between net trade credit and short-term bank loans is predicted (**H2a**). Consequently, a decrease in the reliance on short-term bank loans is likely as net trade credit grows. Simultaneously, a complementary effect between the trade credit supplied and short-term bank loans among small-sized firms is anticipated (**H2b**), implying that an increase in short-term bank loan utilisation will correspond to an increase in trade credit supplied. Furthermore, a substitution effect between the trade credit demanded and short-term bank loans for small-sized firms is projected (**H2c**). A decrease in the reliance on short-term bank loans will likely lead to an increase in trade credit demanded.

Turning to medium-sized firms, a substitution effect between net trade credit and short-term bank loans is hypothesized (**H3a**). Consequently, an escalation in net trade credit is likely with a decrease in the usage of short-term bank loans. For trade credit supplied, a complementary effect is proposed (**H3b**), meaning that an increase in short-term bank loans will correspond to a higher utilisation of trade credit supplied among medium-sized firms. Likewise, a substitution effect between the trade credit demanded and short-term bank loans for medium-sized firms is projected (**H3c**).

Finally, for firms classified as large in size, a complementary effect between net trade credit and short-term bank loans is anticipated (**H4a**). Hence, an increase in net trade credit is expected with an increase in short-term bank loan utilisation. Similarly, a complementary effect between the trade credit supplied and short-term bank loans among large-sized firms is predicted (**H4b**). However, a substitution effect between the trade credit demanded and short-term bank loans is expected (**H4c**), indicating that an increase in the reliance on short-term bank loans will lead to a decrease in trade credit demanded.

A synthetic summary of the hypothesised effects and the hypotheses numbering is shown in Table 2 for convenient reference.

Table 2.
The hypothesised effects concerning the relation between short-term bank loans and trade credit

Sample part		Hypotheses numbers and expected sign for trade credit measures					
		Net trade credit (NTC)		Trade credit supplied (STC)		Trade credit demanded (DTC)	
All sizes		H1a	+	H1b	+	H1c	-
Size groups	Small	H2a	-	H2b	+	H2c	-
	Medium	H3a	-	H3b	+	H3c	-
	Large	H4a	+	H4b	+	H4c	-

Note: '+' indicates a complementary effect between trade credit and short-term bank loans, whereas '-' indicates a substitution effect.

Source: author's own elaboration.

The procedure of verification of the aforementioned research hypotheses is outlined in the subsequent section of the study.

3. Data and methods

The source of data for empirial research is the BACH (2023) database, known as the Bank for the Accounts of Companies Harmonised. This comprehensive dataset contains aggregated financial information from various European companies and is updated yearly. It offers detailed insights into company balance sheets, income statements, cash flow statements, and financial indicators. The BACH data is divided into four size categories: small, medium, SMEs, and large firms. Small firms have turnovers under 10 million euros, medium-sized ones range between 10 and 50 million euros, while large companies exceed 50 million euros in turnover.

Furthermore, the BACH database provides standardized annual financial data for non-financial companies in twelve European Union countries. These countries include Austria (AT), Belgium (BE), Czech Republic (CZ), Germany (DE), Spain (ES), France (FR), Croatia (HR), Italy (IT), Luxembourg (LU), Poland (PL), Portugal (PT), and Slovakia (SK).

The database also classifies companies according to the NACE system, with the study using the first-level classification which covers sectors like Agriculture, forestry and fishing (A), Mining and quarrying (B), Manufacturing (C), Electricity, gas, steam and air conditioning supply water (D), Water supply, sewerage, waste management and remediation activities (E), Construction (F), Wholesale and retail trade, repair of motor vehicles and motorcycles (G), Transportation and storage (H), Accommodation and food service activities (I), Information and communication (J), Real estate activities (L), Professional, scientific and technical activities (M), Administrative and support service activities (N), Education (P), Human health and social work services (Q), Arts, entertainment and recreation (R), and Other service activities (S).

The research covers 12 countries, 17 industries, and 3 size categories, analysing data from 2000 to 2020 due to data availability. As for the dependent variables, three trade credit measures were used to assess different aspects of trade credit behaviour: net trade credit, trade credit supplied, and trade credit demanded. The explanatory variables were selected based on past research highlighting factors impacting trade credit. Detailed variable definitions are in Table 3.

Table 3.
Definition of dependent and explanatory variables employed in the analysis

Variable character		Symbol	Formula
Dependent		NTC	Net trade credit = (Accounts receivable – Accounts payable) / Assets
		STC	Supply of trade credit = Accounts receivable / Assets
		DTC	Demand of trade credit = Accounts payable / Assets
Explanatory	Firm-specific financial ratios	SBL	Short-term bank loan = Current amounts owed to credit institutions / Assets
		FXA	Collateral = Fixed assets / Assets
		INV	Inventory = Inventories / Assets
		LIQ	Cash at hand = Cash and available bank amounts / Assets
		CGS	Costs of goods sold = Costs of goods sold, materials and consumables / Net turnover
		LEV	Debt ratio = Debt / Equity
		ROA	Return on assets = Net operating profit / Assets
		TAT	Total asset turnover = Net turnover / Assets
	Dummy variables	SIZE	Size groups of firms (SM, ME, LA)
		CT	Countries (AT, BE, CZ, DE, ES, FR, HR, IT, LU, PL, PT, SK)
		IND	Industrial sectors by NACE (A, B, C, D, E, F, G, H, I, J, L, M, N, P, Q, R, S)
		YEAR	Years (2000, …, 2020)

Source: author's own compilation.

The research design and methods aligned with its main goals: to establish if trade credit and short-term bank loans work together or replace each other in business short-term funding, and to uncover how firm size indirectly affects such funding choices. As a result, the investigation covers both the whole dataset and distinct size categories separately.

The initial phase of the research aimed to identify the level and variation of trade credit measures and their driving factors. This was achieved by examining descriptive statistics within three size groups. After the preliminary descriptive analysis, a correlation study was carried out, and potential multicollinearity was addressed using the variance inflation factor (VIF).

The data structure, encompassing both cross-sectional and time series data, necessitates adopting a panel data approach to investigate the relationship between trade credit, bank credit, and control variables. This constitutes the core of the empirical analysis in this study. Verifying research hypotheses outlined in the preceding section is based on panel data regression analyses both for the entire dataset and separately for each size category. The version of the model for all size groups is represented by formula (1):

$$TC_{cist} = \beta_0 + \beta_1 SBL_{cist} + \beta_2 FXA_{cist} + \beta_3 INV_{cist} + \beta_4 LIQ_{cist} + \beta_5 CGS_{cist} + \beta_6 LEV_{cist} + \beta_7 ROA_{cist} + \beta_8 TAT_{cist} + \beta_9 SIZE_s + \beta_{10} CT_c + \beta_{11} \gamma_i IND_i + \beta_{12} YEAR_t + \xi_{cist}, \quad (1)$$

where TC_{cist} denotes one of the three trade credit measures (NTC_{cist} – net trade credit, STC_{cist} – supply of trade credit, DTC_{cist} – demand for trade credit) for country *c*, industry *i*, firm size *s* in year *t*. The formula includes structural parameters $\beta_{1\text{-}12}$, a random error term ξ, and variables specified in Table 3.

Since there are three separate dependent variables, the model has been segmented into three corresponding forms: (1a) addresses net trade credit as the dependent variable, (1b) focuses on trade credit supplied, and (1c) concentrates on trade credit demanded. The letter extensions applied to the model numbers correspond with the symbols employed for hypothesis numbering.

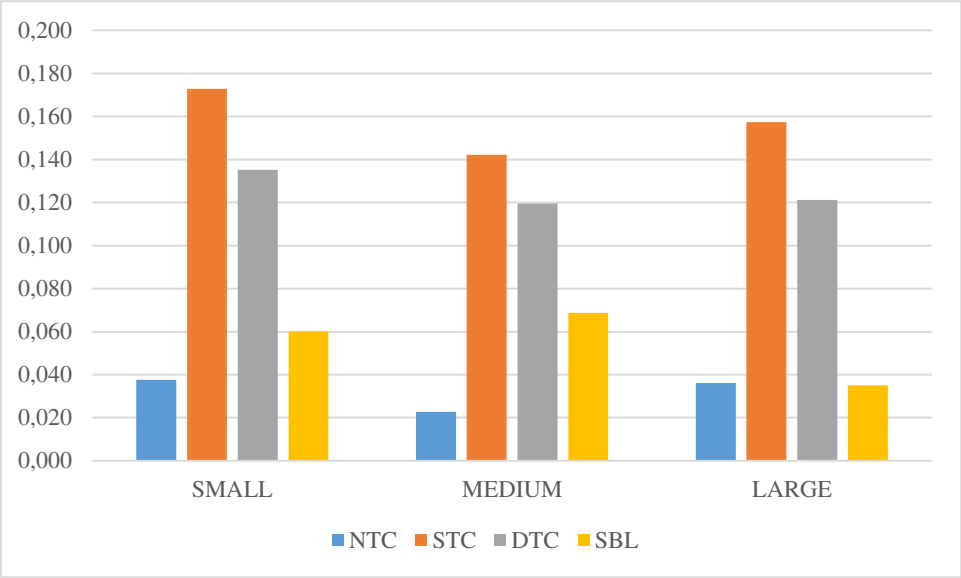
During the panel data modelling process, different approaches such as pooled OLS, fixed-effects, and random-effects models were considered. Initially, models (1a)–(1c) were estimated via pooled OLS for the complete dataset, followed by the removal of insignificant variables. Panel specification tests were employed to identify the most suitable model. Appropriateness of the pooled OLS model was assessed through joint significance testing and checks for individual effects. The Hausman test distinguished between fixed and random effects, demonstrating the suitability of the fixed-effects (FE) model for all cases. This led to a re-evaluation of models (1a)–(1c) with the inclusion of dummy variables. Subsequently, a Wald test was conducted for dummy variables related to size, country, industry, and year. The subsequent step involved adjusting model (1) for estimation within each size group, leading to equation (2), achieved by excluding size dummy variables:

$$TC_{cist} = \propto_0 + \beta_1 BKL_{cist} + \beta_2 COL_{cist} + \beta_3 INV_{cist} + \beta_4 CSH_{cist} + \beta_5 CGS_{cist} + \beta_6 DBT_{cist} + \beta_7 ROA_{cist} + \beta_8 TAT_{cist} + + \beta_9 CT_c + \beta_{10} \gamma_i IND_i + \beta_{11} YEAR_t + \xi_{cist}, \quad (2)$$

Model (2) was also estimated in variations (2a), (2b), and (2c) for different trade credit measures, akin to the extended dataset model.

4. Results and discussion

As indicated in the previous section, the first stage of the analysis was aimed at the preliminary recognition of the main trade credit patterns based on the basic statistics. Additionally, in the context of the topic of this study, it is also informative to trace the level of short-term institutional finance relative to trade credit measures across size classes of firms. That is why the ratio of short-term bank loan was the only explanatory variable included in Figure 1.



Note. NTC – net trade credit, STC – supply of trade credit, DTC – demand for trade credit, SBL – short-term bank loans ratio. Detailed formulas of ratios as in Table 3.

Figure 1. Mean values of trade credit measures and short-term bank loan ratio across size classes.

Source: own elaboration based on BACH (2023).

A glance at the mean values of the trade credit ratios across the three size groups reveals several size-related patterns concerning short-term financing strategies. Regarding net trade credit, it is evident that small firms exhibit a higher level of credit extension to customers compared to their medium and large counterparts. In contrast, medium firms appear to adopt a more conservative approach with the lowest mean net trade credit. Large firms fall in between, signifying varying credit extension strategies based on firm size.

In terms of the supply of trade credit, small firms demonstrate the highest mean value, suggesting that they are most generous with offering trade credit to their customers. Large firms also exhibit a notable mean in this respect, reflecting a substantial supply of trade credit. In contrast, medium firms display a comparatively lower mean trade credit supply, indicating a reduced relation of accounts receivable to assets.

Examining the demand for trade credit, small firms report the highest mean value, implying a greater demand for trade credit, potentially to support their operations and growth. Large companies, although lower than small firms, still exhibit a notable mean trade credit demanded. Medium firms display the lowest mean in this area, suggesting a relatively lower requirement for trade credit.

Finally, considering the short-term bank loan ratio, small firms show a moderate reliance on short-term bank loans. Medium firms, on the other hand, exhibit a slightly higher mean ratio, indicating a relatively greater dependence on short-term bank loans for financing. Large firms report the lowest mean, potentially indicating a lower reliance on such financing and, possibly, greater financial stability through alternative means.

To address the risk of multicollinearity in the empirical analysis, a correlation study was undertaken to examine the relationships between variables. The findings are summarized in Table 4, which includes correlation coefficients for the entire sample, spanning different size groups, countries, industries, and years. Furthermore, Table 5 provides values of the Variance Inflation Factor (VIF), a metric employed to detect multicollinearity in regression analysis.

Table 4.
Matrix of correlations for total sample

Ratio	NTC	STC	DTC	SBL	FXA	INV	CSH	CGS	LEV	ROA
STC	0,608*									
DTC	0,038*	0,817*								
SBL	0,005	0,233*	0,290*							
FXA	-0,408*	-0,769*	-0,670*	-0,202*						
INV	-0,103*	0,276*	0,423*	0,348*	-0,552*					
CSH	0,151*	0,172*	0,107*	-0,105*	-0,387*	-0,049*				
CGS	-0,356*	0,076*	0,354*	0,237*	-0,136*	0,571*	-0,204*			
LEV	0,083*	0,284*	0,298*	0,243*	-0,273*	0,086*	-0,081*	-0,136*		
ROA	0,029*	0,054*	0,047*	-0,021*	-0,106*	-0,030*	0,246*	-0,066*	-0,123*	
TAT	0,037*	0,454*	0,545*	0,121*	-0,468*	0,221*	0,265*	0,258*	0,094*	0,307*

Note: * – significant at $p < 0.5$.

Source: author's calculations based on BACH (2023).

Table 5.
Variance inflation factors for total sample

	Dependent variables							
	SBL	FXA	INV	CSH	CGS	LEV	ROA	TAT
VIF	1,221	2,588	2,576	1,513	1,930	1,308	1,195	1,603

Source: author's calculations based on BACH (2023).

Despite several significant correlations among variables, indications of considerable multicollinearity problems seem to be limited. The highest VIF value for the entire sample stands at 2.59, which is approximately half the threshold typically regarded as indicating low to moderate multicollinearity, a widely accepted criterion in most instances (Kutner et al., 2004). While the correlation and VIF data for size-specific subgroups are not fully presented in this study, the findings suggest that multicollinearity among predictor variables within each size category is not a major issue.

The validation of research hypotheses formulated in the previous section relies on panel regression findings, particularly focusing on the statistical significance and the nature of the connection between the short-term bank loan ratio (SBL) and trade credit measures, which serve as the dependent variables. Significantly positive relations suggest a complementary effect, indicating that both financing methods mutually reinforce each other. Conversely, significantly negative associations suggest a substitution effect, where one type of financing tends to replace the other. Table 6 displays the panel regression results for the entire dataset using equations (1a) to (1c). Based on the Hausman test results, the chosen model incorporates adjustments for endogeneity and unobserved heterogeneity through fixed effects (FE) estimation, while robust errors are employed to address heteroscedasticity and autocorrelation concerns.

Table 6.
Results of panel regression models (1a–c) for total sample

Variable or specification	Model number and dependent variable symbol					
	(1a) NTC		(1b) STC		(1c) DTC	
	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
const.	0,288***	0,010	0,496***	0,014	0,203***	0,013
SBL	0,109***	0,027	0,127***	0,044		
FXA	-0,263***	0,009	-0,540***	0,015	-0,273***	0,013
INV	-0,271***	0,016	-0,403***	0,022	-0,129***	0,019
LIQ	-0,209***	0,022	-0,405***	0,027	-0,190***	0,029
CGS	-0,066***	0,005	0,023***	0,008	0,092***	0,007
LEV	-0,066***	0,008	0,018*	0,010	0,088***	0,008
ROA			-0,047***	0,007	-0,036***	0,008
TAT	-0,014***	0,003	0,020***	0,005	0,034***	0,004
SIZE	ME**		ME***, LA***		ME***, LA***	
CT	none		none		none	
IND	F*, H***, I***, J***, L*, M**, N***, P***, Q***, R***		E**, F***, G***, H***, I***, J***, L***, M***, N***, R**, Q***		E**, F***, G***, H***, I***, J***, L***, M***, P*, Q***, S***	
YEAR	2015**		2002*, 2008*, 2014*, 2020*		2002**, 2005**, 2011***, 2014**, 2017**, 2020**	
No. obs.	8797		8797		8796	
R^2	0.468		0.725		0.663	
AIC	-30905.0		-27044.9		-29295.1	
Hausman test	63.8 [0.000]		249.0 [0.000]		239.7 [0.000]	
Wald joint significance robust F test						
SIZE	6.07 [0.014]		17.1 [0.000]		24.1 [0.000]	
CT	n/a		n/a		n/a	
IND	19.28 [0.000]		12.6 [0.000]		15.3 [0.000]	
YEAR	4.43 [0.036]		3.5 [0.008]		5.8 [0.000]	

Notes: Interpretation of parameters in relation to small firms for size dummies, Austria for country dummies and agriculture for industry dummies.
* – significant at the 10% level,
** – 5%,
*** – 1%.
For dummy variables values of estimates were replaced with the list of items (symbols of size groups, countries, industries and years) for which the estimate value was significant accompanied by the significance level. Hausman test refers to the pooled OLS model before the inclusion of dummy variables.

Source: authors' calculations based on (BACH, 2023).

From the model estimation results for all-sized firms, it is evident that for both net trade credit and trade credit supplied, the observed effects align with the expected complementary effect, thus providing support for hypotheses H1a and H1b. This consistency across trade credit measures suggests a robust trend in the data. However, with reference to the trade credit demanded, the results indicate that the hypothesis H1c, which anticipated a substitution effect for this metric, did not find support in the category of all-sized firms. Instead, the observed lack of significant relationship signifies no discernible effect.

The models estimations results for specific size categories (2a-2c), i.e. small, medium and large firms, although not reported here in details, serve as grounds for the validation of hypotheses H2 through H4. Table 7 presents a concise summary of the validation of research hypotheses related to trade credit measures and their expected effects across different firm size categories.

Table 7.
Summary or research hypotheses validation

Trade credit measure	Firm size	Hypothesis symbol	Anticipated effect	Effect found	Support found
Net trade credit (NTC)	All	H1a	complementary	complementary	**supported**
	SM	H2a	substitution	complementary	rejected
	ME	H3a	substitution	complementary	rejected
	LA	H4a	complementary	complementary	**supported**
Trade credit supplied (STC)	All	H1b	complementary	complementary	**supported**
	SM	H2b	complementary	complementary	**supported**
	ME	H3b	complementary	substitution	rejected
	LA	H4b	complementary	no effect	unsupported
Trade credit demanded (DTC)	All	H1c	substitution	no effect	unsupported
	SM	H2c	substitution	no effect	unsupported
	ME	H3c	substitution	substitution	**supported**
	LA	H4c	substitution	no effect	unsupported

Source: author's calculations based on (BACH, 2023).

Several patterns emerged in the investigation of trade credit measures and their relationship with short-term institutional financing across size categories of firms. The study initially hypothesized that a substitution effect would be observed between the short-term bank loan ratio and net trade credit for small and medium firms. Surprisingly, the analysis revealed a complementary effect for both of these size classes. This finding challenges the initial hypothesis, suggesting that in these cases, both financing methods mutually reinforce each other rather than act as substitutes. Conversely, for large firms, the initial hypothesis of complementary effects between short-term bank loan and net trade credit was confirmed, indicating that these firms do indeed exhibit a complementary financing relationship.

Moving on to trade credit supplied, the research initially anticipated a complementary effect across all firm sizes. The results only partially supported this hypothesis, with complementary effects observed for small firms. However, the analysis revealed a substitution effect for medium-sized firms, suggesting that in some instances, trade credit supplied may replace short-term bank loans for these firms. Interestingly, for large firms, the analysis indicated no significant effect, which contradicts the anticipated complementary relationship.

Lastly, regarding trade credit demanded, the research initially hypothesized a substitution effect, implying that short-term bank loans would replace trade credit demanded. However, the analysis yielded mixed results. For small and large firms, no significant effect was observed, indicating that the substitution hypothesis was not supported. In contrast, medium-sized firms displayed a substitution effect, where short-term bank loans did indeed replace trade credit demanded.

In conclusion, the findings reported in Table 5 reveal the complexity of the relationships between short-term institutional financing and trade credit measures, as well as the variability of these relationships across different firm sizes. While some relationships align with the initial hypotheses, others deviate from expectations, highlighting the diverse interplay between these financing methods within the context of firm size.

The prevalence of complementary effects, as opposed to substitution effects, within the context of trade credit measures and firm size can be attributed to a complex interplay of factors. One key factor contributing to this prevalence is the notion of business synergy. This synergy arises when trade credit measures and firm size mutually reinforce each other, enhancing their respective benefits. For instance, larger firms often possess greater bargaining power, enabling them to negotiate favourable trade credit terms and effectively manage their trade credit relationships.

Additionally, the diversity of firm characteristics within the category of all sizes adds another layer of complexity. This diversity can lead to varied effects across different firms. Larger firms, with their unique attributes, may naturally lend themselves to complementary relationships, whereas smaller firms may experience substitution effects due to constraints on resources and operations.

Furthermore, industry-specific factors also play a vital role. Different industries exhibit distinct operational dynamics, which can influence the strength and nature of the relationships between trade credit measures and firm size. Some industries may inherently foster complementary relationships, while others may emphasize substitution effects more prominently.

In summary, the prevalence of complementary effects highlights a harmonious relationship between trade credit measures and short-term institutional financing for all-sized firms as total. However, the variability in results, particularly for trade credit demanded, underscores the intricate and multifaceted nature of these relationships. It becomes evident that various factors, including business synergies, firm characteristics, methodological choices, and industry-specific dynamics, collectively shape these outcomes.

5. Conclusions

The research conducted in this study investigated the relationship between trade credit patterns and short-term institutional financing across different firm sizes. The key findings can be summarized as follows. The analysis of mean values of trade credit metrics and the short-term bank loan ratio reveals diverse financial strategies and risk profiles across firms of different sizes. Small firms emphasize credit extension and trade credit reliance, medium firms exhibit a middle-ground approach, whereas large firms prioritise financial stability with potentially diversified financing strategies. The analysis of basic statistics provides initial indication that firm size influences trade credit behaviours and financing decisions in the business landscape.

Contrary to the initial hypothesis of a substitution effect, the analysis revealed complementary relationships between net trade credit and short-term bank loans for both small and medium-sized firms. In these cases, it was found that these financing methods mutually reinforce each other rather than acting as substitutes. Large firms did exhibit a complementary financing relationship, as initially hypothesised.

While the research initially anticipated a complementary effect across all firm sizes in trade credit supplied, the results only partially supported this hypothesis. Complementary effects were observed for small firms, but medium-sized firms displayed a substitution effect, suggesting that trade credit supplied may replace short-term bank loans for these firms. Interestingly, for large firms, no significant effect was observed, which contradicts the anticipated complementary relationship.

The study initially hypothesized a substitution effect in trade credit demanded, implying that short-term bank loans would replace trade credit demanded. However, the analysis yielded mixed results. Small and large firms showed no significant effect, indicating that the substitution hypothesis was not supported. In contrast, medium-sized firms displayed a substitution effect, where short-term bank loans did replace trade credit demanded.

These findings highlight the complexity and variability of the relationships between short-term institutional financing and trade credit measures across different firm sizes. The prevalence of complementary effects can be attributed to factors such as business synergies, firm characteristics, and industry-specific dynamics, which collectively shape the outcomes of these relationships. Overall, the study reveals the unobvious interplay between these financing methods within the context of firm size.

Future research paths could include examining industry-specific variations in trade credit and short-term financing, as well as international comparisons of firms' decision-making processes within this area.

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SPECIAL ECONOMIC ZONES (SEZS) AS AN ELEMENT OF SUSTAINABLE DEVELOPMENT IN EMERGING COUNTRIES: A CASE OF POLAND

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Purpose: The article aims to provide readers with insight into the economic benefits stemming from the existence of SEZ and to indicate how these zones impact regional development. Through the analysis of these aspects, the article aims to highlight the significance and potential of SEZs as a tool supporting economic and regional development. The primary accomplishment of this paper lies in demonstrating how special economic zones can serve as zones for the establishment of clusters.
Design/methodology/approach: Analysis of the economic benefits arising from the presence of SEZs.
Findings: The main objective of this article is to examine and present the benefits arising from the existence of SEZs, as well as to analyze the effects that SEZs have on regional development in emerging countries, including Poland. The article also shows the specificity of cooperation within clusters in the particular economic zones in Poland. The paper focuses on identifying the positive aspects associated with the functioning of SEZs and analyzing the impact of these zones on a specific region. Paper includes examples of specific regions/ territories that have benefited from the existence of SEZs and have achieved successes in terms of economic and regional development. The research hypothesis postulates that SEZs play a constructive role in advancing regional development, specifically by facilitating increased foreign investments and reducing unemployment.
Originality/value: The presented cases can serve as case studies that illustrate the real effects of SEZs in specific areas. The primary achievement of this paper is in illustrating the role of SEZs as core facilitators for the formation of clusters.

Keywords: special economic zones (SEZs), clusters, regional development, sustainable development, FDI, Poland.

Category of the paper: Research paper.

1. Introduction

Clusters and Special Economic Zones (SEZs) are both strategic economic development initiatives that aim to foster economic growth and enhance competitiveness. The establishment of SEZ is a lengthy, expensive and long-term oriented undertaking. The suitable selection of Special Economic Zones is essential to achieve the goals of export-led growth and value creation. Incorporating sustainability issues into such planning within the Zone 3.0 paradigm is critical to achieving the Sustainable Development Goals (SDGs) by 2030. One of the key objectives of creating special economic zones is stimulating entrepreneurship and attracting new investors. There has been noticed a significant impact of special economic zones on socio-economic growth included higher investment and job creation, overall regional development, external trade, foreign direct investments (FDI) inflow, as well as aspects linked with the labour market.

The launch of SEZs is high on the agenda of governments and policymakers to encourage and enhance the process of industrialization, attract FDI for export-oriented manufacturing and lay the foundation for robust economic growth. Governments have focused on developing facilitation centers, dedicated areas and investor-friendly policies to encourage export and encourage capital appreciation. The most successful and widespread policy is the establishment of SEZs, which not only boost industries but also transform the industrial process to eliminate the concept of the space economy.

There is no doubt, that the creation of SEZ is a lengthy, expensive and long-term oriented undertaking. In fact, proper selection of SEZs is essential to achieve the goals of export-led growth and value creation. Incorporating sustainability issues into such planning within the Zone 3.0 paradigm is critical to achieving the Sustainable Development Goals (SDGs) by 2030.

Nonetheless, establishing SEZs is a costly and precarious undertaking that demands meticulous planning. These zones are created to fulfill a range of policy goals. The initial objective is to attract foreign direct investment (FDI) (Łukaniszyn-Domaszewska et al., 2023) and boost exports through industrialization or upgrading of existing industries. A secondary aim is to address unemployment in remote and marginalized regions (Dorożyński et al., 2016). Another goal involves leveraging economic policies or capitalizing on bilateral economic engagements between nations (Pakdeenurit et al., 2017). Additionally, SEZs may serve as experimental spaces for testing specific strategies and policies (Jankowska, 2016). Lastly, they can contribute to the enhancement of overall quality of life.

Several key factors such as location, connections, workforce, suitability of industries, incentives and facilities, and market orientation are important in the decision-making process to set up SEZs. In addition, environmental conditions and resource availability need to be considered in the planning and policy making processes to maintain symmetry in the natural environment and ecosystem of the areas considered for SEZ.

Generally, SEZs are characterized by (1) being a physically defined region, (2) being under a unified administration, (3) offering tax advantages, (4) streamlining procedures and customs, and (5) having a more lenient policy and legal framework compared to the broader nation. (Zeng, 2016). Such zones help in catapulting new technologies, catalyze economic development by export orientation, and upgrade and optimally utilize the existing infrastructure of a particular region (Ambroziak, Hartwell, 2018) that otherwise normally faces hindrances in doing so (Barbieri et al., 2019).

The aim of the article is to show the essence of SEZs from the point of view sustainable development in emerging countries, including Poland. The article also highlights the distinct nature of collaboration within clusters within SEZs in Poland. The focus of the article is on identifying the positive facets linked to the operations of SEZs and scrutinizing their influence on a particular region. The paper incorporates instances of specific regions or territories that have reaped benefits from the presence of SEZs, attaining successes in terms of both economic and regional advancement. These presented cases can serve as illustrative case studies showcasing the tangible effects of SEZs in distinct locales. Consequently, the article aims to offer readers insight into the economic advantages stemming from the existence of SEZs and to underscore how these zones contribute to regional development. By dissecting these aspects, the article strives to underscore the importance and potential of SEZs as a tool for bolstering both economic and regional progress. The research hypothesis asserts that SEZs have a positive impact on regional development, particularly concerning the attraction of foreign investments and the reduction of unemployment.

The principal achievement of this paper is in demonstrating how SEZs can function as hubs for the establishment of clusters. The applied research approach involves examining literature and accessible information to explore the economic advantages that emerge from the existence of Special Economic Zones (SEZs).

2. Literature review

After World War II, countries that had previously been under colonial rule experimented with various models of economic growth. Some focused on import substitution, while others adopted a pro-export approach. Particularly, the latter approach was associated with the need to attract foreign capital and advanced technology. SEZs played a role in promoting this, as they facilitated job creation, increased trade, and exports, as well as the attraction of foreign investment. SEZs are defined as small geographical areas that integrate principles of a free market to attract additional foreign investment. They are managed locally and are associated with distinct preferential policies, including customs and administrative procedures (Crane et al., 2018). The created favorable investment environment acts as a magnet in them,

encouraging investment and settlement Chen et al., 2022). Establishing SEZs falls under initiatives characterized as long-lasting, costly, and long-term (Ahmed et al., 2020), yet also profitable. As a tool for fostering economic growth, SEZs are particularly appreciated in the context of the People's Republic of China. Analyzing articles dedicated to SEZs indexed within the Web of Science (WoS) and Scopus databases, it can be observed that texts concerning Chinese SEZs account for nearly half of all articles dedicated to SEZs (242 records out of 520 in the WoS database and 59 out of 120 records in the Scopus database, respectively). China is one of the prime examples of SEZ being seen as a successful venture, as well as an important tool to attract foreign investment and stimulate economic growth (Rodrigues, Steenhagen, 2022).

Economies' needs have evolved over time, including an increasing demand for acquiring foreign technologies. Similarly, the objectives of SEZs have also evolved. SEZs vary in scope, operating principles, and focus on specific areas (such as SME development, foreign trade, economic diversification, regional growth (Naeem et al., 2020)), by their location (along the coastline/in the interior of the country), type of investments (domestic/foreign), etc. (Joshi, Bhatia, 2016). In 1959, there was only one SEZ in Ireland. By 1975, there were already 79 SEZs in operation, and in 2019, there were 5400 existing SEZs with 500 more in the process of being established (Naeem et al., 2020). Establishing SEZs, especially since the early 1990s, along with FDI (Łukaniszyn-Domaszewska et al., 2023), has been a crucial instrument for stimulating the economic growth of emerging economies (Romyen et al., 2019). In the case of the People's Republic of China, the introduction of SEZs enabled the transition from a centrally planned system to a market economy (Crane et al., 2018). SEZs rely on the external context, and alterations in this environment affect the roles these zones serve (Liu et al., 2018). Creating SEZs can stimulate economic expansion both within and beyond the zone (Romyen et al., 2019), including within neighboring counties (Lu, 2022).

Recently, there have been many studies on the impact of SEZs on regional development, including sustainable development (Ambroziak, Dziemianowicz, 2021; Stojčić et al., 2022; Dugiel, 2022; Ma et al., 2022; Arbolino et al., 2022; Dziemianowicz et al., 2019). Nevertheless, despite a massive recent proliferation of SEZs, there is virtually no quantitative research on what drives their dynamism (Frick et al., 2019).

Research conducted by Susanne A. Frick, Andrés Rodríguez-Pose and Michael D. Wong (2019) indicate that the context of the country largely determines the performance of SEZs. Companies are looking for cheap locations, but close to big cities. The proximity of large markets as well as pre-existing industrialization also increase the performance of SEZs. In contrast, incentives and other program-specific variables are highly context-dependent and not structurally correlated with SEZ scores.

Research on SEZ emphasizes that these zones contribute to the creation of regional disparities - economic differences between regions with SEZs and regions without SEZs. China is an example, with a division between the more developed eastern part of the country and the rest of the regions, especially in the western part (Crane et al., 2018). However, SEZs can also be used to reduce these disparities, for example, by strategically locating SEZs related to advanced technologies, thereby shortening the period of economic development gap between less developed and more developed areas (Wang et al., 2022).

The attributes of SEZs also encompass the aspect that they (as outlined by Vats et al., 2018):

- Provide financial incentives to companies and individuals alongside improved regulatory and administrative frameworks.
- Draw in skilled individuals and rapidly expanding businesses.
- Foster independence and establish an appealing environment for both living and conducting business.
- Supply necessary infrastructure and services catering to industrial, commercial, and residential functions.

There are many types of SEZs based on their objectivity and operations. Table 1 provides the types and details of their characteristics.

Table 1.
Types of SEZs

No.	Type of SEZ	Characteristics
1.	Free Trade Zones (FTZ)	FTZs duty-free fenced in designated areas providing storage, and distribution facilities for trade, transshipment, and re-export operations.
2.	Export Processing Zones (EPZ)	EPZs are industrial areas specializing in 1 industry or a combination primarily focusing at foreign markets.
3.	Comprehensive Special Economic Zones (SEZs)	Comprehensive or Multifunction SEZs are large industrial amalgamations having industrial, service and urban-amenity operations.
4.	Industrial Parks (IP)	Industrial Parks are at large manufacturing or R&D based sites that work at a smaller scale as compare to comprehensive SEZs.
5.	Enterprise specific— single factory zones	Provide incentives to individual enterprises regardless of where their location is, and they are not required to be located in any specific geographical location.
6.	Bonded areas	These are secured territories, in which goods stored, manipulated, or can undergo manufacturing operations without payment of duties. The major difference is that a "bonded area" is subject to customs laws and regulations whereas an FTZ is exempted.
7.	High tech zones	These are aimed at promoting R&D activities and advancement in technology or industries based on science, e.g., pharmaceutical.
8.	Eco-industrial zones or parks	These SEZs focus on sustainability concerning waste reduction and improving the environmental performance of companies.

Source: Ahmed et al., 2020.

Another typology considers the division of SEZs into generations from I to V. The first-generation SEZs placed a strong emphasis on FDI and the facilitation of exports. Subsequent second-generation SEZs adopted a more diversified and versatile approach spanning multiple sectors. The evolution into third-generation SEZs highlighted a dual focus on enhancing competitiveness while also prioritizing environmental sustainability. The fourth-generation SEZs were characterized by their incorporation of contemporary services and a business-friendly orientation. In contrast, the fifth-generation SEZs, known as intelligent cities built upon digital technologies, exhibit a heightened commitment to sustainable developmental endeavors (Zeng, 2021a).

Some conducted studies point out that within SEZs, a significant amount of energy resources is consumed and a substantial amount of CO2 is emitted (You et al., 2021). Similarly, in this regard, the academic community seems to be divided, and within SEZs, more environmentally-friendly solutions conducive to sustainable development are also being implemented, including the reduction of CO2 emission (Chen et al., 2022), implementing monitoring and control (Grant et al., 2020), or serving as incubators for green economy (Mohiuddin et al., 2014). For example, Beata Ślusarczyk and Katarzyna Grondys (2018) have noted that in Poland, municipalities belonging to SEZ develop in line with the concept of sustainable development (compared to municipalities outside of SEZ) in areas such as:

- Economic aspects: higher levels of entrepreneurship and lower unemployment.
- Social aspects: higher population density and population in the working age group, lower internal migration.
- Environmental aspects: higher share of green areas, lower levels of PM2.5 and PM10 emissions (compared to the most polluted cities).

In addition to aspects related to sustainable development, SEZs are also associated with industrial enclaves, within which the creation of innovative solutions (patents obtained) is intensified, and their individual zones serve as nodes of knowledge connections (Li et al., 2022).

3. Research methodology

An analysis process of the economic benefits arising from the presence of SEZs is presented below (Figure 1). It is related to the hypothesis that SEZs have a positive impact on regional development. It particularly concerns the attraction of foreign investments and the reduction of unemployment.

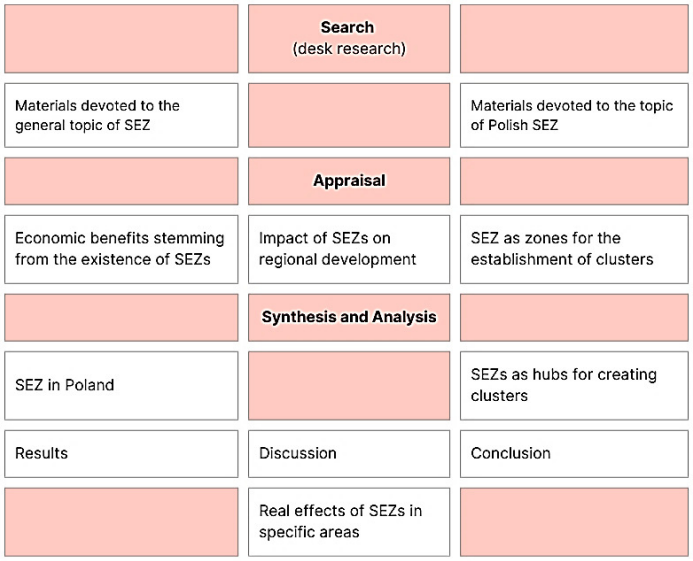


Figure 1. Analysis process.

Source: own preparation.

4. Results

4.1. SEZs in Poland

A special economic zone is a separate, uninhabited part of the country's territory where business activity may be conducted under preferential conditions defined in the Act on SEZs of 20 October 1994 (Journal of Laws of 2007, no. 42, item 274; Journal of Laws of 2008, no. 118, item 746). SEZs were created, in particular, to:

- accelerate the economic development of regions,
- manage post-industrial property and infrastructure,
- create new jobs,
- attract foreign investors to Poland.

The idea of SEZs as separate areas of a country's territory where the law defined better conditions for economic activity originated in Roman times (with the beginnings of free ports), and was further developed in the Middle Ages (Hanseatic League). The duty-free zone in Puerto Rico, established in 1951, is considered to be the first economic zone in today's understanding of the term (Żaguń et al., 2009).

SEZs in Poland were established explicitly to enhance regional development, crafting a series of investment incentives designed to boost investment attractiveness in particular regions (Ambroziak, Hartwell, 2018). The analysis conducted by Adam A. Ambroziak and Christopher A. Hartwell showed that SEZs have had a strongly positive impact upon the

development of the least-developed regions in Poland, while in relatively richer ones the effect was weak or even negative.

Generally, SEZs in Poland have been designed as an instrument used to support local and regional labour markets in areas particularly shackled with problems inflicted by economic transformation (Dziemianowicz et al., 2000; Peszat, Szlachta, 2017). With regards to this, Polish SEZs are not very different from many other economic zones around the world (Park, 1997; Yeung et al., 2013; Zeng, 2015; Moberg, 2015; Farole, 2011; Leong, 2013; Wang, 2013).

The first SEZ in Poland was established in Mielec in 1995 and since then their number has grown rapidly. Poland's newest economic zone is the Kraków SEZ, which opened in 1998. All Poland's existing SEZs were established in the 1990s. Initially, the Council of Ministers created 17 zones but in practice only 15 were launched, and 14 still function today.

The idea of SEZ in Poland was hotly debated by the Polish government and the European Commission because of the financial support offered to business investors in SEZ. At that time, the main problem consisted of adjusting the tax incentives offered to investors in SEZs to regional investment state aid rules (Ambroziak, 2009; 2014).

Poland has emerged as a significant attraction for investors, both domestically and internationally, primarily due to the incentives and special economic zone (SEZ) benefits it provides to investors. In the years 2006 and 2007, approximately PLN 10 billion per year was invested in Poland's SEZs, resulting in notable growth. In 2007 alone, employment within these zones increased by 25%, creating 36,000 new jobs. Informal data for the first half of 2008 indicated record-breaking investments, totaling around PLN 7 billion. As a result, this period marked a peak performance for many of these zones. It is estimated that the cumulative investment across all 14 SEZs reached about PLN 50 billion in 2008 (Żaguń et al., 2009).

Nonetheless, SEZs go beyond mere financial investments and job creation – they also play a pivotal role in enhancing the overall competitiveness of the nation's economy. This includes technology and know-how transfer, as well as fostering collaboration in regions covered by the zones.

The effects of SEZs in Poland have been extensively studied, with various attempts to evaluate their impact on different aspects. These include: a) the relationship between SEZs and local authorities (explored by Dziemianowicz in 2016), b) the influence of zones on socio-economic growth, encompassing increased investments and job creation (studied by Ernst & Young in 2011, Jensen in 2018), c) the broader regional development (analyzed by Laskowski in 2013, Ambroziak & Hartwell in 2018), d) external trade (investigated by Nazarczuk & Umiński in 2019), e) the inflow of foreign direct investment (examined by Dziemianowicz et al. in 2019), and f) labor market-related aspects (explored by Kryńska in 2000). These conclusions regarding the impact of SEZs on unemployment are clear-cut, as they stem from analyses that encompass zone operations across all regions of the country at various levels of regional classification.

Basically, SEZs in Poland are designated areas where economic activities occur under special preferential conditions. One defining characteristic of SEZs is their territoriality, which means that the benefits are confined to specific geographic areas within the country. However, it is noteworthy that entrepreneurs have the option to request an "extension of SEZ", enabling the establishment of a zone within an existing enterprise.

A pivotal incentive offered as public support to investors locating their projects within SEZs is the exemption from income tax. Public support takes the form of reimbursing costs related to a new investment project. Consequently, the investment expenditure (or the expense associated with newly hired employees) pertaining to such a project serves as the basis for calculating the extent of tax relief granted to the entrepreneur.

However, in practical terms, simply undertaking an investment project is not enough to qualify for income tax relief. The zone entity must also generate taxable income at an appropriate level to be eligible for this incentive. Consequently, this feature makes the instrument highly susceptible to economic fluctuations and decreases in project profitability. As a result, it genuinely operates as an investment incentive under specific market conditions.

SEZs can function as tools to stimulate investments. Despite the aforementioned limitation of tax relief as an investment incentive, SEZs have significantly contributed to Poland's economic growth over the last two decades and have attracted numerous investments. This success can be attributed to various factors, including those that are sometimes overshadowed by the focus on tax benefits. Some of these often underestimated benefits include:

- Improved infrastructure (SEZs were typically established in highly industrialized regions, often reusing infrastructure from declining traditional industries); these zones also encompassed strategically advantageous investment areas.
- Access to a skilled workforce (particularly in regions with a strong industrial heritage).
- Streamlined procedures (a business-friendly approach from the outset, with Zone Management playing a significant role in fostering collaboration with local government entities).
- Investment promotion efforts - investors frequently begin their search for plots within these designated zones.

Currently, there are 14 SEZs in Poland. Each SEZ comprises several to several dozen subzones located throughout Poland. The infrastructure of areas belonging to the SEZ is well-developed, making them highly attractive for both Polish and foreign investors. Since their inception, SEZ have attracted investments worth nearly 112 billion Polish zlotys, and companies operating within the SEZ have created 312,000 jobs. According to the current regulations, SEZs will operate until December 31, 2026 (Deloitte, n.d.).

Table 2 presents Polish SEZs under the jurisdiction of the minister responsible for economic affairs (Ministerstwo Rozwoju i Technologii, n.d.).

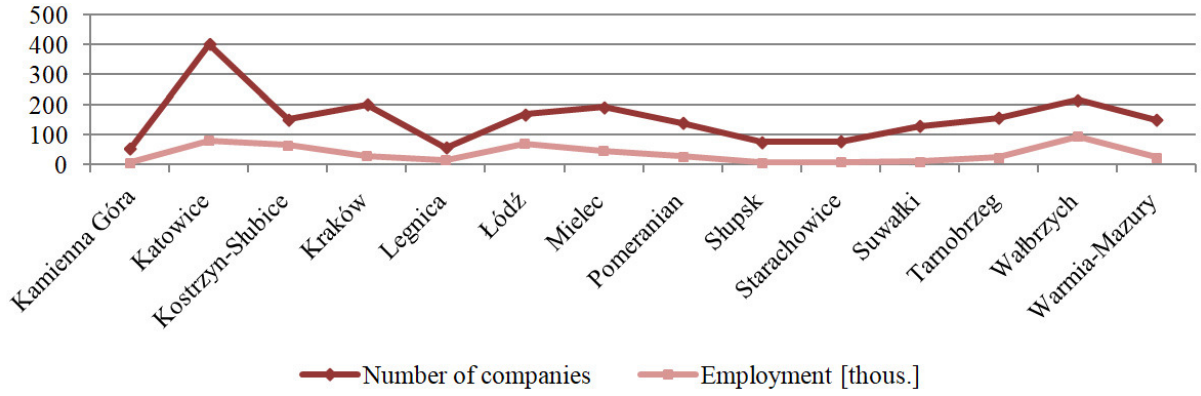
Table 2.
Area and location of Polish SEZs

No.	SEZ	Voivodeship	Area in hectares
1.	The Kamienna Góra Special Economic Zone	Lower Silesian Greater Poland	373,83
2.	The Katowice Special Economic Zone	Silesian Lesser Poland Opole	2347,34
3,	The Kostrzyn-Słubice Special Economic Zone	Lubusz West Pomeranian Greater Poland	1868,05
4.	The Kraków Special Economic Zone	Lesser Poland Subcarpathian	707,78
5.	The Legnica Special Economic Zone	Lower Silesian	1763,77
6.	The Łódź Special Economic Zone	Łódź Greater Poland Masovian	1339,17
7.	The Special Economic Zone Euro-Park Mielec	Pomeranian Kuyavian-Pomeranian West Pomeranian Greater Poland	2039,99
8.	The Pomeranian Special Economic Zone	Pomeranian West Pomeranian Greater Poland	899,37
9.	The Słupsk Special Economic Zone	Subcarpathian Lesser Poland Lublin West Pomeranian	1495,65
10.	The Starachowice Special Economic Zone	Świętokrzyskie Masovian Opole Łódź Lublin	644,46
11.	The Suwałki Special Economic Zone	Podlaskie Warmian-Masurian Masovian	635,07
12.	The Tarnobrzeg Special Economic Zone	Subcarpathian Masovian Świętokrzyskie Lublin Lower Silesian	1743,30
13.	The Wałbrzych Special Economic Zone	Lower Silesian Opole Greater Poland Lubusz	2921,70
14.	The Warmia-Mazury Special Economic Zone	Warmian-Masurian Masovian	1057,38

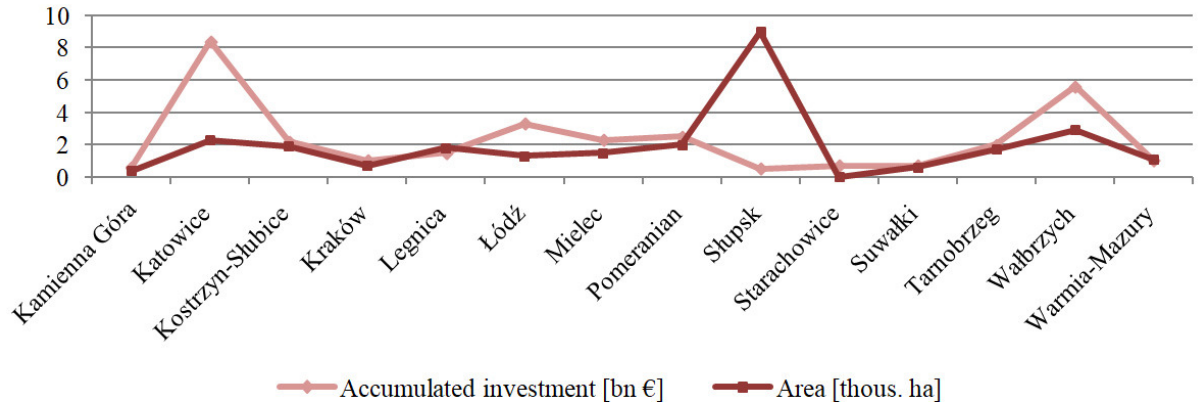
Source: Own elaboration based on: Ministerstwo Rozwoju i Technologii, n.d.

Their main characteristics are illustrated in Figure 2a-b, displaying the quantities of active companies, their workforce, invested capital, and developed territories. The graphical representation also portrays the economic advantages stemming from the existence of SEZs in Poland.

The SEZ located in Katowice stands out as the largest among Polish SEZs in terms of active company count, housing a total of 400 firms. On the contrary, the smallest in this regard are Kamienna Góra SEZ, encompassing 53 companies, and Legnica SEZ, housing 57 companies. On average, Polish SEZs accommodate approximately 154 enterprises. Employment within these SEZs varies from 7,000 individuals (as seen in Słubsk SEZ) to 95,000 individuals (exemplified by Wałbrzych SEZ). The most substantial cumulative investments are associated with Katowice SEZ, amounting to €8.4 billion, while the lowest investments are observed in Słubsk SEZ, Kamienna Góra SEZ, Starachowice SEZ, and Suwałki SEZ, all at €0.7 billion each. The territorial expanse of Polish SEZs ranges from 0.4 thousand hectares (as seen in Kamienna Góra SEZ) to 2.9 thousand hectares (exemplified by Wałbrzych SEZ) (ESPON, 2020; Tax benefits from business activities within the Special Economic Zone, n.d.).



a)



b)

Figure 2. The main characteristics of Polish SEZ.

Source: ESPON, 2020; Tax benefits from business activities within the Special Economic Zone, n.d.

On the other hand, the research presented in the report: Ernst & Young 2011, SEZs after 2020, Ernst & Young demonstrates the impact of SEZs on various aspects of economic growth, including the labor market, investments, and GDP. Below are the main conclusions that can be formulated based on the conducted analysis (Table 3).

Table 3.
The impact of operating SEZs in Poland on the economic outcomes of subregions and counties in years 2002-2010

Element of economic growth	Conclusions
Labor Market	In areas where SEZs are operational, there is an average decrease in the unemployment rate ranging from 1.5 to 2.8 percentage points for subregions and from 2.3 to 2.9 percentage points for counties. Increasing the investment capital within the zone by PLN 100 million leads to a reduction in the subregion's unemployment rate by 0.17 to 0.33 percentage points, and in the county, this reduction ranges from 0.19 to 0.25 percentage points. The expansion of employment by 1,000 positions within the zones corresponds to a decrease in the subregion's unemployment rate by 0.4 to 0.9 percentage points, while at the county level, this decrease falls within the range of 0.7 to 1.0 percentage points.
Investments	Within the subregions hosting SEZs, the gross investment in fixed assets per capita is elevated by approximately PLN 250 to 600, and in counties, this increase ranges from about PLN 510 to 570, when compared to other relevant subregions and counties. The addition of 1,000 jobs within these zones contributes to a rise in the gross investment in fixed assets per capita by around PLN 90 to 105 in subregions and approximately PLN 150 to 160 in counties.
Gross Domestic Product (GDP)	In the subregions hosting SEZs, the GDP per capita is typically elevated by approximately PLN 1,300 to 2,500 compared to other subregions. This indicates a higher GDP per capita ratio, ranging from about 3.9% to 7.5% above the average GDP per capita for Poland when compared to other subregions. The addition of 1,000 jobs within these zones results in an augmented GDP per capita within the corresponding subregion, increasing by roughly PLN 310 to 460.

Source: Ernst & Young, 2011.

Taking into account the analysis of the literature, as well as available research on this subject it can be stated that the economic benefits of SEZs are multifaceted and can have a significant impact on both the local and national economy. The table 4 presents some of the key economic benefits of Polish SEZs include.

It's important to note that the economic benefits of SEZs can be influenced by various factors, including the effectiveness of policies, infrastructure development, local conditions, and global market trends. Therefore, careful planning, monitoring, and adaptability are crucial to maximizing the positive economic impact of SEZs.

Table 4.
Economic benefits stemming from Polish SEZs

Economic benefit	Characteristics
Increased Foreign Direct Investment (FDI)	SEZs often attract higher levels of foreign direct investment due to the favorable business environment, tax incentives, streamlined regulations, and infrastructure support. This influx of investment can contribute to economic growth and job creation
Export Growth	SEZs are designed to promote export-oriented industries. By offering incentives and facilitating access to global markets, SEZs can boost a country's exports, generating foreign exchange earnings and improving the balance of trade.
Job Creation	The establishment of SEZs leads to the creation of new jobs in various sectors, including manufacturing, services, and logistics. This helps alleviate unemployment and improve the standard of living in the region.
Industrial Development	SEZs foster industrialization by providing modern infrastructure, utilities, and logistical support. They attract a diverse range of industries, leading to the growth of industrial clusters and supply chains.

Cont. table 4.

Technological Advancement	SEZs often encourage the transfer of technology and expertise, as they attract multinational corporations and promote collaboration between local and foreign businesses. This can lead to technological innovation and upgrades in local industries.
Skill Enhancement	The presence of SEZs can stimulate skill development and human capital formation through training programs and education initiatives. This enhances the employability of the local workforce and contributes to long-term economic growth.
Increased Tax Revenue	While SEZs offer tax incentives to businesses, the increased economic activity can still lead to higher tax revenues for governments, which can be reinvested in public infrastructure and services.
Stimulated Ancillary Businesses	SEZs can stimulate the growth of ancillary businesses that provide services and support to the companies within the zone, such as transportation, warehousing, and utilities.
Reduced Regional Disparities	By promoting economic activity in specific regions, SEZs can help reduce regional disparities and promote balanced development across the country.
Attracting Global Companies	SEZs create a conducive environment for global companies to establish their presence. This not only brings in investment but also enhances the reputation of the country as a favorable destination for business.

Source: Own elaboration.

4.2. SEZs as hubs for creating clusters

The clustering of industries and enterprises within SEZs has the potential to induce a phenomenon known as the cluster effect, attracting interconnected industries and suppliers to the vicinity. This occurrence can result in heightened cooperation, the exchange of knowledge, and the realization of economies of scale. Building upon the classical definition of a cluster as provided by M.E. Porter (1998; 2000), it is assumed that a cluster is viewed as a spatial concentration of firms, which may not necessarily have a formalized character, and whose members may not be aware that they operate within cluster boundaries - in literature, this type of activity is referred to as a natural cluster. Only a conscious, organized effort aimed at improving the cluster's competitiveness and the deliberate participation of key players can be referred to as a cluster initiative. This type of cluster is more crucial for regional development and SEZs, as it creates an organized network of diverse entities that have a more formalized character (Furman et al., 2002; Morgulis-Yakushev, 2017; Mackiewicz, 2019). Cluster initiatives can therefore be defined as "organized regional sectoral networks among business partners focused on improving innovative performance and international competitiveness". Key representatives of the given cluster are involved in the initiative, and they intend to influence its development in a more conscious and systematic manner. Typically, these representatives come from economic, scientific, and business sectors (Figure 3).

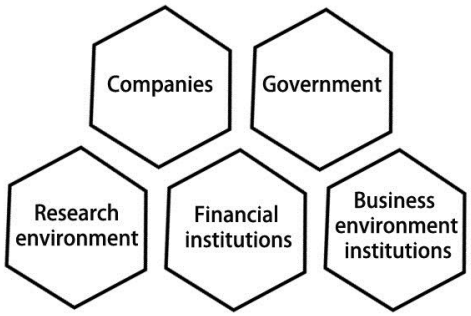


Figure 3. Five types of entities constituting clusters.

Source: Sölvell et al., 2003-2006, p. 25.

Cluster initiatives are often financed by their participants as well as from public funds within cluster development support programs (Baron, 2009). The cluster encompasses (Sölvell, 2008):

- different members, both companies and organizations (representatives: private, public, and higher education institutions),
- cluster organization with a headquarters, manager, website, etc.,
- initiative board (supervisory body),
- initiative funding (from sources: international, national, regional, local, membership fees, etc.).

The Green Book of Cluster Initiatives (Sölvell et al., 2003-2006, pp. 21-24) emphasizes that a cluster initiative refers to a specific project or type of organization with a cluster character. Cluster initiatives include, among others: Autocluster Styria (Austria), Scottish forest industry cluster (Scotland), Plastic Valley (Poland), Valley of the Rising Sun (Lithuania). See: (Sölvell et al., 2003-2006, pp. 19, 110, 119). Also in the publications of Polish researchers, cluster initiatives include the following cluster organizations: Telecom City (Blekinge, Sweden), Silesian Timber Cluster, Medycyna Polska, Wielkopolskie Horses and Carriages, Gdańsk Construction Cluster (Poland) (Brodzicki et al., 2008).

Within the area of a given cluster's occurrence, one or several cluster initiatives in a specific industry can be established. By engaging in activities by entities surrounding the business, clusters can contribute to fostering entrepreneurship, activating the population, attracting external investors, and even result in positioning companies in the given area, which will lead to the development of local organizations and the activation of entrepreneurial activities among various entities (see Figure 1). There is a substantial body of literature focused on assessing such cluster initiatives (Klemens, 2010).

It is estimated that cluster initiatives are an effective tool for concentrating resources and funds, as well as facilitating knowledge and know-how transfer, enhancing innovation, and so forth (Lundequist, Power, 2002; Lundmark, Pettersson, 2012; Pavelkova et al., 2021; Yan et al., 2021). The perspective of potential benefits stemming from cluster initiatives for businesses and regions thus encourages governmental authorities and other partners to implement a policy promoting clusters through three important actions:

- Increasing productivity (through collaborative efforts, access to information and public goods).
- Enhancing innovation (through joint research).
- Creating new businesses (by filling niches and expanding cluster boundaries).

Moreover, Li and Wang (2019) demonstrate that cluster development attracts various research-oriented organizations, thus creating an incubation platform for other entities. According to Wennberg and Lindqvist (2010) companies located in strong clusters create more jobs, generate higher tax revenues, and offer higher wages for employees. Similar conclusions were drawn in the publications by Ketels and Protsiv (2021), who examined the impact of clusters on industry wage levels and regional prosperity. Likewise, Alberti and Belfanti (2021) demonstrated that clusters generate shared value and contribute to creating economic and social opportunities. Thus, they are an ideal solution for fostering sustainable development of all entities within SEZs, where clusters and cluster initiatives influence the behaviors of interconnected entities and the knowledge-sharing process (Canet-Giner et al., 2022). Initiatives built in this manner are often the result of actions taken by public or local government authorities (Brodzki, 2004). It involves governments of countries or local authorities determining themselves which industries in a given area have the greatest potential for development and, as a result, should be supported in the first place. This initiative is carried out based on a local development strategy, thereby providing local authorities with the appropriate tools to effectively encourage action and support business-related institutions and organizations, and through them, companies clustered around them, to create conditions for effective operations within the SEZ area.

In fact, clusters can be found within SEZs, as businesses operating within an SEZ may naturally cluster together to benefit from shared resources and specialized skills. SEZs can foster the growth of clusters by providing the necessary infrastructure, regulatory framework, and incentives that encourage companies to collocate within the zone. Clusters and SEZs can reinforce each other, with SEZs attracting a variety of industries that might naturally form clusters based on proximity and industry relationships.

In summary, while clusters and SEZs have distinct purposes and mechanisms, they can intersect and mutually reinforce each other in certain cases. Clusters promote industry collaboration and specialization, while SEZs provide a policy-driven environment to attract investment and foster economic growth.

5. Discussion – SEZs in regional development

SEZs can have a significant impact on regional development. They are designed to attract investments, stimulate economic growth, create jobs, and enhance the overall competitiveness of a region. The analysis of economic benefits arising from the existence of SEZs in Polish regions has demonstrated that SEZs have had a positive impact on the labor market, investments, and GDP. Similar conclusions are drawn by the report from the World Bank, companies operating within SEZs tend to exhibit superior performance compared to firms not located in SEZs (World Bank, 2017). Additionally, provinces with SEZs have the potential to attract more Foreign Direct Investment (FDI) than provinces without SEZs (Chuop, 2022). Table 5 presents the main effects of the impact of SEZs on regional development.

Table 5.
Effects of the impact of SEZs on regional development

Effect	Description
Investment Attraction	SEZs offer various incentives such as tax breaks, reduced regulations, and infrastructure support to attract domestic and foreign investments. This influx of capital can lead to the establishment of new businesses and industries in the region.
Job Creation	The establishment of businesses within SEZs creates employment opportunities for the local population. As industries grow and expand, more jobs are generated, reducing unemployment rates and improving the economic well-being of the region.
Technology Transfer and Innovation	SEZs often attract technologically advanced industries. The presence of these industries can facilitate the transfer of advanced technologies, knowledge, and skills to the local workforce, promoting innovation and increasing the region's technological capabilities.
Infrastructure Development	SEZs often require the development of infrastructure, including roads, utilities, and transportation systems, to support the businesses operating within them. This infrastructure development can benefit the entire region and improve connectivity.
Export Promotion	Many SEZs focus on export-oriented industries. This can lead to an increase in exports from the region, contributing to a favorable balance of trade and boosting the overall economic growth.
Cluster Effect	The concentration of industries and businesses within SEZs can create a cluster effect, where related industries and suppliers are drawn to the area. This can lead to increased collaboration, knowledge sharing, and economies of scale.
Spillover Effects	The positive developments within SEZs can spill over to neighboring areas, contributing to the overall economic development of the region. Local businesses can benefit from increased demand for goods and services generated by SEZ activities.
Human Capital Development	SEZs often require a skilled workforce. This can encourage investments in education and training programs, enhancing the skills of the local workforce and improving overall human capital in the region.
Regional Competitiveness	By attracting investments and fostering economic growth, SEZs can enhance the competitiveness of the region on both national and international levels.

Source: Own elaboration.

Nonetheless, other studies indicate that the impact of SEZs on development can be diverse. It is important to note that the impact of SEZs on regional development can vary depending on factors such as:

- Zone location including country- and regional-specific business environment and investment climate (Dorożyński et al., 2021), particularly related to the required capital (FIAS, 2008);

- The size of the zone (the most effective are among others large SEZs located in poor areas and not too far from urban centres (World Bank, 2017));
- The distance of the area from the zone (the most effective radius is up to 50 km (World Bank, 2017));
- Zone type (Wang et al., 2022);
- Industry presences (Frick, 2023), and its type that attracted;
- The level of local infrastructure and HR availability (Frick, 2023);
- Promotional activity (among others tax allowances, which attract investments and equity of companies managing the zone, which generates jobs (Dorożyński et al., 2021)). However, it's important to highlight that the mentioned World Bank report underscores that promotional efforts (such as incentive packages) have been depicted as exerting only a restricted influence on the effectiveness of these zones. The findings from Naeem et al. (Naeem, 2020) indicate, among others that the promotion should be based on competitiveness rather than fiscal incentives. This group also includes the creation of shopping malls, townships, and amusement parks within the zones that attract people and contribute to the economic development of that region (Joshi, Bhatia, 2016);
- The effectiveness and quality of governance and administration within the SEZs (Zeng, 2021b), including competition between the companies managing the zones (Dorożyński et al., 2021), as well as elaboration of the clear vision of the zone development (Naeem et al., 2020).

It's worth highlighting that the conducted analysis did not reveal any negative effects associated with SEZs, as indicated by other studies. Potential negative effects such as land displacement (Kabita Kumari Sahu, 2013; Physicians for Human Rights, 2014), environmental concerns (Aung et al., 2022; Ahmed et al., 2020), and unequal distribution of benefits (Hornok et al., 2023; Crane et al., 2018) should also be carefully considered and addressed to ensure balanced and sustainable regional development.

The primary accomplishment of this study lies in illustrating the role of SEZs as central points for the development and organization of clusters.

Nevertheless, the study encompasses certain limitations and weaknesses, specifically centered around restricted applicability. Conclusions drawn from a singular study might not hold relevance for diverse situations, groups, or environments due to disparities in demographics, culture, or economic circumstances. Furthermore, there exists a limitation related to data. The study relies on a limited dataset or outdated information, the results may not accurately reflect the current state of affairs. Inaccurate or incomplete data can weaken the study's validity. A research limitation is also the fact that the authors assumed only positive effects associated with the existence of SEZs, whereas other studies indicate that SEZs may also entail potential negative effects.

The conducted analysis confirms that SEZs have a positive impact on the labor market, influx of both domestic and foreign investments, as well as on the GDP. Nevertheless, it would be worthwhile in future research to compare various regions that have SEZs with those that do not, and examine economic indicators. A direction for future research should also involve analyzing potential negative effects associated with SEZs that were not demonstrated in this study, yet are acknowledged by the authors' knowledge. In future research, it is worth using the perspective of cluster types (shown in Table 1 or within generations I-V) for the presentation of Polish SEZs, as well as examining their impact on regional development.

6. Conclusion

The analysis confirmed the research hypothesis that SEZs have a positive impact on regional development, especially in terms of attracting investments and on the job market, including the reduction of unemployment. The analysis conducted in the paper indicates that SEZs can play a significant role in fostering economic growth and attracting investments in specific regions. SEZs create favorable conditions for businesses by providing various incentives such as tax breaks, infrastructure support, and streamlined regulatory processes. As a result, they often lead to increased industrialization, job creation, and improved infrastructure in the designated areas.

SEZs can attract both domestic and foreign investors, driving innovation and technological advancement. By concentrating businesses in a specific geographic area, SEZs promote collaboration, knowledge sharing, and the development of specialized supply chains. These clusters of related industries can lead to increased productivity, economies of scale, and enhanced competitiveness on a global scale.

However, the impact of SEZs can vary depending on factors such as the location, governance, and policies implemented within each zone. Additionally, there might be concerns related to environmental sustainability, social inequalities, and potential negative effects on the local community.

Clusters can indeed exist within SEZs, as companies operating within an SEZ may naturally come together to leverage shared resources and specialized expertise. Clusters are organic and often emerge naturally based on industry dynamics, shared resources, and collaborative relationships among stakeholders. Clusters promote collaboration, knowledge sharing, innovation, and specialization within a specific industry or related industries. Companies within a cluster collaborate to improve their competitive advantage, share best practices, access shared resources, and engage in joint research and development activities. Clusters encourage knowledge spillovers, promote innovation, attract talent, enhance productivity, and foster a supportive ecosystem for business growth.

SEZs have the potential to cultivate cluster development by offering the essential infrastructure, regulatory framework, and incentives that encourage businesses to co-locate within the designated area. The symbiotic relationship between clusters and SEZs can be observed, with SEZs drawing in diverse industries that could organically form clusters based on their geographic proximity and industry connections. Although clusters and SEZs serve distinct purposes and utilize different mechanisms, there are instances where they intersect and mutually bolster each other. Clusters facilitate collaboration and specialization within industries, whereas SEZs establish a policy-oriented environment aimed at attracting investments and nurturing economic growth.

In conclusion, while SEZs can bring about positive economic and developmental changes in regions, careful planning, monitoring, and adaptive policies are essential to ensure their long-term success and positive impact on regional growth. As a direction for future research, it is advisable to indicate the analysis of regions hosting SEZs in comparison to those without them. A forthcoming research could also encompass an analysis of potential adverse outcomes linked to SEZs, which were not elucidated in this study but are recognized by the authors. Subsequent research could also consider adopting the framework of cluster categorizations (as presented in Table 1 or within generations I-V) to portray Polish SEZs, alongside an assessment of their influence on regional progress.

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THEORETICAL FOUNDATIONS OF ENTERPRISE VALUE MANAGEMENT

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Purpose: The article aims to analyse the theoretical foundations of value management in both large enterprises and small and medium-sized businesses.
Design/methodology/approach: The achievement of the objective involved the critical review of both national and international literature as the primary research method.
Originality/value: Financial management, in theory and practice of a developed market economy is characterized by high dynamics, high level of evolution of the subject, scope and determinants of decisions made. At the same time, the basic goal of all enterprises is effective financial management as a determinant of the success or failure of an economic unit. When analyzing the financial management process, first of all, it is necessary to define the main goals, functions and management instruments, and then compare the company's goals with the goals of financial management.
In the literature on the subject and in practice, you can meet many goals of the company's activity, i.e. maximizing profit, maximizing sales, achieving a satisfactory level of profit, survival of the company, but all these categories are directly or indirectly related to the profitability. However, the qualification of profit maximization as the superior goal of the enterprise raises a lot of controversy. On the other hand, profit maximization should not be treated as the goal of the company's activity, as it focuses on current effects, ignoring such an important issue as the structure of revenues over time. This gap is filled by maximizing the value of the owners' wealth.
Undoubtedly, the main goal of the company is to maximize the financial benefits of the owners. Therefore, the question arises if this issue can be treated as the primary goal in the group of small and medium-sized enterprises.
Each unit that conducts business activity must have at its disposal adequate capital which is the basis for the initiation and development of the company's activity. This capital can be obtained in many ways, but a significant part has to be contributed by co-owners. Of course, there are many groups of co-owners ranging from shareholders to sole proprietorship. Each shareholder expects to achieve specific benefits. Thus, he wants to be entitled to a share in the company's profits. The investment will be made in such a unit that will allow to obtain the greatest benefits, and therefore obtain the highest rate of return.

Keywords: value of enterprise, shareholder value, EBITDA, Invest capital.

1. Introduction

A comprehensive enterprise value management system integrates all key areas of economic entity management. These areas relate to valuation, capital budgeting, periodic performance measurement, remuneration based motivation, and internal and external communication, with the fundamental link between these areas being the concept of enterprise value and the common denominator tool being the periodic performance measure, the primary task of which is to promote decisions aimed at maximising shareholder value. However, the scope to which an enterprise value management system is used is often insignificant and tends to be limited to when an enterprise's financial performance is calculated with the help of a given measure and then valued in the market. At the turn of the twenty-first century management by value was the prevailing concept in corporate finance. Such management focused on maximizing a company's value and, as a consequence, its value for stakeholders including, in particular, business owners. The overriding aim of business - generating the highest possible profits i.e. maximizing the financial result - was replaced by maximizing of a company's value. The reason behind that change of perspective was the fact that healthy financial performance was not necessarily translated into maximized shareholder value, therefore a better measure of a company's performance was sought after. The accounting model based on historical cost was not sufficient to meet that objective. What was needed was the type of valuation which could reflect the present value of an entity's assets. The search led to the development of a fair value concept, which was to become the best measure of value. Fair value has been used in the Polish balance-sheet law since 2002. However, it continues to be controversial. The critics of that approach claim that fair value based valuation provides another argument for the uselessness of valuation in volatile market conditions, instead of showing a clear view of business reality.

Modern enterprise value management methods aim to respond effectively to dynamically changing markets, generate competitive advantage and, as a result, increase the chances of success. Value enterprise management methods include:

1. Benchmarking this method involves comparing an enterprise's own solutions with those of other entities. The information obtained is used to improve the functioning of the enterprise, increase revenue and improve customer service.
2. Controlling – this model involves the determination of the measures and criteria by which individual processes are evaluated.
3. ERP – Enterprise Resource Planning – specialist and complex software, the purpose of which is to support business processes conducted within a particular enterprise.
4. Process management – this method aims to respond to dynamic changes both inside and outside an organization.
5. CRM Customer Relationship Management – a model based on building relationships with customers.

6. Competence-based management – a method involving the use of employee knowledge and experience.
7. Outsourcing – delegating tasks to external entities.
8. Lean Management –a management method involving the optimisation of processes by reducing the time spent on non-value-added tasks.

Value remains of interest to many sciences, primarily economics, but also psychology, sociology, philosophy, and ethics. The concept of value in economics has evolved with the development of the economy. In antiquity, Socrates equalled value with the good – "the true good is virtue". In the Middle Ages, St Thomas Aquinas engaged in considerations on fair exchange, which should be based on an exchange of equal value, "value is clearly linked to labour, its quantitative and qualitative expression" (Hostyński, 2006). In the 17th century, William Petty attempted to define the essence of value – "the father of wealth is labour and its mother is land". In the 18th century, Adam Smith distinguished between value in use and value in exchange. "The articulation of value has the double significance of the good's utility or the ratio at which a good exchanges for another" (Landreth, Colander, 1998). In the 19th century, Karl Marx further developed the definition of value in use and value in exchange of a good and introduced the concept of social labour – abstract labour as a source of value in exchange (Stankiewicz, 2000). Michael Porter's defined value as "the amount that buyers are willing to pay for a product offered to them by a company". This approach, however, was applicable in a competitive environment where there is no dominance of a particular supplier or significant shortages in the market (Porter, 1985).

In the 20th century, research on value creation focused on three areas (Maćkowiak, 2013):

1. value for managers,
2. value for owners,
3. value for stakeholders.

Research on value was conducted within two strands:

1. customer value,
2. shareholder value.

The concept of customer value was formulated in 1964 by Peter Drucker in his work "The Practice of Management". Shareholder value, on the other hand, originated in the 1950s and developed through the application of the CAMP model linking return on investment to the level of risk. Alfred Rappaport, pointing out that "profit is an opinion, cash is a fact", was the first to criticise accounting profit as a measure of an enterprise's performance and its value (Rappaport, 1999).

The late 20th century brought significant changes in management styles, objectives and priorities of business. As a result, enterprise value maximisation, understood as increasing the value of invested capital, became a priority. Contemporary enterprise theory posits that the primary goal of all decisions taken in an enterprise is to maximise its market value (Fisher, 1995).

The 2007-2009 economic crisis triggered further evolution in the concept of value and initiated a process of moving away from maximising value for shareholders to increasing value for stakeholders. However, it is important to note that if stakeholder value is maximised, shareholder value also increases in most cases.

The analysis of how enterprises approach the issues of value should take into account the problem of value creation itself. Value creation can be achieved through (Dyduch, 2022):

1. developing the creative strategy that embraces innovation,
2. focusing on strategic leadership,
3. communicating challenging strategic issues throughout the organisation,
4. creating highly diverse teams,
5. providing organisational members with access to creative methods and experiences,
6. designing and building systems that nurture innovation,
7. investing in ideas that do not at first seem to be a strategic fit by spanning boundaries and breaking down barriers for innovation.

Literature studies and the enquiries into the nature of enterprise value management reveal that this issue tends to be researched in the context of large enterprises that have the adequate facilities and organisational units able to implement a system aimed at increasing value. Literature does not address the problem of value management in the group of micro, small and medium-sized enterprises. In this group, two basic issues should be noted: the objective of conducting economic activity and the scale and structure of the organisational framework.

2. Value measurement in accounting theory

Accounting is frequently equated with valuation and measurement, as evidenced by its definition as the skill of measuring, describing and interpreting activity, or as the theory and system of measuring economic value increased in the process of management, or, finally, economic measurement and the system of this measurement in economic entities. The prime goal of accounting is to assess economic and financial performance. Accounting is also seen as a retrospective and prospective information and control system (Zieniuk, 2018; Meigs, Meigs, 1986; Dobija, 1997; Burzym, 1993; Micherda, 2006; Brzezin, 1998). Thus, on the one hand, the primary function of modern accounting is to address the information needs of financial statement recipients, while performance measurement remains of lesser importance. On the other hand, however, it is emphasised that measurement is the essence of accounting, whereas the recipients' perception of information comes secondary (Micherda, 2001; Zieniuk, 2018). In accounting terms, the analysis of enterprise value should be started with the four approaches to its definition:

- book value,
- replacement value,
- liquidation value,
- enterprise multiple derivative.

The financial statement, or more precisely the balance sheet, presents the measurement of assets and liabilities. The analysis of an enterprise's equity allows for the determination of the net asset value. Net assets are defined as total assets less debt capital. The valuation of the balance sheet items is carried out pursuant to the regulations stipulated in the Accounting Act. The legal norms make valuation comparable between companies. Naturally, the book value often differs from the market value of an enterprise. The major factors responsible for this are inflation, the physical and moral wear-and-tear of tangible and intangible assets, organisational capital, and exchange rate differences. This discrepancy means that the book value stemming from the balance sheet valuation of assets and liabilities should not be used to assess enterprise value.

Replacement value is the value of the investment that would have to be made in order to recreate an enterprise, the so-called replacement value. Assuming that an investor willing to pay a certain price for an enterprise expects the investment to be economically profitable. The use of replacement value, i.e. what an investor would have to pay to recreate the enterprise, seems abstract. As a result, similarly to book value, it does not meet the expectations.

Liquidation value corresponds to the revenue generated by the liquidation of an enterprise. For an investor, such value would be important in the case of the liquidation of an enterprise, whereas it is not useful for the valuation of the business.

Value as an enterprise multiple derivative involves the assessment of the value of an enterprise using a multiple of the profits it generates. The weakness of this method arises when the enterprise does not generate a profit and suffers a financial loss.

The valuation methods in accounting discussed above are related to the foundation of accounting, which is the true and fair view concept, identifying the need to reflect reality faithfully and truthfully through a fair and clear presentation of an enterprise's capital and financial position and its performance in the financial statements. However, globalisation, the rate of economic growth in the world, and socio-economic changes have caused that the objective of conducting economic activity has become enterprise value creation rather than profit generation. This is closely linked to the fact that the stakeholders of the financial statements are oriented towards managing this value. Accordingly, it has become particularly important to provide information about the enterprise to predict and describe its future (Mazur, 2018). Unfortunately, this function is not performed by the information included in the accounting and financial statements as stipulated in the Accounting Act or international accounting standards. It is therefore necessary to transform the financial statements in such a way that information that allows value management can be obtained.

3. Value measurement in accounting theory

Enterprise value management is defined in a variety of ways, but they all refer to the pursuit of the highest value for the enterprise. The concept is seen as a management philosophy that pertains to how an enterprise operates with the goal of maximising value for the owners and their invested capital. The main assumption of enterprise value management is therefore to make various types of strategic or investment decisions that will facilitate enterprise value maximisation. Enterprise value management is also recognised as an element in the overall management of an enterprise that allows for linking its strategy to its financial performance (Waśniewski, 2011). Enterprise value creation involves the conduct of regular analysis in order to identify value-creating activities. It is also necessary to determine the checkpoints that support strategic thinking. Four elements should be noted here (Dyduch, 2022):

1. what level of value will be created,
2. how value will be created,
3. how value will be presented,
4. how value will be preserved.

Table 1.
Definitions of value management in national and international literature

Authors	Definition
A. Black, P. Wright, J.E. Bachmann	Value management is a system that aims at maximising shareholder value by streamlining the resources, strategies, processes and performance evaluation criteria of an enterprise. "Management by value as an integrative process designed to improve strategic and operational decision-making by focusing on the key drivers of an enterprise's value".
R. Borowiecki, A. Jaki, J. Kaczmarek	Enterprise value management is the process that affects an enterprise's all relevant executive subsystems and involves initiating changes towards more efficient use of resources. The process is oriented towards maximising the enterprise's goal.
T. Copeland, T. Koller, J. Murrin	Management by value as an integrative process designed to improve strategic and operational decision-making by focusing on the key drivers of an enterprise's value.
A. Cwynar, W. Cwynar	An enterprise value management system is the system in which all decisions made by managers are subordinated to the objective of maximising the value of invested capital.
T. Dudycz	Value management focused on creating maximum benefits for owners is called enterprise value management. Value management is a management philosophy that applies analytical tools and processes to focus the individual objects of an organisation around the creation of value for owners.
W.M. Grudzewski, J. Hejduk	A set of activities oriented towards a favourable change in the factors that increase an enterprise's assets and develop restructuring programmes to stimulate the efficiency of resource consumption and meet customer expectations, thus reaching a high market position by achieving a competitive advantage.
J. Kaczmarek	Enterprise value is equated with an enterprise's ability to increase the capital invested in it.
J.A. Knight	Value management is a concept that combines an enterprise's strategy with its finances in order to maximise the enterprise's value.
M. Krajewski	Enterprise value should be considered from a financial and non-financial perspective. Financial and non-financial values are not separate values, but complement each other.

Cont. table 1.

M. Michalski	Value management is a variant of strategic management, with the primary objective of maximising value for the owners
W. Pluta	Value management involves using the concept of the market value of an enterprise in analysing, evaluating, undertaking and then controlling strategic and operational processes. It is an approach in which management objectives and processes, as well as the relevant calculation methods, are subjected to enterprise value maximisation.
A. Rappaport	The need to develop a concept orienting an enterprise's management system towards maximising its market value arose when the separation of ownership from management and the dispersion of ownership created the need to implement instruments shifting enterprise management systems towards increasing shareholder value and, as a result, achieving the enterprise's primary objective.
P. Szczepankowski	"the concept of managing an enterprise by focusing management activities and processes on maximising its value from the point of view of the interests of the owners and the capital they invested. It assumes the control of an enterprise's operational and investment activity in order to achieve the primary objective of its existence - to increase value".
W. Skoczylas	Value management is a management system based on maximising the market value of an enterprise by seeking to ensure above-average efficiency that guarantees an operating profit above the cost of capital.
P. Waśniewski	It can be defined as a management philosophy that refers to the operation of an enterprise, which aims to maximise its value because of the interests of the owners and their capital.
W. Wielgórka	Enterprise value management should be understood as a management system consisting of adequate tools and actions leading to an increase in the value of the enterprise.
W. Wielicki, R. Braun	Enterprise value management is based on the premise that an organisation's most important objective is value maximization.

Source: own elaboration based on: Borowiecki, Jaki, Kaczmarek, 1999; Black, Wright, Bachmann, 2000; Copeland, Koller, Murrin, 1997; Cwynar, Cwynar, 2002; Dudycz, 2005; Grudzewski, Hejduk, 2008; Knight, 1998; Michalski, 2001; Pluta, 2009; Wielgórka, 2012; Skoczylas, 1998; Maćkowiak, 2009; Maćkowiak, 2013; Wielicki, Braun, 2009; Waśniewski, 2011; Kaczmarek, 2014; Szczepankowski, 2012.

The analysis of the definitions of enterprise value management clearly shows that all proposals equate value management with maximising an enterprise's value. At the same time, the authors identified value drivers. These drivers are presented in Table 2.

Table 2.
Enterprise value drivers

Author	**Drivers**
A. Rappaport	- operating cash flows, - discount rates, - debt
D. Walters	- customer loyalty management, - inclusion of suppliers and customers in the value creation process, - financial leverage, - operational leverage, - strategic and operational cash flows, - capacity management.
J. Copacino	- cash, - invested capital, - cost of capital.
A. Black, P. Wright, J.E. Bachman	- strategic factors – risk, profitability, growth, - financial factors – operating cash flows, discount rates, debt, - operational factors – overheads, production, productivity.

Cont. table 2.

A. Damodaron	- free cash flows for an enterprise, corresponding to the after-tax cash flow the enterprise would obtain if it was not in debt, - expected growth in operating profit, - asset life, which allows for the determination of the time when cash flows can be realistically forecasted.
T. Copeland, T. Koller, J. Murrin	Factors contributing to an enterprise's value are individual in nature.

Source: own elaboration based on: Maćkowiak, 2009.

The analysis of the above definitions reveals the most important characteristics of enterprise value management (Maćkowiak, 2019):

1. it is a management philosophy that uses analytical tools and processes to steer the organisation towards the main objective of creating value for the owners,
2. it is a term that describes an enterprise management philosophy based on the principle of economic value creation,
3. enterprise value management is based on achieving a rate of return exceeding the cost of capital,
4. it is a concept focused on enterprise value maximisation,
5. the primary goal of an enterprise is to maximise shareholder value so, accordingly, the structure of an enterprise serves this goal,
6. it is a structure for measuring and managing an enterprise in order to create long-term value for the owners,
7. a concept based on value creation rather than accounting profit.

4. Value measurement in accounting theory

The implementation of an enterprise value management system aims to supply compatible tools, the application of which is intended to cause, as a result of investment decisions made by managers in accordance with the NPV maximisation principle, the economic value of an enterprise to increase systematically above the level of its equity capital, thus testifying to the above-normal return on assets (Cwynar, Dżurak, 2010).

Enterprise value management is a modern management system incorporating tools and procedures for making strategic and operational decisions aimed at increasing the long-term value of an enterprise and increasing the wealth of its owners.

The essence of this system amounts to (Jaki, 2014; Starovic, Cooper, Davis, 2004; Szablewski, Pniewski, Bartoszewicz, 2008):

1. identifying the long-term enterprise value maximisation and the increase in the wealth of shareholders and owners as the primary goal of the enterprise,

2. evaluating capital expenditure from the point of view of the expected rate of return and the weighted average cost of capital. Enterprise value is created when the rate of return on invested capital exceeds its weighted average cost,
3. recognising the importance and change sensitivity of the various determinants of value: sales growth rate, operating profit margin, cash tax rate, investment in working capital and fixed assets, weighted average cost of capital,
4. applying the measures of shareholder value creation in order to motivate managers and inform on enterprise performance.

Shareholder theory, shareholder value maximisation has been the dominant principle of corporate governance over the past decade or so. However, the world financial crisis triggered the debate as to whether it is still ethical to pursue shareholder value maximisation. The growing changes in the business environment of an economic entity make it necessary for enterprises to develop competitive value management models focused not only on economic benefits, but also on meeting the sustainable expectations of society and all stakeholders (Barrena, López, 2015).

There is a growing awareness in society that the goal of an enterprise should not be limited to just one group – the owners. Stakeholder value theory is, in a sense, the opposite of shareholder value theory. Stakeholder value theory assumes that an enterprise's goal is to benefit all groups in its environment. Proponents of this theory indicate that taking all these groups into account will be the best way to maximise enterprise value (Howell, Nwanji, 2004; Freeman, 1984; Malik, 2012; Donaldson, Preston, 1995; Rzepka, 2018).

By citing arguments in favour of adopting shareholder value maximisation as the primary goal, it is also implied that considering the perspective of stakeholders has no valid justification. The main issue is the divergence of competing expectations expressed by different stakeholder groups. Thus, consumers expect low prices and high product quality, employees high wages and stable employment, suppliers low risk and fast payment. The general public will be interested, for example, in environmental protection. Analysing such expectations, it is difficult to determine how to satisfy all these needs and at the same time increase enterprise value. Rather, it is necessary to select and identify the entities directly related to the enterprise and increase enterprise value through the prism of these entities. They may include customers, employees, suppliers, creditors.

Whether an enterprise adopts shareholder or stakeholder value maximisation, the overriding goal is always to survive and grow.

The analysis of the cited definitions of enterprise value management, value drivers, and doubts reveals three points to be noted:

1. cash flow,
2. time,
3. the concept of shareholders and stakeholders.

When an enterprise's value is based on its long-term cash flows, it is possible to assess its competitive capacity, which is the foundation for its survival and growth. Using the notion of shareholder value maximisation, many authors argue that it is cash flows as opposed to changes in share price that determine this value (Wrońska, 2004). Another issue to be addressed is that of time. Enterprise value maximisation as a primary goal means a long-term perspective should be adopted. If an enterprise adopts a short-term perspective, a risk exists that decisions that are taken will not necessarily translate into value creation. An example of this would be accounting malpractices and their consequences.

The proponents of financial goals believe that the objectives of the owners are divergent from the objectives of other stakeholders, so they disregard the expectations of the other interest groups in value creation. In contrast, researchers who disagree with this position argue that an enterprise, while respecting the objectives of all major stakeholders, fulfils its responsibility to the owners at the same time (Pachciarek, Szarek, 2017).

Stakeholder theory takes a much broader view of an enterprise's business goals and the beneficiary of the value it creates is every stakeholder in the organisation.

The analysis of the areas of activity where drivers of value for stakeholders originate from indicates the following ones (Pawłowska, 2016):

1. changes in the enterprise aimed at applying new technologies or launching a new product,
2. obtaining financial and economic benefits, e.g. stemming from increased profitability or cost reduction,
3. obtaining social benefits, e.g. image, reputation, credibility.

Table 3.
Expectations of all groups with an interest in corporate value

	Expectations, benefits	**Effect on an enterprise**
Owners/ Shareholders	Attractive investment, increased enterprise value, dividends, indirect benefits, power and prestige	They do not interfere in the running of an organisation, but derive income from their shares.
Supervisory board	An enterprise's security and growth: ensuring the compliance with legal norms, responsible management, remuneration, prestige	They influence an organisation through their right to vote.
Managers	Personal professional success: high remuneration, profit sharing, appreciation in share price, bonuses and other benefits, professional and social status	
Employees	Quality of life and professional success, high income, stability, employment, opportunity to develop professional qualifications	They are the people responsible for the execution and implementation of the entire project. They form project teams.
Creditors	Attractive investment: return of borrowed capital with interest, security, power	
Customers	Satisfaction of needs, good cooperation: security and stability of supplies, good quality products, professional service, customer service	Their role is to exchange money for an organisation's products or services. The term customer embraces a variety of institutions and organisations, e.g.: individuals, other enterprises, schools, distributors, hospitals.

Cont. table 3.

Suppliers	Survival and development, profitable cooperation, increased value of a supplier's enterprise	They supply an organisation with goods, raw materials, and other services.
Competitors	Competition respecting moral principles and professional ethics, fair play	Competition positively influences the development of an organisation by motivating it to extend its operations and improve performance, seeking to expand into new markets.
Society	Fairness and growth: sustainable job creation, high income, support for education and culture	
Analysts and rating agencies	Information: preparation of an opinion on an enterprise in the investment context, but also to provide information to the general public and specific groups about an enterprise's situation and its sustainability	
Ecologists	Sustainable growth, care for the ecosystem, monitoring an enterprise's direct environmental impact	
State/state authorities	Prosperity, stable financial system, high revenue, sustainable job creation	They control the operations of organisations to protect the public interest and ensure compliance with free market principles.

Source: Maćkowiak, Poniatowska, 2021; Mikołajewicz; Maćkowiak, 2013.

In conclusion, enterprise management should primarily serve the interests of an enterprise itself, rather than any particular stakeholder groups, whether they are owners or other stakeholders. Enterprise value management should focus on increasing the value of an enterprise regardless of what method or metric is used.

5. Evolution of enterprise value management metrics

Regardless of an enterprise's organisational and legal form, every owner expects an increase in its value in the long term. As a result, both modern financial theory and business administration studies recognise an enterprise's market value maximisation as the primary goal of its activity (A. Jaki, 2011). Enterprise value maximisation is classified as one of the financial objectives. The benefits of an enterprise's owners are related in the long term to the increased value of the invested capital. The direct reflection of its value is its market value of the enterprise in which it was invested.

Enterprise value management metrics can be classified based on a variety of criteria.

Performance measures used in enterprise value management can be divided into two groups:

1. accounting-based performance measures,
2. value-based measures.

Alternatively:

1. standard enterprise valuation methods, which are used primarily to determine the value of an enterprise for the purpose of transforming the ownership structure. They basically embrace three groups of methods: asset-based, income-based and mixed,
2. non-standard enterprise valuation methods.

Accounting measures are usually different types of profit determined in accordance with accounting principles. The most common accounting measures include: ROI, ROA, ROE, RONA, ROCE, EPS (Maćkowiak, 2022).

The 21st century is the time of significant changes in the priorities of doing business. Enterprise value maximisation, defined as increasing the capital invested by the owners, has come to the fore. The idea of value measurement stems from the conviction that information presented in accounting books and financial statements is an insufficient basis for decision-making. The shortcomings of profit as the primary performance measure are becoming increasingly evident. It was observed that, for many enterprises, accounting profit did not necessarily imply a growth in the value of the enterprise. This happens when the profit generated falls short of investors' expectations or the rate of return they require. Profit is an accounting entry that, through the use of creative accounting, may not adequately reflect economic reality.

Accounting measures are based on the data presented in the profit and loss account prepared in accordance with the provisions of the Accounting Act. As they are based on accounting data, they share all the shortcomings that are associated with accounting profit.

The most important shortcomings of accounting measures include (Dudycz, 2002; Sierpińska, 1999; Rappaport, 1999; Rutkowski, 1999; Maćkowiak, 2013):

- the level of profit is strongly influenced by accounting policy, i.e. the legal framework of accounting regulations in force in a given country (e.g. different inventory valuation methods, different depreciation methods),
- the amount of cash is not equivalent to the profit generated,
- ignoring investment issues,
- the financial result does not take into account the change in the value of money in time, which means that the change in the value of accounting measures does not reflect the change in an enterprise's value,
- not all items disclosed under assets have an impact on the profit made by an enterprise (e.g. investments under way),
- some liabilities depend on effective management (e.g. trade payables, the volume of which depends on trade credit, which is in turn related to the position and credibility of the enterprise, i.e. on the quality of management),
- the net financial result reflects the result of all events that took place in an enterprise, including those that are incidental and one-off (other operating income, other operating expenses, financial income and expenses).

This caused a need to replace profit with another measure to estimate an enterprise's value. As a result, the concept of economic profit was developed. In literature, economic profit is used as the main tool of the enterprise value management system.

In its basic form, economic profit is accounting profit; its construction is based on data obtained from the balance sheet, income statement and notes. Economic profit draws on Alfred Marshall's concept of residual profit. The main difference between profit in the income statement and economic profit is the inclusion of the opportunity cost of equity capital. "The fundamental difference between accounting profit and economic profit relates to the statement that an enterprise is not truly profitable until its revenues are sufficient to cover its production and it also ensures owners a normal rate of return on invested capital"(Cwynar, Dźubak, 2010). Accordingly, economic profit takes into account the cost of the entire capital invested in an enterprise's assets.

The universal formula for economic profit is as follows:

Economic profit = return on capital – cost of capital

Non-standard methods used to measure enterprise value include enterprise value metrics. These metrics can be divided into two groups according to the figures that form the basis of control:

- metrics based on net operating profit, e.g. economic profit, economic value added, market value added,
- metrics based on cash flows.

The most popular metric based on economic profit is EVA, which has been in use since 1991, when Bennett Steward published "The Quest for Value". Enterprise value management was long identified with creating economic added value (Maćkowiak, 2022).

The basic formula for economic value added is as follows:

EVA = net operating profit after tax (NOPAT) – weighted average cost of capital (WACC) x invested capital (IC).

In consequence, value creation is based on three components:

- NOPAT,
- cost of capital,
- capital employed.

Simultaneously, the creators of EVA proposed adjustments to profit and capital employed. In total, more than 160 adjustments were proposed and their application depends on the decisions made in an enterprise.

As F. Weissenrieder points out, economic value added was indeed developed for value management, but less as a metric and more as an incentive (Weissenrieder, 1998; Dudycz, 2001). In the early years of the introduction of economic value added, it seemed that it was the best measure of enterprise value management. First all, economic added value, based on economic profit, eliminates the majority of the shortcomings of accounting profit. However, some critical opinions argued that it does not eliminate the shortcomings of accounting metrics

because it is still based on accounting data, despite its different construction. As a result, a problem arises what metrics could be used to measure enterprise value management if not economic added value.

The analysis of the advantages and disadvantages of economic value added, a number of issues should be raised, as presented in the table below.

Table 4.
Advantages and disadvantages of economic value added

Advantages of economic value added	**Disadvantages of economic value added**
The inclusion of the total cost of capital, both own and third-party	Short-term metric
Internal metric	A large number of adjustments
Information on whether value for owners increases or decreases	Problems with determining the cost of equity capital
Fostering the decentralisation of management	Conflict between EVA and enterprise value
Possibility of conducting comparison between enterprises irrespective of their capital structure	Problems with assessing the Beta coefficient
Application as an early warning signal	
Compliance with the NPV method	

Source: own elaboration based on: Kubacka, 2018; Nowicki.

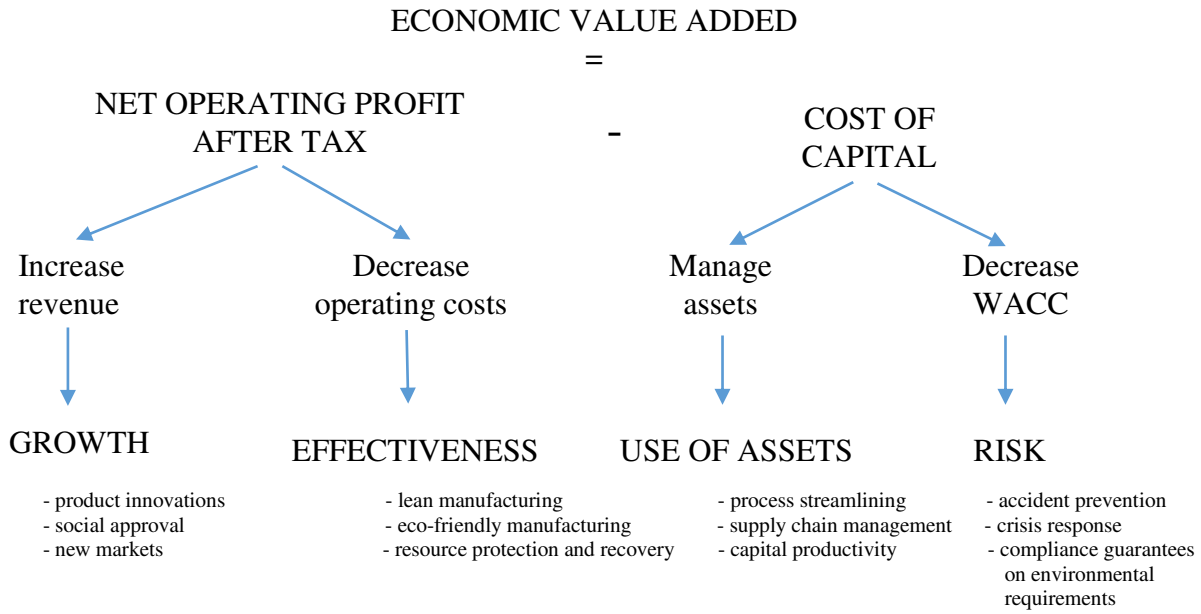

Figure 1. Deaggregation of EVA.

Source: Kochalski, 2016.

However, literature offers many examples of the conflict between economic value added and enterprise value (Jaki, 2012):

1. EVA depends on invested capital so the board may seek to reduce the value of this capital by, for example, carrying out a restructuring that does not increase operating cash flow and its costs reduce the value of capital employed, or replacing conventional purchases with operating leases,

2. the board may manipulate future growth by increasing the current EVA at the expense of reducing its future investment,
3. the possibility of influencing the cost of capital, which is risk-related; the primary measure of an enterprise's risk is the beta coefficient, determined based on historical data,
4. the possibility of choosing from 160 adjustments to achieve the desired level of EVA,
5. it is not confirmed that EVA correlates better with enterprise value or encourages shareholder value creation,
6. the low correlation of EVA with an enterprise's market value; this is a consequence of the calculation of EVA, which is based on nominal rather than market data.

The critical observations presented above that concern the application of economic added value to enterprise value management lead to the conclusion that this metric should not be used for enterprise value appraisal in isolation. It definitely can and should be used as one of the components in enterprise value management. Cash flow based measures of value creation are primarily: shareholder value added, cash flow based return on investment, and cash value added.

Shareholder value added represents the present value of future cash flow balances discounted at the weighted average cost of capital.

Shareholder value maximisation can be adopted as an enterprise's financial goal. The calculation of total enterprise value in the SVA model consists of three components (Daszyńska-Żygadło, 2015):

- the current value of operating cash flow in a given period - its final value depends, to a large extent, on the volume of sales revenue, although it is also affected by factors such as the operating profit margin, the value of capital expenditure in excess of depreciation, and the cash tax rate;
- the residual value - also referred to here as the baseline or base value. It is calculated using an appropriate residual value model (e.g. a perpetual annuity model) for the period beyond the forecast horizon. In practice, this means estimating the residual value for each year of the forecast, with the assumption that cash flows, which do not include new investments, do not change;
- the current market value of securities held for sale and other investments - those that do not have a major impact on an enterprise's operations and can be easily monetised.

Return on investment expressed in cash flows is a relative measure of the financial gains earned from an investment and it is interpreted as the discount rate at which the sum of the discounted gross cash flow balances over the life of the project equals the investment expenditure incurred during the initial period.

Cash value added, on the other hand, shows the excess cash flow generated by the investment on the cash outlay incurred for the investment.

Market value added informs on the excess market value of the enterprise on the value of the capital invested in a given period.

The analysis of the examples of the most popular enterprise value management metrics discussed above reveals their complex structure as well as their advantages and disadvantages. Each economic entity should implement an enterprise value management system adequate to its own needs and capabilities, identifying the areas and procedures in a precise manner.

6. Conclusion

The implementation of an enterprise value management system can encounter a number of obstacles. First of all, an enterprise should consider the purpose of implementing such a system. It is necessary to define what it means to increase value for owners. Another problem involves choosing an adequate measure, because no metric demonstrating the short-term effects of value creation can be regarded as the only objective reflection of the enterprise value creation process, as this value is primarily linked to investors' expectations concerning the future rate of return (Daszyńska-Żygadło, 2015).

The considerations concerning the implementation of enterprise value management should recognise a special group of enterprises – small and medium-sized entities. These are the entities that do not often have their own accounting or financial analysis departments. In such entities, it is difficult to implement an enterprise value management system in the form that is proposed by consulting firms. However, small and medium-sized entities may also be interested in value management, but from a slightly different perspective.

The analysis of the advantages and disadvantages of enterprise value management metrics helps identify key factors that will allow value management to be monitored without being excessively complicated.

Accordingly, in a simplified form, value management can be comprised in these three elements (Kumor, Maćkowiak, 2018):

- EBITDA,
- invested capital,
- cash flows.

Based on these three elements, a scorecard of basic financial metrics can be built.

The proposed solution has some limitations that need to be considered. First, an enterprise has to keep full accounting in compliance with the Accounting Act. Second, it cannot prepare simplified financial statements as the data presented in such a manner will be insufficient. Third, it has to keep cost records by nature. Finally, risk-related issues and the time value of money will not be considered.

Various factors that support the application of VBM to SMEs can be identified. These include (Britzemaier, Kraus, Hanerle, Mayer, 2013):

- VBM helps to ensure the going concern and competitiveness of an enterprise in a constantly changing environment by the consideration of risk-adjusted profitability and increasing awareness of strategic issues.
- VBM supports the fulfilment of the stricter rating requirements of Basel II through reconciliation of rating criteria and the aims of VBM.
- Owing to the special significance of meta-economical, non-financial goals in SMEs, the orientation on VBM ensures the rationality of the management. Independently from that, value orientation explicitly implies ecological, ethical and social goals and prevents these issues from being neglected.

Reasons for the lack of application are manifold. Hirsch et al. states that the lack of application of VBM (in family businesses) is supported by scientific practice. The majority of publications on VBM implicitly refer to large traded companies. A more practical and empirically proven barrier for the avoidance of VBM is that SMEs are confronted with limited financial and personnel resources as well as a lack of knowledge about VBM. SMEs link the implementation of VBM to the extension of their IT systems and the hiring of additional staff, both of which may result in higher costs (Britzemaier, Kraus, Hanerle, Mayer, 2013).

By introducing the enterprise value management system, one obtains information on the management of working capital, capital employed, operating profit and free cash flow.

For small enterprises listed on the New Connect financial market, and therefore using the capital market, the value management system may be the basis for further analysis.

Due to the fact that there will be other shareholders next to the owner, it will be reasonable to supplement the system with measures such as (Maćkowiak, 2017):

- economic added value,
- added value for shareholders,
- market added value.

A multi-dimensional value management system in a small and medium-sized enterprise is a tool that takes into account the specificity of the largest group of economic entities, i.e. small and medium-sized enterprises. By analyzing the objectives of activities, both financial and non-financial, a set of measures was selected that will allow the implementation of enterprise value management in this group of entities.

Traditional financial analysis is based primarily on accounting profit. However, not always increasing profit means multiplying value for owners. At the same time the enterprise may generate profit, but may have a problem with financial liquidity. This means that the profit made does not have to fully cover the cost of capital, and the wealth of shareholders is multiplied when there is a surplus of profit over the cost of capital. It should also be noted that cash flow, i.e. cash, better illustrates whether an individual multiplies the wealth of the owners. (Maćkowiak, 2022)

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A NEW CONCEPT OF VALUE MANAGEMENT IN SMEs

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Purpose: The article aims to propose a model for enterprise value management for micro, small and medium-sized entities. In literature, the concept of enterprise value management is commonly associated with large organizations that possess well-established accounting, financial, or controlling departments. Furthermore, they have the necessary potential and resources to implement a fairly complex enterprise value management system. The situation is different for small and medium-sized entities. These businesses often do not have their own accounting department, outsourcing accounting to external providers, and they tend to see accounting as a necessary evil. The purpose of the model is to define the foundations of value management in SMEs and develop a simplified, organizationally effective and cost-efficient solution that could become the first step towards value management in such entities.
Design/methodology/approach: The proposed recast financial statements will provide clearer information on the financial condition of economic operators.
Findings: The financial statements were analysed in terms of the availability of information necessary for value management in a group of small and medium-sized enterprises. Financial statements prepared in accordance with the Accounting Act or IFRS were found not to provide the information necessary to manage the value of the company, hence the proposal for its transformation and appropriate improvements.
Practical implications: The presented model can be applied by a group of small and medium-sized entities that will be interested in multiplying the value for the owners and that do not have the appropriate background in the form of finance and accounting departments.

Keywords: value of enterprise, economic value added, finance statement, cash flow, EBIT, invest capital.

Category of the paper: Research Paper, Viewpoint.

1. Introduction

The SME sector accounts for the majority of business entities in Poland. According to Statistics Poland, in 2019 micro-enterprises were the most numerous group – 97%. The share of small businesses amounted to 2.2%, that of medium-sized enterprises – 0.7%, while large enterprises accounted for only 0.2%. The majority of all entrepreneurs in the SME sector are

natural persons conducting economic activity. Legal persons and organizational entities without legal personality account for 13% of small and medium-sized enterprises. In 2020, the largest number of entities were established in the following sectors of the economy: construction, dealership and repair of motor vehicles, followed by professional, scientific and technical activity, and manufacturing. The pandemic, the war in Ukraine, and inflation are having an increasingly strong impact on the Polish economy. Following the increases in gas and electricity bills in mid-2022, 200,000 businesses closed or suspended trading.

In compliance with the EU Commission Regulation 800/2008, businesses are classified into a particular SME category based on their size. Two indicators must be taken into account:

- the number of employees not higher than 250 persons,
- financial performance – an annual turnover below EUR 50 million.

P. Drucker (P. Drucker, 2009) took the size of the entity as a criterion and distinguished:

1. a microbusiness (a one-person business or a partnership),
2. a small business (boss-employee),
3. a medium-sized business (multi-level connections),
4. a large business (a management board and a supervisory board make decisions).

The small and medium-sized enterprise sector plays a key role in the Polish economy. The distinguishing features of this sector are:

- - ability to adapt and respond to change quickly,
- - ability to create jobs, e.g. for local communities,
- - the low cost of the job position and the presence of SMEs in all areas of the economy,
- - motivation of owners and employees to work.

The sector is also characterized by weaknesses:

- fragmentation and dispersion of companies,
- difficult access of micro-businesses to funding for growth and innovation, resulting in untapped potential,
- self-funding reduces the opportunity to scale up,
- low level of investment,
- inexperienced entrepreneurs,
- low economic potential,
- price competitiveness,
- low level of cooperation between enterprises.

The analysis of the origins of SMEs reveals two types of entrepreneur orientation (Lemańska-Majdzik, 2013; Deakins, Whittam, 2000):

1. opportunistic entrepreneurship,
2. forced entrepreneurship.

Opportunistic entrepreneurship originates from positive motivations to run a business, such as building autonomy, fulfilling one's potential, and taking on new challenges. The nature of SMEs means that the need for achievement is of particular importance for owners. Enterprises are distinguished by the motivation to continuously improve their work, the owners strive to take risks and prefer difficult tasks, and are driven by distant goals. It is important to recognize the presence of dominance in entrepreneurship, which can manifest as a lack of subordination. Dominance is often motivated by a desire for power. Such businesses tend to grow dynamically and have a clear vision of their activity. The other type of entrepreneurship is driven by the need to secure funding to make a living.

The analysis of the drivers behind the establishment of small and medium-sized enterprises should account for the elements included in Table 1.

Table 1
Positive and negative drivers

Positive drivers	**Negative drivers**
- a fresh start, - new opportunities, - curiosity, - spotting interesting opportunities, - the need to improve "one's life", - unexpected inflow of capital, - purposeful activity connected with the pursuit of dreams and desires, - profit-driven motivation, - independence.	- inability to make a living, - lack of job satisfaction, - losing a job, - unemployment, - problems in a business, - fear of losing a job, - a change in the family situation.

Source: own elaboration based on: Szarucki, Ericsson, Larsson, 2007; Glina, 2007.

The goal of setting up a business can be considered through the prism of financial benefits and non-financial benefits. Financial benefits relate to the increase in the value of the business and the use of assets to achieve above-average profits. They can be defined from two perspectives: that of the buyer and that of the seller of a business. The factors that buyers focus on include (Rinne, Wood, Hill, 1986; Turczyński, Mojsiewicz, 2001; Smithson, Smith, Wilford, 2000; Michalski, 2005):

- current and future cash flows,
- the cost of capital used to finance an SME,
- the volatility of current and future cash flows and the likelihood of disruptions to regular debt repayments and the consequent risk of business failure.

The seller of a business will look at the value he or she can obtain from selling the enterprise. Non-financial benefits, on the other hand, relate to economic independence, the absence of a boss, working for oneself, time for family, status, or the satisfaction of owning a business.

In literature, most studies focus on identifying barriers to SME development (Kamińska, 2011). The assumption exists that barriers to SME development are the same as the constraints that hinder the growth and development of all enterprises (Daszkiewicz, 2004). The analysis of barriers to development proposes various classifications of barriers based on the business

environment, the time when barriers arise, or the place where they occur (Skowronek-Mielczarek, 2013). On the other hand, universal barriers also exist and they are independent of the stage of the enterprise's life cycle or the characteristics of the SME sector in a given region. Universal barriers are connected with three areas: management and motivation, potential, and market structure (Barber, Metcalfe, Porteous, 1989). D.J. Storey, in turn, distinguishes three groups of barriers to the development of enterprises operating in the market: financial, management-related and demand-related barriers (Storey, 1996).

2. Barriers to the development of SMEs

The structure of capital in enterprise, the cost of its raising, and its valuation attract a lot of consideration in literature. Small and medium-sized enterprises always show preference for internal sources of financing. This is largely due to credit discrimination (unfavorable credit terms). When looking for other sources of financing, they increasingly use the capital market, e.g. New Connect, or start-up opportunities. New technologies, modern manufacturing, and the introduction of new products require financial investment. Lack of financial resources is a fundamental barrier to business management. The majority of small enterprises are underinvested and their share capital is the cause of a chronic shortage of working capital (Daszkiewicz, 2004). Another barrier is the innovation and technical barrier, related to obsolete machinery and difficult access to new technologies. Among economic determinants, the most important barriers are those related to the rates of taxes, the financial and legal system, and social security (Leszczeński, 2008).

Legal barriers should also be taken into account as they embrace instability of legal regulations, vagueness of legal regulations, retroactive enforcement of legal regulations, or administrative restrictions, such as concessions. T. Łuczka identifies five barriers to small business growth: legal, economic, management, educational and social (Łuczka, 2005).

Barriers to growth can also be divided into internal barriers[1] and external barriers[2]. Internal barriers fall into the following categories: business management problems, size and volume, human capital problems, financial barriers. Barriers related to business management concern both organizational strategy and its implementation as well as other aspects of a business's operations. This applies to wrong development strategy and inappropriate decisions, but also the problem related to the owner and organizational structures (Ziemba, Świerszczak, 2013). Factors occurring in the SME environment can also be divided into general factors, which

[1] Internal barriers: size, organizational structure, operational strategy, production capacity, financial resources, material resources, human resources, knowledge and technology, skills and competencies of employees;

[2] External barriers: legal barriers, informational and educational barriers, infrastructure barriers, economic policy barriers, market barriers, social barriers.

reflect the economic processes characteristic of the period in which the enterprise operates, and specific factors, which concern the growth of a specific enterprise (Steinerowska-Streb, 2017).

Table 2.
Factors fostering and hindering the growth of small businesses

Area	Growth fostering factors	Growth hindering factors
Planning	- demographic variables, - personal traits, - values and convictions	- lack of ambition and vision, - anti-business, hobbyist approach, - protectionism in lifestyle, - maturity stage in the life cycle
ompetences	- education, - knowledge of different areas of business, - an increase in the number of products, assets, - legal form of the business, - active learning through informal networks.	- forced managerial appointments, - narrow skills profile, - material expansion, - an organizational structure built in the absence of time and resources.
Market opportunities	- market conditions, - access to financing, - public sector regulation, - labour market.	- weak internal position of the sector, - high dependence on the external environment, - unfavorable financial conditions, - adverse attitude of local authorities to the development of entrepreneurship.

Source: Morrison, Breen, Ali, 2003; Kamińska, 2015.

3. Information limitations of the financial statements prepared in accordance with the accounting act

The primary source of financial information is the financial statement. It is, or rather it should be, but - in the context of enterprise value management - the information it contains is unintelligible. Modern financial statements are obliged by the International Financial Reporting Standards Conceptual Framework to provide financial information about the reporting entity that is useful and reliable for all stakeholders. The usefulness of this information is also connected with the assessment of the entity's future situation, including future net flows.

The question arises as to whether all the information about the financial situation contained in financial statements prepared in accordance with the concept of a true and fair view will achieve the objective set out in the Conceptual Framework regarding the entity's future situation. The financial statements in their present form refer to the past situation, while the future situation involves the expected developments. Undoubtedly, the crisis of confidence in accounting information was influenced by the introduction of the fair value category in the measurement, which had basically as many proponents as opponents.

Analyzing the models operating in accounting in terms of the implementation of the concept of true and fair view, two concepts can be identified (Mazur, 2015):

- transactional theory,
- value theory.

The transactional theory is primarily based on the information contained in the income statement. The analysis primarily involves profitability and its reflection in the income statement. The value theory, on the other hand, concerns the information contained in the balance sheet. In this respect, it is important to determine the correct value of net assets as of the balance sheet date. The limited scope of balance sheet information is the result of omitting important components, such as employee qualifications or synergies (sharing of different assets). Providing information useful for decision-making will be the core of the concept of valuation at projected prices using discounted future cash flows. However, the question arises as to what method to use to measure the discounted flows of the individual assets and then what method, based on the carrying values thus established, to use to forecast future cash flows (Mazur, 2015).

4. Enterprise value management model

Enterprise value management in an SME consists of two stages:

1. the transformation of the financial statements,
2. the development of value management metrics.

The transformation of the financial statements is a consequence of the fact that the financial statements are incomprehensible and do not provide value management information. A study was carried out comprising a group of companies listed on the Warsaw Stock Exchange. The analysis of the financial statements and the information they contained led to the conclusion that the report prepared according to the Accounting Act or IFRS does not provide the information necessary to determine the three elements of the proposed enterprise value management model. The versatility of the model stems from the fact that it can be used by large entities and then no simplifications, such as risk omission, are applied. In contrast, SMEs can use the model with the simplifications mentioned above.

The basic assumption of the SME value management model is the evaluation of the business, not the valuation of the enterprise value. This assumption means that the model cannot be used for SME valuation primarily because enterprise value measurement is based on long-term forecasts. In the case of SMEs, due to cost and organizational constraints such forecasts are usually not made, which means that the analysis has to be based on historical data. Ex-ante analysis certainly allows for a more precise selection of business objectives and methods for their implementation, but for SMEs, which for known reasons can often not afford the costs associated with a competent analysis or controlling department.

In an enterprise that does not prepare formalized long-term plans, ex-post analysis will certainly provide information that can contribute to improved value management and, in the long term, influence both the way in which the enterprise is financed and how it performs.

Another limitation relates to the income tax included from the NOPAT calculation. This tax does not reflect the actual tax rate due to the statistical nature of NOPAT adopted in the concept. The application of a nominal tax rate causes that the calculated NOPAT value is a theoretical value. It is important to assume that the tax used to calculate NOPAT is eliminated in the item of other cash flows. Another simplification is the omission of market risk. This is a simplification similar to the use of historical data rather than performance forecast from the model's simplifications.

5. The scope of the enterprise value management model

The analysis of the definitions of enterprise value management reveals that this philosophy of enterprise management focuses all activities on maximizing value for the owners. It applies analytical tools and processes to concentrate the individual components of the organization on value creation for the owners (Dudycz, 2002).

For SMEs, the enterprise value management model will be based on three elements (Kumor, Maćkowiak, 2018):

1. operating profit after tax,
2. capital employed,
3. cash flows.

Until recently, the financial result was seen as the best measure of an enterprise's performance. However, it has now been replaced by cash flows. Over the last years, the traditional approach to measuring profit in accounting has been heavily criticized. The accounting system should provide information for decision-making by investors. Due to the criticism of accounting profit, gross profit has been replaced by a different category - 'economic profit'. The analysis of the data from financial statements showed that, despite generating high profits, companies still suffered liquidity problems. Using profit to assess an enterprise's value, two groups can be distinguished: absolute measures and relative measures. Absolute accounting measures include: EBIT, EBITDA, NOPAT, EBITDAAT, and EPS (Maćkowiak, 2019). The idea of EBIT is based on the desire to be able to identify all the capabilities of an enterprise.

The NOPAT operating profit is used for enterprise value management. This is the category of financial result that is not sensitive to decisions concerning the financing of an enterprise's assets, while it tends to respond to changes in operating factors. Profit can be calculated in two ways (Maćkowiak, 2013):

1. the direct method,
2. the indirect method.

The direct method takes the following form:

NOPAT = sales revenue – operating costs = earnings from sales (EBIT) – income tax on EBIT

In contrast, the indirect method is as follows:

NOPAT = sales revenue – operating expenses = EBIT – interest expenses = EBT – income tax on EBT = net profit + interest expenses (1 - T).

The shortcomings of accounting profit include, for example, that it takes into account neither risk nor dividend policy, but they do not affect the model, due to the simplifications adopted in the model and the characteristics of SMEs.

The proposed model requires costs to be recorded according to type. The transformation of the income statement is aimed at obtaining information on how efficiently a given enterprise operates and on the value of its revenues or earnings. Similarly to the traditional income statement, the starting point is revenue from the sale of products, goods and materials, which should be adjusted by the change in the state of products in order to obtain the category 'value of products'. The value of products should be decreased by costs according to type, excluding the cost of personnel and depreciation. This establishes the 'added value'. The category of added value and the separate reporting of labor costs provide information on wages and their impact on the financial result. The inclusion of labor costs allows EBITDA to be determined. EBITDA has to be adjusted by the last cost by type – depreciation and amortization, as well as other operating expenses and revenues and, as a result, EBIT is determined. The purpose of using EBIT is to identify all the capabilities of an enterprise. It should be noted that it is not possible to calculate EBIT based on financial statements prepared according to the national regulations. The EBITDA category is a rough measure of the cash generating capability of an enterprise's assets. Additionally, EBITDA is less susceptible to accounting manipulation regarding, for example, non-cash accruals, provisions or write-downs. NOPAT, the category of profit used in enterprise value management, is a category of the financial result which is not sensitive to decisions regarding the assets of the enterprise, but responds to changes in operational factors.

The second element of the enterprise value management model is invested capital and its cost. Invested capital is one of the key elements in enterprise value management. According to L.H. Sloan, invested capital is a key barometer of an enterprise's future success (Krajewski, 2006). N. Roztocki, on the other hand, defines capital employed as the value of liabilities less invoiced payables and accruals (Makelainen, Roztocki, 1998).

Based on the information contained in the Polish balance sheet law, invested capital can be calculated as follows (Maćkowiak, 2009):

Invested capital = assets – goodwill – capitalised operating leasing – interest-free liabilities – accruals – provisions for liabilities – fixed assets under construction

Transforming invested capital into adjusted invested capital allows the book value to be transformed into economic value.

Adjusted invested capital = equity + equity equivalents[3] *+ interest-bearing debt capital + debt capital equivalents – sum of discounted future operating lease payments*

Invested capital is one of the key components that will be included in the model. The primary strength of enterprise value management measures is the inclusion of the cost of capital.

In order to determine capital employed, it was necessary to transform the financial statements so that they fit the purposes of the enterprise value management model. The balance sheet prepared according to the balance sheet law is transformed into a 'value balance sheet'. The value balance sheet consists of capital employed and total financing. The main difference concerns the structure of the balance sheet. The distinction between assets and liabilities (sources of financing) is abandoned. Capital employed consists of three elements. The starting point is current assets, consisting of receivables, inventories, short-term accruals and other assets (receivables from taxes, duties, social security, receivables claimed in court and other short-term receivables), current liabilities, consisting of payables, other accruals, tax payables, special funds, short-term provisions. Current liabilities subtracted from current assets give the value of working capital. In the second step, the value of working capital must undergo adjustments, which include: tangible fixed assets, intangible assets, long-term investments, long-term accruals, long-term liabilities to related parties, negative goodwill, other long-term accruals, deferred tax liabilities and long-term provisions. Importantly, elements of assets are shown with a plus sign, while liabilities are shown with a minus sign. The other side is total financing. The first element is equity, minority interests, long-term financial liabilities and long-term financial receivables. Total financing also includes cash and all short-term investments, but also short-term loan liabilities, and debt securities. The value of total financing is decreased by liabilities and increased by assets. Of course, the value of capital employed equals the value of total capital.

This transformation of the balance sheet will allow, among other things, for the exclusion of payables. Trade payables should not be included in the financing of enterprise operations as they are not a stable form of financing. The level of financing must be established without current liabilities, as financing that includes this type of liabilities is not reliable. The transformed value balance sheet fully shows the actual financing needs, which were not identified based on the traditional balance sheet. The introduction of the formula of assets minus current liabilities and equity plus financial liabilities makes it easy to control credit limits or financing strategies.

The third element of the model is free cash flow. Cash flow is considered one of the best indicators in enterprise value management. Cash flow will be determined based on data obtained from the other two elements, namely EBIT and the balance sheet. Above all, the cash

[3] Equity equivalents: provisions related to LIFO stock valuation, deferred tax provisions, accumulated goodwill amortisation, other provisions.

flow from the model cannot be equated with the third element of the financial statement, i.e. the cash flow statement. The starting point is net debt at the beginning of the period adjusted for EBIT and income tax (notional tax), which allows NOPAT to be determined. The NOPAT profit is adjusted for: depreciation, capital expenditure, proceeds from the sale of fixed assets, changes in provisions, changes in working capital, and changes in other current assets and liabilities. The result is free cash flow. The transformed cash flow statement is based on an analysis of net debt rather than cash balances as in the financial statement.

Based on the data of companies listed on the WSE, the information obtained can be used to calculate the economic value added, or market value added. In this case, the risk, which is an element of the cost of equity taken into account by the beta coefficient and the risk premium, is also included. The available information also allows for the determination of economic profit. If positive economic profit is obtained, shareholder wealth is multiplied. This is because profit fully covers the capital employed adjusted for the cost of capital. Economic profit is the same as EVA, without adjustments. The analysis of economic profit, EVA, and MVA should also pay attention to the trend. The absence of a trend may indicate the absence of a strategy aiming to achieve synthetic improvement in an enterprise's financial performance.

6. Conclusion

The research area covered in this article is relevant and important in terms of financial management in a small and medium-sized enterprise. The problems faced by such enterprises include the constant search for directions and decisions that will allow them to achieve an ever higher level of business activity leading to an increase in its value. Another important aspect involves the streamlining of an enterprise's operations to achieve higher efficiency. The growth-oriented enterprise value management system has a significant impact on an enterprise's strategy and management. Management ideas and concepts related to maximising enterprise value for owners have spread particularly strongly in recent years. The proposed system allows micro, small and medium-sized enterprises to implement these ideas.

The theoretical aspect of the model draws on the research initiated by A. Rappaport and T. Kaplan, who introduced the ideas of enterprise value management, but they and their successors left a certain gap in their studies. The traditional financial statements, which are still in use, do not provide information that would sufficiently serve the purposes of enterprise value management. This gap was filled with a procedure for the transformation of the financial statements and, as a result, the creation of the 'value scorecard'. Most studies in literature on enterprise value management mainly concern large enterprises. In contrast, the model presented in this article is the first to take into account the characteristics of small and medium-sized

enterprises. Regardless of the simplifications that are applied in the preparation of the financial statements of small and medium-sized enterprises, it is possible to apply the 'value scorecard'. The model is a response to the gap that stems from the demand for information related to the value management of a small and medium-sized enterprise. The application of the system provides information on EBIT, EBITDA, capital employed, and free cash flow. Based on the research carried out, it was observed that owners of micro, small and medium-sized enterprises, who use full accounting (they are not entities keeping accounting records on the basis of a tax card or a revenue and expense ledger) focus primarily on profit.

It is a multidimensional approach, which takes into account capital employed and free cash flow alongside EBIT and EBITDA.

The behavioral approach is reflected in the applied simplifications, which aim to make the enterprise value management tool as simple to implement as possible. Accordingly, historical data are used instead of a forecast, risk is not taken into account, as this is overly complicated for a professional with no background in finance, and the inverse of the P/E ratio is used as an approximation of the cost of equity.

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INTERNET ENTREPRENEURSHIP OF SMALL ENTERPRISES IN LUBLIN VOIVODESHIP

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Purpose: The Internet and digital technologies have a significant role in the functioning of modern businesses. They enable effective communication and running business globally, helping improve operational efficiency and increase competitiveness. The Internet is a source of entrepreneurial ideas and creates many business opportunities. Various business ventures are initiated, implemented and managed using Internet technologies. The purpose of the article is to present theoretical considerations and results of empirical research on Internet entrepreneurship of small enterprises from the Lublin region.
Design/methodology/approach: Achieving the stated objective involved the use of two research methods. The first was the method of literary criticism on Internet entrepreneurship, which formed the basis for the methodological assumptions. The second method was the diagnostic survey, a structured interview technique that allowed hypotheses to be verified. The research results allowed for assessing the range of small business activities conducted using the Internet.
Findings: The research undertaken revealed that small businesses perform numerous entrepreneurial activities via the Internet. They are mainly related to information exchange and customer service. It was found that the higher the employment, the greater the extent and intensity of these activities. Companies operating on a larger scale are also using more Internet tools. Younger units obtain more effects from the use of the Internet. It has been found that entrepreneurs are aware of the benefits of strengthening Internet entrepreneurship.
Research limitations/implications: The research enabled the verification of the adopted assumptions and the implementation of the set goal. Analysis of the respondents' answers provided information on small business Internet entrepreneurship. The interviews conducted indicated the need to modify the research tool. The presented research procedure has some limitations due to the methods adopted, the research tool and the small size and non-random nature of the sample.
Practical implications: Research can help guide small businesses towards more effective and systemic use of the Internet in the execution of business processes.
Orginality/value: The research's originality involves providing new information on small business Internet entrepreneurship and resulting effects.

Keywords: Small businesses, Internet entrepreneurship, Internet, ICT.
Category of the paper: Research paper.

1. Introduction

Economy 5.0 requires significant changes in how companies operate and their business models. The Internet and Information and Communications Technologies (ICT) are becoming central factors for successful operation and growth. However, in order to find oneself in the rapidly changing digital reality, it is necessary not only to have access to modern technologies but also the ability to use them. This is a particularly difficult challenge for small businesses, which often have insufficient financial, human and technological resources.

The Internet universe gathers a significant part of the society around the world. Businesses and consumers alike obtain a wide range of information and data from the global network. The internet is a significant support for running a business. Having a business in the virtual space is even becoming a necessity. Most people's daily lives rely on Internet search engines, social media and online shopping. Entrepreneurs who do not feel the need to use the potential of the Internet for their business, or who do not have the necessary skills, are unlikely to be able to maintain their position in the market.

In small business, skilfully seizing the opportunities and avoiding the risks associated with the digital transformation of the economy is becoming a key success factor. The transition to the digital world has many dimensions and involves virtually every aspect of a company's operations. It is based on continuous development and flexible adaptation to changes related to ICT developments. It often requires a complete redesign of the processes within the organisation. This means that entrepreneurial activities are required in both real and virtual reality. The former is an integral part of the company's day-to-day operations, while the latter opens up various development opportunities for the company. Internet entrepreneurship can be considered as the business's digital activity involving engaging in intensive activities in Internet and ICT use (Mieszajkina, Myśliwiecka, 2022).

The presented pilot study aims to analyse in which areas and to what extent the Internet is used by small enterprises operating in the Lublin region. The research was conducted in 30 units meeting the criteria for being a small business (Ustawa z dnia 2 lipca 2004 r., art. 105).

2. The essence of Internet entrepreneurship

The phenomenon of entrepreneurship is multidisciplinary and therefore difficult to define unambiguously. The science of entrepreneurship is developing rapidly around the world. New views and theories presented by theorists and practitioners from different scientific disciplines are being published. A new type of entrepreneurship – Internet entrepreneurship – has emerged with the growing role of the Internet in socio-economic processes, the increasing virtualisation of markets and organisations and the development of ICT. It is usually associated with setting up and running an online business. It includes activities related to the use of virtual space and ICT to identify business opportunities, create innovative products and services, reach a wide global audience, connect with business partners, etc. (Anim-Yeboah et al., 2020; Bednarczyk et al., 2019; Glinka, Gudkova, 2011; Le Dinh et al., 2018; Zhao et al., 2016).

The European Commission sees online entrepreneurship much more broadly, emphasising that it includes not only new businesses but also transforming existing ones by creating and using innovative digital technologies (European Commission, 2013). According to Hull et al. (2007), it involves digitising some or all of what would have been physical in a traditional organisation. In the view of Davidson and Vaast (2010), this is a search for opportunities based on the use of digital media and other ICTs. According to A. Roslan-Karaś and J.E. Wasilczuk (2015), it is entrepreneurship practised online using network tools, exploiting the opportunities created by the network and applying various online business models.

Summarising these and other definitions, it can be concluded that Internet entrepreneurship is a form of economic activity in which key tasks related to management, innovation or customer relations are conducted using networks and computer tools. It involves the transfer of a company's activities into a virtual space and the interactive, networked connection between producers, cooperators, suppliers and consumers that create the network (Romanowska, Cylwik, 2004; Malara, 2006; Mieszajkina, 2018).

Internet entrepreneurship activities provide a number of benefits for businesses. These include (Bank Pekao, 2018):

- accelerating and simplifying communication within the organisation,
- increasing business efficiency through data analysis,
- creating cross-organisational virtual teams where members can share knowledge and ideas in real time,
- effective use of existing resources from a strategic and operational perspective.

Internet entrepreneurship has a long history, with the first publications on the subject appearing in the early 1990s. The continuous and rapid development of digital technologies is fostering the creation of various ventures whose business models are based on generating value through electronic information via data networks (Kollmann, 2006; Kraus et al., 2019). As a result, researchers and practitioners around the world have become increasingly interested

in the issue. Kollmann et al. (2022), in an extensive analysis of the academic literature, found that Internet technologies – the basis of Internet entrepreneurship – were also the first major factor in the creation of digital ventures.

The emergence of newer and more advanced digital tools contributes to strengthening digital transformation processes and, consequently, broadening the scope of online entrepreneurial activities at organisational and individual levels. Successful Internet entrepreneurs, however, accept the dynamic nature of the digital world and seek out and exploit new opportunities to create value and achieve business goals in the online environment. This requires knowledge, the ability to adapt, creativity, strategic thinking and an understanding of how Virtual Reality works.

3. The use of the Internet in the activities of small enterprises

Internet entrepreneurship is currently one of the most important factors for the success of small business. ICT implementation has a decisive impact on the course and quality of ongoing organisational processes, the level of employment, the way in which resources are used and how stakeholders are communicated with, as well as many other important aspects of running and developing a business (Mieszajkina, 2020).

The Polish Agency for Enterprise Development has been analysing the development of Internet entrepreneurship in small business for several years. The 2022 'Report on the State of the Small and Medium-Sized Enterprise Sector in Poland' (Skowrońska, Tarnawa, 2022) notes that entrepreneurs are constantly expanding their activities in this area. This has been significantly impacted by the COVID-19 pandemic and the associated constraints, as a result of which companies have been forced to reorganise their work and find new ways of performing basic tasks and communicating with stakeholders. In 2020, 26.2% of small enterprises reported an increase in the level of ICT use in their business compared to the previous year. There has been an increase in the number of online meetings using instant messaging (21.7%), an increase in the percentage of employees with remote access to company e-mail (11.2%), an increase in the percentage of employees with remote access to company systems and applications other than e-mail (13.1%) and an increase in electronic sales (5.7%). The report also presents other parameters characterising online small business entrepreneurship in 2021:

- broadband Internet access – 98.2%,
- equipping employees with mobile devices enabling mobile Internet access – 75.7%,
- having their own website – 67.2%,
- using paid cloud computing services – 24.4%,
- use of the Internet of Things – 14.9%,

- using social media – 42%,
- conducting a security audit of the company's information system – 22.8%,
- use of ERP tools – 24.1%, CRM – 25.5%.

Comparing the data presented in the report, it should be noted that small enterprises' growth parameters are several times lower than large enterprises. Nevertheless, it is undeniable that more and more entrepreneurs, including small enterprises, are aware of the need to digitalize their business and to engage in entrepreneurial activities using ICT. Internet solutions support and streamline the management processes of a small business, facilitate collaboration within the organisation and with stakeholders and allow you to reach customers and contractors anywhere in the world.

The current state of digital technologies used by small Polish enterprises is unsatisfactory. There are a number of barriers to online small business development (Lewandowski, Tomczak, 2017; Mieszajkina, Myśliwiecka, 2022; Orłowska, Żołądkiewicz, 2018):

- significant digital competency deficiencies,
- insufficient funding, limiting technology availability and the purchase of appropriate software,
- low economic potential of enterprises, which leads them to focus more on current activities and not on investment decisions,
- the perception that using ICT is costly and that the investment in its implementation is disproportionate to the benefits achieved,
- no apparent need for ICT implementation,
- low internationalisation, not forcing adaptation to more digitised partners.

The low digital activity of small businesses is a disturbing phenomenon. This is not surprising given that, in the context of the European Union, the Polish economy as a whole is digitising much more slowly than most EU countries. The latest edition of the Digital Economy and Society Index (European Commission, 2022) ranks Poland 24th (4th from last, ahead of Greece, Bulgaria and Romania) with a score of 40.5, less than 77% of the EU average.

In today's global digital world, the role of Internet entrepreneurship is crucial. It is based on a creative approach to using ICT to create innovative products, services and business models. New ideas and revolutionary solutions are being developed as a result, changing the methods of working, communicating, and doing business. It is easier to reach stakeholders from a global perspective, and you can do business regardless of geographical borders. Internet entrepreneurship fosters the transformation of traditional business models into digital ones through solutions such as e-commerce, sharing economy platforms, online subscriptions, etc. This enables the creation of flexible and innovative business structures. The Internet provides entrepreneurs with a wide range of tools and resources to facilitate operations, support growth and allow greater flexibility in time and workplace management. These include business management support systems, software, e-commerce platforms, cloud services, analytics tools,

social media and many others. However, for Internet entrepreneurship to become a key factor in the success of small businesses, it is necessary to strengthen the commitment of those who own them. They should have a clear vision of how to harness the potential of the internet to grow the business, invest in developing the digital competencies of their team, and create an entrepreneurial culture that encourages innovating, experimenting and being open to change.

4. Research methodology

According to W. Czakon (2014), the research procedure provides for the implementation of a sequence of a number of research procedures. It can be formulated in more or less detail depending on the needs of the research. The first stage of the research presented here involved analysing the literature relating to Internet entrepreneurship. A method of literature criticism was used. Based on this, a research gap was identified in relation to the role of Internet entrepreneurship in small business development. There is a general perception that using the Internet and ICT is the domain of large enterprises. Numerous observations and analyses are presented in the literature in relation to this group of enterprises. Research on Internet entrepreneurship in small business is much less frequent. Simultaneously, they usually cover the entire micro, small and medium-sized enterprise sector. However, it is difficult to generalise about their development potential as the sector is very diverse and heterogeneous in many respects. Considering that small entities have the greatest problems in this regard (Mieszajkina, 2020), the research was conducted in this group of enterprises.

The next steps are to define the research problem, purpose and hypotheses. The following research problem was formulated: To what extent do small businesses use the Internet in their operations? The following research questions were posed:

1. For which business activities do small enterprises use the Internet?
2. For which activities are small businesses more likely to use the Internet?
3. What role do small enterprises attribute to the Internet in business development?
4. What Internet tools are most commonly used by small enterprises?

The research purpose was to analyse in which spheres and to what extent the Internet is used in small enterprises' activities. The research hypotheses are as follows:

H1. Small enterprises most often use the Internet for customer service activities.

H2. Smaller enterprises in terms of employment perform fewer business activities via the Internet.

H3. Small enterprises with a wider range of activities use more Internet tools in their activities.

H4. Younger enterprises achieve better results by using the Internet.

The research was conducted as an in-depth piloted study. To verify the hypotheses, a diagnostic survey was conducted using a structured interviewing technique, which involved asking a series of standardised closed-ended questions and analysing the responses. The results obtained from respondents could be compared by using close-ended questions. During the interviews, particular threads were developed by asking in-depth or clarifying questions. This helped to determine whether the questionnaire questions were fully understood by the respondents. Conducting the interviews was the first stage of further research, which will be carried out using a survey technique.

The questionnaire contained 21 questions. The research was conducted in 30 small enterprises in May 2021. The sampling was non-random, using an occasional sample made up of people readily available to the researchers. Research sample structure (number of enterprises):

- number of employees: 10-19 people – 16; 20-29 people – 5; 30-39 people – 4; 40-49 people – 5,
- Enterprise age: less than one year – 3; 1 to 3 years – 4; 4 to 6 years – 11; more than 7 years – 12,
- industry: manufacturing – 4; trade – 7; services – 24 (results do not add up to 30, as in some cases more than one industry was indicated),
- location of business: city of over 500,000 inhabitants – 11; city of 100,000 to 500,000 inhabitants – 8; city of 50,000 to 100,000 inhabitants – 3; city of up to 50,000 inhabitants – 6; rural areas – 2,
- enterprise area: local – 13, national – 12, international – 5.

The survey contained filter (conditional) questions that redirected respondents to the question appropriate to the answer given.

5. Research results and analysis

Firstly, respondents were asked whether their companies use the Internet and online tools when conducting their business. A negative answer was given by 3 people. Therefore, questions related to the verification of hypotheses 1-4 were answered by 27 respondents.

To verify hypothesis 1, respondents were asked to answer 2 questions. Responses were given on a scale from 1 – the Internet is not used, to 5 – it is used very often. In the first question, respondents were asked to identify the business activities that are conducted via the Internet in their enterprises.

Table 1.
Business activities for which enterprises use the Internet (number of responses)

Business activities	Rating					Average rating
	1	2	3	4	5	
Information exchange	0	1	1	5	20	4.6
Searching for information	1	0	4	8	14	3.8
Communicating information to stakeholders	3	2	2	6	14	3.6
Invoicing	3	2	4	6	12	3.4
Banking	3	2	7	5	10	3.3
Advertisement	3	2	4	9	9	3.3
Remote work	7	1	4	4	11	3.1
Customer service and support	6	2	3	5	11	3.1
Sale of goods	8	3	7	2	7	2.6
Administration	8	4	3	7	5	2.6
Videoconferencing	11	1	3	6	6	2.5

Source: own elaboration.

The most common use of the Internet by small enterprises was for e-mail communication with stakeholders and information gathering and communication, either through a website or a business card on the Internet. The research was conducted in the period just after the COVID-19 pandemic restrictions were lifted, but it was not very common for the surveyed units to use the Internet to organise remote working and customer service and support. The least frequent use of the network was for video conferencing.

The second question concerned the Internet tools used by small enterprises (Table 2). Responses were given on a scale from 1 – the company does not use the tool, to 5 – it uses it very often.

Table 2.
Internet tools used by enterprises (number of responses)

Internet tools	Rating					Average rating
	1	2	3	4	5	
Website	2	0	2	7	16	4.3
Social media	1	1	4	7	14	3.8
Business card on the Internet (Google)	8	2	8	4	5	2.6
Audience statistics	12	2	5	3	5	2.3
Google Analytics	13	3	5	2	4	2.1
Google My Company	16	2	3	2	4	1.9
Google AdWords	18	1	3	2	3	1.7
Pixabay	21	3	2	0	1	1.3

Source: own elaboration.

The most commonly used tools were the website and social media. More advanced tools such as Google Analytics, Google My Company, Google AdWords, audience statistics, Pixabay are not in use by the majority of respondents. This may indicate that their employees do not have the necessary knowledge for the use of more sophisticated Internet tools.

The next questions related to the two most commonly used tools. Respondents rate their companies' websites well – most contain all necessary information, are clear and professionally designed. The main objectives that companies want to achieve through the use of a website include: providing information about products and services and consumer opinions, creating

a corporate image and attracting new customers. The second most frequently used Internet tool was social media, e.g. Facebook, Instagram. Respondents' answers suggest that companies focus mainly on presenting up-to-date contact information and displaying images of products or service delivery methods. Summarising the information presented, it can be concluded that hypothesis 1 has been positively verified.

The second hypothesis assumed that smaller enterprises in terms of employment perform fewer business activities via the Internet. Figure 1 presents data on the percentage of units that use the network very often in their activities (answers '4' and '5'), divided into two groups: number of employees from 10 to 29 people and from 30 to 49 people.

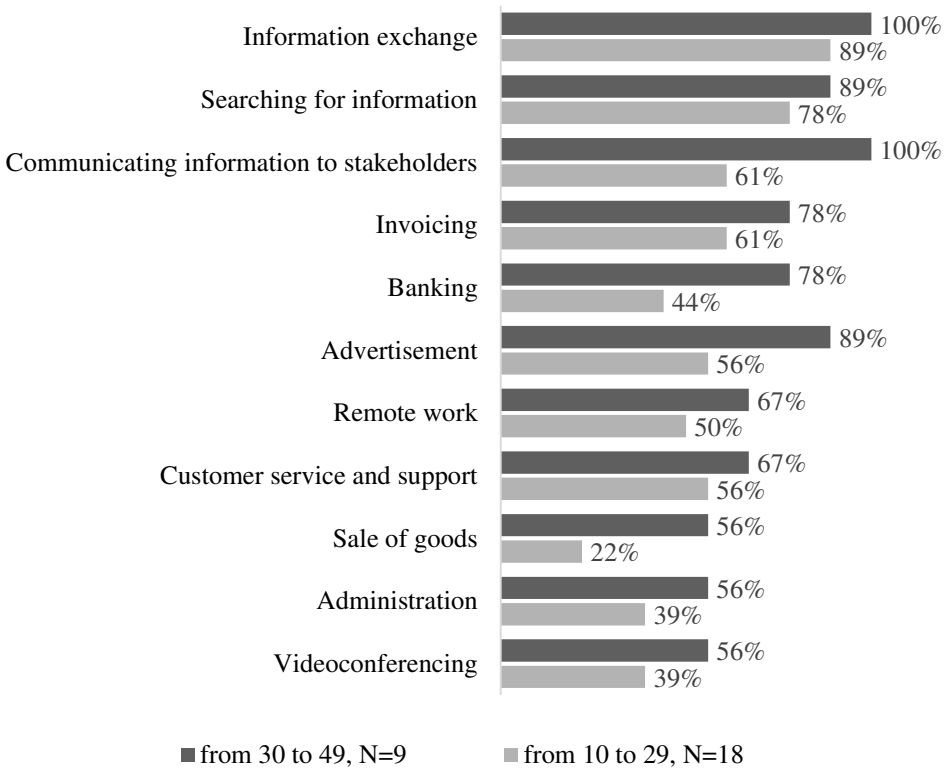

Figure 1. Business activities conducted by small enterprises by number of persons employed.
Source: own elaboration.

A higher proportion of enterprises with between 30 and 49 people employed use the Internet more frequently for each of the activities mentioned. It is much more common for larger companies to use the network to communicate with stakeholders, sell goods and conduct banking transactions. Hypothesis 2 can therefore be assumed that enterprises with fewer employees perform fewer business activities via the Internet.

The third hypothesis stated that smaller enterprises with a wider range of activities use more Internet tools in their activities. The frequency with which tasks are conducted using tools was considered because tools can be said to be in use when they become part of the company's daily practice. Figure 2 presents data on the percentage of international, national and local companies that use each online tool frequently and very frequently (answers '4' and '5').

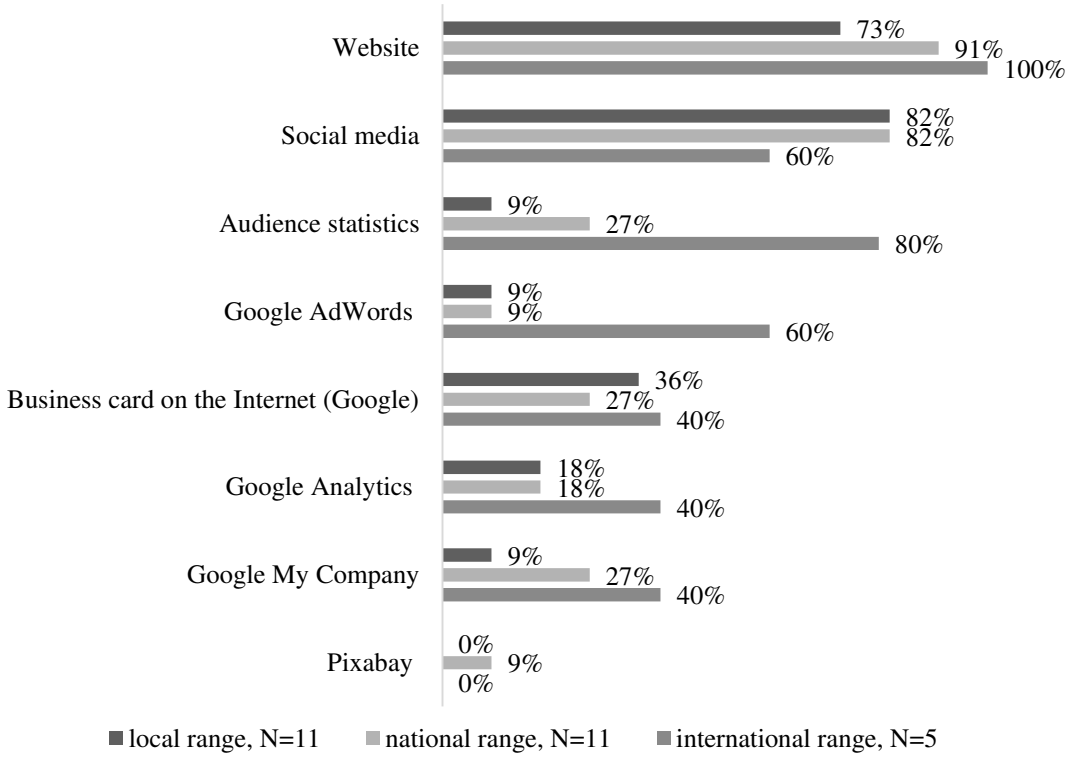

Figure 2. Internet tools used by small enterprises divided by business coverage.
Source: own elaboration.

All of these tools, except Pixabay, are used by a higher proportion of internationally active companies. Two tools – Pixabay and social media – are used by a higher proportion of national and local companies. In order to verify hypothesis 2, the rank method was used, which consists of ranking the observations due to one variable and giving them new values in the form of ranks. Descending order was used (highest frequency – rank 1). The data are presented in Table 3.

Table 3.
Ranks of enterprises according to frequency of Internet tool use

Area of enterprise activity	Website	Social media	Audience group statistics	Google AdWords	Business card on the Internet	Google Analytics	Google My company	Pixabay	Sum of ranks
International	1	2	1	1	1	1	1	2	10
National	2	1	2	2	3	2	2	1	15
Local	3	1	3	2	2	2	3	2	18

Source: own elaboration.

Enterprises functioning internationally have the lowest rank sum and thus the highest frequency of Internet tool use. Therefore, there is no reason to reject Hypothesis 3.

Hypothesis 4 concerned the achievement of effects by the surveyed enterprises through the use of Internet tools. Respondents rated on a scale from 1 – no effect, to 5 – significant effect (Table 4).

Table 4.
Evaluation of the effects obtained by the enterprises through the use of the Internet (number of responses)

Internet tools	Rating					Average rating
	1	2	3	4	5	
We receive inquiries about products/services via the Internet	1	0	3	13	10	4.1
We are able to respond to customer enquiries more efficiently	1	1	4	9	12	4.1
More customers are aware of the existence of our company	1	1	7	7	11	4.0
We have improved our company image	1	3	5	8	10	3.9
We achieved higher revenues	1	2	6	10	8	3.8
We achieved goals that would not otherwise have been possible or would have been too costly	1	2	8	7	9	3.8
We started to use new forms of communication within the team	2	1	7	10	7	3.7
We receive orders for products/services via the Internet	1	5	5	7	9	3.7
We provide a better standard of service to our customers	1	2	8	9	7	3.7
We conduct more effective marketing activities	2	1	6	12	6	3.7
We have improved the flow of information in the company	3	3	4	9	8	3.6
We have succeeded in gaining a competitive advantage	2	2	11	7	5	3.4
We eliminated the need for personal contact with stakeholders	4	5	4	8	6	3.3
We have reduced or eliminated some costs	3	6	7	8	3	3.1
We have dispensed with the support of intermediaries during the transaction	6	3	5	7	6	3.1
We started operations in foreign markets	17	5	0	1	4	1.9

Source: own elaboration.

Significant effects were achieved by small enterprises in the area of communication with customers (first two positions in Table 4) – answers '4' and '5' were given by more than 78% of respondents. Almost 67% said that the Internet had helped to raise awareness of the existence and improve the company's image, as well as generate more revenue. In order to verify hypothesis 4, Figure 3 presents data on the percentage of surveyed units in each age group who rated the effects achieved as significant ('4' and '5' responses).

In most cases, the units with up to and including three years of experience in the market stated that they had achieved significant results through the use of Internet tools. All of them confirm that customer awareness of the company's existence has increased and that they are receiving significantly more enquiries about products and services via the Internet. By using descending rankings, the sum of the ranks of the older companies was 28, the younger ones 19. Hypothesis 4 can therefore be considered confirmed.

Figure 3. Effects obtained by small enterprises through the use of the Internet divided by the age of the enterprises.

Source: own elaboration.

Subsequently, respondents were asked whether the COVID-19 pandemic had increased the use of the Internet in the company's activities. A positive response was given by 15 of them. Most enterprises have introduced activities that are new to them, such as remote working, video conferencing and online advertising. The next question related to enterprises' intentions to expand their use of the Internet. It was addressed to all respondents, regardless of whether they use the Internet or not (N=30). The responses are shown in Figure 4.

Figure 4. Enterprises' intentions to expand their activities via the Internet.

Source: own elaboration.

Respondents relate the future to Internet entrepreneurship, with the vast majority planning to develop activities in this area – 26 people gave a positive response.

6. Conclusions

Small enterprises use the Internet and simple, generally available Internet tools in their activities. The information obtained during the research provides a positive assessment of entrepreneurs' intentions in the area of digitalisation. There is a general agreement that many tasks can be performed more efficiently and effectively thanks to the opportunities ICT provides. The Internet is growing in number of users every year and is constantly creating new and realisable business opportunities. In the hands of competent entrepreneurs, it can be a powerful tool. The survey did not ask about the extent to which units were prepared for the development of Internet entrepreneurship in terms of organisation, technology and competence. These are the directions of further scientific research of the authors. The respondents' answers on the tools used and the results obtained show that enterprises mainly use tools that do not require specialised knowledge.

The results presented here have some limitations due to the pilot nature of the study, non-random sampling and small number of respondents. However, some recommendations can be made. Primarily, the focus should be on strengthening digital managerial competencies. Knowing how ICT can improve existing processes and tasks is now essential. In a small business, it is often not possible – or even necessary – to employ specialists such as IT experts, analysts or programmers. It is possible to use the outsourcing of IT services effectively. Strengthening Internet entrepreneurship can be done by applying for European Union funding for the computerisation of SME enterprises. Another opportunity that small business representatives can take advantage of is to collaborate with universities that teach and conduct research in computer science, digital technologies, artificial intelligence, etc. Students in internships and dissertations under the guidance of experienced researchers and practitioners can provide significant support for digitisation processes.

Small business may need a radical transformation to operate effectively in the evolving digital economy. Virtual reality is constantly creating new opportunities through the emergence of innovative digital technologies and infrastructure. In addition to opening up new opportunities for entrepreneurs, digitisation has a wider impact on value creation and capture (Nambisan et al., 2019). According to P. Kubisiak, the challenges facing today's entrepreneurs are extremely difficult. However, they constantly require the search for new strategies and the introduction of changes, significantly impeding their functioning. Those who are able to build value in these unpredictable and volatile conditions, however, achieve high levels of leadership, management and strategic mastery (Kubisiak, 2023).

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SPATIAL VARIATIONS IN THE LEVEL OF ENTREPRENEURSHIP IN EUROPEAN UNION COUNTRIES

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Purpose: Entrepreneurship, coupled with competitiveness and innovation, is currently a major driver of socio-economic development, contributing to the creation of new jobs and enhancing the prosperity of local communities. The aim of this study is to analyze and evaluate the level of entrepreneurship in the European Union (EU) countries in 2020, highlighting the similarities in entrepreneurship levels across the examined countries.
Design/methodology/approach: The ease of doing business index was used to assess the level of entrepreneurship and to rank EU countries in terms of their entrepreneurial environment. To supplement this research, Ward's method was employed to identify clusters of geographical units with similar levels of entrepreneurial potential.
Findings: Levels of entrepreneurship vary significantly among EU countries. The study identified countries with very low, low, high, and the highest levels of entrepreneurial potential. The substantial gap between top-ranking countries and those at the end of the list points to significant territorial disparities in the level of entrepreneurship within EU countries.
Social implications: Investigating the level of entrepreneurship is a vital aspect of assessing the socio-economic development of geographical units and the living standards of local communities. Therefore, understanding the nature of spatial differentiation in entrepreneurship levels across countries is essential. This understanding plays a significant role in shaping the socio-economic development of geographical units and influences the realization of development priorities for individual countries and the EU as a whole. Entrepreneurship is one of the pillars of the European Employment Strategy, aimed at reducing unemployment levels, and consequently, poverty and social exclusion.
Originality/value: The findings of this research can aid in entrepreneurship management by state governments, especially in terms of facilitating business start-ups and modifying the financial and tax systems to better cater to entrepreneurs' needs. Moreover, the results of this analysis can serve as a knowledge source for both national and regional economic policy actors, as well as EU policymakers. It provides valuable insights into public support strategies aimed at enhancing entrepreneurship levels in future development programming perspectives.

Keywords: Entrepreneurship, Socio-economic development, European Union, Ease of Doing Business Index, Ward's Method.

Category of the paper: Research paper.

1. Introduction

Entrepreneurship, coupled with competitiveness and innovation, is currently a major driver of socio-economic development, contributing to the creation of new jobs and enhancing the prosperity of local communities. Entrepreneurship, in its broadest sense, poses a significant challenge, especially in today's modern knowledge and information-based economy. This fresh knowledge is pivotal in molding the information revolution, which, as per K. Wach, "(...) is swiftly and dynamically undergoing redefinition and reconfiguration towards the entrepreneurial revolution. The entrepreneurial society has indeed become the bedrock of the economy and economic growth" (Wach, 2014, pp. 14-15).

Given the interdependencies that exist at the entrepreneurial, regional, and national levels, the entrepreneurial environment is a crucial factor in activating territorial units. The aim of this study is to analyze and evaluate the level of entrepreneurship in the European Union (EU) countries in 2020, highlighting the similarities in entrepreneurship levels across the examined countries. The analysis covers the year 2020, – utilizing complete, current data from the Doing Business Database.

To fulfill the research objective, the synthetic index of ease of doing business was assessed, and Ward's clustering method (1963, pp. 236-244) was utilized. Based on this indicator, the ranking of EU countries in terms of entrepreneurship levels was determined, while cluster analysis helped identify groups of geographical units with similar levels of entrepreneurship. The focus of this article is the territorial aspect of variations in entrepreneurial potential across the 27 EU countries in 2020. To comprehensively present the issue, we employed the ease of doing business indicator, sub-indicators (10 categories), and a set of diagnostic variables. Data from the Doing Business Data Bank (Doing Business 2020) was used to evaluate the level of entrepreneurship. While working towards the research objective, special attention was given to spatial variations in the level of entrepreneurship among the studied countries. The analysis enabled us to identify countries with very low, low, high, and the highest levels of entrepreneurship.

2. Entrepreneurship – conceptual scope

Entrepreneurship is a complex and multifaceted subject, which explains why a unified theory of entrepreneurship has yet to emerge. Despite the plethora of terms for the concept, finding a precise definition of this economic category in literature is challenging. This topic attracts scholars from various economic and social fields. Consequently, representatives of many scientific disciplines – including economics, demography, law, psychology, sociology,

political science, cultural studies, and management – have addressed the issue of entrepreneurship (Kapusta, 2006, p. 17; Ferreira et al., 2017). The different methods, research techniques, goals, and planes of analysis have not contributed to a clear and universal definition. However, most attempts to interpret this concept emphasize its economic aspect (Duraj, Papiernik-Wojdera, 2010, pp. 19-21). In economics, entrepreneurship is definitively linked with the activities of economic agents aiming at generating maximum profits through efficient resource allocation.

The pioneers of the scientific approach to entrepreneurship were: R. Cantillon and J.B. Say. It's widely accepted that the term "entrepreneurship" first started to be used by J.B. Say, who also categorized types of entrepreneurs. Say believed that entrepreneurship's essence is found in the entrepreneur's behavior, who relocates economic resources from less productive to more productive areas, thus increasing production and enabling higher profits (Piecuch, 2010, p. 15). For both Cantillon and Say, the entrepreneur's primary function was risk-bearing.

Contemporary scientific research on understanding the nature of entrepreneurship refers mainly to the theories of J. Schumpeter, F. Knight, and the Austrian School (Gaweł, 2007, p. 14). According to these schools of thought, entrepreneurship is:

- "The introduction of new combinations of company organization – new products, services, sources of raw materials, production methods, markets, and forms of organization" (J. Schumpeter);
- "Earning profits in exchange for bearing uncertainty and risk" (F. Knight);
- "Bearing uncertainty, coordinating production resources, innovating, and providing capital" (B. Hoselitz);
- "A purposeful activity aimed at establishing and developing a profit-oriented business" (A. Cole) (Gołębiowski, 2014, p. 11).

The abundance of definitions and diverse interpretations, along with the concept's multifaceted nature, make it challenging to determine a universal definition of entrepreneurship. However, it can be considered from the following perspectives (Makieła, 2008, p. 9):

1. The process: Entrepreneurship as the act of building and creating something new, such as a new business. It's an organized sequence of actions, under given premises, that utilizes an innovative idea to generate financial gains in the market. This perspective emphasizes the ability to seize opportunities, innovate, and manage risks and uncertainties.
2. Traits: A set of characteristics that describe an entrepreneur's actions. Traits such as activity, dynamism, a willingness to take risks, adaptability to change, and an ability to recognize and seize opportunities are typically associated with entrepreneurship.
3. Innovation: This relates to the introduction of newness, reform, and improvement across all spheres and areas. Any enhancement of equipment and machinery, system reform, or creation of new things, values, or phenomena can be considered innovative.

H. Landström further identifies three functions of entrepreneurship as a scientific discipline (Landström, 2010, pp. 11-13; cited in: Wach, 2014, pp. 14-15):

- Entrepreneurship as a market function;
- Entrepreneurship as a function of the individual entrepreneur;
- Entrepreneurship as a process, distinguishing between the process of creating new products and the process of discovering opportunities.

Furthermore, entrepreneurship can be understood in both narrow and broad terms (Guerrero et al., 2020; Gumbau-Albert, 2017). The narrow understanding of entrepreneurship captures it as the act of starting a new or managing one's own business (Doing Business, 2020; Ferreira et al., 2017; Markowska et al., 2019). This approach enables measuring entrepreneurship, for instance, through the proportion of newly established companies in the total number of firms active in the market. On the other hand, a broad definition of entrepreneurship entails the search for and exploitation of market opportunities, the implementation of innovations, and risk-taking (Markowska et al., 2019; Sanjay, Karri, 2006; García-Peñalosa, Wen, 2008). Entrepreneurship can occur at different levels: companies - micro level (Larsson, Thulin, 2019; Wach, 2015, pp. 28; Audretsch, Link, 2019; Audretsch, Link, Lehmann, 2020; Link, Morris, van Hasselt, 2021), regions - meso level (Fritsch, Wyrwich, 2014; Huggins et al., 2017), and countries - macro level (Saunoris, Sajny, 2017; Ferreira et al., 2017; Nițu-Antonie, Feder, Munteanu, 2017; Rodrigues, Brás, Soukiazis, 2019). Some literature also highlights entrepreneurship within industries, sectors, or social groups, such as women (Hopp, Martin, 2017).

Presently, entrepreneurship is widely seen as a factor of production alongside labor, land, and capital. It plays a role in the creation and implementation of products, boosting the regional economy (Jędrzejewski, 2015, p. 56). The primary elements of the entrepreneurial environment, as identified by theorists, include an innovative environment, institutional infrastructure, and a favorable social climate. A well-ordered combination of these elements is crucial for stimulating regional development (Huggins, Thompson, 2015, pp. 105-106; Jędrzejewski, 2015, p. 49; Glinka, Gudkova, 2011, pp. 53-55).

Assessing the influence of entrepreneurship on regional development is a much-discussed topic. Theorists D. Valerie and R. Peterson (2009, p. 462) contend that entrepreneurship impacts regional development through efficient resource utilization, innovative activities, and heightened competition. These effects are long-term, becoming apparent over time. For entrepreneurship to effectively contribute to a region's development, the region needs to have supportive economic, psychological, legal, and institutional conditions, along with a strategic utilization of its academic potential (Kola-Bezka, 2010, p. 404; Aparicio, Urbano, Audretsch, 2015).

3. Research methodology

The "Ease of Doing Business" index was employed to examine the variation in entrepreneurship levels across EU countries[1]. This index was devised by World Bank[2] economists and has been published since 2005 under the name "Doing Business: Comparing Business Regulation in 190 Economies". A country's ranking is based on the average of the following ten sub-indicators (Doing Business, 2020, Comparing..., p. 5):

1. Starting a Business: Procedures, time, cost, and paid-in minimum capital required to establish a limited liability company for both men and women.
2. Dealing with construction permits: Procedures, time, and cost to complete all the formalities required to construct a warehouse, along with the quality control and safety mechanisms in the construction permitting system.
3. Getting electricity: Procedures, time, and cost to get connected to the electrical grid, the reliability of the electricity supply, and the transparency of tariffs.
4. Registering property: Procedures, time, and cost to transfer property, and the quality of the land administration system for both men and women.
5. Getting credit: Movable collateral laws and credit information systems.
6. Protecting minority investors: Rights of minority shareholders in related-party transactions and in corporate governance.
7. Paying taxes: Payments, time, and total tax and contribution rate required for a company to comply with all tax regulations as well as post-filing processes.
8. Trading across borders: Time and cost to export the product of comparative advantage and to import auto parts.
9. Enforcing contracts: Time and cost to resolve a commercial dispute, and the quality of judicial processes for both men and women.
10. Resolving insolvency: Time, cost, outcome, and recovery rate for a commercial insolvency and the strength of the legal framework for insolvency.

The report provides data on individual indicators, as well as two aggregate measurements, which include:

- ease of doing business ranking;
- Distance to Frontier (DTF) Index: a measurement that indicates how far an economy (on average) deviates from the best performance achieved by any of the 190 surveyed economies under each of the developed indicators.

[1] It's worth noting that in the World Bank's research, entrepreneurship is seen as the process of starting and running a business (Doing Business, 2020).

[2] Other organizations studying entrepreneurship in the European market include the OECD, the European Commission, and the Global Entrepreneurship Monitor.

The score is normalized from 0 to 100, where 0 is the lowest value and 100 represents the best practice limit. A higher ranking signifies better, typically simpler, regulations for conducting business and stronger protections for property rights.

Regrettably, the index was discontinued in 2021 due to controversy over its calculation and ranking. Thus, 2020 was the last year in which entrepreneurship research was conducted utilizing this index[3]. However, in May 2023, The World Bank published a methodology to replace the existing index[4].

The calculated indicator was utilized to rank EU countries in terms of the identified level of entrepreneurship. The value of the ease of doing business index facilitated the categorization of countries into four groups according to their levels of entrepreneurship (Zeliaś, 2000):

I Countries with the highest levels of entrepreneurship, $w_i \geq \overline{w_i} + S_{wi}$;

II Countries with high levels of entrepreneurship, $\overline{w_i} \leq w_i < \overline{w_i} + S_{wi}$;

III Countries with low levels of entrepreneurship, $\overline{w_i} - S_{wi} \leq w_i < \overline{w_i}$;

IV Countries with very low levels of entrepreneurship, $w_i < \overline{w_i} - S_{wi}$.

where:

w_i – value of the synthetic indicator;

$\overline{w_i}$ – arithmetic mean of the synthetic indicator;

S_{wi} – standard deviation of the synthetic indicator.

The analysis was supplemented by spatial classification of units based on their potential to foster entrepreneurship using cluster analysis. The premise of this analysis is the segmentation of data to identify homogeneous objects within the population studied. The division of a group into individual groups is carried out in such a way as to obtain clusters in which the elements in the same group are similar to each other and at the same time different from the elements in the other groups (Gatnar, Walesiak, 2004).

Ward's method, which belongs to the hierarchical methods of object classification, was used to group EU countries into clusters. This method minimizes the sum of squares of distances from the centroid of the newly formed cluster. Consequently, a group will comprise objects that are least differentiated by the describing variables. Thus, Ward's method ensures homogeneity within clusters and heterogeneity between clusters, and therefore is considered to be most effective (Panek, Zwierzchowski, 2013; Ward, 1963; Strahl, 2006; Młodak, 2006; Szkutnik et al., 2015). The analysis produces a dendrogram, which graphically interprets the results. The next stage of the research involves determining the optimal number of classes.

[3] The United Kingdom was excluded from the research because it ceased to be a member of the EU as of February 1, 2020, despite a "transition period" in mutual relations stipulated by the EU Withdrawal Agreement.

[4] The World Bank Group launched a new flagship initiative called the Corporate Business Ready (B-READY) program, which annually assesses the business and investment environment worldwide. B-READY enhances and replaces the Doing Business program (Business Ready).

The research was conducted using standardized variables[5] derived from World Bank data, with Euclidean distance used for clustering. The analysis using Ward's method enabled the clustering of countries that are most similar to each other and maximally different from others in terms of the selected characteristics determining the level of entrepreneurial potential. The resulting synthetic entrepreneurship index W_i takes values between 0 and 100. A value closer to 100 indicates that the object (country) has a higher level of entrepreneurship. In the conducted study, a critical value was determined on the basis of the analysis of the graph of the course of agglomerations. After observing the largest increment, in which numerous clusters are formed approximately at the same connectivity distance, there is a cut-off dividing the set into classes.

4. Level of entrepreneurship in European Union countries in 2020 based on the ease of doing business index

The World Bank's Doing Business 2020 report provides a relevant ranking for assessing the ease of doing business, which is instrumental for our subject of study – the level of entrepreneurship. It is worth noting that the World Bank's analysis encapsulates entrepreneurship as the process of initiating and operating a business. Leveraging the synthetic index of the ease of doing business, we constructed a ranking of EU member states according to their entrepreneurial potential (refer to Table 1 and Figure 1). The values of the sub-indicators are shown in Figure 2. The countries under study were categorized into groups with the highest, high, low, and very low levels of entrepreneurial potential, utilizing the arithmetic mean and standard deviation of the synthetic indicators. The classification of countries based on the entrepreneurship index revealed significant disparities in their potential. The gap between the highest value of 85.29 (achieved by Denmark) and the lowest value of 66.14 (achieved by Malta) in 2020 was a substantial 19.15 points.

Table 1.
Level of entrepreneurship in European Union countries in 2020 based on the ease of doing business index

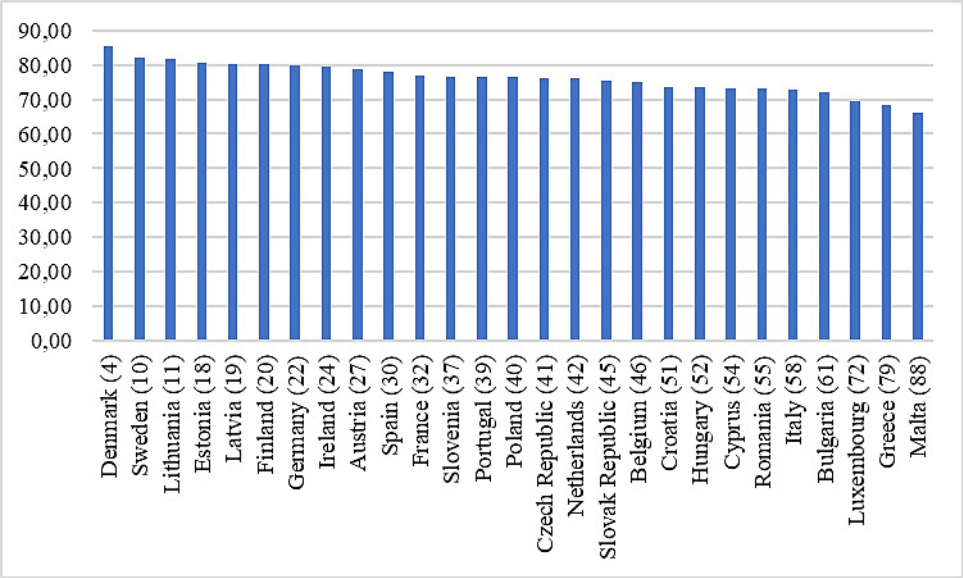
Ranking position	Country	Indicator value *Wi*
Group of countries with the highest level of entrepreneurship		
$Wi \geq 80.59$		
1.	Denmark	85.29
2.	Sweden	81.99
3.	Lithuania	81.62
4.	Estonia	80.62

[5] Statistica 13.1 software was used for the calculations.

Cont. table 1.

Group of countries with the high level of entrepreneurship		
$76.22 \leq Wi < 80.59$		
5.	Latvia	80.28
6.	Finland	80.18
7.	Germany	79.71
8.	Ireland	79.58
9.	Austria	78.75
10.	Spain	77.94
11.	France	76.80
12.	Slovenia	76.52
13.	Portugal	76.47
14.	Poland	76.38
15.	Czech Republic	76.34
Group of countries with a low level of entrepreneurship		
$71.84 \leq Wi < 76.22$		
16.	Netherlands	76.10
17.	Slovak Republic	75.59
18.	Belgium	74.99
19.	Croatia	73.62
20.	Hungary	73.42
21.	Cyprus	73.35
22.	Romania	73.33
23.	Italy	72.85
24.	Bulgaria	71.97
Group of countries with a very low level of entrepreneurship		
$Wi < 71.84$		
25.	Luxembourg	69.60
26.	Greece	68.42
27.	Malta	66.14

Source: own study based on Doing Business 2020 and Doing Business 2020. Region Profiles European Union (EU).



*In parentheses are the positions of EU countries in the ranking of 190 countries in the world.

Figure 1. Spatial variation of the level of entrepreneurship in EU countries in 2020.

Source: own study based on data from Table 1.

The countries with the highest level of entrepreneurial potential in 2020 were: Denmark, Sweden, Lithuania and Estonia[6]. The entrepreneurship index in these countries ranged from 85.3 to 80.6 and was 1.1 to 1.05 times higher than the EU average. These countries thereby hold a significant business advantage over other member countries. One determining factor of each country's ranking is the procedure for establishing a business, which is primarily seen by entrepreneurs as a key driver of entrepreneurship.

Denmark led the ranking primarily due to its top position in the sub-indicator: Dealing with construction permits, scoring 87.88 points (Fig. 2b). In other categories, Denmark secured high positions, ranging from 3rd to 5th, with an 11th place ranking among EU countries for Starting a Business (Fig. 2a). Danish law contains the fewest procedures, which have been streamlined over the years. Denmark has taken steps to make it easier to start a business by lowering the minimum capital requirement for limited liability companies from $22,850 to $14,620 in 2011, enabling real estate registration and introducing electronic filing of land registry transfer applications in 2013, reducing the required minimum capital again in 2015, introducing an online platform to complete business and tax registration simultaneously in 2016, and reducing the cost of obtaining building permits and eliminating building permit fees in 2020. It's noteworthy that the average period in Denmark, as well as in the Netherlands, from submission of documents to receipt of confirmation of registration is the shortest among the EU countries at 3.5 calendar days. The cost of setting up a company, analyzed as a percentage of per capita income, is among the lowest in Denmark at 0.20% of income (in Slovenia it is zero). However, the combined tax and contribution rate calculated as a percentage of profit was 23.80% (5th in the EU). Notably, Denmark ranked 4th out of 190 countries worldwide, trailing only New Zealand, Singapore, and Hong Kong SAR, China (Fig. 1).

[6] Chapter 4 of the article is based on Doing Business 2020. Comparing Business Regulation in 190 Economies and Doing Business 2020. Region Profiles European Union (EU).

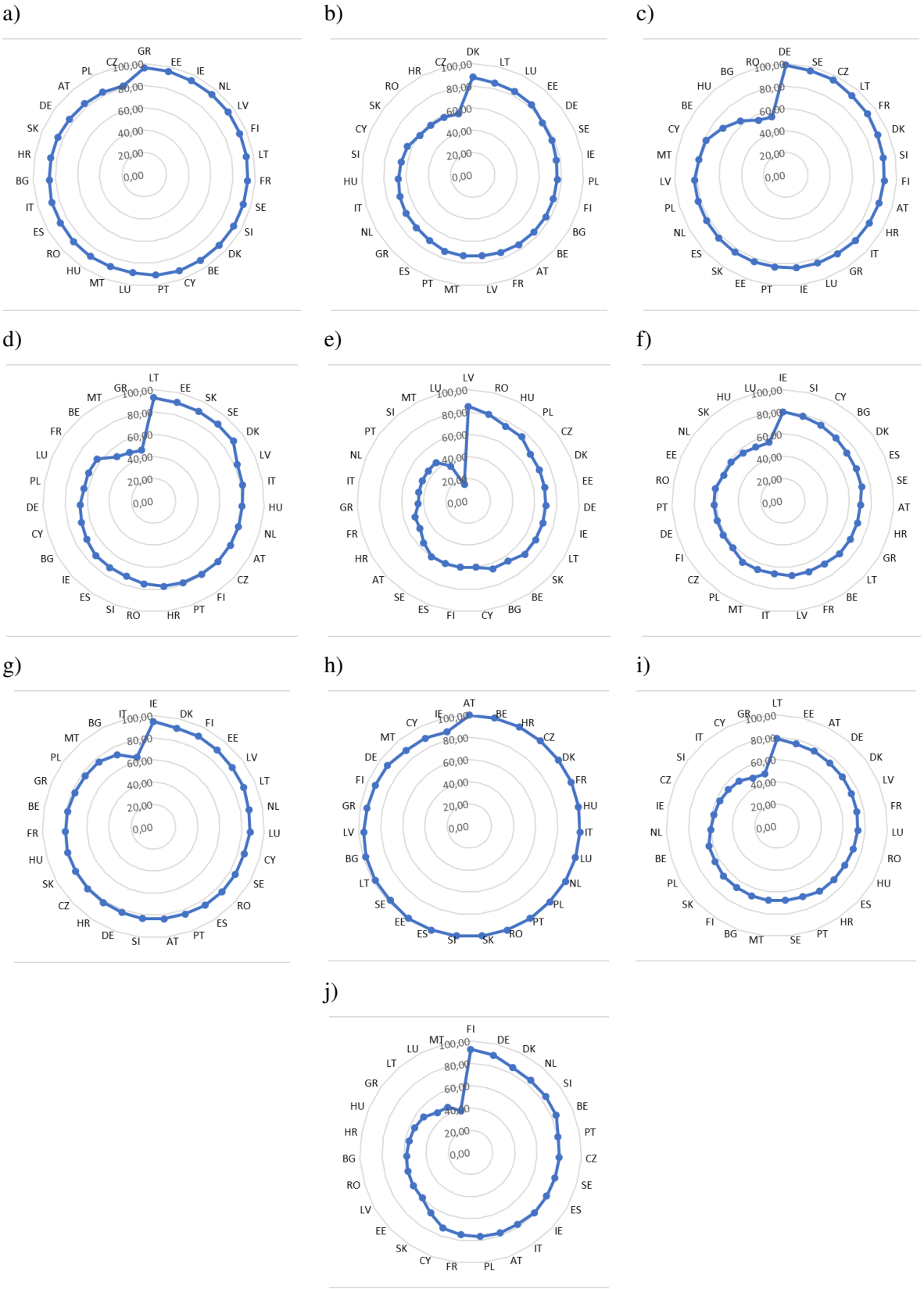


Figure 2. Values of the sub-indicators in European Union countries in 2020
a) Starting a business; b) Dealing with construction permits; c) Getting electricity; d) Registering property e) Getting credit; f) Protecting minority investors g) Paying taxes; h) Trading across borders; i) Enforcing contracts; j) Resolving insolvency.

Source: own elaboration based on Doing Business database.

Sweden's potential for entrepreneurship was mainly determined by high scores in the sub-indicators for the following categories: Getting Electricity (2nd position; 96.21 points), Registering Property (4th position; 90.11 points), Dealing with Construction Permits (6th position; 78.05 points), Protecting Minority Investors (7th position; 72 points) and 9th position for the category: Starting a Business and Resolving Insolvency with sub-indicator values of 93.11 points and 79.51 points, respectively (Fig. 2a-d, 2f, 2j). Over the years, Sweden's procedures for establishing and operating businesses have evolved to reduce restrictions. Among the changes made were: in 2011, it became easier to register real estate, the requirement to obtain a waiver of pre-emption from the municipality was eliminated, investor protection was strengthened by requiring greater corporate disclosure, and transactions between interested parties were regulated. Additionally, the minimum capital requirement for limited liability companies was halved. Sweden reduced the corporate income tax rate in 2014, facilitated real estate registration by fully implementing a new real estate registration system in 2015, required company registration with the Companies Registry within five days in 2016, and facilitated property transfers by increasing administrative efficiency and introducing a so-called independent and separate map error reporting mechanism in 2017. The average time to set up and confirm a business in Sweden is 7.5 calendar days, which is in line with the rest of the Nordic countries. The cost of starting a business in Sweden, calculated as a percentage of per capita income, is 0.5%. The combined tax and contribution rate analyzed as a percentage of profit was 49.10%, which put Sweden in 20th place in the EU. Notably, entrepreneurship in Sweden was characterized by sub-indicators that exceeded the average values for the EU for the 9th category, with the exception of the Getting Credit category, which was at the same level for both the EU countries and Sweden, at 60.0 points (Fig. 2e). In terms of entrepreneurial potential, Sweden ranked 10th among the world economies surveyed (Fig. 1).

Lithuania ranked 4th in the group of countries with an entrepreneurship index of $Wi \geq 80.59$ (index score of 81.62 points). The country's high ranking was primarily due to high scores in the following categories: Registering Property (1st place; 92.97 points), Enforcing Contracts (1st place; 78.80 points), Dealing with Construction Permits (2nd place; 84.87 points), Getting Electricity (4th place; 92.94 points), and Paying Taxes (6th place; 88.81 points) – Fig. 2b-d, 2g, 2i). Lithuania ranks weakest for the Resolving Insolvency sub-indicator (25th; 46.69 points) – Fig. 2j. In the Registering Property category, the registration time is 3.5 calendar days, and the cost calculated as a percentage of the value of the property was 0.8%, which is less than six times lower than the EU average. This is one of the lowest values among all EU countries, earning Lithuania 3rd place after Poland and the Slovak Republic. Lithuania has a limited number of procedures (4) and a short establishment time of 5.5 calendar days, which is more than 2.2 times faster than the average time in the EU. The cost of starting a business accounted for 0.50% of per capita income, which was more than six times lower than the EU average. However, the minimum value of paid-in capital, analyzed as a percentage of per capita income, was 16.0%, two times higher than the EU average. In Lithuania,

the combined tax and contribution rate (as a percentage of profit) was 42.60%, 2.4 percentage points higher than the EU average. All these indicators are the result of measures Lithuania has taken to improve the level of entrepreneurship; among them are:

- making it easier to start a business by introducing online registration of limited liability companies and eliminating the notarization requirement for incorporation documents (2013);
- strengthening the secured transactions system by expanding the scope of movable property that can serve as collateral (2014);
- making it easier to start a business by eliminating the need for a company stamp and speeding up value-added tax (VAT) registration (2015);
- making it easier to start a business with the introduction of online VAT registration (2016);
- getting electricity: speeding up the acquisition of electricity due to the introduction of a time limit for the power company to carry out the necessary connection procedures and a reduction in the connection tariff (2017);
- getting electricity: making it easier to procure electricity by streamlining procedures and imposing deadlines for issuing internal electrical installation inspection certificates (2018) and launching an integrated digital application and reducing the cost of new connections (2020);
- protecting minority investors: strengthening protection for minority investors by increasing corporate transparency (2018) and introducing greater disclosure requirements for individual compensation of directors and other senior officers (2019);
- paying taxes: facilitating tax payments by introducing an electronic filing and payment system for VAT, CIT, and social security contributions (2018);
- trading across borders: facilitating exports by improving the automated customs data management system (2019);
- revising regulations on working time, paid annual leave, as well as notice period and severance pay in case of dismissal (2019).

It should be noted that Lithuania ranked high, 11th in the entrepreneurship ranking among the 190 world economies analyzed (Fig. 1). This result is not surprising when considering the aforementioned measures aimed at improving entrepreneurship conditions.

Estonia also recorded a high ease of doing business index at 80.62 points. The country's entrepreneurship stood out for its high levels in the sub-indicators Trading across Borders (99.92), Starting a Business (95.36), Registering Property (91.02), and Paying Taxes (89.88) – Fig. 2a, 2d, 2g, 2h). All these categories exceeded the EU average. Estonia's impressive results were primarily due to the limited number of procedures (3), a short business set-up time of 3.5 calendar days (the EU average was over 12 calendar days), and the cost of establishing a business, which accounted for 1.0% of per capita income and was lower than the EU average

(3.20%). In contrast, the minimum value of paid-in capital was 13.10%, which was 0.6 times the EU average. Note that this value is zero in the following countries: Belgium, Bulgaria, Cyprus, Czech Republic, France, Greece, Ireland, Italy, Latvia, Netherlands, and Portugal. The tax system in Estonia is also significant in the context of entrepreneurship; the combined tax and contribution rate (as a % of profit) was 47.80%, exceeding the EU figure by 1.2 times. Estonia has implemented several changes to enhance the level of entrepreneurship. These include: improving access to credit by enabling out-of-court enforcement of collateral (2011), increasing the premium rate for unemployment insurance (2011), amending Estonia's bankruptcy law to increase the survival chances of viable companies facing insolvency by streamlining procedures and changing qualification requirements for bankruptcy administrators (2011), removing the restriction on night work and shortening the notice period and severance pay applicable to layoffs (2011), easing contract enforcement by reducing court fees (2014), and simplifying business startups by allowing minimum capital to be paid at the time of company registration (2016). Estonia ranked 18th in the entrepreneurship ranking of world economies (Fig. 1).

The largest group, in 2020, consisted of the following 11 countries with high levels of entrepreneurship: Latvia, Finland, Germany, Ireland, Austria, Spain, France, Slovenia, Portugal, Poland, and the Czech Republic. Latvia ranked highest in the categories of: Starting a Business (5; 94.14pts), Paying Taxes (5), Registering Property (6), and Enforcing Contracts (6) – Fig. 2a, 2d, 2g, 2i). The indicators for doing business in Latvia include: the number of procedures (4), the time it takes to set up a business - 5.5 calendar days (2.2 times longer than the average time in the EU), and the cost of setting up one's own business, which accounted for 1.5% of per capita income and was 1.7 percentage points lower than the EU average. In 2019, Latvia increased the cost of paying taxes by increasing the effective corporate tax burden and in 2018 made it easier to enforce contracts by introducing an electronic case management system for judges. Latvia ranked 19th in the Doing Business ranking (Fig. 1).

Finland ranked first for the Resolving Insolvency sub-indicator, with a value of 92.69 pts (Fig. 2j). Setting up a business in the country takes 13 days, and the cost of starting a business is 0.70%, 4.5 times lower than the EU average. The total tax and contribution rate (% of profit) is 36.60%. Among the measures introduced in Finland in 2019-2020 are: lowering the cost of paying taxes, introducing a new, more efficient online portal for filing corporate income tax returns called "MyTax" (2018), and making it easier to start a business by reducing fees and processing time for online company registrations (2020). Finland reached 20th place in a ranking of 190 countries (Fig. 1).

Germany's third position in the high-entrepreneurship group, with a synthetic index value of 79.71, was primarily related to the high value of the Getting Electricity sub-indicators: 98.80 pts (1st place), Resolving Insolvency: 89.81 pts (2nd place), and Enforcing Contracts: 74.10 pts (4th place) – Fig. 2c, 2i-j. The number of procedures in Germany is nine, the time to set up a business is eight days, and the cost of setting up a business accounts for 6.5% of per

capita income, which is more than two times the EU average. Among the measures to strengthen entrepreneurship, the following should be highlighted: the adoption of a new bankruptcy law, which facilitated judicial restructuring of distressed companies and increased creditor participation (2013), and the facilitation of contract enforcement through the introduction of an electronic system for filing initial claims and electronic handling of the process without the need for paper documents (2020). Germany achieved 22nd place in the Doing Business 2020 ranking (Fig. 1).

Ireland was a leader in the fields of: Protecting Minority Investors (1st place), Paying Taxes (1st place), Starting a Business (3rd place), and Dealing with Construction Permits (7th place), with sub-indicator values respectively: 80.00; 94.59; 94.40; and 76.58 points (Fig. 2a-b 2f-g). However, the aggregate assessment of entrepreneurial potential was downgraded due to the low value of the indicator for the Trading across Borders category - the last position; the value of the sub-indicator was 87.25 points, and almost three-fifths of the countries reached the subject value of 100 points. While the time to set up a business in Ireland is long - 11 days - it is somewhat compensated by the low cost of 0.1% of per capita income, which is 32 times lower than the EU average. It should be noted that the Paid-in Minimum Capital (% of income per capita) in the studied country is zero. Strengthening entrepreneurial capacity has taken place in the country under study through: introducing an online business registration system (2013), protecting minority investors by introducing legislation stipulating that directors can be held accountable for breaches of their fiduciary duties (2016), facilitating contract enforcement by making a performance measurement report available to the public to show the court's performance (2018), introducing a consolidated law on voluntary mediation (2018), and improving access to credit information through a new credit registry (2019). In a ranking of 190 world economies, Ireland ranked 23rd (Fig. 1).

The entrepreneurial potential in Austria was competitive with other EU countries in the areas of Enforcing contracts (3rd place; 75.49pts) – Fig. 2i and Trading across borders (Fig. 2h). However, it should be noted that a value of 100pts for this sub-indicator was achieved by fifteen other countries besides Austria. In Austria, starting a business involves 8 procedures, the time to set up a business is rather long at 21 days (more than 1.6 times the EU average), and the cost of starting a business is 4.70% of per capita income (7th compared to other EU countries). The cost of registering property was 4.6% of the property's value, and the total tax and contribution rate (% of profit) is 51.40%, more than 1.3 times the Union average. Among the measures that have served to improve the level of entrepreneurship are facilitating property transfer by requiring all registration applications to be submitted online (2011), enacting a law that simplifies restructuring proceedings and gives priority to the interests of debtors (2012), and amending working time regulations (2020). In the aforementioned classification, Austria was ranked 27th among the world's economies – Fig. 1.

Spain recorded the highest sub-indicator for the Protecting minority investors category with a value of 72 points (Fig. 2f). For other categories, the indicators for Spain were at levels that ranked the country above the 10th position. In Spain, the time to set up a business was comparable to the EU average at 12.5 calendar days, while the cost was 3.9% of per capita income. However, the cost of registering property, analyzed as a percentage of the property's value, was 6.1%. Other taxes paid, calculated as a percentage of profit, amounted to 0.7%. Spain's efforts to ease the process of doing business included eliminating the requirement to obtain a municipal permit before starting a business, improving the efficiency of the commercial registry and simplifying business registration (2014), introducing an electronic system that connects several public agencies, reducing the statutory corporate tax rate (2015), strengthening protection for minority investors by requiring shareholder approval for major sales of company assets (2016), and clarifying ownership and control structures (2020), easing the process of obtaining electricity by upgrading Madrid's electricity grid (2017), and simplifying contract enforcement by reducing court fees for filing lawsuits (2018). Spain ranked 32nd in the global ease of doing business ranking (Fig. 1).

France ranked 34th in the Doing Business 2020 index, with a value of 76.80pts. France achieved the highest sub-indices for Getting electricity (5th place; 92.01 pts), Enforcing contracts (7th place; 73.47 pts), and Starting a business (8th place; 93.15 pts) – Fig. 2a, 2c, 2i). These metrics were reflected in the details, with 5 procedures, a timeline of 4 calendar days, and a start-up cost of 0.70%. It should be noted that the paid-in minimum capital is zero. In contrast, the cost of registering real estate was 7.30% of the property's value, and the cost of obtaining electricity was 5% of per capita income, which was the lowest among EU countries (approximately 23 times lower than the EU average). France has introduced numerous measures to facilitate entrepreneurial activities, including shortening the time for registering a company at a one-stop shop (2015), introducing a corporate tax credit and reducing the rate of labor tax paid by employers (2016), reducing the cost of obtaining construction permits (2017), reducing the rate of social security contributions and training (2018), making it easier to obtain electricity (2019), and changing the Labor Code regarding severance pay for employees after one, five, and ten years of employment.

Slovenia ranked 12th among EU countries in the level of entrepreneurship, with an index value of 76.52 pts. (37th in the world ranking – Fig. 1). Notably, Slovenia achieved a sub-indicator value of 78 pts in the Protecting minority investors category, ranking 2nd (Fig. 2f). Particularly commendable in this category is the indicator of the strength of minority investor protection, where Slovenia scored 39 pts out of a maximum value of 50 pts. The Resolving insolvency sub-index reached 84.40 pts, placing the country 5th globally (Fig. 2j). The process of setting up a business in Slovenia is relatively easy, involving just three procedures and incurring no start-up costs. Measures introduced to bolster entrepreneurship include utilizing more online services for business set-up (2011), streamlining the process of construction permits by removing the need for approval from the water and sewerage supplier

(2014), improving access to credit information (2018), and simplifying contract enforcement (2019). However, in 2019, Slovenia complicated the process of starting a business by mandating companies to declare beneficial ownership independently from the business set-up process.

Portugal scored 76.47 pts on the ease of doing business index, placing 39th in the Doing Business 2020 Ranking (Fig. 1). The country excelled in the Resolving insolvency category (80.17 pts – Fig. 2j; 7th place), boasting a resolution rate of 100%. Establishing a business in Portugal takes approximately 6.5 days, involves six procedures, and costs 1.90% of per capita income. The paid-in minimum capital in Portugal is zero. The total tax and contribution rate (% of profit) stands at 39.80%, in line with the EU average. Portugal has introduced various measures to enhance entrepreneurship, such as simplifying construction permits by streamlining the inspection system (2012) and enforcing strict time limits on urban project processing and simplification of the related procedures (2013), abolishing the obligation to report to the Ministry of Labor when starting a business (2014), accelerating the approval process for electrical connections (2017), reducing the corporate tax rate (2017), and limiting the maximum duration of fixed-term contracts (2017).

In the 2020 global ease of doing business ranking, Poland placed 40th among 190 economies (Fig. 1). Within the EU, Poland ranked 14th, with an index value of 76.38 pts. This was influenced by the sub-indicators for Getting credit (4th place; 75 pts) and Trading across borders (100pts alongside 14 other EU countries) – Fig. 2e, 2h. Within the latter category, four indicators show zero values: Time to export: Border compliance (hours), Cost to export: Border compliance (USD), Time to import: Border compliance (hours) and Cost to export: Documentary compliance and Cost to import: Documentary compliance (USD). Hence, these indicators each score 100 pts. In Poland, the process of setting up a business involves five procedures, a relatively long time frame of 37 calendar days, a start-up cost of 11.6% of per capita income, and a required minimum capital of 9.3% of per capita income. In recent years, Poland has implemented numerous reforms across the ten indicators measured by Doing Business, such as: Getting electricity: speeding up the procurement of electricity by implementing a new customer service platform to better track requests for new commercial connections (2020), Enforcing contracts: simplifying contract enforcement by introducing an automated system for randomly assigning cases to judges (2019), Dealing with construction permits: streamlining the process of obtaining a construction permit, Getting electricity: expediting electricity connections by eliminating the need for an excavation permit, which shortened the time of the aforementioned work, Resolving Insolvency: facilitating insolvency resolution by introducing new restructuring mechanisms, such as changing the voting procedure for restructuring plans and enabling greater creditor participation in bankruptcy proceedings.

The Czech Republic has the highest number of procedures to start a business - 9, and a long timeframe of 24.5 calendar days, which is twice the EU average. However, the cost of setting up a business is 1.1%, 2.1 percentage points lower than the EU average. The categories of Getting electricity and Getting credit are particularly commendable, with sub-indicator scores

of 95.58pts and 70pts respectively (Fig. 2c, 2e). Their corresponding global rankings are: 3 and 5, respectively. It's worth noting that the minimum paid-in capital as a percentage of per capita income is zero. The cost of obtaining a building permit is 0.20% of the warehouse value, which is 9.5 times lower than in other Union countries[7]. The cost of property registration is 4% of the property value, and the cost of enforcing contracts is 33.8% of the claim value. Positive changes in the Czech Republic that have improved entrepreneurship over recent years include accelerating tax payments by promoting electronic devices (2013), simplifying contract enforcement with changes to the Civil Procedure Code (2015), reducing the cost and time of business registration (2017), expediting electricity acquisition by assigning staff to handle all incoming applications (2017), and reducing business start-up costs by introducing lower fees for limited liability companies (2018). The Czech Republic ranks 15th among EU countries in terms of entrepreneurship, with an index value of 76.34 pts (Fig. 1).

Countries such as the Netherlands, Slovak Republic, Belgium, Croatia, Hungary, Cyprus, Romania, Italy, and Bulgaria form a relatively large group with an entrepreneurship index in the range of $71.84 \leq Wi < 76.22$. The Netherlands, ranked 16th, scored an index value of 76.10 pts. The country achieved its highest sub-index values in the Starting a business and Resolving insolvency categories, with respective scores of 94.34 pts and 84.42 pts (Fig. 2a, 2j). Factors like the number of procedures (4), the average business start-up time (3.5 days), and the start-up cost (4%) were favorable. The Slovak Republic achieved its highest sub-indicator values in the Registering property category, with an index value of 90.21 pts. The property registration procedure takes 3 days, and the registration cost is zero. Belgium, ranking 18th among all countries analyzed for entrepreneurial potential, scored 74.99 pts, below the EU average. The country's strengths lie in the Trading across borders (100 pts, shared with 14 other countries) and Resolving insolvency categories (6th place; 84.07 pts). The time to resolve insolvency is less than a year (compared to the EU average of over two years), the cost of the insolvency process is 3.5% of the asset value, and the resolution rate is 1% (the Union average is 1.85 pts). Croatia had the next highest sub-indicator for the Trading across borders category at 100pts. Setting up a business in Croatia involves seven procedures, takes 19.5 days, and costs 6.20% of per capita income (1.9 times the EU average). However, the lowest index was for Getting credit, at 50%. Croatia ranks 51st among global economies (Fig. 1).

Hungary and Cyprus rank 20th and 21st, respectively, in terms of entrepreneurship, with indicator values of 73.42 pts and 73.35 pts. Hungary stands out with a high sub-indicator value in the Getting credit category at 75 pts (Fig. 2e), and a Getting Credit total score of 12 pts (comparable to the EU average of 11.89 pts). The business establishment process in Hungary involves six procedures, takes seven days, and costs 4.5% of per capita income. Cyprus,

[7] Several methodological assumptions were made about the nature of the property under construction to perform a comparative analysis of results for all 190 economies participating in the study (Doing Business, 2020).

on the other hand, has a high sub-index on Paying taxes at 85.48 pts – Fig. 2g. The combined tax and contribution rate is 22.4% of profit (compared to the EU average of 40.02%). In Cyprus, starting a company involves five procedures, takes six days, and costs 5.60% of per capita income. No minimum share capital is required in this country. Both Hungary and Cyprus have comparable costs for building permits, at 0.6% and 0.9% of warehouse values, respectively.

Countries ranking lower, with relatively low levels of entrepreneurial potential, include Romania, Italy, and Bulgaria. The synthetic index in these countries, as well as in Group III as a whole, was lower than the EU average (76.5%), falling within the range of 73.33-71.97%. Thus, it can be noted that these countries shared a shortfall in entrepreneurial potential compared to the EU average. Among the listed countries, Romania recorded the best results in the categories: Starting a Business (87.68 pts), Paying Taxes (85.22 pts), and Getting Credit (80 pts) – Fig. 2a, 2e, 2g. Establishing a company in Romania takes an average of 20 days and costs 0.3% of the average per capita income. This result is less favorable than the EU average, where setting up a company takes about 12.7 days, even though the cost in Romania is higher at about 3.2% of per capita income. Romania recorded the lowest score for Getting Electricity – 53.67pts (last place in the ranking of EU countries), where the cost of getting electricity accounted for 405.8% of per capita income. The country's entrepreneurship index was 3.17 percentage points lower than the EU average.

In Italy, the sub-indicators for the following categories were the most favorable: Starting a Business (86.81 pts), Getting Electricity (86.08 pts), and Registering Property (81.75 pts) – Fig. 2a, 2c-d. The cost of starting a business in Italy is 13.8% of per capita income, the highest of the three analyzed countries. It should be noted that in Italy (as well as in Bulgaria) the minimum share capital is zero. The cost of registering a property is 4.4% of its value, 0.36 percentage points above the EU average. In the country under study, the contract enforcement process took an average of 1120 days and cost 27.6% of the value of the litigation.

Bulgaria recorded the highest sub-index values for: Trading Across Borders (97.41 pts), Starting a Business (85.40 pts), Dealing with Construction Permits (75.98 pts), and Protecting Minority Investors (74 pts) – Fig. 2a-b, 2f, 2h. The process of establishing a business in Bulgaria involves 21 procedures, which takes about 23 days and costs 1% of per capita income. The cost of registering the property is 2.8% of its value. In Bulgaria, one must follow 18 procedures to obtain a building permit, which takes 97 days (1.85 times less than in the EU) and costs 3.4% of the warehouse value. Bulgaria was ranked 61st in the Doing Business 2020 ranking (Fig. 1).

The last group, with a very low entrepreneurship rate, included Luxembourg (69.60 pts), Greece (68.42 pts), and Malta (66.14 pts). Luxembourg recorded the highest sub-indices for: Starting a Business (88.83 pts), Getting Electricity (84.31 pts), and Dealing with Construction Permits (83.87 pts) – Fig. 2a-c. Luxembourg's weak position was due, among other things, to the lengthy incorporation process – 16.5 days – and the high value of the required minimum share capital – 17.20% of per capita income (in 11 EU countries no minimum capital is

required). Greece stood out with the highest sub-indicator in the Starting a Business category (96 pts – 1st place) and Getting Electricity (84.74 pts) – Fig. 2a, 2c. The former indicator is a result of the ease of incorporation, meaning that a Greek citizen only has to go through four procedures that take four days and cost 1.5% of per capita income (more than twice lower than the EU average). In contrast, obtaining electricity requires five procedures, takes 51 days, and costs 68.2% of per capita income (EU average is 114.92%).

Lastly, Malta, closes the group of countries with very low levels of entrepreneurship and is at the bottom of the EU's ranking in entrepreneurial potential. The value of the indicator deviates significantly from the EU average, by 10.36 percentage points. Malta achieved high sub-indices for Starting a Business (88.19 pts) and Getting Electricity (79.28 pts) – Fig. 2a, 2c. Both the time to set up a business (20.5 days) and the cost of setting it up (6.7%) were higher for the average Maltese resident than the EU average (by 8.3% and 3.5%, respectively).

In summary, the analysis conducted shows disparities in the level of entrepreneurship among EU countries. The spatial inequality is evidenced by the gap between the leader of the ranking and the country closing the classification, which is 19.15pts, as well as the number of territorial units in each group. In 2020, countries with the highest and high levels of entrepreneurship were the more numerous group (15), while countries representing Group III and IV accounted for 12 territorial units.

5. Grouping European Union countries by level of entrepreneurship using Ward's method

A multivariate analysis using Ward's method was employed to complement the analysis on the level of entrepreneurship in EU countries using the ease of doing business index. This method was used to comprehensively assess the level and diversity of entrepreneurship across EU member states. Based on it, potentially homogeneous groups of EU member states were distinguished by characteristics describing entrepreneurial potential. Countries belonging to the same group were considered similar in terms of the analyzed characteristics. Indicators from the Doing Business Data Bank (Doing Business 2020) were used to create a typology of countries by the level of entrepreneurship thus defined. The results of the classification carried out using Ward's method are shown as a dendrogram (Fig. 4). The number of groups was determined based on the agglomeration flow chart, which presents the bond distances that define the successively formed classes (Fig. 3).

Ten clusters were distinguished based on this data (Fig. 4). The classification of countries resulted in the formation of single, double, triple, and quadruple element groups. The first typological class consisted of Austria, Belgium, Spain, and Portugal. These countries were characterized by scoring above 70 pts in the "Dealing with Construction Permits" category.

They also shared similar traits in the following categories: Minimum Outage Time in the "Acquiring Electricity" category, Total Tax and Contribution Rate (% of Profit), Profit Tax (% of Profit), and Cost (% of Claim) in the "Resolving Insolvency" category.

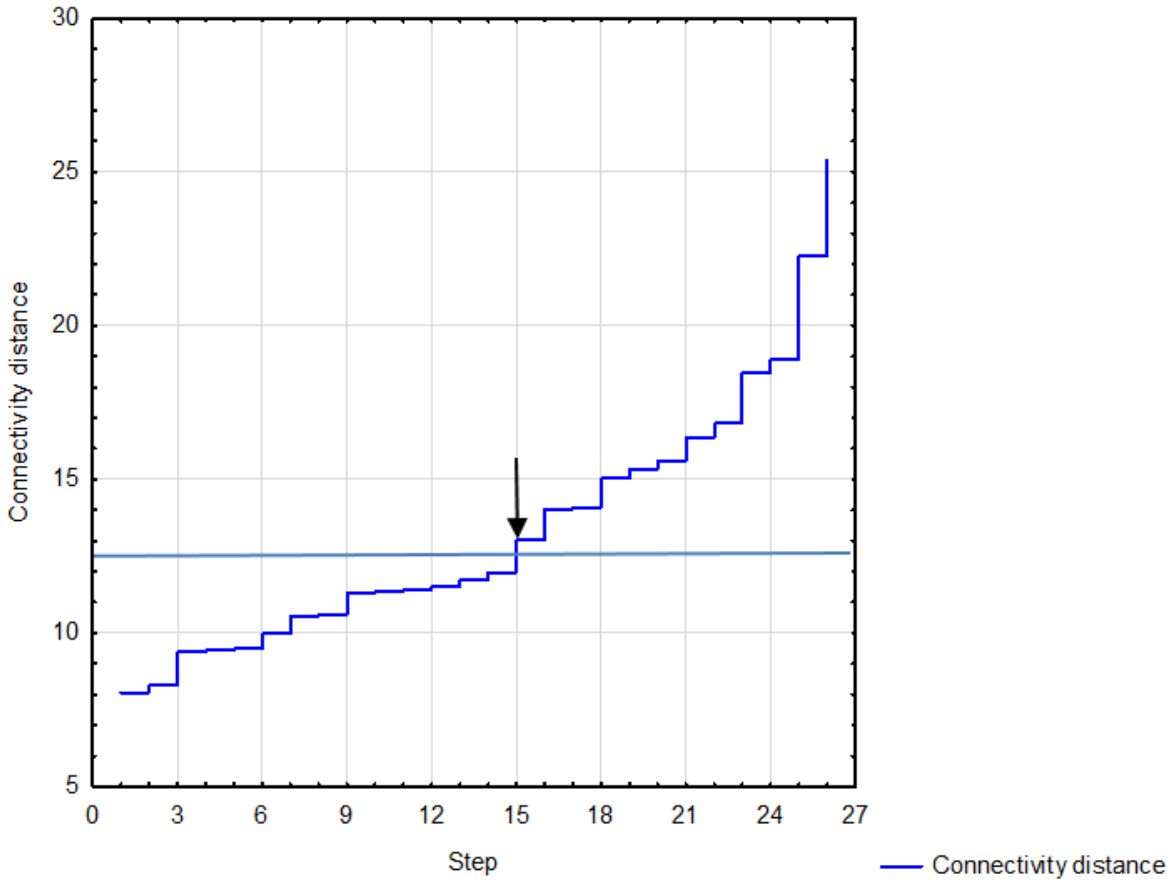


Figure 3. Diagram of the course of agglomeration for 2020.

Source: own compilation based on Doing Business database.

France formed the second typological class. The distinctiveness of this cluster probably resulted from the highest value for the Total Tax and Contribution Rate characteristic in the "Paying Taxes" category.

The clustering indicated a similarity in entrepreneurship levels between Croatia and Slovenia, forming cluster 3. Both countries reported similar trait values for the Cost (% of property value) for the Registering property category, Cost (% of claim) for the Enforcing contracts category.

Germany and Poland formed the fourth typological class, characterized by their similarity in Court Fees (% of Claim) and Enforcement Fees (% of Claim) for the "Enforcing Contracts" category. Both countries fall within the group with high levels of entrepreneurship.

The fifth group included two "New" EU countries: the Czech Republic and the Slovak Republic. These countries demonstrated similarities in "Starting a Business", Cost (% of Warehouse Value) in the "Dealing with Construction Permits" category, and selected characteristics in "Paying Taxes". Both countries achieved an entrepreneurship index value below the EU average.

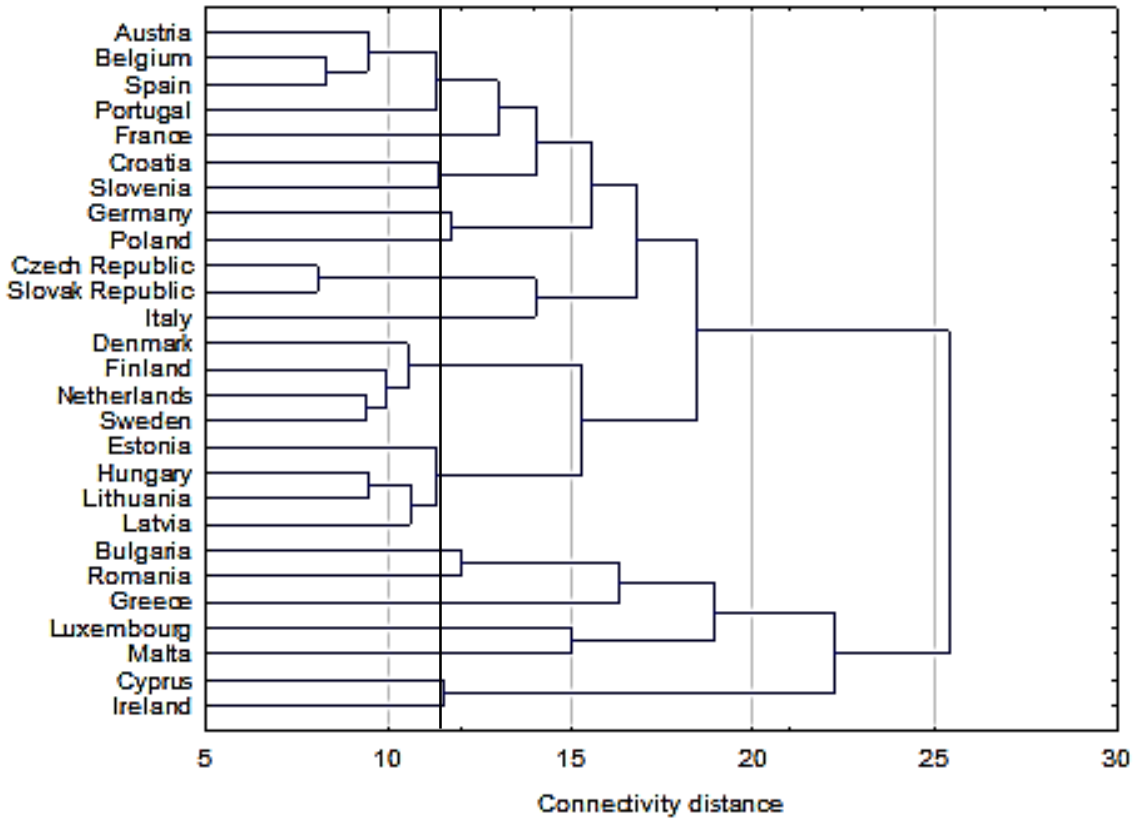


Figure 4. Clusters of EU countries with similar levels of entrepreneurship in 2020.

Source: own compilation on Doing Business database.

The sixth group only included Italy, which was notable for having the highest startup cost ("Starting a Business") and the highest Total Tax and Contribution Rate (% of Profit) in the "Paying Taxes" category.

The seventh group consisted of four "Old" EU countries, namely Denmark, Finland, the Netherlands, and Sweden. The cost (% of Warehouse Value) for the "Enforcing Contracts" category, the Strength of Insolvency Framework Index in the "Resolving Insolvency" category, the Quality of Land Administration Index in the "Registering Property" category, and the number of procedures for starting a business were all at similar levels in these countries.

The eighth class included Estonia, Hungary, Lithuania, and Latvia. These countries stood out mainly for their low values within the "Starting Business" category, i.e., the number of procedures, time, and cost of starting a business. Hence, these countries achieved high sub-indices for this category, respectively: 95.36 pts, 88.19 pts, 93.27 pts and 94.14 pts. They also reported a low cost of obtaining a building permit.

Bulgaria and Romania formed the ninth group. They were characterized by a large number of procedures and a long time required to set up a business, a low cost associated with setting up a company, a low level of required share capital (zero for Bulgaria), and a high cost of enforcing contracts.

The tenth, eleventh, and twelfth groups consisted of single-element sets, namely Greece, Luxembourg, and Malta, distinguished by the following: a) Greece was characterized by a large number of procedures (17) and a long time to obtain building permits (180 days), and an average cost of registering the transfer of real estate; b) Luxembourg was notable for a very low cost of obtaining building permits, the highest number of tax payments per year ("Paying Taxes"), and a low cost of enforcing contracts; c) Malta recorded an above-average cost of establishing a business, a very long time to deal with building permits, and the highest cost in the EU of registering the transfer of real estate (13.5% of the property value).

The thirteenth focus included: Cyprus and Ireland. These countries were categorized into this group based on having no minimum share capital, an above-average cost of registering the transfer of real estate, and a low combined tax and contribution rate (% of profit).

6. Conclusions

Entrepreneurship is a key driver of innovation and competitiveness among countries and plays a significant role in evaluating the level of socio-economic development of territories and the living standards of local communities. Therefore, understanding the nature of spatial variation in entrepreneurship, which greatly influences the socio-economic development of these territories, is crucial.

The carried-out analysis leads to the following conclusions:

EU countries demonstrate substantial variation in entrepreneurship levels. The gap between the highest-ranking countries and those trailing indicates notable territorial inequalities in entrepreneurial potential. Using a synthetic index to measure entrepreneurship, the distance between the leading country (Denmark) and the lowest-ranked country (Malta) was found to be 19.15 points. In 2020, the majority of EU countries exhibited high levels of entrepreneurship (15 out of the total).

Using this synthetic index, an effort was made to identify the disparities in entrepreneurship levels among member countries. Countries with an above-average synthetic index were regarded as having an entrepreneurial advantage, while those with a below-average synthetic index were viewed as facing an entrepreneurial gap. Out of the 27 member countries, twelve had a synthetic index higher than the EU average, ranging from 1.2 times (Denmark) to equal to the average (Slovenia), demonstrating their entrepreneurial advantage. Conversely, fifteen countries had an index below the EU average, indicating an entrepreneurial deficit.

It is important to note that the study's results were impacted by the COVID-19 pandemic, which severely disrupted the business environment in 2020, including the temporary closure of several business sectors. This led many to hesitate to start new ventures, as existing businesses grappled to stay afloat. The EU economy experienced a decline of nearly 2.4 million jobs in 2020, marking a 1.8% decrease compared to 2019.

Enhancing the business environment can effectively maintain high levels of entrepreneurship and lay a robust foundation for sustainable development. EU member states should intensify efforts to foster a conducive business climate and environment. Measures include reducing the time, number of procedures, and costs of starting a business; tailoring the financial and tax system to suit entrepreneurs' needs; and eliminating unnecessary regulations and excessive bureaucracy to lower operating costs. The study confirmed that EU countries are implementing reforms to improve the business environment and, consequently, increase entrepreneurship levels.

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ASSESSMENT OF TRANSACTION VALUES BETWEEN AFFILIATED ENTITIES

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Purpose: The research aims to assess the impact of internal cash flows resulting from the links between business entities.
Design/methodology/approach: The study will use the method of obtaining empirical material (data from the stock exchange, own database created on the basis of consolidated financial statements). Subsequently, methods of economic analysis presented in the literature were presented and used to calculate the value of transactions between related parties.
Findings: The research presented in the article indicates that there are significant measurable values of internal cash flows, which, if not taken into account, result in an underestimation of the value of the company and informs that the assessment of the financial position of related parties requires adjustment for the value of internal cash flows.
Research limitations/implications: The article presents the measurement method and results of measuring the value of internal cash flows in 31 companies listed on the Warsaw Stock Exchange for the period 2010-2020. The data was hand-collected by compiling the author's own database. Subsequent studies will present ways to assess internal cash flows and use in evaluating the situation of related parties.
Practical implications: The article shows how to assess the value of transactions occurring between related parties. Measuring these transactions indicates the value of cash that flows between these entities. Cash from these transactions should be taken into account in the evaluation of related parties, as classical financial indicators are not able to properly assess the financial position of related parties.
Originality/value: Transactions between related parties lead to the creation of internal cash flows called in foreign literature, the phenomenon of tunneling. The analysis of this phenomenon allows you to assess the financial situation of capital ties and take into account their impact on the financial performance of capital groups.

Keywords: internal cash flow, tunneling, related parties.

Category of the paper: Research paper.

1. Introduction

The assessment of related party transactions is an important issue that is an integral part of the financial management of affiliated entities and forms the basis for assessing the financial condition of the parties. Valuing an affiliated company based on consolidated financial statements is challenging because these types of financial statements merge the financial data of the affiliates at the stage of consolidation of financial statements, which causes some research problems. First of all, the specifics of the company cannot be taken into account when assessing its financial position, as the affiliated entity consists of many entities (closely held companies) operating in different areas. Consolidated financial statements do not reflect the numerous capital and organizational links between the entities. Moreover, consolidated financial statements present the results of the affiliated companies as if they were a single entity (IFRS 10). In summary, the correct assessment of the financial position of affiliated parties is limited by the source of information. Since 2008, it has been mandatory under IFRS to additionally present affiliated entities' transactions in the consolidated financial statements as supplementary information, which indicates that the data have a significant impact on the financial position of a closely held corporation. According to ISFR 24, a related party transaction is a transfer of resources, services, or obligations between a reporting entity and a related party, regardless of whether a price is charged (MSR 24). Therefore, the article aims to present a method for valuing transactions between related parties forming a group of companies (a capital group). Related parties engage in transactions by selling products, goods, and materials; making loans, receiving interest on loans and dividends on their shares; purchasing debt securities; and also engaging in other transactions. The occurrence of these events is strictly regulated by law and results from the application of transfer pricing and reverse financing rules known as ‘thin capitalization’. These transactions give rise to cash flows (internal cash flows) that are omitted in the consolidation phase of the statement of cash flows and do not affect the final value of the consolidated statement of cash flows of the affiliated entity, which in practice means that we assess the related entity as a single entity (because this is the purpose of the consolidated financial statements, in which the flows occurring between affiliates are omitted).

The dynamically changing environment and thus the functioning of related parties in the global arena influence the need to improve the existing tools for assessing a company's financial condition. Therefore, the primary contribution of such a study will be the evaluation of internal cash flows in the context of the financial position of affiliated entities.

The research in this article aims to assess the value of internal cash flows resulting from transactions between related parties. To achieve this goal, it was necessary to formulate the following research hypothesis:

H(0): The value of internal cash flows is an incentive for the establishment of capital groups.

2. Literature Review

Internal cash flows are a research problem that has yet to be sufficiently studied in the Polish literature. The analysis of the literature has made it possible to distinguish two research streams: theories of cash holding and the phenomenon of tunneling.

Shleifer and Vishny (1986) were among the first to discuss tunneling, i.e., the role of a major shareholder in providing benefits to all shareholders. This positive view of blockholders was further elaborated by Grossman and Hart (1988) and Harris and Raviv (1988). The common phenomenon of tunneling is treated as a transfer of value from minority shareholders to majority shareholders or a transfer of benefits to managers at the expense of shareholders. Tunneling can be divided into three types (Atanasov, Black, Ciccotello, 2008): cash flow tunneling, asset tunneling, and equity tunneling. Asset tunneling can be further divided into asset tunneling "in", i.e., overpricing assets, or "out", i.e., selling assets of related parties below their market value. Cash flow tunneling removes part of the current cash flow through transfer pricing or contractor compensation that exceeds market standards. Equity tunneling involves increasing the shareholding of a majority shareholder at the expense of a minority shareholder, e.g., through share dilution, freeze-outs (also called a shareholder squeeze-out), insider trading, hostile takeovers, or other financial transactions that discriminate against minority shareholders (La Porta et al., 2000).

In Polish literature, the phenomenon of tunneling has not yet been clearly defined, but it is possible to find related concepts and studies. According to P. Mielcarz (2009), the value of majority shareholdings or controlling stakes differs from that of minority shareholdings, and what distinguishes these shareholdings from each other is called private benefit. Private benefits constitute free cash generated by a company solely in favor of the owners of controlling stakes, i.e., so-called exclusive flows. They are the result of:

- additional flows generated by the company through trade and civil transactions between the controlling and the controlled company,
- legal and tax regulations that create grounds for different taxation of capital gains (including dividends) of investors with controlling stakes and owners of non-controlling interests,
- forcing an investment policy on the controlled company, thus creating exclusive flows benefitting the controlling entity.

Another study touching on the problem of transactions between related parties was conducted by M. Aluchna in 2010. The results enabled the creation of a typology matrix of related parties based on their development directions, taking into account the ownership structure and the importance of the internal or external market. The great importance of the internal market implies that companies operating as part of an affiliated group (or a capital group) want to create their own market, where they create demand and supply and offer

products and services to each other. In such a market, companies do business mainly with other companies in the group and are quite reluctant to include companies from outside the group. The greater importance of the internal market is observed in countries with a weaker institutional order and a lower level of trust. The second level considered in the creation of the matrix of group types is the ownership structure of the company. A concentrated structure implies the presence of a controlling shareholder who exercises control over the group. In such cases, preferred shares are often used and pyramid structures are highly prevalent. They are also found in countries with less advanced regulations meant to protect minority shareholders in the capital market and the low importance of the stock market as an external source of financing.

K. Byrka-Kita (2012) also indirectly addresses tunneling by exploring the benefits of controlling a company in business valuation. The author points out that the benefits derived from exercising control come down to the use of the company's resources or benefits with the exclusion of minority shareholders - and in most cases at their expense. These benefits can be both monetary and non-monetary.

A review of Polish literature shows that tunneling in Polish companies is not directly addressed. Moreover, previous Polish research ambitions on family businesses describe corporate governance only in passing and usually on a theoretical rather than a practical basis. The global interest in family ownership stems from the fact that family companies are an important part of the economic system and that their continuity and success significantly affect the stability and efficiency of the economy, both nationally and globally. Therefore, it seems to be of interest to carry out a study in Poland, identifying family-owned businesses and also examining the phenomenon of tunneling to evaluate its impact on the management of these companies.

Nowadays, cash holding is a widely discussed research topic. It became popular in the last decade of the 21st century after the 2008 financial crisis; however, the first theories were developed back in the second half of the 20th century:

- Miller and Orr's model of the demand for money (1966),
- pecking order theory (1984),
- free cash flow theory by M.C. Jensen (1986),
- the trade-off model by Ferdows and De Meyer (1990),
- Opler's research (1999).

Research on cash holding was conducted by Ferreira and Viley (2004), followed by Ahmed and Streimikiene (2020), who investigated the influence of the external environment on the phenomenon of cash holding in a company. The research by Hendrawata (2019) shows that companies in developing countries are accumulating more and more cash. Phan (2019), on the other hand, describes this phenomenon as corporate savings. In Poland, Bialek-Jaworska's (2017) research identified factors that influence Polish non-financial firms' lending to other firms, starting with motives for recognition and sources of funds. Bialek-Jaworska (2017) derived the following conclusions from the study, which confirmed international research and

their links to the tunneling phenomenon. Cash holding is prompted by a transactional motive, protection from the risks associated with the use of derivatives, investment opportunities, and borrowings. Non-financial firms try to follow in the footsteps of financial institutions by lending money obtained from their cash flow, especially when they have long-term investments (Bialek-Jaworska, 2017). A summary of the theories and studies on tunneling and the phenomenon of cash holding is compiled in Table 1.Tables, figures and formulas – continuous numbering in the text.

Table 1.
Literature review of internal cash flow

Cash holding theories	Tunneling phenomenon
Jensen (1986) free cash flow theory Ferdows and De Meyer (1990) – the trade-off model Miller and Orr (1966) – the model of the demand for money pecking order theory (1984) Opler (1999) Ferreira and Viley (2004) Hendrawata (2019) – more cash in companies in the developing countries Moshin, Ahmed, Streimikiene (2020) – external environment Phan (2019) – corporate savings Białek-Jaworska (2017) – non-financial companies behave like financial institutions	According to Kee-Hong, Jun-Koo, Jin-Mo (2002), tunneling is the transfer of value from majority shareholders to minority shareholders or the transfer of companies' assets and profits to their controlling shareholders. La Porta et al., (2000) state that tunneling works when a controlling shareholder transfers a company's resources or does so without transferring assets. Mielcarz (2009) – exclusive flows Mioduchowska-Jaroszewicz (2013) – calculation formula internal cash flows

Source: own research.

Economic policy uncertainty and financial development affect a company's cash holding policy before and after a global financial crisis, as evidenced by another study based on data from Chinese non-financial firms from 1997-2018, published in 2022 (Legesse, Guo, Wang, et al.). Firstly, economic policy uncertainty increases cash holdings and sensitivity to operating cash flows. On the other hand, financial institutions and market developments reduce the sensitivity of corporate cash holdings to cash flows. Finally, the impact of economic policy uncertainty on firms' cash sensitivity to operating cash flow decreases with financial developments. Companies adjust their cash holding policies in response to changes in economic policy and financial developments, suggesting that macroeconomic factors determine the precautionary motives for holding cash.

An analysis of the literature on cash holdings and tunneling shows that there are no studies that present a way to measure internal cash flows, that is, they take into account the aspect of economic events occurring between related parties. Thus, it is proven that the literature has not found ways to measure the value of transactions occurring between related parties. The article fills the research gap in this regard.

3. Data and methodology

This article aims to analyze the external cash flows of affiliated entities in the years 2010-2020 using the example of Polish business entities listed on the Warsaw Stock Exchange in Poland. The study was based on 31 annual financial statements. The selection of the companies for the study was very difficult in terms of homogeneity of the study sample, as they should be related parties preparing consolidated financial statements in accordance with IFRS rules, taking into account IAS 24, i.e., presenting transactions between the related parties, operating in the same industry and/or closely related to that industry, for no less than 11 years. Private companies from the construction, metallurgy, metal industry, and machinery and equipment manufacturing sectors were selected for the study. Finally, 341 observations (11 years, 31 companies) were used for the study. Data for the study were collected independently by the author to form a research base by compiling financial data from consolidated financial statements of 'related party transactions'.

The formula (1) below shows the method of measuring the value of internal cash flow (Mioduchowska-Jaroszewicz, 2013):

$$CF\ internal = \sum Pin\ (Lin) - \Delta\ Rec + \Delta Liab + \ Ri - Ci - B + L + Bx \qquad (1)$$

where:

CF internal – internal cash flow in related parties in the group of companies,

Pin (Lin) – profit (loss) from mutual transactions,

Δ Rec – change in accounts receivable,

ΔLiab – change in accounts payable,

Ri – interest income,

Ci − interest cost,

B – borrower, loans received,

L – lender, loans granted,

Bx – extra benefits – profits (losses) gained from factors such as transfer pricing, 'thin capitalization', cash management.

4. Research results

The results shown in Table 2 were obtained based on Formula 1.

Table 2.
Value of internal cash flows in related parties

Item	Data in thousands PLN										
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
1.	37 917	18 148	16 740	-7 187	21 956	15 681	6 815	20 183	12 366	0	0
2.	0	0	-169	985	-141	-1167	-1878	-1086	-1266	0	0
3.	-1 227	0	-1 245	-7	-779	-6 744	-12 743	30 469	10 694	0	0
4.	120184	139651	38271	143366	134049	160241	162958	-61757	-262th	-139th	-82670
5.	52 020	3 619	-57 992	-92 028	3 395	-46 197	-42 346	40 659	68 820	14 142	835th
6.	-14244	-28616	-17686	-59232	-11086	-24336	-14309	-4952	-6812	-8559	0
7.	-28800	11492	-53	-7127	10518	-12304	-5104	-17956	-19479	18016	-34446
8.	0	0	0	0	0	0	0	0	0	0	0
9.	0	0	0	0	0	-6 073	-6 988	2 218	-2 917	6 989	-20 591
10.	0	0	14103	-10720	4891	4139	-11737	17453	5053	3715	-1533
11.	44036	14558	5538	30125	6149	12182	10815	2773	2688	0	0
12.	-4397	-7489	-3988	-5292	-3111	-6612	-1714	-6823	1301	-3184	208
13.	0	0	0	0	0	0	0	0	0	8788	-4238
14.	-1653	-30492	11920	-16207	-24700	-879	-98	-1640	230	-2686	712
15.	1140	0	0	-2292	26 695	16529	0	0	0	0	0
16.	59622	30982	-18811	-50339	1152	-97043	48276	-143026	-166562	3729	-11
17.	-48712	-54029	64138.2	-36139	-32496	-429.3	-66.2	0	0	0	-249
18.	-90980	-112901	-230364	-171935	-346498	-107512	-2222	-618	-796	99873	0
19.	6	0	0	26	-5294	0	0	0	-132	0	0
20.	4568	-88423	-10105	18925	-26965	-111343	-16913	0	0	0	0
21.	277723	130184	179365	-379132	-123859	18237	-413267	-4607	-465820	0	0
22.	1339	858	-2211	3591	1498	1360	-2770	1095	2383	-23908	4012
23.	-51598	-25350	51413	51280	111910	106268	81332	95209	2164	13979	-7152
24.	-16400	-13652	-24890	0	1479	13115	16857	57736	137689	135591	140997
25.	84655	50 246	-37 695	7 659	-61 231	-32 017	-8 073	-133th	47 479	2 015	0
26.	97631	1413	2859	-867	-49994	23168	19705	-4823	17838	49517	0
27.	0	0	11804	-1	8167	28052	22258	15843	18844	18844	25321
28.	0	-2748	-3886	7832	14210	11613	14321	7133	6073	-1369	3221
29.	-4403.14	15651	22988	13492	19373	21060	13377	44107	71509	92437	0
30.	1111	1353	945	787	1072	64461	67947	14047	20279	23004	-17577
31.	4745.3	2628.7	-351	-1106.4	-850.6	-1068.7	-18.3	-0.53	-0.075	-0.025	-0.162

*th – thousands (000).

Source: own research.

Table 3.
The name of the company considering the number from Table 2

Name	**Item**	**Name**	**Item**	**Name**	**Item**
ABM solid	1.	Elektrobudowa	11.	Impexmetal	21.
ATREM	2.	Elektrotim	12.	Introl	22.
AWBUD	3.	Energoinstal	13.	KBP Dom	23.
Boryszew	4.	Erbud	14.	Mennica	24.
BUDIMEX	5.	FAM	15.	Mirbud	25.
Ceramika Nowa Gala	6.	Famur	16.	Mostostal W-wa	26.
Cognor	7.	Ferro	17.	Mostostal Zabrze	27.
Decora	8.	Ferrum	18.	Patentus	28.
Dekpol	9.	Herkules	19.	PGO	29.
Drozapol	10.	HUTMEN	20.	Selena	30.
ZUE	31.				

Source: own research.

The value of internal cash flows presented in Table 2 shows a very high variability of results and, in terms of value, a large differentiation between the companies. The variation of the absolute values shows the need to create indicators, that is, to evaluate these values considering the main financial categories: assets, revenues, and change in cash. The results from Table 2

also show that the values of these flows are positive and negative and are due to transactions between related parties, which should be treated as inflows (positive amounts) to the controlling company and outflows (negative amounts) from the controlling company (Formula 1). In this way, we obtained the values of cash flows circulating between related parties (Figure 1), which are not included in the assessment of the financial position of related parties because they are not presented in a typical financial statement that is the basis for the valuation of the financial position of related parties, i.e., the consolidated statements of financial position and comprehensive income.

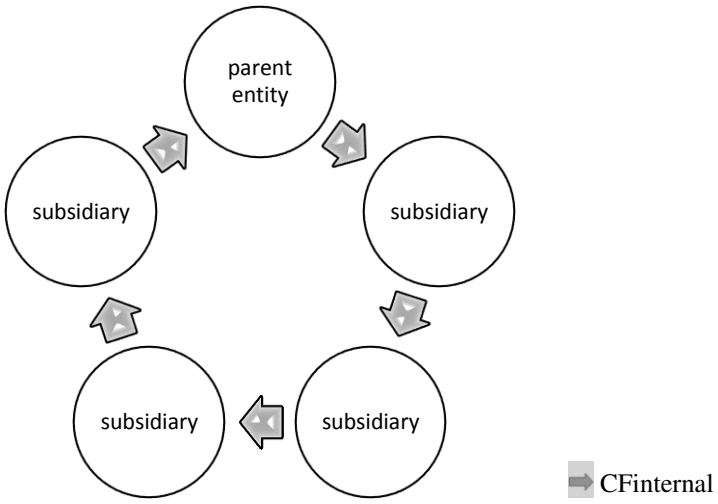

Figure 1. Circulation of internal cash flows.
Source: own research.

5. Conclusions

The research hypothesis was positively verified against the background of the research results, thus achieving the purpose of the study. The value of internal cash flows is important for the evaluation of the financial position of companies. Future research articles will present the results of studies that consider the data on the value of internal cash flows in reference to other financial categories, which will facilitate comparisons and help create econometric models to determine the impact of internal cash flows on various aspects of related party activities. In addition, it should be noted that internal cash flows:

- and their significance is confirmed by a literature review of theories of tunneling and cash holding in the studied companies (a general worldwide trend of global capital groups),
- and the occurrence of significant and measurable values indicates that the companies are undervalued,

- indicate that the phenomenon of tunneling exists among the related parties,
- are a driving force for the formation of capital groups,
- indicate that the valuation of the financial position of related parties requires adjustment based on the value of internal cash flows.

The presented method of measuring transactions between related parties is extremely important in assessing the financial position of related parties and in valuing the value of these parties. The issue presented points to the direction in the study of related parties, provides an opportunity for the tax authorities to control transactions that may be outside of taxation. In addition, the value of intra-group transactions can cause to regulate the value of profit. Thus affecting the benefits of owners (tunneling). In addition, the value of internal cash flows informs about additional cash found in the related party (cash holdings).

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EVOLUTION OF THE LABOUR MARKET ORGANIZATION – THE ROLE AND POTENTIAL OF HYBRID WORK FOR THE GENERATION Z

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Additional results and copies of the software and surveys used to generate the results presented in the article are available from the head author at pawel.modrzynski@pbs.edu.pl

Purpose: The aim of the paper is to determine how the development of digital competences affects the organization of the labour market.
Design/methodology/approach: The authors focused on combining two areas, i.e. the object - students (generation Z) and the subject - the preferred form of work organization in the future. The conducted research shows the correlation of digital competences of the Z generation with the possible organization of business models of the labor market. The survey used the survey method, the survey technique, the research tool of which was a questionnaire.
Research limitations/implications: Generation Z are characterized by excellent knowledge of using modern technologies and have digital competences, and the use of mobile devices has become an element of their everyday life. A characteristic feature of this generation is its mobility, which also translates into preferences regarding the future work model. The experience gained during remote learning can be used by future employers to effectively implement the hybrid work model, in which the temporary possibility of remote work is the preferred form of work for the Z generation. Undoubtedly, the issue that requires further research is the effectiveness of management and motivating employees who perform part of their work. tasks in the form of remote work.
Originality/value: The review of the research carried out so far, the analysis of the scope of their objective and subjective scope as well as the indicated limitations of the research allowed the authors to identify key research areas that should be the subject of further analysis. The key factor determining the future of remote (and hybrid) work are digital competences, understood as the ability to use devices and applications based on Internet communication. The authors drew attention to a research gap that should be analyzed, and which could significantly enrich the existing research - the subjective scope of the research should include a group of people who during the pandemic gained extensive experience in remote

communication and work (learning) remotely, and who potentially are perfectly able to use modern technologies - a group of current students.

Keywords: Digital Business Transformation, business models, hybrid working, management, COVID-19, Generation-Z.

1. Introduction

The period of the COVID-19 pandemic was an organizational challenge for many companies, organizations and entities, in which remote work tools were implemented on a large, previously unprecedented scale. A lot of research to date has focused on the effectiveness of this form of completion of tasks, whether in the context of work, its effectiveness, cost optimization, or in the context of education. As Mosteanu (2020) points out, this gave rise to pedagogical tools such as digital campuses and online learning in general. However, education was equally affected by the rise of digital technologies as was the corporate workplace. These technologies, both in the school and work environments, were uniquely tried and tested during the COVID-19 pandemic. When this unique phenomenon took place, many educational facilities and businesses were forced to go online and operate remotely. Remote work and the shift towards hybrid work environments has been the subject of research for many years (Baker et al., 2007; Ruth, Chaudhry, 2008; Shin et al., 1999). The framework of the theoretical background has been divided into three areas: remote work, remote learning and generation Z in order to precisely define the context of the research issues.

Our study focuses on undergraduate and graduate education not only because we believe this is where technology has the most use and impact but also because this is where it is the most sophisticated. Our study also provides insight into travel-related aspects of remote work. We learn about the points of view of students regarding the digital world as well as their repercussions from the COVID-19 pandemic. This is important if we are to move forward in striving to understand the digital world and its impact on educational outcomes for hybrid and remote environments. Moreover, this paper promotes many areas of further study. For example, questions of work-life balance may include if novel technologies will allow us to bridge comfortable living spaces with enticing work. Issues such as city organization or landscape perusal may also be affected when we think about redesigning metropolitan spaces.

The paper contains three hypotheses that are tested using survey methodology on a large sample of participants. Demographics span various geographic locations and the primary age group is 21-25 years of age. Findings make conclusions and suggestions that have implications for a variety of forms of labor organization. The primary finding is that participants prefer hybrid work over remote or traditional forms.

2. Literature

Remote work

Organizational changes occupy a unique place in management sciences. As Bejinariu et al. (2017) noted they are undoubtedly multithreaded, complex and difficult to implement. They cause that the extant patterns of action are replaced by new ones, the effect of which no one can predict. However, Hallencreutz & Turner (2011) indicated the most important thing is that such a change should not only be caused by changes in the environment, but also Choi (2011) noted take into account its complexity and multi-context nature, because the source of changes are various situations that may evolve and change existing states.

Many scholars (Bailey, Breslin, 2021; Kiers et al., 2022; Men, Robinson, 2018; Ruck, Men, 2021), have pointed out that looking ahead, the changes that are taking place will mainly affect those in the area of work organization - from management, through setting work goals to communication as well as in the competency and social context of employees. Changes accompany organizational life and require a response. As Amis and Greenwood (2000) portrayed those companies that are able to predict them and use their potential have a chance for development.

Gardner and Matviak (2020), Mueller-Langer and Gomez (2022), George et al. (2020) emphasized the changes that were first brought about by the pandemic were related to lockdown, maintaining social distancing, and as a consequence, many employees switched to remote work. Asadzadeh and Pakkhoo (2020), De`, Pandey and Pal (2020) indicated avoiding the spread of the Covid-19 pandemic has forced the whole world to use information and communication technologies in novel ways. As He at al. (2021) noted these tools became widely used in work and schools. Kumar et al. (2020) presented, that face-to-face business meetings, school education and administrative work have been transferred to the virtual world. Ofosu-Ampong & Acheampong (2022) indicated, that remote work has therefore become a necessity to achieve the company's goals. The dynamically developing pandemic forced the learners and the majority of working people to accept the limitations.

As indicated in the Gartner report (Fasciani, Eagle, Doherty, 2021), more than half of entrepreneurs in 2025 will use online meetings. All activities must be compatible with IT processes, and this in turn poses a challenge for interoperability, building (e-) trust or the ability to use digital technologies (Szymanowski, 2016). As indicated in table 1, organizational changes will be necessary at every stage of business management and will cover various aspects.

Table 1.
Potential area and scope of organizational changes after the pandemic - literature review

Author	Areas of change	Scope of organizational changes
(Amis J., Greenwood R., 2020)	Front-line Staff, well-paid knowledge workers and managers	Values and interests, ideas
(Junnaid, M.H., Miralam, M.S., Vikram, 2020)	Managers' telework experiences, leadership style	Attitudes, practices, organizational commitment, formal interaction,
(Chen, Sriphon, 2021)	Relationships between employers and employees	Building incorporates trust, collaborating, and sharing leadership
(Chatterjee et al., 2022)	Workplace, strategy	Mobility and flexibility
(Ofosu-Ampong, Acheampong, 2022)	Working system	Social perspective for shaping work experience
(Bick et al., 2020)	Work from home	Occupation and age of employees, industry business conditions, demand
(Bonacini et al., 2021)		Income, inequality

Source: own study based on the conducted research.

The restrictions that were introduced resulted in a change in social behaviour in all areas of the organization's functioning. Physical and mental changes in the implementation of daily professional duties have taken a new face that requires adaptation. As indicated Chen and Sriphon (2021), Roemer et al. (2021), the greatest problem of organizational changes results from the lack of positively shaped organizational relationships rife with trust and commitment.

Work, which until the time of the pandemic was for many a place of performance of duties, changed the location - and this made people doubt themselves - both in terms of task completion and the degree of commitment (Chatterjee, Chaudhuri, Vrontis, 2022; Ofosu-Ampong, Acheampong, 2022; Ng et al., 2022). In addition, the pandemic drew the attention of researchers to the existence of a relationship between the work performed (competences, knowledge that employees have) and the amount of remuneration (Bick et al., 2020; Martins et al., 2021) as well as the tendency to work from "home" (Bonacini et al., 2021). The thread of economic issues began to intertwine with what is invisible and very individual.

The issue of working from home, remotely, online has been the subject of research for many years (Shin et al., 1999; Baker, Ellen, Avery, Gayle, Crawford, 2007; Ruth, Chaudhry, 2008). They saw potential in remote work, but there was no phenomenon that would trigger it. As the Ofosu-Ampong & Acheampong (2022) noted so far, technologies have served people in their everyday personal and professional life, however, the way they are used has not fallen into today's framework. As Kagermann (2015) pointed out organizations that, in their strategic perspective, took into account the approach to knowledge developed in a classic way (direct contact), had to focus on digital technologies. Moreover, Mansi (2013) argued that the digitization of enterprises has become a necessity not only for survival, but also for development in the market arena.

According to OECD research (OECD, 2022), the time of the pandemic did not cause a sharp increase in the access to and use of information and communication technologies by employers and employees. It can be seen that investments in this area were carried out in a balanced and stable manner. Therefore, it can be assumed that access to technology has not become the

problem, but the problem was rather people's attitude to new working conditions. Research (2022 State Of Remote Work, 2022; More Remote Work Opportunities May Make Suburbs More Desirable, 2020; State Of Remote Work 2018, 2018; State Of Remote Work 2020, 2020; Dixon, 2019; Owl Labs & Global Workplace Analytics, 2021) shows that few in the world have worked from home, and since March 2020, more than half have used this solution.

The threat to the lives of the human population became this stimulus, and day-to-day remote work became the form of work organization across the globe. We will feel the effects of the pandemic in a few years, and the direction in which they develop will depend on the accompanying factors. The pandemic became the impetus for the acceleration of what was inevitable. It provided us with a new look at the possibilities of adaptation in crisis situations. Great shifts in ways of thinking or acting begin with the individual and can arise from small, sudden changes. Undoubtedly, they require new patterns of conduct, because what has been the beaten path so far becomes an e-book open to new solutions.

Remote learning

During the first two decades of the 21st century, the use of information technology has sky-rocketed in education. Starting with Apple's introduction of the Macintosh in 1984 and its promotion in primary school education in the USA, through presentation technologies such as PowerPoint and the use of smartboards, finally to the implementation of video-communication technologies such as Zoom in 2011 in classroom setting, technology has been at the forefront of education in the past 40 years. Van der Zwaan (2017) claimed that the focus on technology has been fundamental in growing knowledge during this generation and continues to develop vehemently throughout the worldwide landscape. This includes all levels of education, from primary school to graduate studies. It is perhaps dubious at which level of education is information technology most salient. Grimes & Warschauer (2008) noted that while students rely on their laptops and tablets to take notes, complete assignments and keep track of learning, the software packages available for their use have proliferated. It is impossible to name all of the burgeoning software currently being used by students since novel ones are emerging regularly. Their applications include note-taking by voice-recording and hard-writing recognition to blended reality use of photography and text scanning. Many of them are fundamentally tied to understanding and ability to apply these novel technologies.

Some key statistics about remote learning (UNICEF.org) include in the period between March 11, 2020 and February 2, 2021, schools have been fully closed for an average of 95 instruction days globally, which represents approximately half the time intended for classroom instruction. Of these 214 million students, 168 million in 14 countries missed almost all classroom instruction time due to school closures.

It is important to note the difference between online learning, which has been present in education for a couple of decades and remote learning, which is the emergency method that has been used during the Covid-19 pandemic. So Mosteanu (2020) asked the question is whether the digital campus, including procedures such as online learning, are useful as pedagogical tools? These issues are fundamental to understanding how to implement digital learning further as it becomes more and more important. It is necessary to understand how online presentations of coursework and online discussion contribute to learning. To do so, we have to explore the extent of use of these technologies among student populations and their understanding of how they are applied (see table 2).

Table 2.
Characteristics of the remote learning - literature review

Author	Summary of Key Points
(Carter Jr et al., 2020)	Strategies of the self-regulated learning (SRL) framework for K-12 students learning in online environments to support remote learning with online and digital tools during the COVID-19 pandemic. The main types of strategies that have emerged from previous studies include asking students to consider how they learn online, providing pacing support, monitoring engagement and supporting families.
(Morgan, 2020)	In response to the spread of COVID-19, a new coronavirus, many U.S. schools have implemented remote learning. This approach to education can prevent students from experiencing setbacks during school closures. However, some schools do not have enough resources to provide learning opportunities for students, and not all children have internet access at home. Schools that can implement online learning equitably can improve their approach if they follow the guidelines of reputable organizations such as the International Society for Technology in Education.
(Ali, 2020)	In light of the rising concerns about the spread of COVID-19 and calls to contain the Corona Virus, a growing number of tertiary institutions have shut down in regards to face-to-face classes globally. The Corona virus has revealed emerging vulnerabilities in education systems around the world. It is now clear that society needs flexible and resilient education systems as we face unpredictable futures. A meta-analysis methodology was adopted for this study and pertinent literature was visited to capture the essence of continued learning during these unprecedented times. Findings reveal that universities worldwide are moving more and more towards online learning or E- Learning. Findings also reveal that apart from resources, staff readiness, confidence, student accessibility and motivation play important function in ICT integrated learning. This exploratory paper proposes that staff members should use technology and technological gadgets to enhance learning especially during these exceptional times. Findings also propose online and remote learning as a necessity in times of lock downs and social distancing due to COVID-19 pandemic. It also provides a strong platform for further research.
(Heitz, Laboissiere, Sanghvi, 2020)	This forced and abrupt move to remote learning has not been easy. However, it can provide institutions with an opportunity to experiment and innovate. Piloting new approaches and building on practices that are proved to work can help create positive and enduring changes. Universities may find that they have a new remote-learning capability that can be integrated with on-campus instruction, to everyone's benefit, when this crisis has passed.

Source: own study based on the conducted research.

It is key to underline the importance of trust within the world of educational digitalization. This should be what guides proliferation of technologies, rather than control over the resources. As indicated by Peters et al. (2010) we should strive to create an environment where students feel comfortable and confident in their learning and ability to apply technologies to educational issues.

In the popular press, the criticism for remote learning is jarring. Hobbs and Hawkins (2020) reported that teachers interviewed refer to *building a plane and flying it at the same time*. The COVID-19 pandemic crisis provided a methodological backdrop for studying the remote learning phenomenon and studies have proliferated since its onset in March 2020. Several studies (Garbe et al., 2020; Roos et al., 2021; Gayatri, 2020; Ribeiro et al., 2021) emphasized the importance of equipping parents with the appropriate tools to overcome obstacles in remote learning and providing useful projects for students to undergo. The role of technology is fundamental here. Parents must be proficient in adopting technology and applying it to their everyday lives in order to be able to assist their children in remote learning.

When we move to university and academic online learning this adoption of technology is also key to understanding how we can prevail in this new environment. The structural changes necessary in our approach to learning are incredibly subtle and can also be significant. Organizations have to shift their use of technology in order to substantially coexist with the new state of things. The future of remote learning is not set in stone, but it is surely going to forge a path toward domination. It is key for us to understand the precise mechanisms in play when integrating technology to remote learning. This study, among others, seeks to understand how digitalization will impact the future of students who have been raised with remote learning and how their use of technology will affect the structure and purpose of the working environment.

Generation Z

For many years, researchers (Lyons, Kuron, 2014) have been studying the phenomenon of generational diversity, looking for differences resulting from the conditions that shape their attitudes and behaviour. Several scholars (Wescott, 2017) have characterized generations since the 1940s. Generational diversity undoubtedly contributes to the development of the organization (Bhayana et al., 2021; Ardueser, Garza, 2021; Urick et al., 2017). Moreover, others (Lapoint and Liprie-Spence 2017; Smith and Garriety 2020) indicated that their concept is derived from age differences (Chillakuri, Mahanandia, 2018; Srinivasan, 2012) from personality traits and from a situational approach and socialization process (Baum, 2020; DelCampo et al., 2017; Singh, Dangmei, 2016).

The 21st century brought technological development in which the youngest generation had full access to the Internet and tools integrated with it (Burton et al., 2019). Generation Z, also known as generation C (Hardey, 2011), iGen (Maioli, 2016), XD, digital natives (Bennett et al., 2008) are people born at the turn of the 20th and 21st centuries (after 1995), constituting about 26% of the population (Wise, 2022).

Attempts to characterize generation Z are largely based on theoretical considerations, because in recent years this generation could be assessed through the prism of their adolescence. However, we are now at a point where Generation Z begins to enter the labor market with potential, and therefore they will become verifiable. Table 3 reviews the literature in this area.

Table 3.
Characteristics of the Z generation - literature review

Author	Summary of Key Points
(Hardey, 2011)	People who are creative, want a fast career, like to create content that will bring them followers, always connected to the Internet via phones, susceptible to content posted on the web.
(Shatto, Erwin, 2016)	Children of two or multiracial parents, interpersonal relationships built on the basis of different cultural perspectives, accepting and open to differences, perfectly coping with technology, high activity on social networks, streaming, relying on mobile technology, learning through observation and practice rather than reading, searching for information from Google™ and believing in their uncritical credibility, quickly get frustrated, short attention span.
(Singh, Dangmei, 2016)	A generation with an informal, individual and simple and direct way of communicating, and social networks are an essential part of their lives. Entrepreneurial, trustworthy, tolerant, optimistic about the future, although they are impatient and quick in thinking. They are not very ambitious and addicted to technology, and have a low concentration of attention. They are benefit-oriented, and at the same time conscious and oriented towards environmental protection (CSR) and no waste. Identity is shaped by technology; they lack the ability to solve problems. In addition, they have analytical and decision problems. Transparency, independence, flexibility and personal freedom are non-negotiable aspects of their work ethics.
(Dimock, 2019)	People with access to mobile devices, WiFi networks and mobile broadband services. Access to social networks, social media. With constant connectivity as well as entertainment and communication on demand. The views of this generation are not yet fully formed and are evolving as they grow.
(Burton et al., 2019)	A generation that has access to the Internet, social media and smartphones all their lives. This translates into their awareness of social networks, marketing and advertising. Well informed, they are afraid of being unemployed and of the financial crisis and therefore they are frugal.
(Christensen et al., 2018)	Easy access to instant information. They do not know life without the Internet, smartphones and social media - which are normal communication and information-seeking tools. Conscious of their own brand, independent, enterprising, but also pragmatic. They expect broadly understood flexibility of work. Teamwork-oriented and result-oriented. From birth, they are accompanied by natural disasters, international terrorism, recession, and war in Europe.
(Smith, Garriety, 2020)	A generation with a tendency to independence and flexibility. People who do not recognize authority and hierarchy. They are lazy but intelligent.

Source: own study based on the conducted research.

Generation Z is focused on using modern technologies during every moment of their lives. It may seem that this generation should be able to use these technologies without any problems in order to balance professional and personal life. Their employers face a challenge because this generation is characterized by frequent events with traumatic consequences - ranging from climate change to armed conflicts. It seems that the generation Z will require constant changes in shaping their professional attitude, which will be driven by constant stimuli forcing them to be active in meeting them. Therefore, it becomes reasonable to examine the expectations of the youngest adult generation in order to initially verify the directions of changes that should be made for the work of this generation to be effective and efficient.

3. Empirical part

Research model and hypotheses development

The research on remote work (including hybrid work) conducted so far covers multifaceted areas. Ofosu-Ampong and Acheampong (2022), as well as Saura et al. (2022) and Mueller-Langer and Gómez-Herrera (2022) focused on the use of modern technologies in the organization of remote work. Undoubtedly, the period of the pandemic caused by the Covid-19 virus forced enterprises, public institutions and other entities to carry out their statutory tasks using communication and remote work tools. Ofosu-Ampong and Acheampong (2022) studied the impact of such factors as: competitive advantage, compatibility level and complexity of the technologies used, organizational structure, support for managerial staff or employees' competences on the implementation of a remote work system. In turn, Saura, Ribeiro-Soriano and Saldana (2022) pointed out that during the Covid-19 pandemic, there was an increase in the use of modern technologies, and their implementation significantly accelerated, and this had a significant impact on the stress level of employees. Mueller-Langer and Gómez-Herrera (2022), analyzing the costs of remote and traditional work in the short and long term, indicated the significant impact of the development of modern technologies on reducing the costs of remote work and its increasing use in the future. Tramontano, Grant and Clarke (2021) pointed to the key role of employee competences in building the digital resilience of an organization (enterprise) to risks and increasing the benefits of implementing remote work, including its effectiveness and productivity. According to Tramontano, Grant and Clarke (2021), it is easier for people with digital competences to achieve the so-called life balance.

Many scholars, including Chatterjee, Chaudhuri & Vrontis, (2022) have focused on researching the effectiveness and efficiency of remote work management. Modern technologies have allowed many enterprises and organizations to function continuously in times of turbulent environment and threats (Covid-19), and the experience gained in this field will result in implementation of remote work as a permanent model of work organization. The financial and technology sectors have already implemented the work from home culture model, which enables employees to perform their job duties without the need to travel to work. The key element of this system is remote access to the IT systems of these entities (Carnevale, Hatak, 2020; Hodgson, 2020; Mariani, Fosso Wamba, 2020).

The comparison of work carried out in a traditional way to remote work made it possible to compare the effectiveness of both of these forms. Martinsa, Góesa & Nascimento (2021), analyzing the labor market in Brazil, noticed that every fifth employee performs work that could be successfully performed remotely, if he had been equipped with the appropriate tools. In many of the cited studies, the aspect of social relations, mutual contacts between employees or team building efficiency is discussed in a smaller or broader context. Jämsen, Sivunen & Blomqvist, (2022), while researching the public sector in Finland, noticed that for most employees' mutual

relations and communication in remote work was a significant challenge. When designing the research, the authors also paid attention to the aspect of protection and impact on the environment of remote work. The work (Fabiani et al., 2021; Soroui, 2021) who analyzed greenhouse gas emissions resulting from, inter alia, transport restrictions during the Covid-19 pandemic and remote work organization. They pointed out that the greater the distance between the respondent's home and workplace, the higher was the result of accepting remote work, declared by them. Moreover, significant factors influencing the acceptance of remote work included: higher income and a better (healthier) lifestyle. Fabiani et al. (2021) indicate that from an environmental point of view, remote working is always sustainable when long daily commuting (over 10 km) is avoided. In summary, judicious use of remote working could reduce the environmental impact of any organization that employs office workers, as well as improving their job satisfaction and lifestyle.

The review of the research carried out so far, the analysis of the scope of their objective and subjective scope as well as the indicated limitations of the research allowed the authors to identify key research areas that should be the subject of further analysis. It seems, therefore, that the key factor determining the future of remote (and hybrid) work are digital competences, understood as the ability to use devices and applications based on Internet communication. Moreover, the subjective scope of the research conducted so far included employees of various sectors of the economy, and the objective scope focused on the comparison of specific factors of remote work with traditional work. The authors drew attention to a research gap that should be analyzed, and which could significantly enrich the existing research - the subjective scope of the research should include a group of people who during the pandemic gained extensive experience in remote communication and work (learning) remotely, and who potentially are perfectly able to use modern technologies - a group of current students. The above-described literature review and theoretical considerations lead us to the following research hypotheses:

H1: Digital competences and openness to the use of modern technologies are of key importance in the future labour market.

H1a: The distance learning experience of students will have a positive impact on the development of remote work in the future.

H1b: Remote work will expand the scope of the labor market.

Materials and methods

The scope of the research was divided into two main areas, which allowed to verify the hypotheses and research goals put forward in the research. The first area concerned the examination of digital competences of students, while the second area allowed us to learn about the respondents' expectations regarding the organization of future work and the factors determining the choice of the form of future work.

The survey used the survey method, the survey technique, the research tool of which was a questionnaire. The questionnaire consisted of three parts - the introduction, the main part consisting of 19 questions and the demographic part, specifying the demographic and social characteristics of the respondent. The survey was conducted via the Internet and the questionnaire was prepared on the Qualtrics online platform. The study was conducted in February and March 2022.

470 students from the following countries participated in the study: Poland (23.4%), Germany (14.5%), Turkey (11.9%), United Arab Emirates (11.7%), Italy (8.9%), Ukraine (6.6%), Spain (6.2%), Lithuania (6.0%), the United States (4.3%), Thailand (3.4%) and Estonia (3.2%). The group of respondents included 61.3% of women, 35.5% of men and 3.2% of respondents refused to provide this information. The survey was mainly attended by young people, as 79.6% of respondents aged up to 25 were students of universities (48.7%), technical universities/universities (33.8%), and schools of economics, business and law (5.3%). Most of the respondents participate in classes conducted in their mother tongue (71.9%), while for 28.1% of students, the language of instruction is English (see table 4).

Table 4.
Demographic information of participants

Demographic	Characteristics	Frequency	Percent
Gender	Male	288	61.3
	Female	167	35.5
	Prefer not to say	15	3.2
Age	Up to 20 years old	93	19.9
	From 21-25 years old	281	59.7
	From 26-30 years old	28	5.9
	From 31-40 years old	30	6.3
	From 41-50 years old	34	7.2
	Over 50 years old	4	0.9
Nationality	United Arab Emirates	55	11.7
	Germany	68	14.5
	Estonia	15	3.2
	Spain	29	6.2
	Italy	42	8.9
	Lithuania	28	6.0
	Poland	110	23.4
	Thailand	16	3.4
	Turkey	56	11.9
	Ukraine	31	6.6
	United States	20	4.3
Education	Business School or Law School	25	5.3
	Full University	229	48.7
	Liberal Arts College	15	3.2
	Medical School	8	1.8
	Other	34	7.2
	School of Technology/Polytechnic	159	33.8
Language of education	English	132	28.1
	Other	338	71.9

Source: own study based on the conducted research.

The scope of the research - including a group of students, i.e. people up to 25 years of age (79.6% of respondents), made it possible to analyze and learn about the competences and preferences of choosing the form of a work model by the so-called Generation Z - a generation that does not know life without the Internet, social media, which is open and very mobile. The conducted survey thus filled the research gap in the selection of the participant group. The review of the literature and the analysis of the research conducted so far focused on various aspects of remote work carried out by working people who, mainly due to the COVID-19 pandemic, were forced to perform their previous professional duties remotely. Thus, research on work efficiency (Martins et al., 2021) or mutual relations of employees (Carter Jr et al., 2020; Jämsen et al., 2022; Jämsen, Sivunen, Blomqvist, 2022; Yang et al., 2021) focused on comparing work carried out in a traditional way with remote work.

The current generation of students, firstly, is used to using modern technologies on a daily basis, and secondly, they have extensive experience in remote learning, working in decentralized teams and remote communication, which can be successfully used in future work. When designing the research, it was assumed that what is new and a challenge for the older generation - the use of instant messaging and online platforms for communication and work, for young people - generation Z, is something completely natural (Sakdiyakorn et al., 2021). Figure 1 presents selected research questions assigned to the hypotheses posed in the research.

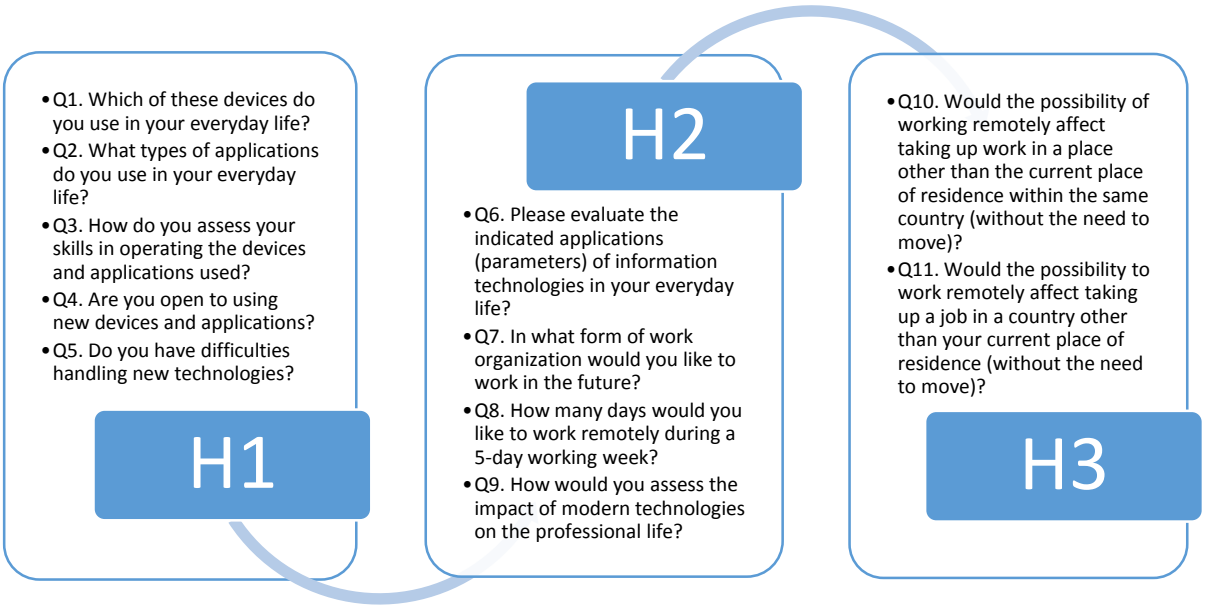

Figure 1. Assigning selected research questions (Q1-Q11) to individual research hypotheses.
Source: own study based on the conducted research.

Spearman's rank correlation coefficients were used to verify the research hypotheses. Table 5 contains a summary of the results of individual correlations.

Table 5.
A list of correlation indicators for the verification of research hypotheses

Hypothesis	Questions	Spearman's correlation index	Significance interval
H1	Q1	0.1940	0.0500
	Q2	0.2185	0.0150
	Q3	0.1535	0.0268
	Q4	0.2035	0.0032
H2	Q6	0.1668	0.0233
	Q7	0.2046	0.0028
	Q8	0.4810	0.0000
	Q9	0.2249	0.0011
H3	Q10	0.2249	0.0011
	Q11	0.2057	0.0029

Source: own study based on the conducted research.

The use of the Spearman's rank correlation allowed to state that all the studied variables, such as: digital competences, openness to the use of modern technologies, experience in the field of distance learning, are statistically significant for the choice of the form of work organization. The correlation index shows a relatively small positive correlation and is in the range [0.1535; 0.4810].

Discussion

The analysis of the collected results allows for a broader look at the potential of remote work as a future, possible form of work organization. The research results for selected questions and research areas, which were particularly important in the process of formulating and verifying the research goals and hypotheses, are presented below and presented in detail. The mobility of the young generation translates into the use of devices in everyday life. The smartphone has become the most universal and widely used device today - over 84% of respondents indicated that they use their smartphone constantly, and for comparison, the laptop is used with the same frequency by over 34% of respondents (see figure 2). When designing solutions for remote communication, used for study or work, it should be taken into account that smartphones are becoming the most important mobile devices.

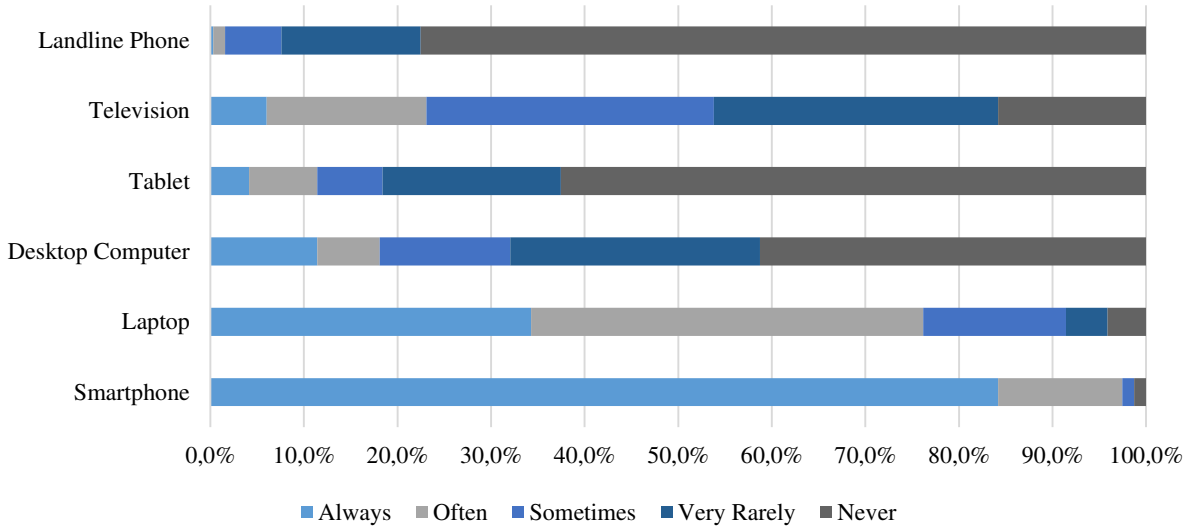

Figure 2. The use of Internet tools in everyday life in the opinion of the respondents.
Source: own study based on the conducted research.

Over 84% of the surveyed participants rated the ability to use modern technologies and devices very highly. Only 3% of the respondents indicated that they did not have any skills in this area. Ofosu-Ampong and Acheampong (2022) indicated in their research that people open to technological innovations are also more open to the implementation of modern solutions in companies. The research conducted by the authors also confirmed this thesis. As many as 87.0% of the surveyed respondents described themselves as people open to the use of modern technologies. Moreover, 73.0% of the respondents did not mention any difficulties with operating and using modern technologies. The openness of respondents to the use of modern technologies translates into the assessment of its usefulness. Over 81.0% of respondents indicated the use of modern technologies for learning or work carried out from anywhere. This aspect of mobility was the most important for the surveyed group of respondents. The use of technology for learning or remote work was positively assessed by 78.7% and 77.8% of the respondents, respectively. The next places in the assessment were: use in business communication (76.2%), private (74.0%), source of entertainment (69.2%) or access to cultural events (63.8%). Many researchers (Modrzyński et al., 2020; Yang et al., 2022; George et al., 2020) indicated the occurrence of health problems resulting from too long working time at the computer, which was also confirmed by the research conducted by the authors. However, the level of health complaints is not the most frequently indicated problem resulting from the use of modern technologies. The most frequently reported problems were: spending a lot of time in front of a computer/smartphone (57.0%), the problem of dependence on modern technologies (41.3%) or problems with concentration (38.7%) (see figure 3).

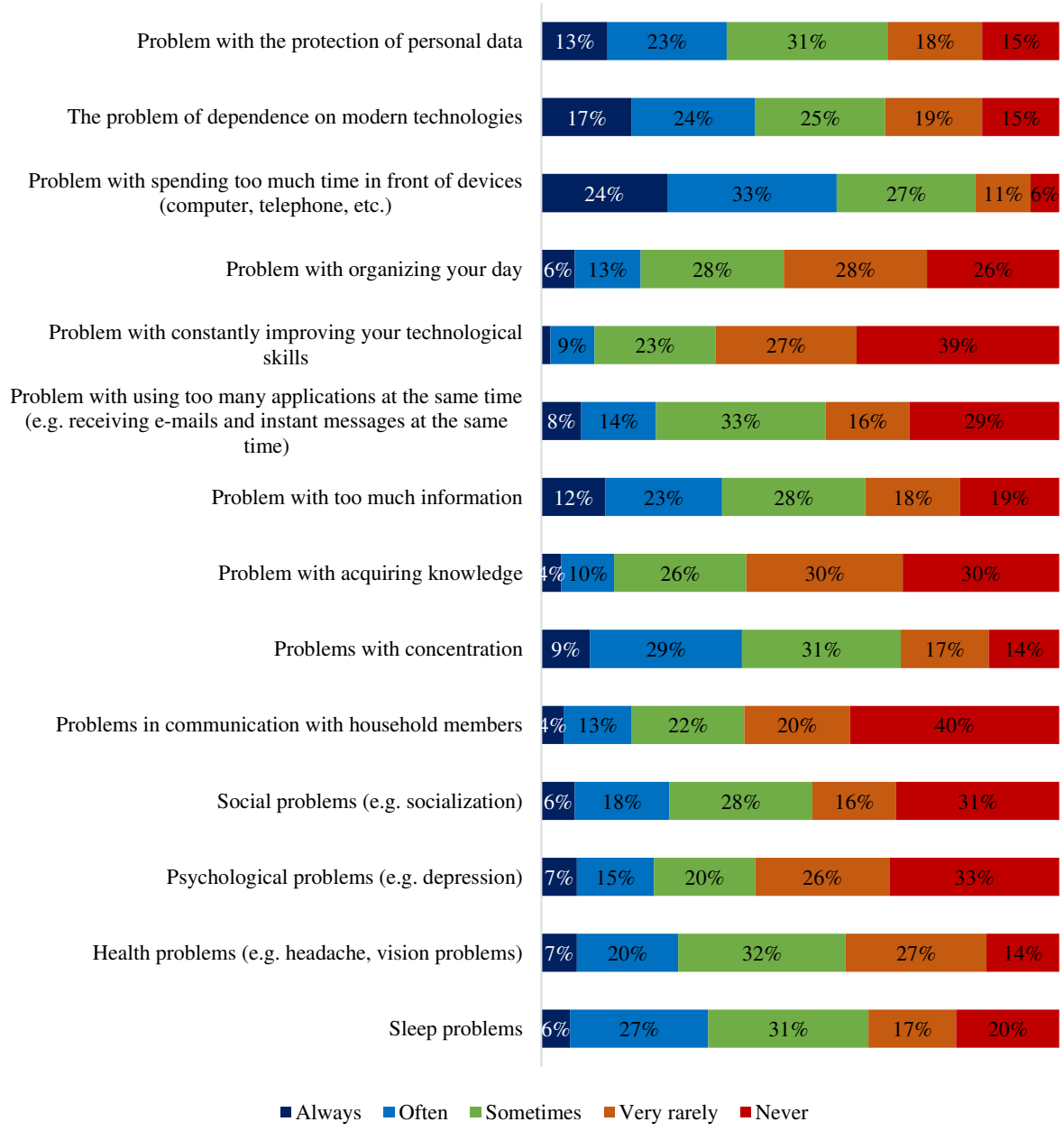

Figure 3. The frequency of occurrence of problems related to the use of modern technologies in the opinion of the respondents.

Source: own study based on the conducted research.

An interesting fact is that the surveyed group, i.e. the respondents belonging to the generation Z, rated the positive aspect of modern technologies in terms of professional matters much higher, i.e. the possibility of remote learning and, in the future, remote work, than in the context of personal life. The respondents indicated that social relations should be implemented in direct contacts (see figure 4).

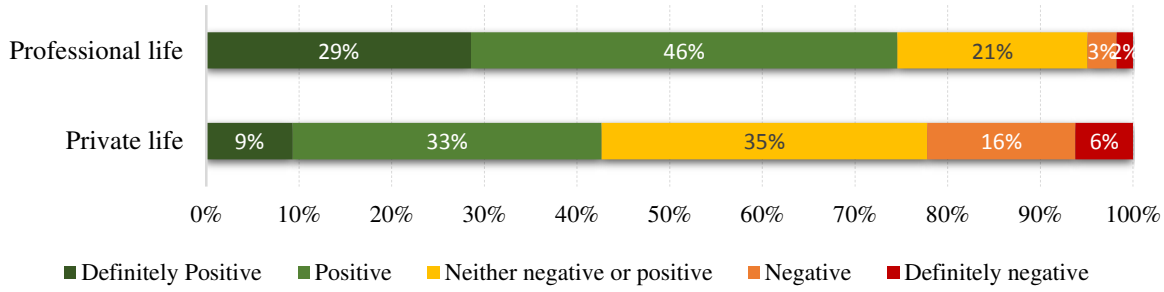

Figure 4. The influence of modern technologies on professional and private life in the opinion of the respondents.

Source: own study based on the conducted research.

Ranking use of modern technologies high in professional life translated into the choice of the preferred model of work by the respondents. Hybrid work and remote work are possible future scenarios for the evolution of the organization of work systems. Nearly 65% of respondents declared the will to work in the form of hybrid work and 7% only in the form of remote work, every fifth respondent (22.5%) would like to work in the traditional model - at the employer's premises. In the group of respondents who highly rated their digital competences, i.e. the skills in using modern technologies, the interest in the modern form of work organization is greater - hybrid work 68.0% and remote work 9.7%. If the analysis takes into account the parameter for assessing the respondents 'openness to the use of modern technologies, then an increase in respondents' attention with hybrid (72.4%) and remote (8.6%) work can also be noticed. In this group of respondents, the traditional form of work enjoys the least interest (14.3%). It is interesting that for the analyzed generation Z, hybrid work is the preferred form of work, regardless of the low assessment of own digital competences or the reluctance to use new technologies (see table 6). Therefore, the presented research indicates that the mobility attributed to the characteristics of Generation Z, to which the surveyed group of respondents belongs, is a key feature of this group, which has a significant impact on the perception of the world.

Table 6.
Preferred forms of work organization in the opinion of the respondents

Work organization	Total	How do you assess your skills in operating the devices and applications used? - Very good answers only	Are you open to using new devices and applications? - Definitely yes answers only	Do you have difficulties handling new technologies? - Definitely no answers only
Hybrid work	**64.8%**	68.0%	72.4%	68.6%
Remote work	**7.0%**	9.7%	8.6%	6.7%
Traditional work	**22.5%**	17.5%	14.3%	19.0%
I have no opinion	**5.7%**	4.9%	4.8%	5.7%

Source: own study based on the conducted research.

The organization of hybrid work can be varied. There are various configurations of combining traditional office work and remote work. In the studied group, the opinions of the respondents were also divided. However, the idea of hybrid work can only be considered in a model in which we will work from home or other place for at least two days. Less than 1.9% of respondents are interested in hybrid work in which we work remotely only one day a week. Every third respondent prefers hybrid work with 3-day remote work, and every fourth with 2-day remote work. Also, every fourth respondent indicated the possibility of hybrid work, in which one week is carried out entirely remotely, and the next one is carried out traditionally in the company's premises (see figure 5).

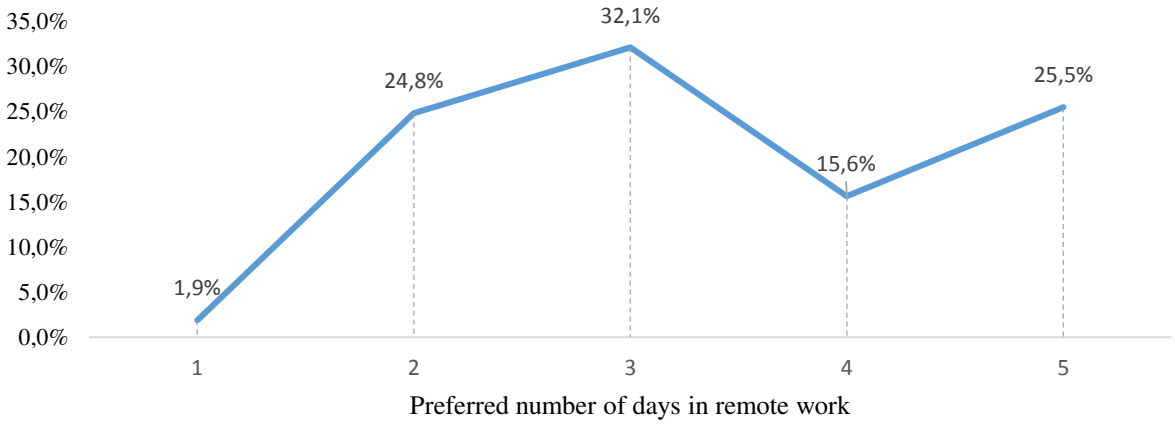

Figure 5. Preferred number of days in remote work in hybrid work in the opinion of the respondents. Source: own study based on the conducted research.

The evolution of the form of work organization towards a wider use of the hybrid model, in which employees have to commute less frequently, will have significant implications for urbanization processes. Sustainable urban development is one of the main concerns of policy-makers, and the growing urban population and urbanization have caused a number of socio-environmental impacts on people (Kalhor, Emaminejad, 2019). So far, the development of cities has been closely related to the increase in the number of inhabitants, which resulted in a number of negative effects, including an increase in CO2 (Sufyanullah et al., 2022). So, will hybrid work change this trend? According to 92% of respondents, the reduction of the costs of commuting to work is the main advantage of hybrid work. In addition, 86% of respondents indicate greater flexibility of work and on the days when we work remotely, we save not only money for commuting, but most of all we save time for commuting (84% of respondents). Remote work, e.g. from home, favors a more relaxed business etiquette (80%), and thus reduces the time needed to prepare for work (73%). A decisive challenge for remote and partially hybrid work are aspects related to human resource management in an enterprise, covering such areas as: building social relationships, motivating employees, implementing new duties or building systematic work habits (see figure 6).

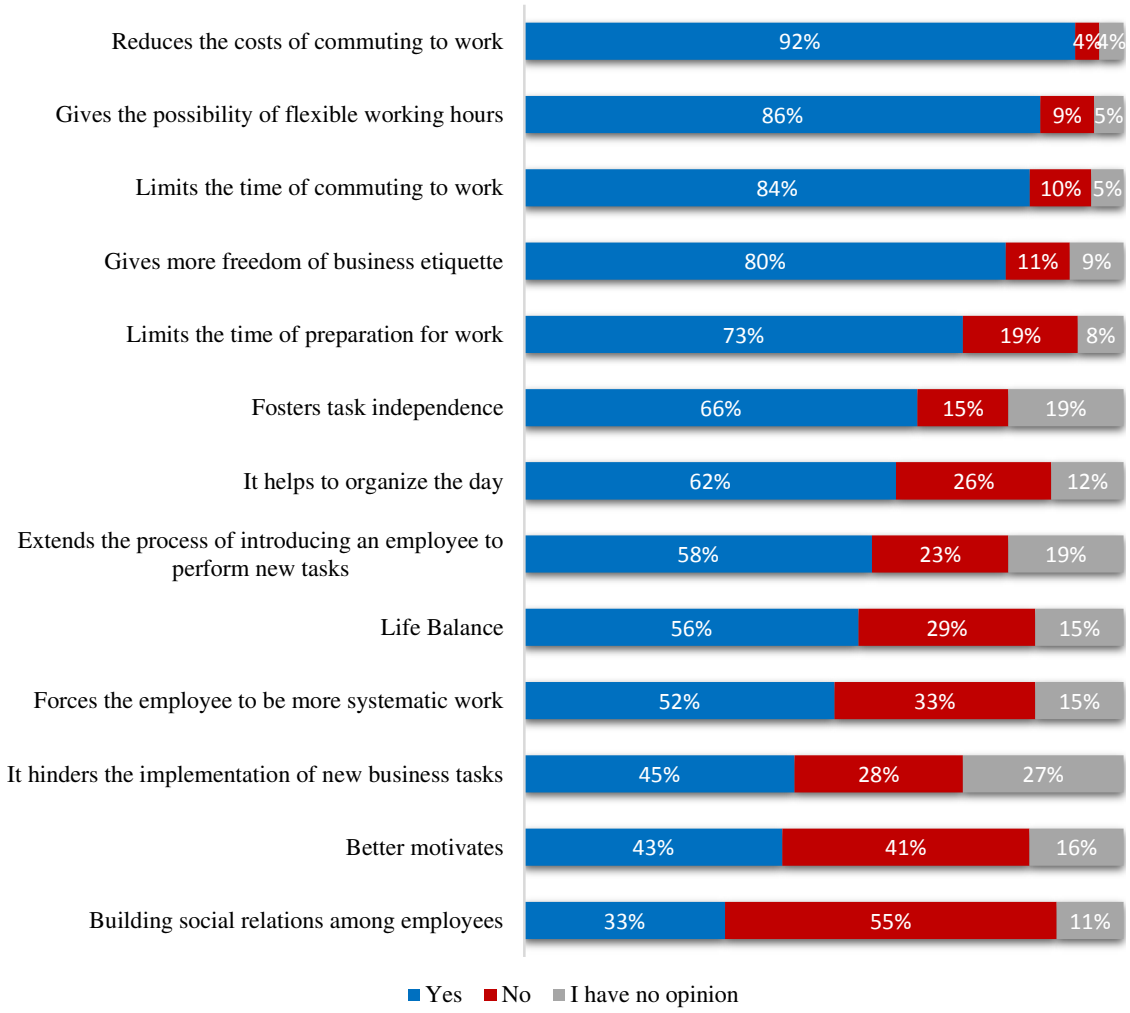

Figure 6. Presentation of the results for the question: *Do you agree with the following statements related to the work performed remotely or hybrid?*

Source: own study based on the conducted research.

The organization of work in a hybrid or remote form is not only an opportunity for employees to save time and costs of commuting, or easier organization of the working day, but above all it is a new opportunity to expand the scope of the labor market. Thus, for employers, it is easier to recruit employees for a given job position. The possibility of taking up a job in another place (city) without the need to move was declared by as many as 61.9% of the respondents. On the other hand, every fifth respondent (19.9%) would not be interested in working outside their place of residence. Similar research results were obtained in the case of questions about the possibility of taking up work outside the country of residence, thus significantly increasing the distance between the place of residence and the employer's seat. In this case, 63.3% of the respondents would be interested in working in another country, and 22.1% are against this possibility (see table 7).

Table 7.
Hybrid or remote work and employee mobility in the opinion of the respondents

Research questions	Definitely yes	Rather yes	I have no opinion	Rather not	Definitely no
Would the possibility of working remotely affect taking up work in a place other than the current place of residence ***within the same country*** *(without the need to move)?*	26.5%	35.4%	18.1%	12.4%	7.5%
Would the possibility to work remotely affect taking up a job ***in a country other than your current place of residence*** *(without the need to move)?*	29.6%	33.6%	14.6%	13.7%	8.4%

Source: own study based on the conducted research.

The decision to work outside the place of residence or even outside the country of residence are not associated with the assessment of the respondents' ability to use modern technologies. In this study, the Pearson correlation coefficient was 0.0416859, which indicates that there is no correlation between these variables.

4. Research implications

This study has provided several practical implications that organizations' practitioners and managers could apply. Generation Z - today's students who will enter the labor market in the next few years are characterized by excellent knowledge of using modern technologies and have digital competences, and the use of mobile devices has become an element of their everyday life. A characteristic feature of this generation is its mobility, which also translates into preferences regarding the future work model. The experience gained during remote learning can be used by future employers to effectively implement the hybrid work model, in which the temporary possibility of remote work is the preferred form of work for the Z generation. Undoubtedly, the issue that requires further research is the effectiveness of management and motivating employees who perform part of their work. tasks in the form of remote work. The widespread use of hybrid work will have implications for both employers and employees. Adopting this form of work organization will allow for the expansion of the labor market area for both groups of entities.

The results of the research clearly showed that employees are open to looking for work outside their place of residence, even outside the country. For employees, this means a much wider area of potential employers, and for employers it means access to a larger group of specialists. In addition, the implementation of remote or hybrid work involves the need to provide greater security of access and data flow between enterprises, organizations and their employees, who can perform their official duties outside the workplace. Building secure, open networks will be a key aspect for IT departments. In a study commissioned by the Polish

Agency for Enterprise Development PARP, which was carried out in March 2020, for 64% of the surveyed companies, the key aspect of their operation is to ensure technical conditions for remote service of performed tasks and to identify technologies and solutions with the greatest potential for the future (PARP, 2021). Already today, cybersecurity is a key area of computerization. An interesting research area is the impact of the organization of remote or hybrid work on environmental protection. Reducing CO2 emissions by reducing the need to travel to work can be important for future spatial planning and, inter alia, urbanization processes.

5. Conclusions

For people open to change, the possibility of hybrid or remote work gives the opportunity to work in a much wider span of locations, which will make it easier for these people to navigate the labor market. In this respect, the place of residence and the place of work no longer have to overlap. Instead, the attractiveness of cost of living will be independent of salaries. People will be able to live where it is affordable to do so, and append to their living quarters a workspace that will allow them to achieve productivity on levels equitable to when traditional work was taking place.

The research conducted is in line with the scientific considerations concerning the study of models of organization and effectiveness of remote work that was popularized during the Covid-19 pandemic. The research conducted here is based on cross-sectional data, which should be extended and repeated, and the subjective scope of the research should be extended, which will allow us to verify the correlation of factors such as the nature and type of studies to assess the future model of work organization.

The study was conducted on a group of 470 students from different countries. The obtained qualitative data limited the selection of statistical tools to evaluate the phenomena and relations taking place. Therefore, it is worth considering changing the scale of possible responses in order to obtain numerical values and to support the verification of research hypotheses with quantitative statistics. It is important to note that the subject pool in which our respondents are found will earn and contribute value in places where wages are high and no workspace will be required for them. According to the authors, this is an interesting research area that should be further explored in the future that can overcome the problem of limited statistical techniques. Will the use of modern technology have a positive impact on the broadly understood sustainable development, both in terms of urbanization, social development or life balance?

The authors imply some answers to these questions, namely the realignment of city centers as spaces for work and population generally will decline sharply. Further, work life balance will transform to an amalgamation of the two, where we work from home and live where we work. However, it remains unclear whether or not this will positively impact society or individual mental health.

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Appendix

*Tau Kendall correlation coefficients***

		Q20	Q2_1	Q2_2	Q2_3	Q2_4	Q2_5	Q2_6	Q3_1	Q3_2	Q3_3	Q3_4	Q3_5	Q3_6	Q3_7	Q3_8	Q3_9	Q3_10	Q3_11	Q3_12	Q3_13
Q20	correlation coefficient	--																			
	Significance (two-sided)	.																			
	N	208																			
Q2_1	correlation coefficient	,157*	--																		
	Significance (two-sided)	0,019	.																		
	N	208	221																		
Q2_2	correlation coefficient	-0,06	0,074	--																	
	Significance (two-sided)	0,376	0,232	.																	
	N	208	221	221																	
Q2_3	correlation coefficient	0,095	0,047	-,180**	--																
	Significance (two-sided)	0,123	0,437	0,002	.																
	N	208	221	221	221																
Q2_4	correlation coefficient	,179**	0,023	,179**	,202**	--															
	Significance (two-sided)	0,005	0,709	0,002	<,001	.															
	N	208	221	221	221	221															
Q2_5	correlation coefficient	0,013	0,081	0,07	0,026	0,082	--														
	Significance (two-sided)	0,832	0,18	0,22	0,638	0,155	.														
	N	208	221	221	221	221	221														
Q2_6	correlation coefficient	-0,02	-0,03	,120*	,190**	,151*	,241**	--													
	Significance (two-sided)	0,769	0,668	0,049	0,002	0,015	<,001	.													
	N	208	221	221	221	221	221	221													
Q3_1	correlation coefficient	0,059	,263**	-0,01	0,095	0,031	0,048	-0,1	--												
	Significance (two-sided)	0,366	<,001	0,873	0,11	0,609	0,422	0,105	.												
	N	208	221	221	221	221	221	221	221												
Q3_2	correlation coefficient	0,079	,429**	0,103	0,003	0,037	,160**	-0,1	,366**	--											
	Significance (two-sided)	0,224	<,001	0,085	0,956	0,541	0,006	0,127	<,001	.											
	N	208	221	221	221	221	221	221	221	221											
Q3_3	correlation coefficient	0,054	-0,01	,142*	0,082	,208**	0,037	0,086	0,082	0,035	--										
	Significance (two-sided)	0,4	0,882	0,018	0,164	<,001	0,528	0,171	0,186	0,572	.										
	N	208	221	221	221	221	221	221	221	221	221										
Q3_4	correlation coefficient	,207**	,200**	0,061	,147*	,253**	0,064	0,122	,201**	,203**	,186**	--									
	Significance (two-sided)	0,002	0,002	0,314	0,014	<,001	0,281	0,055	0,002	0,001	0,003	.									
	N	208	221	221	221	221	221	221	221	221	221	221									
Q3_5	correlation coefficient	,127*	,278**	0,044	0,093	,144*	,113*	0,018	,195**	,260**	0,104	,320**	--								
	Significance (two-sided)	0,043	<,001	0,447	0,105	0,015	0,047	0,765	0,001	<,001	0,081	<,001	.								
	N	208	221	221	221	221	221	221	221	221	221	221	221								
Q3_6	correlation coefficient	0,081	0,035	-0,08	,256**	0,044	0,009	0,019	,187**	0,037	-0,06	0,087	,163**	--							
	Significance (two-sided)	0,199	0,575	0,151	<,001	0,459	0,874	0,76	0,002	0,539	0,349	0,152	0,005	.							
	N	208	221	221	221	221	221	221	221	221	221	221	221	221							
Q3_7	correlation coefficient	0,079	0,049	0,082	0,067	,343**	-0	0,067	-0,01	-0,02	0,113	,211**	,171**	0,116	--						
	Significance (two-sided)	0,224	0,443	0,175	0,256	<,001	0,978	0,286	0,89	0,761	0,066	<,001	0,004	0,054	.						
	N	208	221	221	221	221	221	221	221	221	221	221	221	221	221						
Q3_8	correlation coefficient	0,06	,154*	0,045	-0,03	,117*	-,153**	0,007	,160**	,171**	0,085	0,086	,169**	,151**	,212**	--					
	Significance (two-sided)	0,341	0,013	0,437	0,661	0,048	0,007	0,909	0,008	0,004	0,153	0,156	0,004	0,01	<,001	.					
	N	208	221	221	221	221	221	221	221	221	221	221	221	221	221	221					
Q3_9	correlation coefficient	0,031	0,047	0,055	,142*	0,095	,159**	,170**	-0,02	0,1	,141*	,200**	0,086	0,029	0,11	0,02	--				
	Significance (two-sided)	0,622	0,456	0,354	0,014	0,11	0,006	0,006	0,738	0,098	0,019	0,001	0,143	0,627	0,07	0,69	.				
	N	208	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221				
Q3_10	correlation coefficient	0,117	0,071	0,08	,199**	,122*	0	-0,02	,166**	0,096	,178**	,201**	0,107	-0,03	,231**	0,07	,381**	--			
	Significance (two-sided)	0,063	0,252	0,173	<,001	0,039	0,996	0,805	0,006	0,109	0,003	<,001	0,067	0,652	<,001	0,22	<,001	.			
	N	208	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221			
Q3_11	correlation coefficient	0,094	0,117	0,018	-0,02	,215**	0,024	0,018	0,026	0,036	,124*	,130*	0,109	0,091	,251**	,205**	,183**	,183**	--		
	Significance (two-sided)	0,141	0,062	0,764	0,714	<,001	0,678	0,776	0,67	0,558	0,041	0,035	0,065	0,124	<,001	<,001	0,002	0,002	.		
	N	208	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221		

		Q20	Q2_1	Q2_2	Q2_3	Q2_4	Q2_5	Q2_6	Q3_1	Q3_2	Q3_3	Q3_4	Q3_5	Q3_6	Q3_7	Q3_8	Q3_9	Q3_10	Q3_11	Q3_12	Q3_13
Q3_12	correlation coefficient	0,099	,162**	0,088	0,075	,250**	0,04	0,061	0,059	,121*	0,087	,212**	,167**	-0,02	,236**	,205**	,147*	,183**	,294**	--	
	Significance (two-sided)	0,112	0,009	0,13	0,191	<,001	0,485	0,317	0,33	0,043	0,144	<,001	0,004	0,77	<,001	<,001	0,012	0,002	<,001	.	
	N	208	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	
Q3_13	correlation coefficient	0,004	-0,01	0,03	0,014	0,115	0,116	,135*	0,077	-0	0,068	,156*	,160**	0,055	,172**	,201**	,189**	0,095	,197**	,170**	--
	Significance (two-sided)	0,956	0,914	0,619	0,811	0,061	0,051	0,034	0,22	0,969	0,272	0,014	0,009	0,369	0,01	<,001	0,002	0,118	0,001	0,005	.
	N	208	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221

Source: Own study based on the conducted research.

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EUROPEAN UNION'S DIGITIZATION POLICY – ASSUMPTIONS AND DIGITAL ACHIEVEMENTS OF MEMBER STATES

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Purpose: The European Union is setting increasingly ambitious objectives for digitization, aiming to be a global leader. This involves assessing the level of digitization among EU member states and identifying the key challenges facing the EU, given the priorities established.
Design/methodology/approach: An analysis of the level of digitization in EU countries was conducted using secondary data collected by the European Commission as part of its monitoring of digital policy with the Digital Economy and Society Index (DESI). This analysis included a descriptive evaluation of the overall index and its sub-indices. In addition, EU countries were grouped by similar levels of digital development through cluster analysis using Ward's method.
Findings: The level of digitization within the EU is high. The leaders in the overall DESI ranking include Finland, Denmark and the Netherlands. However, the countries least advanced in developing a digital economy are Romania, Bulgaria and Greece. The study's results reveal clear geographical differences. The gap between the leading country and the one in the lowest position is significant. While all countries are advancing in the four dimensions monitoring digital transformation, the distance to the 2030 goals is still significant, even among the digitization leaders. A key area of challenge includes human capital with insufficient digital skills, as well as the digital transformation of SMEs. A hierarchical clustering search for similarities between countries showed that the clusters formed depend somewhat on their place in the DESI ranking. Countries with low levels of digitization, such as Romania and Bulgaria, have the strongest clustering. Leaders in the development of the digital economy also exhibit strong clustering.
Research limitations/implications: By its very nature, this article has limitations, primarily arising from the complexity of the subject matter discussed and the restricted number of research methods utilized. These limitations are also due to changes in the DESI methodology, which complicates reference to statistics that have not been updated. In planning future research activities, a significant and intriguing direction will involve a detailed study of the dimensions of the DESI index.
Practical implications: The digital transformation impacts citizens and businesses across all EU countries. This understanding lends cognitive value to the current progression of the EU's digital transformation, indicating key challenges in this field.
Originality/value: This article employs an original DESI descriptive analysis approach, enriched by an examination of similarities between member states.

Keywords: digital single market, digital transformation, European Union digital goals, Ward's method.

Category of the paper: research paper.

1. Introduction

With the advent of the Internet and the digital economy, the European Union's internal digital market has gained prominence. Progressive European integration involves the construction of a single market, which eliminates all national trade barriers and ensures the enhancement of economic and social prosperity, all while respecting the environment. More specifically, the EU establishes an internal market among member states where the free movement of goods, services, people, and capital is guaranteed (Treaty on the Functioning of the EU, 2020). As per the Treaty, the concept of the internal market represents an "area without internal borders" with uniform competition rules (TFEU Article). The realization of the common market, officially functioning since 1993, continues unabated, yet national barriers persist in many areas, including legal, technical, or administrative aspects. A 2020 publication from the European Commission detailed 13 major user-perspective barriers (for businesses and consumers), some of which included practical obstacles. Attention was given to difficulties in obtaining information, intricate administrative procedures for selling goods and services abroad, rejection or diversion of orders in cross-border purchases, problems with skill shortages or mismatches, and language barriers (EC, 2020).

Over the decades of the EU's operation, cooperation among member states has expanded into various areas where collective action proves more beneficial than individual country efforts. One such area is the digital single market, which generally entails the removal of national barriers to online transactions. In keeping with the EU's vision, a digital single market can facilitate access to information, enable the development of superior business and administrative models, and contribute to productivity improvements through lower transaction costs, dematerialized consumption, and reduced environmental impact. The growth of e-commerce benefits consumers through the rapid development of new products, lower prices, a wider selection, and improved quality of goods and services. It also leads to an increase in cross-border trade, bolstering the development of the Community's internal market. Additionally, the proliferation of e-government services simplifies the process for EU consumers and businesses to access job opportunities, fulfill requirements, and explore other business prospects online. The EU's shared vision for digitization implies a widespread adoption of modern solutions in the expansive area of data and connectivity. This includes European cloud computing, ethical artificial intelligence, secure digital identities, and supercomputing infrastructure. Achieving this vision necessitates investment in all areas of

digitization, starting with digital skills, supercomputing, and high-speed connectivity as part of a comprehensive strategy.

The purpose of this article is to assess the level of digitization among the European Union member states and to identify the key challenges the EU faces considering the adopted priorities.

2. EU digital policy – assumptions and priorities for digital transformation:

EU member states, forming an integration group, have an open and competitive single market with a robust industrial base and skilled citizens. Globally, the Union asserts itself as a player in rules-based international trade. These strengths present an opportunity to leverage them towards achieving the community's ambitious digital policy goals. The presumption is that this policy should guarantee a prosperous, human-centric digital future for citizens and businesses that is sustainable, and upholds cybersecurity and democratic principles in both public and private sectors (Carlsson, Rönnblom, 2022).

However, the European economy is vulnerable, susceptible to risks, and lags considerably behind the United States and China in terms of investments in ICT technologies and citizen skills, including public administration personnel (EC, 2021; Dudzik et al., 2022; Olszewska, 2020). A significant weakness of the EU's digital space is that most digital technologies are developed outside the Community. This is evident in key technology areas such as processors, Internet platforms, and cloud infrastructure, where 90% of data is managed by U.S. companies and less than 4% of the leading Internet platforms are European. By contrast, European-made microchips account for less than 10% of the European market share (EC, 2021). The COVID-19 pandemic has emphasized the problems associated with dependence on critical technologies from outside, or reliance on a few large tech companies. It led to an influx of counterfeit products and cyber theft. Additionally, the pandemic highlighted the detrimental impact of misinformation on democratic societies. However, it also revealed a new digital divide stemming from disparities in the ability to fully benefit from an enriched, accessible, and secure digital space offering a comprehensive range of services, expanding beyond the previous divide between urban and rural or geographically remote areas. A similar scenario is seen among businesses, some of which have not fully digitized and are thus unable to reap the benefits of a modern digital environment (EC, 2021). The previously mentioned lack of digital capabilities and skills among employees serves as a significant barrier to maximizing the use of digital technologies in companies, especially small and medium-sized enterprises (SMEs) (Scuotto et al., 2021; Wiktor, et al., 2021; Łukaszuk, 2022; Grzyb, 2019).

Therefore, the EU must pursue an active digitization policy to maintain its position on the international stage and to ensure the fulfillment of its integration goals. This framework is established by adopted documents in which the Community defines development priorities based on diagnosed internal and external conditions. These efforts aim to create a digital single market – a free and secure space where citizens can shop online in other countries, and companies can sell goods and services across the Union regardless of location (EU Council and European Council Portal; Cenamor et al., 2019).

The concept of a single market is included in the "Europe 2020 Strategy". Among the seven guiding initiatives for its implementation, the "European Digital Agenda" was adopted, underscoring the role of information and communication technologies in achieving the strategy's goals. Subsequent Community documents have upheld this importance, identifying the digital single market as one of the EU's priorities. The Digital Single Market Strategy for Europe adopted solutions for a swift transition from a global to a digital economy. The document identifies 16 key actions based on three pillars: (1) better consumer access to digital goods and services, (2) creating conditions and a level playing field for the development of digital networks and innovative services, and (3) maximizing the growth potential of the digital economy (EC, 2015). These measures are implemented through legislative initiatives of the European Commission and address issues such as unjustified geographical blocking, cross-border parcel delivery services, digital content delivery, and the operation of online platforms (Ratcliff et al., 2023). In 2018, a plan for coordinated support of artificial intelligence in all countries (the "Artificial Intelligence for Europe" strategy) was established. In 2020, a white paper titled "Artificial Intelligence: a European Approach to Excellence and Trust," along with communications on shaping Europe's digital future and a European data strategy, were adopted. The COVID-19 pandemic and its aftermath contributed to the adoption of additional solutions. The European Commission issued a recommendation for a common EU set of tools to facilitate the use of technology and data to combat the ensuing crisis. It also announced a communiqué, "A Decisive Moment for Europe: Repairing and Preparing for the Next Generation," positing that the recovery of the European economy will be achieved through a digital single market, among other means. Central to these efforts are investments in better connectivity, strategic components of the digital supply chain (AI, cybersecurity, 5G, cloud computing infrastructure), and a data-driven economy in a fair environment conducive to doing business.

The EU outlined a roadmap for digitization over the next decade in the EC's communication "Digital Compass for 2030: Europe's Path in the Digital Decade." This document sets out a guide for the Community's transformation in this area, along with a monitoring system and key milestones and measures to achieve the goals. The digital compass identifies four significant developments: (1) a digitally skilled society and highly skilled digital professionals, (2) secure, efficient and sustainable digital infrastructure, (3) digital transformation of businesses, and (4) digitization of public services. The first two developments aim at fostering digital capabilities in the form of skills and infrastructure, while the latter two focus on the

digital transformation of companies and public services. Specific ambitious goals to be accomplished by 2030 have been assigned to the adopted directions (EC, 2021). The EU's approach is to achieve these goals by implementing joint, multinational projects funded by the Instrument for Reconstruction and Enhanced Resilience (European Commission, 2023). The EU also highlighted the basic principles of its digital transformation: a level playing field in digital markets, a secure cyberspace, and upholding fundamental rights online. These principles promote the Community's core interests and values while ensuring the construction of an open digital economy based on investment and innovation flows.

The EU's digital transformation is carried out based on so-called general goals and digital objectives defined at the EU level, linked to specific areas where joint progress is expected. These priorities are outlined by the "Road to the Digital Decade" policy program until 2030 (European Parliament and Council Decision (EU) 2022). This program obliges member states to submit national strategic action plans to the European Commission, which must align with the overall and digital goals and specify how these ambitious objectives will be achieved.

The digital objectives target the four main directions delineated in the aforementioned Digital Compass Communication: digital skills, digital infrastructure, digitization of businesses, and digitization of public services.

The first objective involves cultivating a digitally skilled society and highly skilled digital professionals, with an emphasis on achieving gender balance. The goal is to ensure that by 2030, at least 80% of people between 16–74 years old have basic digital skills, and at least 20 million ICT professionals are employed within the Union. This also includes encouraging women's participation in the field and increasing the number of ICT graduates.

The second objective focuses on developing a secure, resilient, efficient, and sustainable digital infrastructure. The plan entails that all stationary end users will have access to a gigabit network, all populated areas will be covered by a next-generation ultra-high-speed wireless network performing at least as well as 5G, and the EU's production of state-of-the-art semiconductors will constitute at least 20% of the value of global production. In addition, at least 10,000 climate-neutral edge nodes will be deployed, regardless of business location, by 2025, and the EU is expected to launch its first quantum-accelerated computer.

The third objective pertains to the digital transformation of businesses, with the expectation that at least 75% of EU companies will utilize at least one of the following: cloud computing services, big data, or artificial intelligence. Furthermore, over 90% of EU small and medium-sized enterprises (SMEs) should reach a basic level of digital intensity. The EU plans to facilitate the development of innovative scale-up companies and improve their access to financing, potentially doubling the number of "unicorns" — a term referring to (a) companies established after December 31, 1990, which have either surpassed a $1 billion valuation at the initial public offering or sale to an industry investor or (b) achieved such valuation in the most recent round of private venture capital financing, including if the valuation was not confirmed by a subsequent transaction (European Parliament and Council Decision (EU) 2022).

The fourth objective is the digitization of public services. Target: 100% of key public services are to be available online for both citizens and businesses in the EU. Additionally, all citizens should have access to their electronic medical records and electronic identification (eID) measures recognized throughout the EU, granting them control over transactions that require identity verification and sharing of personal data.

Broadly speaking, the general objectives to be achieved at the European Union level include promoting, strengthening, and developing: a human-centered, inclusive, transparent, and open digital environment that respects fundamental rights; collective resilience and narrowing of the digital divide; strategic EU digital sovereignty; digital capabilities; online participation in democratic life; a secure online public service environment; and sustainable, resilient, and energy-efficient infrastructures and technologies, including supply chains, fair and non-discriminatory conditions for users. A total of 11 such goals have been defined, all of which represent areas of cooperation for all member states in terms of compliance with the principles and digital rights contained in the document "European Declaration of Digital Rights and Principles in the Digital Decade".

It's worth noting that the EU also views the development of digital technologies as a means to achieve the goals of the European Green Deal. Digital technologies can help transition to a climate-neutral and more resilient circular economy. The application of digital technologies in fields such as agriculture, energy, construction, industry, urban planning, and services can lead to greener processes and better environmental protection. Companies can utilize digital technologies to achieve higher (energy and material) efficiency with a smaller environmental footprint. Accelerating and maximizing the effects of policies addressing climate change and environmental protection can, according to the policy agenda of the Road to the Digital Decade by 2030, be realized through the use of digital technologies such as artificial intelligence, 5G network, 6G network, blockchain, cloud and edge computing, and the Internet of Things (Decision of the European Parliament and Council (EU), 2022). It is acknowledged that the ongoing digital transformation will enhance the positive impact of EU activities on the environment, climate, and the European economy. Significant benefits are anticipated within the EU industrial sector through alterations in production processes and the implementation of environmentally friendly decisions by consumers and producers. These include changes in the community labor market and the skill level of citizens (Windys, 2021).

3. Monitor progress toward digital decade goals

Monitoring the progress toward the general and digital goals is the responsibility of the European Commission, which uses the DESI and the KPIs (key performance indicators) for each digital objective, defined by an implementing act. The KPIs should be updated as

necessary for continuous effective monitoring and to accommodate technological changes (EP and Council (EU) Decision, 2022). The Digital Economy and Digital Society Index (DESI) is a tool that has monitored digitization since 2014, its methodology is adapted to the current conditions and EU development goals in this area. Specifically, DESI is an annual set of analyses and measurement indicators by which the European Commission tracks the overall digital accomplishments of the EU and member states across various policy dimensions, including progress toward digital goals (EP and Council Decision (EU), 2022). Annual country profiles according to the index are becoming an instrumental resource to support member countries in their digital transformation.

Starting in 2019, DESI includes a scoreboard on women in the digital sector. This assesses the performance of EU countries in the areas of Internet use, Internet user skills, as well as specialized skills and employment, based on twelve indicators. The approach is designed to monitor the digital divide between men and women.

The current enhanced Digital Economy and Society Index allows the tracking of the EU's trajectory in terms of the pace of digital transformation, gaps in European strategic digital capabilities, and implementation of digital principles. The index measures the realization rates of the most important aspects in the four major development directions (EC, 2021).

The effectiveness of implementing digital transformation in the EU depends on the efficacy of the actions taken at the community level and cooperation between the national and community actors involved. According to the provisions of the Road to the Digital Decade, effective and efficient cooperation between the European Commission and member states will be ensured by national strategic action plans for the digital decade covering the period up to 2030 (so-called national action plans). These documents propose nationally measurable, projected trajectories, describing all planned, adopted, or implemented measures to contribute to the achievement at the Union level of the overall goals and digital objectives. These plans should be developed in consultation with key stakeholders such as business organizations, SME representatives, social partners, and civil society.

The monitoring and cooperation mechanism adopted for the Road to the Digital Decade program is designed to create an environment conducive to meaningful innovation and investment by setting a clear direction for the community's digital transformation. The mechanism aims to structure and stimulate cooperation between the European Parliament, the EU Council, the European Commission, and the member states. More broadly, it will promote consistency, comparability, transparency, and completeness of EU monitoring and reporting. An integral part of the monitoring system is the Digital Decade Report, which the European Commission submits and presents annually to the European Parliament and the EU Council The Digital Decade Report should offer an assessment of the progress of the digital transformation toward the digital goals, as well as the status of compliance with the overall goals. An assessment of the progress made will also identify significant gaps or deficiencies in the efforts to date. It also recommends policies, measures, or actions for member states to implement in areas where progress has been insufficient.

4. Research methodology

The study of the level of digitization of EU member states was conducted on the basis of an analysis of secondary data collected by the European Commission as part of its monitoring of digital policy using DESI. The first stage involved a descriptive analysis of the overall Digital Economy and Digital Society Index and its four sub-dimensions. In the second stage, a classification of European Union countries by similar levels of digital development was carried out using cluster analysis. It assumes the segmentation of data in order to extract homogeneous objects from the studied population. Therefore, the community is divided into different groups to obtain clusters in which elements in the same group are similar to each other and distinct from the elements in other groups (Gatnar, Walesiak, 2004). Ward's method, which belongs to the hierarchical methods of object classification, was used to group European Union countries into clusters. This method is unique in the hierarchical group of methods as it uses analysis of variance to determine the distance between clusters. The key to this method is to minimize the sum of squares of deviations within clusters, which ensures homogeneity within clusters and heterogeneity between clusters. As a result, Ward's method is considered the most effective. However, it's worth noting that it tends to cluster a relatively small number of observations and distinguish clusters of similar sizes (Ward, 1963; Młodak, 2006; Szkutnik et al., 2015).

The examination of the digital economy of EU countries using Ward's method was conducted based on 33 standardized variables. Euclidean distance was employed for clustering. The results of the analysis are presented as a cluster tree – a dendrogram, using Statistica 13.3 software. Using Ward's method, it was possible to group into clusters the EU countries that are most similar to each other and are at the same time maximally different from other countries in terms of the selected characteristics. In this study, a critical value was determined based on an analysis of the agglomeration schedule. During the process, after observing the largest increment, in which many clusters are formed at approximately the same bond distance, a cutoff is made that divides the set into classes.

The selection of variables adopted for the study, which characterize the phenomenon under investigation, was determined by the data available from DESI statistics. The source of information was the DESI report, which is prepared by the European Commission based on Eurostat data, information sent by member countries, and with the aid of specialized research and analytical methods. As mentioned earlier, DESI is a composite index that summarizes relevant indicators on the digital performance of EU member states in terms of digital competitiveness. For the implementation of the study, all sub-indicators that constitute the DESI were used, based on the most recent data available (as of July 2023), that is, the DESI 2022 Report (Table 1).

Table 1.
Structure of DESI 2022

Dimension	Sub-dimension	Indicator
Human capital	Internet user skills	At least basic digital skills. % of individuals Beyond basic digital skills. % of individuals At least basic digital content creation skills. % of individuals
	Advanced skills and development	ICT specialists % of working individuals aged 15-74. Women ICT professionals. % of ICT professionals Companies providing ICT training. % of enterprises ICT graduates. % of graduates
Connectivity	Fixed broadband take-up	General use of fixed broadband. % of households Use of fixed broadband connections of at least 100 Mbps. % of households Use of connections of at least 1 Gbps. % of households
	Fixed broadband coverage	High-speed broadband coverage (next-generation access). % of households Coverage of fixed networks with very high bandwidth. % of households Fiber-to-the-premises (FTTP) technology coverage. % of households
	Mobile broadband	5G spectrum. Allocated bandwidth as % of total harmonized 5G spectrum 5G network coverage. % of populated areas Use of mobile broadband services. % of individuals
	Broadband prices	Broadband price index. Score (0–100)
Integration of digital technology	Digital intensity	SMEs with at least a basic level of digital technology use. % of SMEs
	Digital technologies for businesses	Electronic information exchange. % of enterprises Social media. % of enterprises Large datasets. % of enterprises Cloud. % of enterprises Artificial intelligence. % of enterprises ICT for Environmental Sustainability. % of enterprises carrying out pro-environmental activities with the use of ICT that have achieved a medium/high rate of digital technology use E-invoicing. % of enterprises
	e-Commerce	SMEs with online sales. % of SMEs E-commerce turnover. % of SME turnover Cross-border Internet sales. % of SMEs
Digital public services	e-Government	Users of e-government services. % of Internet users. Pre-filled forms. Score (0–100) Digital public services for citizens. Score (0–100) Digital public services for businesses. Score (0–100) Open data. % of maximum score

Source: Digital Economy and Society Index 2022.

The 2022 DESI reports for member states are primarily based on 2021 data and track the progress made in EU countries (in a few instances, missing data was supplemented by 2020 and 2018 data). It's crucial to note that this edition is closely linked to the conditions of the COVID-19 pandemic (European Commission Portal, 2023).

5. The state of digitization in the European Union – DESI 2022

The level of digitization in the European Union varies significantly (Figure 1). Finland and Denmark have the most advanced digital economies, with the overall DESI index value nearing

70. The Netherlands, Sweden, Ireland, Malta, and Spain also demonstrate a significant level of digital development, with indices surpassing 60.

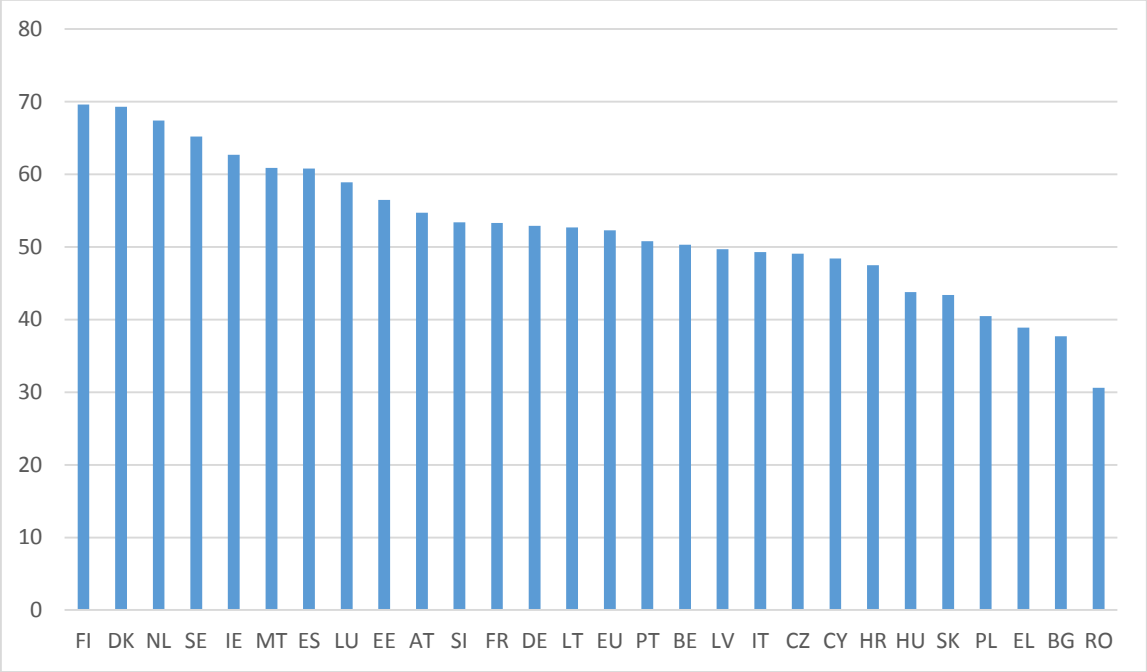

Figure 1. Digital Economy and Society Index (DESI) 2022.

Source: own compilation based on European Commission data.

At the other end of the spectrum, Romania, Bulgaria, and Greece's indices did not exceed 40. Thirteen EU countries fell below the EU average of 52.3, with Lithuania and Portugal closest to this average. There's a significant gap of 39 between the leading and the lowest-ranking countries. Finland scored 2.3 times better than Romania.

Considering the first of the dimensions that compose the DESI – Human Capital – Finland exhibits the highest level of development (Figure 2). The index, consisting of seven sub-elements, reached 71.4 for this country. Finland significantly surpasses the next countries, namely the Netherlands, Ireland, and Sweden (indices ranging between 62-63.1). Romania and Bulgaria have the lowest human capital scores, with indices not exceeding 33. The EU average is 45.7, dividing the member countries nearly 50-50. Thirteen countries fall below the EU average, performing poorly in digital skills, ICT professionals, including women, and ICT training provided by companies.

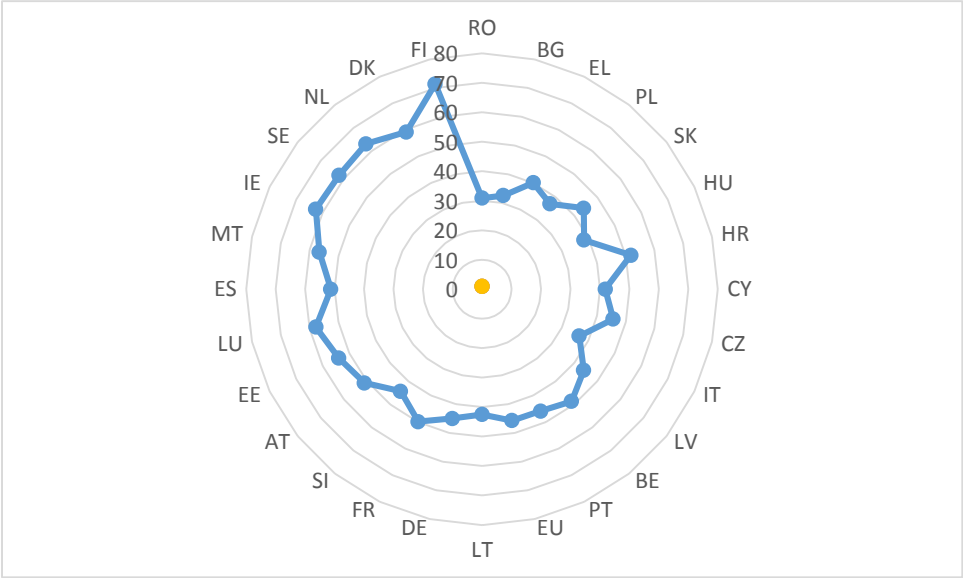

Figure 2. Human capital – DESI 2022.

Source: own compilation based on European Commission data.

Digital infrastructure (connectivity) forms the second dimension of DESI. It comprises ten individual indicators describing next-generation broadband coverage and usage, including 5G, mobile, and broadband services. This dimension demonstrates the least variation among member countries (Figure 3)

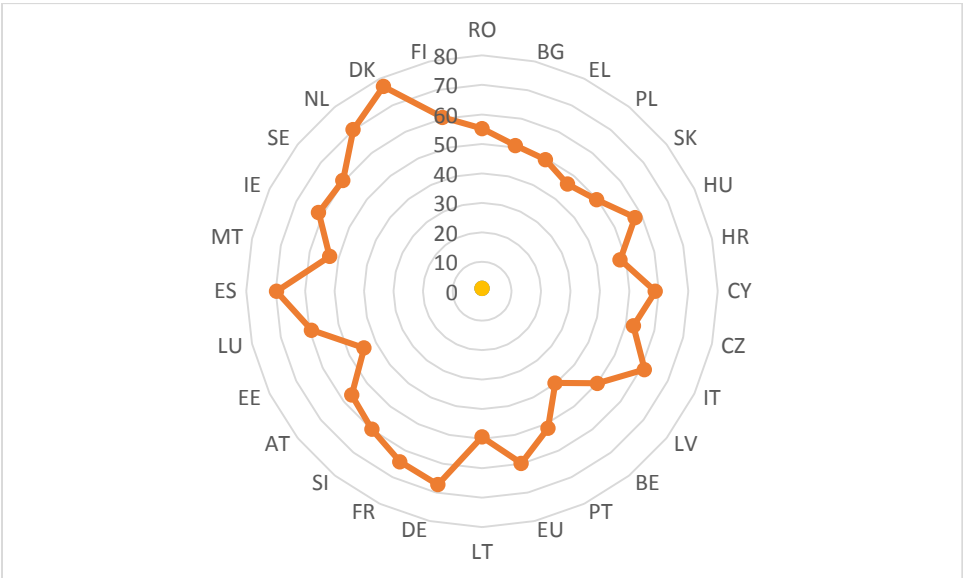

Figure 3. Connectivity – DESI 2022.

Source: own compilation based on European Commission data.

The distance between Denmark (leader) and Bulgaria (last position) is 37.3. Besides Denmark, the Netherlands, Spain, and Germany register the best results in terms of digital infrastructure development, meaning that the overall DESI ranking leaders hold weaker positions. Sweden, Finland, and Ireland rank just above the European average (59.9), taking positions 9, 8, and 7, respectively. Digital infrastructure is least developed in Bulgaria, Estonia,

Poland, and Croatia, with indices below 49. Notably, as many as 18 countries ranked below the EU average.

In the third dimension of DESI – Integration of Digital Technologies, seventeen member countries rank above the EU average (36.1) (Figure 4).

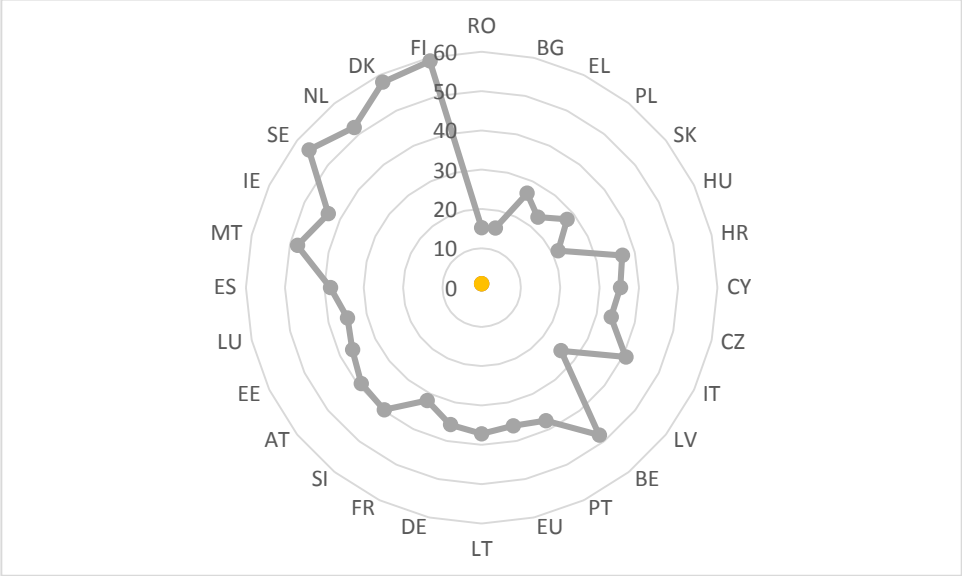

Figure 4. Integration of digital technology – DESI 2022.

Source: own compilation based on European Commission data.

There's a large distance between the leader, Finland, and the lowest-ranked country, Romania, with a gap of 43.9 points, almost four times Finland's score in this area. Denmark, the Netherlands, and Sweden also exhibit high levels of digital integration. In contrast, apart from Romania, Bulgaria, Hungary, and Poland record the lowest scores in the 11 individual indicators that comprise this DESI dimension.

Estonia is the clear leader in the development of digital public services, recording a score of 91.2 (Figure 5). Finland, which ranked next, achieved a significantly lower score of 87.4. The EU average was 67.3, and 15 countries ranked above this score. The fourth dimension of the DESI consists of five indicators that characterize access to and use of public services for citizens and businesses. This is the area that differentiates member states the most out of all DESI dimensions. The gap between Estonia and Romania exceeds 70, indicating that the leader in this category performs over four times better than the country at the bottom of the ranking. Romania's score in terms of digital public services was only 21. The next country from the bottom, Greece, reached an index level of 39.4. Notably, a significant gap also separates Greece from the next-ranked country, Bulgaria, which had an index of 51.9.

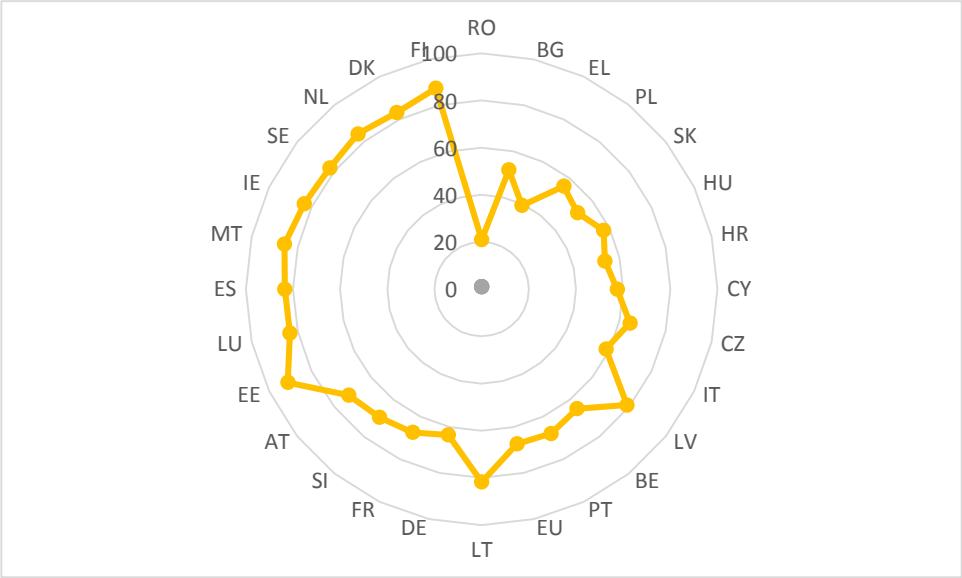

Figure 5. Digital public services – DESI 2022.

Source: own compilation based on European Commission data.

From 2017 to 2022, a clear increase in the level of digitization in member states can be seen (Figure 6).

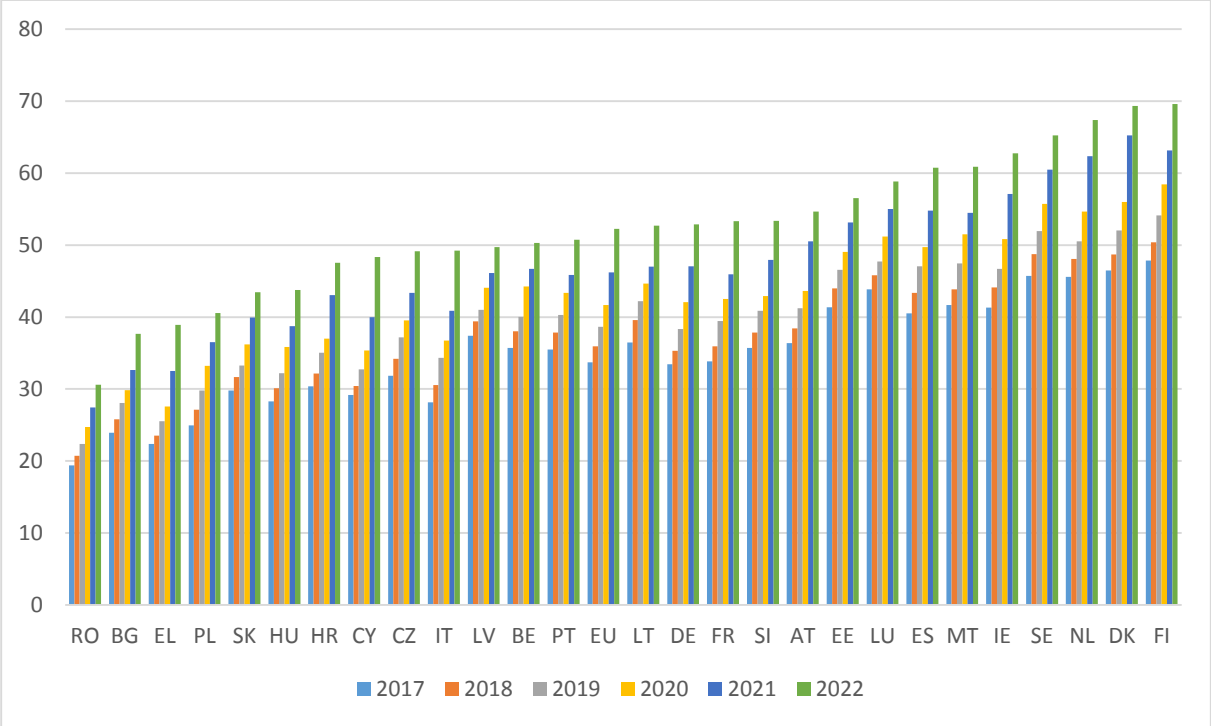

Figure 6. DESI 2017-2022.

Source: own compilation based on European Commission data.

Most countries are progressing in building a digital economy and digital society. The highest growth rates between 2017 and 2022 are evident for Greece, Cyprus, Italy, Poland, Germany, and France. The leaders in digital development are consistently the same countries. However, a significant group of member states ranks near the EU average. Crucially, most of

the member states that had lower levels of digitization at the beginning of the analyzed years are making faster progress than other countries. This may indicate a general trend toward equalization in the digital field in the EU.

Despite the accelerating digital transformation, most countries that ranked below the EU average have not made significant progress in digitization development. This is particularly problematic with regard to digital education and digital skills. Only 54% of EU citizens aged 16-74 have at least basic digital skills. Even the countries at the top of the DESI ranking have considerable ground to cover to meet the EU's targets for 2030, which aim for a rate of 80% (European Commission Portal, 2023a; European Parliament and Council Decision (EU) 2022). A weakness in EU digitization is the percentage of ICT graduates, which averages 6.50% in the EU, while in Ireland and Estonia it is more than twice as high (14.3% and 14%, respectively). There are over six times as many graduates in ICT in Finland (leading position) than in Italy (last position). The shortage of such specialists significantly impacts the adoption of digital technologies by businesses and the underutilization of the potential of the digital economy. (European Commission Portal, 2023).

The transformation of businesses hinges on their ability to quickly and fully adopt new digital technologies. However, the level of implementation of key digital technologies by EU companies remains unsatisfactory. Artificial intelligence (AI) is used by 8% of EU companies. The technology is least developed in Romania, where only 1% of companies are implementing AI. Slightly higher rates are seen in Bulgaria, Cyprus, Estonia, Hungary, and Poland (3% each). The leader in implementing AI technology is Denmark, where 24% of companies use artificial intelligence. In Portugal and Finland, the ratio is 17% and 16%, respectively. The use of big data technologies also remains at a low level in the EU (14% of companies on average). It is least used in Romania (5%), while the highest number of companies use big data technology in Malta (30%), Denmark, and the Netherlands (27% each). Digital transformation for companies assumes that by 2030 at least 75% of EU companies will use at least one of the activities, i.e., cloud computing services, big data, artificial intelligence (Decision of the European Parliament and Council (EU) 2022). EU companies must, therefore, become more proactive in implementing key digital technologies in business operations.

6. Similarities of European Union countries in the level of development of the digital economy based on the Ward method

To identify and group similar entities, a cluster analysis was conducted to assess the similarity of digitalization levels among the studied countries. A hierarchical agglomerative method was used, progressively grouping EU countries into larger clusters. An integral component of this process is the dendrogram cutoff, which determines the number of clusters

in the analysis. During the proceedings, a dendrogram is generated as a graphical representation. In this study, the critical value was determined based on an analysis of a line graph of bond distances relative to successive stages of the bonding process.

The analysis of the 2022 agglomeration flow chart indicates that the dendrogram division should be at the 25th step (Figure 7), i.e., the bonding distance is positioned between 11 and 16.

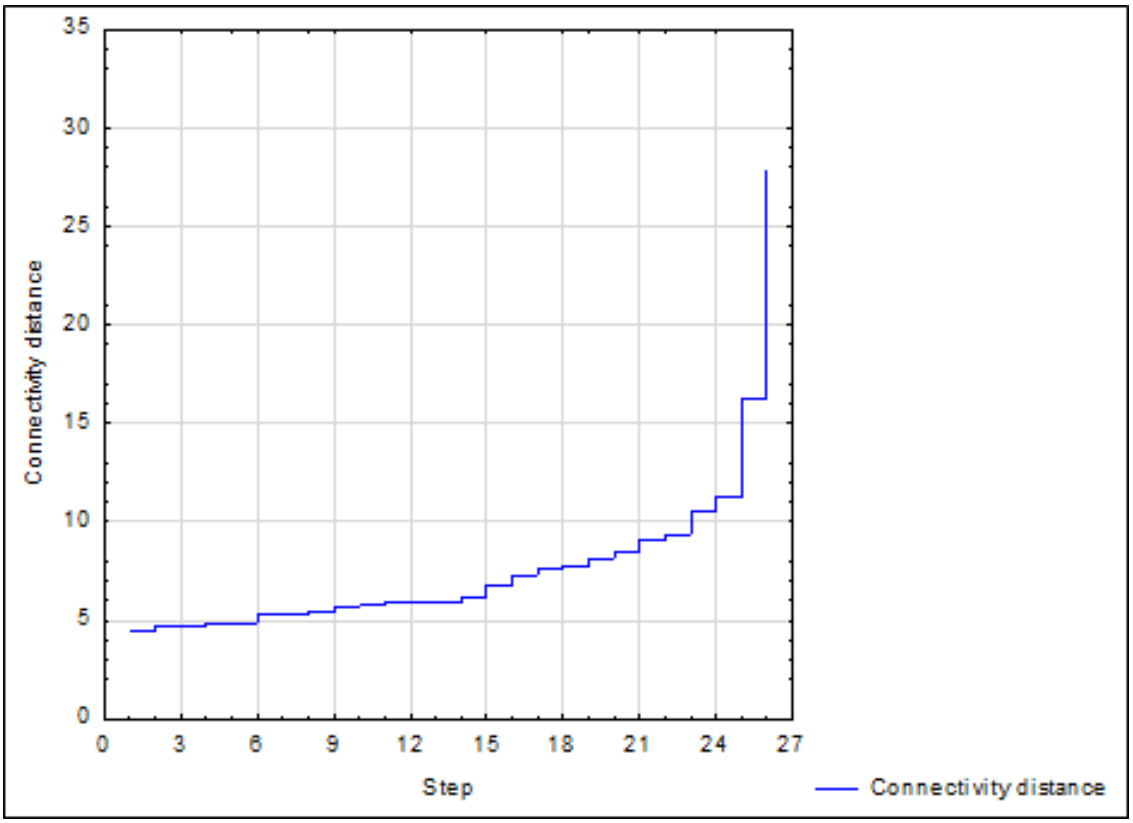

Figure 7. Agglomeration flow chart.

Source: own development.

At a bond distance of 11, four distinct clusters appear, comprising fourteen, two, five, and six relatively homogeneous entities. Meanwhile, at a bond distance of 16, three groups emerge: clusters of fourteen, two, and eleven elements (Figure 8).

Considering the first scenario, i.e., three clusters, there is a noticeable variation in their size. The classification of EU countries yielded the following groups: clusters of eleven, two, and fourteen elements. The second scenario produced clusters of six, five, two, and fourteen elements.

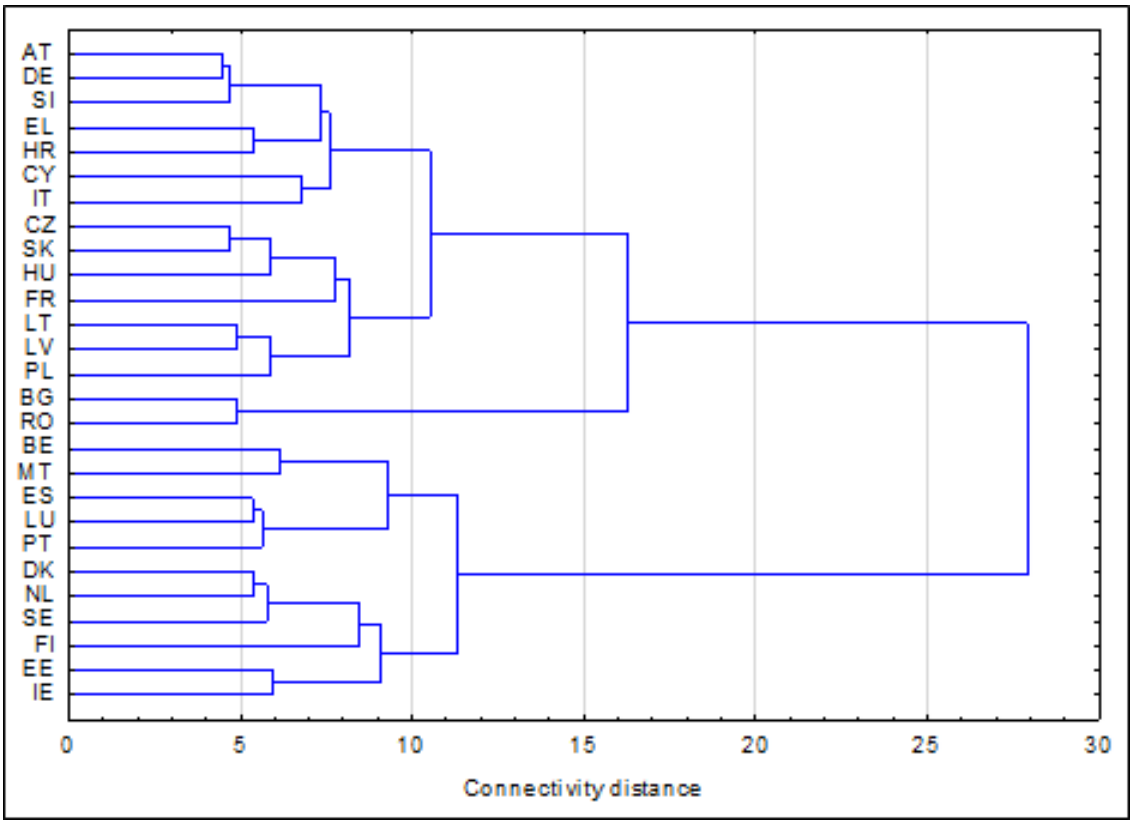

Figure 8. Grouping of EU countries with similar levels of development of the digital economy and digital society.

Source: own development.

In both scenarios, 14 countries were singled out: Austria, Germany, Slovenia, Greece, Croatia, Cyprus, Italy, Czech Republic, Slovakia, Hungary, France, Lithuania, Latvia, and Poland. This is the most populous and diverse grouping. Within this cluster, countries display varying levels of digitization. These countries are characterized by medium to low development of the digital economy and digital society, ranking between 10 and 25 on the overall DESI index. Given the size of this group, it is challenging to discuss structure similarities within the DESI sub-dimensions.

A separate two-element group, appearing in both scenarios, consists of Romania and Bulgaria, representing the so-called "new" EU countries. This group's formation seems to hinge largely on these countries' status as the least digitized within the EU, suggesting a high structural similarity. This demonstrates the high similarity of structures. These countries rank last and second to last on the overall DESI index, clearly distancing themselves from more digitized economies, particularly Romania, which is emphasized above. Examining the four DESI dimensions, the Digital Technology Integration category stands out, where these countries rank last, a full four points behind the next country, Hungary. Similarly, for the DESI Human Capital dimension, Romania and Bulgaria occupy the final two positions. The only contrast appears in the Digital Infrastructure category, where these countries occupy more varied positions, albeit closer to the EU average.

In the three-cluster scenario, the last group consists of eleven elements: Ireland, Estonia, Finland, Sweden, the Netherlands, Denmark, Portugal, Luxembourg, Spain, Malta, and Belgium. These are countries with high and medium digitization levels (based on DESI). These countries, barring Portugal and Belgium, all have an overall DESI above the EU average. Portugal and Belgium, however, have an index above 50, ranking them near the EU average of 52.3. This group predominantly consists of Western and Northern European countries, with Estonia, a Central and Eastern European country, as the exception. It's also worth noting that except for Malta and Estonia, this group comprises so-called "old" EU countries.

In the four-cluster scenario, the previously mentioned group splits into two sets: one with six elements and one with five. The first is the top of the DESI ranking: Ireland (5th), Estonia (9th), Finland (1st), Sweden (4th), the Netherlands (3rd), and Denmark (2nd). Apart from Estonia, all these countries are part of the EU-14, the "old" EU. The structural similarities of these countries are especially apparent in the DESI Human Capital and Digital Public Services dimensions. These countries rank between 1 and 8 in terms of digital economy human capital development. In the DESI Digital Public Services dimension, all six countries rank among the EU's top nine. Noteworthy in this context is Estonia, which boasts the most advanced development of public services, ranking first and outpacing its closest competitor, Finland, by 3.8 points.

The second cluster includes countries such as Portugal, Luxembourg, Spain, Malta, and Belgium. These nations can be categorized as having a medium to medium-high level of digitization. With the exception of Malta, all these countries are part of the EU-13 (the "new" EU). Similarities among their structures are observable in the DESI Human Capital dimension. These countries showcase comparable levels of human capital development, ranking between 6th and 14th in this category. Simultaneously, all these countries scored above the EU average.

7. Challenges for the EU in the digital economy and digital society

The COVID-19 pandemic has compelled European Union countries to bolster their digitization efforts. Some of these endeavors have significantly accelerated the use of digital technologies by citizens and businesses (Georgescu, et al., 2022). Nevertheless, all member states must address the challenges that accompany the global diffusion of advanced digital technologies. As the EU internal market embraces the digital age, it must evolve into an instrument for building a modern, high-tech, digital-based EU economy (Brodny, Tutak, 2022).

A key challenge confronting member states is the issue of human capital with insufficient digital skills. As previously mentioned, just over half of Europeans aged 16-74 possess at least basic digital skills. Digital tools have become an integral part of daily personal, professional

life and societal participation. Thus, EU citizens lacking adequate digital skills are increasingly at risk of digital exclusion. The EU has set a digital target for at least 80% of people to have basic digital skills by 2030. Additionally, reaching 20 million ICT professionals will be a significant hurdle. Although 500,000 ICT specialists entered the labor market between 2020 and 2021, the current total of 9 million EU ICT specialists is still far from the target. This creates a serious shortage of qualified personnel that companies must contend with. According to European Commission data in 2020, more than half of EU companies (55%) reported difficulties in filling ICT specialist positions. To overcome this, significant efforts must be made to retrain and upskill the workforce. Otherwise, this deficiency will pose a serious obstacle to the recovery and competitiveness of EU businesses (Digital Economy and Society Index, EC Representation in Poland, 2022). The disappointing performance of countries in terms of basic digital skills and the pool of ICT professionals necessitates a fundamental shift in the digital skill level of EU citizens. This presents a key challenge for the EU economy. This is true for countries with the lowest levels of human capital development, as well as for leaders. Countries such as Finland, Denmark, the Netherlands, and Sweden, despite leading in terms of citizen skills and ICT professionals, also face widespread skills shortages that hinder progress and contribute to digital exclusion.

The digital transformation of SMEs is another critical area that requires more progress from member states. Many digital solutions were implemented during the COVID-19 pandemic. For example, cloud computing usage reached 34%. However, according to the DESI 2022 report, the use of AI and big data technologies in enterprises is only 8% and 14% respectively, while the Union's target for 2030 is 75%. This ambitious goal is based on the belief that these key technologies carry significant potential for innovations and productivity gains among companies, including SMEs. Yet, only just over half of EU SMEs (55%) have achieved at least a basic level of digitization (the target by 2030 is at least 90%). This indicates that nearly half are not capitalizing on the key technologies and opportunities provided by digitization. It will also be challenging for member states to reach a level of 75% usage of advanced digital technologies, such as AI and big data technology. As previously mentioned, European countries maintain a low level of implementation of artificial intelligence and big data technologies. Even the leading countries (Finland, Denmark, the Netherlands, and Sweden) struggle with a persistently low adoption rate of key digital technologies, measuring below 30% (Digital Economy and Society Index, EC Delegation to Poland, 2022).

Significantly intensified efforts on the part of EU countries are required to ensure the full deployment of ICT infrastructure, particularly 5G networks, which are essential to support high-tech services and applications. Unleashing the potential of 5G networks could pave the way for new services with significant economic and social value, such as network-based and automated mobility, advanced manufacturing, smart energy systems, and e-health. In terms of connectivity, the Union's goal is that by 2030, all European households will have access to a high-speed Gigabit network, and all populated areas will be within the range of a 5G network.

However, realizing this goal appears challenging due to substantial issues in securing timely and investment-friendly access to 5G radio spectrum, as well as delays in issuing the necessary permits for building very high-capacity networks. The broad implementation of ultra-high-capacity networks involves the use of new technological solutions and the execution of substantial investments, presenting a significant financial challenge for telecom operators. In 2021, the penetration of gigabit connections in the EU increased considerably. Networks connecting buildings using fiber optics accounted for 50% of household connections, raising the overall percentage of very high-capacity networks to 70%. Meanwhile, the proportion of 5G networks increased to 66% for populated areas within the EU. However, the allocation of spectrum—an essential prerequisite for the commercial deployment of 5G networks—is still incomplete, with only 56% of the total harmonized spectrum for 5G networks so far allocated across a majority of EU countries. These circumstances do not yet permit full-scale use of advanced applications and could impede the achievement of the desired goals.

The success of the Digital Decade program hinges on the collaborative efforts of member states. Each country, depending on its resources, potential, and factors such as population and economic scale, will contribute differently to the adopted goals. Accelerating digitization through both reform and investment can be achieved via national recovery and resilience plans, for which the EU has allocated €127 billion. These resources will facilitate the digital transformation in member states, which, on average, allocated 26% of their funds to this end—surpassing the mandatory threshold of 20%. However, only a few countries—Austria, Germany, Luxembourg, Ireland, and Lithuania—have chosen to devote more than 30% of their allocated funds to digital transformation (European Commission Portal, 2023a). Failing to meet these challenges could disrupt the development of a modern, intelligent, climate-neutral economy and hinder the achievement of greater economic and social cohesion.

8. Conclusions

Digital transformation in the EU is implemented based on so-called digital objectives defined at the EU level. These are linked to specific areas—namely, human capital, connectivity, digital technology integration, and digital public services—in which collective progress is anticipated. These priorities are outlined by the Road to the Digital Decade 2030 policy program.

The level of digitization in the European Union is high, and the pace of digital transformation is accelerating. Most member states are progressing in building a resilient digital economy and society, thereby strengthening the EU's global standing. The digitization leaders, according to the overall DESI 2022 rankings, are Northern and Western European countries: Finland (1), Denmark (2), the Netherlands (3), Sweden (4), and Ireland (5). Conversely,

the least advanced in the development of the digital economy and society are Romania (27), Bulgaria (26), Greece (25), and Poland (24), representing Southern and Central-Eastern Europe.

The study's results reveal clear territorial differences in the level of member states' digitization. The gap between the ranking leader and the country in the lowest position is significant— Finland's level of digitization is more than twice that of Romania. All countries are making progress in the four dimensions of digital transformation. However, even for the leading countries, reaching the goals set by the European Union for 2030 is a considerable distance away. A significant challenge facing member states involves not only human capital with insufficient digital skills but also the digital transformation of SMEs and the underdeveloped digital telecommunications infrastructure.

When searching for similarities among EU countries regarding the level of development of the digital economy and digital society, using hierarchical clustering, we found that the clusters formed depend on the country's position in the overall DESI ranking. The most solid grouping is that of countries with low levels of digitization, specifically Romania and Bulgaria, which formed the least populous two-element cluster. The cluster analysis reveals a clear distinction between these two countries, particularly in the integration of digital technology and human capital. Denmark, the Netherlands, Sweden, Finland, Estonia, and Ireland cluster together tightly. As leaders in the development of the digital economy and digital society (according to the overall DESI index), these countries share similarities, forming a common class. The structures of these six countries are most noticeably similar in terms of human capital and digital public services. In other aspects, structural similarities are less pronounced. It's worth noting that some similarities exist among member states due to their membership in the so-called old EU-14 or countries that joined the Community in 2004 and later. Similarities are also evident with regard to the location of countries in Western and Northern Europe compared to those in Central and Southern Europe. The clustering observed here is not as distinct as in the case of DESI.

The European Union must rise to the challenges posed by the global diffusion of advanced digital technologies. This particularly involves enhancing citizens' digital literacy, facilitating the digital transformation of SMEs, and ensuring the full implementation of ICT infrastructure. There is a need to bolster concerted efforts by member states to make significant investments through both EU funds and national expenditure. This approach will empower the community to develop key technologies that promote productivity growth and socioeconomic development, fully aligning with its environmental values and objectives. Achieving the overall digital goals by 2030 could position the EU as a frontrunner in the global digital race. The Road to the Digital Decade program undeniably facilitates cooperation between member states and the EU, fostering progress in all areas of digital transformation. This, in turn, strengthens the collective power of the 27 countries on the international stage.

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THE ROLE OF SOCIAL INNOVATION IN PUBLIC ORGANISATIONS

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Purpose: The aim of the paper is to identify the role of social innovation in public organisations and to analyse the selected examples in the context of modern research in Poland and abroad. The reason for doing research on this subject is due to the lack of scientific studies on social innovation related to the public sector.
Design/methodology/approach: The research related to this topic was based on an analysis of literature of the available international and Polish texts.
Findings: The publication focusses on issues of social innovation. The paper identifies the lack of a universal definition of social innovation in the literature and explains the criteria for creating such definitions by researchers. Furthermore, due to the diversity in the tasks and functions of the public sector analysed by researchers in individual countries, the lack of a clear understanding of this concept was highlighted. Particular attention is paid to the possibility of public organisations working with private and nonprofit sectors to implement social innovations to disseminate them and develop further ideas. The article also discusses examples of social innovations implemented in public organisations, in view of contemporary research in Poland and abroad.
Originality/value: The issue discussed in this article concerns social innovation in the public sector, which plays an increasingly important role in meeting the needs of the population. The implementation of social innovations in public organisations is important due to the difficulties faced by societies not only in one country but throughout the world. This relates mainly to permanent changes at the technological, social, and economic levels. In addition, social innovation is a branch of cooperation between public entities, private and non-profit organisations and contributes to solving social problems.

Keywords: social innovation, innovation, public sector.

Category of the paper: A literature review.

1. Introduction

Innovation is not only of academic interest, but also the subject of political and business discussion. This is mainly due to the dynamics of change in the global environment and the challenges of economic, environmental, and demographic problems, including poverty, low

food security, gaps in health and education systems, and climate change (United Nations, 2015). Consequently, the search for new and improved solutions to reduce the conditions that lead to the emergence and persistence of these phenomena is crucial.

In this sense, social innovations are of particular interest, as many authors point out that they play an important role in improving the quality of life of citizens and communities (Olejniczuk-Merta, 2013; Wronka-Pośpiech, 2015; Markowicz, 2019; Pinto et al., 2021; Grilo, Moreira, 2022; Millard, Fucci, 2023). Therefore, society should be the main actor benefiting from this type of innovation. However, it should not be forgotten the cooperation of public, private, and non-profit organisations in implementing innovative solutions and the interconnections created by actions taken.

Given the intensity and complexity of the difficulties confronted by modern societies, the search for tools that meet the needs of their members should be a priority for power figures in many countries. In this sense, it is important to take measures that contribute to increasing the knowledge and awareness of this type of innovation by society, public, private and third-party organisations, as well as the extent of the emergence and impact of social innovation projects. In the face of growing social problems, it also seems important to establish an institution that supports social innovation to develop and spread innovative solutions.

Analysis of literature on this topic has concluded that innovative public sector activities are not only aimed at improving relations with citizens, but primarily at increasing the quality and access of public services provided by local authorities, resulting in improvements in the quality of citizen life. However, it should be emphasised that social innovations in this field are not only related to internal improvements in public institutions, but should have an impact on society.

Despite researchers' interest in the phenomenon of social innovation, theoretical and cognitive analysis revealed a lack of scientific studies on social innovation in public organisations. The identified cognitive gap was reflected in a research gap related to the identification of selected examples of social innovation in public organisations in light of modern research in Poland and abroad.

The lack of social innovation research in public organisations motivated the author to conduct research in this field. Moreover, the author's research indicates that there is a shortage of studies as well as it comes to examples of social innovations implemented in public sector that may inspire other stakeholders. The author hopes that the results of this study will contribute to increasing the knowledge of entities of the public organisations and society about the importance and need for implementation of social innovations and cooperation between public, private, and third-party organisations, thereby creating new networks that will generate ideas of innovation in the future. In addition, the orientation of scientific research towards the public sector was based on the conviction that due to the escalation of problems affecting contemporary societies, attention should be paid to this issue. Furthermore, social innovation is important from the point of view of the public organizations that introduce them, as it has

a positive effect on their image and cooperation with other organizations creates new relationships and can lead to carrying out other projects in the future.

This research was carried out using a literature review methodology to formulate appropriate aim and hypotheses (Czakon, 2020). To fill the identified gaps, the aim of the study was specified as follows:

Diagnose of the role of social innovation in public organisations and analysis of exemplary innovative solutions in this area that have been implemented in selected countries.

In response to this objective, research hypotheses were developed:

H1: Social innovation plays a significant role in public organisations.

H2: Social innovation solutions implemented in public organisations in selected countries address various social problems.

Hypotheses were validated on the basis of the literature review.

2. Literature review

2.1. Social innovation

The term "innovation" has been treated as renewal or change since 400 BC (Gruszewska et al., 2018). In addition, the word is derived from the Latin word "innovatio", meaning to create new things (Tidd, Bessant, 2011), and "innovare" being understood as a renewal (Topoła, Praszczyk, 2002). In the literature, innovation is generally regarded as introducing new products, technologies or solutions, or improving existing products. However, it is impossible to create a universal definition of the term due to the diversity of the researchers' understanding of the term (Lynn, Gelb, 1996; Wyrwa, 2014; Burget et al., 2017; Knosala, Deptuła, 2018). Considering the multidimensional nature of innovation concepts, many types of innovation types are distinguished (Janasz, Kozioł-Nadolna, 2011; Tidd, Bessant, 2011; Zastempowski, 2016; Oslo Manual, 2018) such as: product, organisational, process, marketing, and social innovation.

2.2. The concept and essence of social innovation

In the social sciences and humanities, the term "social innovation" is not new, as the first period of interest in this paradigm dates back to the early 1960s. At that time, the inherent feature of social innovation was the nontraditional or non-typical solution of problems affecting a particular community compared to the available systemic solutions. However, over the years, the understanding of social innovation has expanded to include additional qualities. The current definitions of literature do not merely require the characteristics of a specific social problem's "new" solution, but also emphasise its other characteristics (Wiktorska-Święcka et al., 2015).

Despite the researchers' interest in social innovation (Olejniczuk-Merta, 2013; Voorberg et al., 2015; Wyrwa, 2016; Anderson et al., 2018; Mihci, 2019), the definition of this construct remains uncertain. Based on the analysis of literature and the definitions of social innovation summarised in Table 1, it can be concluded that the understanding of this concept is varied and diverse. It is primarily related to the interdisciplinary nature of social innovation and the focus of individual authors on the various characteristics of this concept, leading to a contradictory interpretation (Ćwiklicki, Tarnawska, 2012; Sempruch, 2012; Kwaśnicki, 2015).

Table 1.
A selection of definitions of social innovation

Author	Social innovation definition
Ogburn (1969)	The author was the first to use the term "social innovation" to describe the "cultural gap" defined as the distance between cultural and technical development.
Mulgan et al. (2007)	"Innovative activities and services motivated by social needs. They are developed and distributed mainly by organisations whose main objective is social activity".
Murray et al. (2010)	Social innovation is considered by these authors as a new concept (product, service, model) that simultaneously meets social needs and creates a new social relationship. This type of innovation is good for society and increases its ability to act.
Olejniczuk-Merta (2014)	The author defines social innovation as a new social action aimed at improving the quality of life of societies and nations.
Voorberg et al. (2015)	According to these authors, social innovation is about creating long-lasting outcomes aimed at meeting social needs by fundamentally changing the relationships, attitudes, and rules between the stakeholders involved in the collaboration undertaken.
Wyrwa (2014)	"New and better ways to solve social problems".
Drucker (2004)	"The ability and willingness of individual members of society to break the habits, perception forms, and types of goals that guide the allocation processes".
Degelsegger, Kesselring (2012)	"'Social' is not a criterion that would allow to differentiate social innovation from economic or technological innovation. All innovations are social processes of interaction and communication (…). Furthermore, all innovation outputs – from the washing machine to the mobile phone – potentially have social outcomes and impacts".
Howaldt, Kopp (2012)	"Social innovation is a new combination and/or new configuration of social practices in certain areas of action or social contexts prompted by certain actors or constellations of actors in an intentional targeted manner with the goal of better satisfying or answering needs and problems than is possible on the basis of established practices".
Phills et al. (2010)	"A novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals".
Hochgerner (2012)	"Social innovation may be considered any activity that expands the capability to act (of parts or the whole of society), and enables or leads to concrete action".
Podręcznik Oslo (2018). Wytyczne dotyczące gromadzenia, raportowania i wykorzystywania danych dotyczących innowacji (2020).	"Innovations defined by their (social) goals of seeking to improve the well-being of individuals or communities."

Source: own study based on literature.

An analysis of the indicated definitions of social innovation in Table 1 concludes that social innovation is a process whose main beneficiaries are individuals and societies, as the implemented initiatives not only improve their quality of life, but, thanks to the cooperation of a wide range of actors from the public, private, and nonprofit sectors in their implementation, new connections within the society are created.

2.3. The creation process and the life cycle of social innovation

In the literature (Gillwald, 2000; Gerometta et al., 2005; Mulgan, 2006; Nicholls, Murdock, 2011; Tanimoto, 2012; European Commission, 2013), 'process' is a characteristic of social innovation. The Guide to social innovation (2013) distinguishes four basic phases of the social innovation process, as shown in Figure 1.

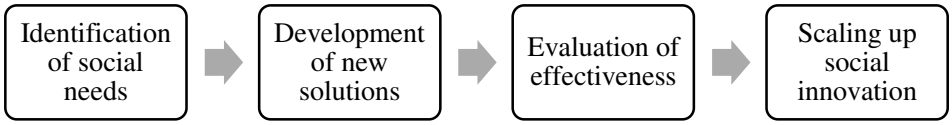

Figure 1. Social innovation implementation process

Source: Own study based on the European Commission (2013).

In the analysis of the process of implementing social innovations, it is important to remember that all phases are aimed at addressing social needs identified in the first step, which have not yet been identified in the community or which have not been adequately or fully met. Meanwhile, the last step is to expand social innovation to have a real impact on the community.

Figure 2 graphically presents the six phases of the social innovation life cycle, as distinguished in the literature. The authors emphasise that this cycle is not always sequential, as some innovations move on to further phases, skipping the initial ones. In addition, there is a feedback loop between the listed phases (Murray et al., 2010).

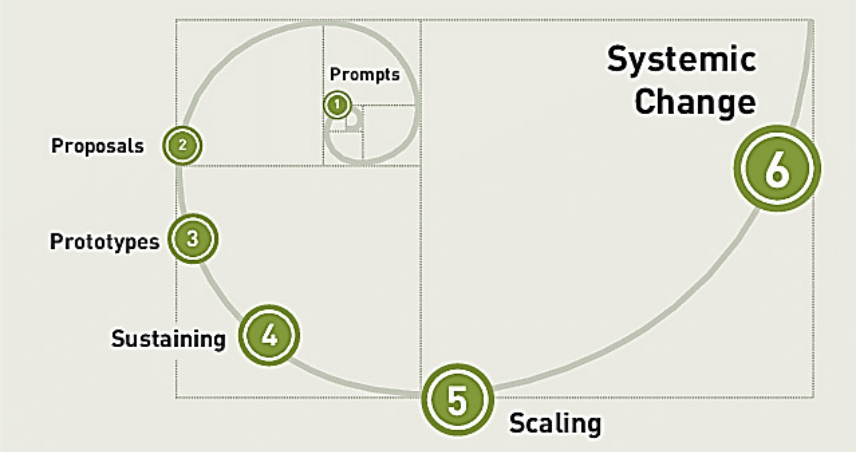

Figure 2. Social innovation lifecycle.

Source: Murray et al., 2010.

The social innovation lifecycle, illustrated in Figure 2, consists of six phases:

a) identification of needs (*prompts, inspirations, and diagnoses*) – recognition of the need to implement social innovation by first identifying new social needs or those that have not been fully or adequately met;
b) generating ideas (*proposals and ideas*) – formulation of ideas that can be a possible solution to identified social needs. It should be emphasised that these ideas may come from a variety of sources;
c) verification of ideas in practise (*prototyping and pilots*) – pilots are conducted to make potential modifications to improve an idea;
d) maintenance (*sustaining*) – this phase includes the implementation of innovative ideas and the development of a business model, management model, funding sources or a plan for the development of operational systems (e.g., supply chain systems, risk management systems);
e) distribution of innovation (*scaling and diffusion*) – the selection of appropriate strategies for the development and dissemination of innovation;
f) change of system (*systemic change*) – the stage of the ultimate objective of social innovation. It is important to emphasise that the implementation of changes requires the introduction and application of a number of elements, from business models to legal regulations to the adoption of new ways of doing and thinking.

The analysis of the above stages of the social innovation process leads to the conclusion that it is locally embedded and takes place in a specific context and environment, e.g., in the sense of a specific country that defines innovation policy and related regulations.

2.4.Public sector characteristics

According to Podlasiak (2009), the entities that make up the public sector perform the three basic functions ascribed to the state today (allocative, redistributive, stabilising) by carrying out tasks using appropriate means and instruments. Citing Miłaszewicz (2014), this results in the alternative use of the terms *state* and *public sector* by authors of publications in different academic fields. The author also emphasises that the term *government sector* is synonymous with the term *public sector* and that a consequence of the financial determinant of the concretisation of tasks and functions of the public sector by public finance is the identical use of the terms *public sector* and *public finance sector*.

Due to the diversity relating to the tasks and functions of the public sector in the different countries analysed by researchers Cole (2010); Schaefer, Warm (2015); Englmaier et al. (2022); Mortimer-Lee (2023), some difficulties are identified in the literature when trying to concretise the term. The selected definitions of the public sector are shown in Table 2.

Table 2.
Selected public sector definitions

Author	Public sector definition
Statistics Poland (GUS) (2023)	"The entirety of national economy entities grouping national property (of the State Treasury and state-owned legal entities), the property of local self-government units or local administration legal persons, and "mixed property", with the majority of the capital (property) of public sector entities. In the case of equal share of public capital (the total share of the ownership of the State Treasury, state-owned legal persons, and local self-government units is 50%) and private (the total share of the ownership of: domestic natural persons, other domestic private units, foreign persons is 50%), a national economy entity is classified to the private sector".
Brol (2013)	According to this author, the public sector is an organisationally subordinate collection of all state and local government entities.
Lubińska (2010)	The set of institutions established by the State to perform public tasks.
Pater, Cywiński (2019)	The part of the economy, which consists of all government and government-controlled enterprises, except private enterprises, voluntary organisations, and households.
Łuczyszyn (2011)	"The public sector is composed of legal persons, non-incorporated organisation entities and special purpose funds under the command of the public authorities, the state and the local authorities. Public sector activities are applied to the state, regional, and local levels, and their activities are based primarily on the provision of social welfare for citizens, the guarantee of national security, and the planning of spatial development".
Teneta-Skwiercz (2017)	"The public sector is part of a nonmarket environment in the company. It is formed by entities of state and local government, organizedly subordinate to public authorities".

Source: own study based on literature.

The analysis of the public sector definitions summarised in Table 2 based on the literature analysis shows that there is no unique and standardised interpretation of this concept, which is also emphasised by Kieżun (2011). When analysing the definitions of the public sector indicated by the authors in Table 2, it is important to note their high multidimensionality and the fact that they consider the public sector from different perspectives.

The literature highlights the possibility of defining the public sector on the basis of three research approaches, shown in Table 3.

Table 3.
Defining the public sector - research perspectives

Public sector	The subjective approach	Within this framework, three sectors are distinguished: public, business and households. Membership of each sector is determined by the nature of the entity's income and expenditure.
	The subject approach	Revenues and expenditures of central and territorial government bodies, insurance funds and public law funds separated from the state budget and state enterprises.
	The functional approach	Entities whose primary objective is to create conditions for the protection of the economic interests of those entities in relation to which they exercise sovereign functions. In this view, the public sector includes state and local government organisational units.

Source: own study based on Przygodzka, 2008 and Struś, 2021.

The research approaches presented in Table 3, on the basis of which the authors are able to interpret the public sector in three perspectives, lead to the conclusion that in the literature the essence of this issue may be understood broadly or narrowly, depending on the criterion adopted. Moreover, the existing ambiguity of concepts may contribute to the problems of analysing the public sector in the context of its reorganisation or performance evaluation.

Furthermore, it is also important to note the characteristics that are attributed to the public sector in the literature. Brol (2013) distinguishes the non-profit nature of the activities of entities constituting the public sector and the possibility of coercion. The author emphasises that it is possible to specify paid services or the production of goods, however, it should not refer to the entire sector, as the main purpose of remuneration in these cases is to induce the minimisation of excess consumption, to lead to the achievement of revenues limiting the incurrence of high fixed costs or the combination of both. The acceptability of coercion, on the other hand, is linked to the institutionalisation of the actors that make up the public sector.

2.5. Examples of social innovation in public organisations

Throughout the world, innovation in the public sector is challenging as it requires coordinated action by different types of public organisation to respond effectively to social and technological challenges. The literature emphasises that innovation in this sector is important not only for enhancing the reputation of governments and the image of public services (Lekhi, 2007), but can also contribute to changes in the management of public services, by increasing efficiency and the level of user involvement and satisfaction. Innovation in the public sector focusses on implementing new or improving existing processes in the organisation (internal orientation) or services (external orientation) (León et al., 2012). Importantly, "Innovation in public administration or the public sphere can be understood as activities concerning influencing, creating, and implementing solutions that can contribute to social change and, therefore, to the emergence of social innovation" (Kwieciński, 2016, p. 522).

It is important to emphasise the important role that social innovation plays in the formulation of environmental policy. It influences social groups and local communities as it creates new ideas or develops existing ideas and solutions to growing problems that affect society. An example of social innovation that addresses this issue with the aim of transforming the city into a climate-neutral and climate-adapted city by 2050 is Berlin's ongoing energy and climate protection strategy since 2014 (Climate-Neutral Berlin 2050 Recommendations…, 2023). Berlin's local authorities emphasise that climate protection concerns everyone and highlight the need to raise awareness of climate protection among citizens in order to achieve informed behaviour and attitudes of the general public in the long term.

An interesting example of social innovation implemented is the Citizen Assessment Tool in the Netherlands, which is a tool aimed at citizens and users of digital public services to assess the effectiveness of the services offered. Anyone who experiences poor or exceptionally good service can report this to an organisation specialised in digital accessibility, by giving a brief

description of the incident and adding attachments. In addition, the description should also indicate the relevant quality requirement as set out in the e-Citizen Charter, a document consisting of the rights of citizens and the corresponding obligations of government bodies in the area of digital relations between these actors, the scope of which includes information exchange, service provision, and political participation (Poelmans, 2006). A complaint or praise made about a digital public service will be forwarded to the public authority that is responsible for its implementation. In this regard, it should be noted that the usage of a citizen review tool does not replace the formal procedure for filing a complaint with a public body.

Another example of social innovation in a public organisation is the 115 number (115: The public administration's customer service, 2023) introduced in Germany, which is a direct telephone line to public authorities and the first point of contact for all kinds of question from citizens, relating to matters such as registering a newly purchased motor vehicle, applying for an identity card, and setting up a business. This type of innovation originated at the 2006 Federal IT Summit, while in 2007 the initial concept of a single number for all public sector bodies was developed. In 2009, the 115 number started operating in the first municipalities, so that other municipalities, state, and federal administrations in Germany could join the bodies after a two-year pilot phase. In addition, many other organisations and associations have expressed interest in joining the number 115 base. More than 550 municipalities, numerous state authorities, and the federal administration, more than 88 bodies and institutions, are currently participating in this initiative. It is also important that entities present in the 115-number database provide the system with information related to the scope of activities of these organisations and that are most frequently requested by citizens, so that each service centre has the possibility of providing an immediate answer to a citizen's question, even related to another entity, without losing quality of service. The special service of 115 is a sign phone, which allows the use of this service for hard-of-hearing and deaf people.

An example of social innovation in a public organisation that deserves attention is the *Virtual Warsaw* app (Virtual Warsaw, 2023), created to improve the ability of visually impaired people to travel through the city using their smartphones. The idea was designed with the cooperation of public and private sector actors - representatives of the Warsaw local government with a local company that was responsible for building personalised Bluetooth transmitters. Potential users of the application were also involved in the development of the project. In addition, nongovernmental organisations, universities and experts in the field of visual impairment were also important stakeholders who influenced the creation of the app, helping the tool's creators to better understand the challenges and needs of the target group. Although the Virtual Warsaw app is in its pilot phase, it is beginning to create opportunities to increase accessibility and independence for visually impaired people. The benefits of implementing the idea should be considered from both the perspective of the user and the Warsaw municipality. The value received by the user of the application is greater independence and, consequently, improved quality of life. The indirect benefit for the local authority,

on the other hand, is improved efficiency. It is important to highlight the interest of almost 40 other cities around the world in replicating this solution.

It should also be noted that during the COVID-19 pandemic, there were examples of social innovations implemented by public organisations in Poland (Łuczyn, 2022). During the initial phase, the activities of the local authorities included mainly helping to supply residents with medical supplies, mainly masks, whose prices were high at the time and often not available on the market. In multiple instances, as part of their initiatives, local government institutions have cooperated with social and civic organisations and local entrepreneurs. One example of such cooperation are projects for the benefit of elderly people, because elderly people are the most at risk of infecting coronavirus - in the municipality of Łapy, elderly people could "(...) find masks sewn by MOPS employees, the Community Self-Help Centre and the Community Centre, as well as members of the village's women's circles and scouts in their mailboxes" (Łuczyn, 2022, p. 2). Furthermore, it is important to keep in mind the actions taken by the local authorities to reduce the number of cases of diseases - for this purpose, technological solutions such as urban surveillance (Gdynia) or drones (Siemianowice Śląskie, Koszalin) are often used. Public organisations have also provided assistance to residents in this difficult period by setting up assistance lines for people in need or providing psychological support to children and youth. Local authorities also took important measures to address parents (e.g., exempting local kindergartens and kindergartens from fees at the time of closure) and entrepreneurs (e.g., reducing or abolishing fees and taxes).

Cooperation between entities representing different sectors is very important in the implementation of social innovations, because each party can bring different aspects to the project depending on its own experience and capabilities. Jointly developed Ordinance No. 2008.2017 of the Mayor of the City of Częstochowa of 8 September 2017, and Housing Management Company "TBS" in Częstochowa, that is connected with assisting people in difficult financial situations in repaying debts incurred by using housing units included in municipal housing resources, and the introduced programs by the Housing Management Company "TBS" in Częstochowa, under the patronage of the Mayor of the City, showing assistance to people who have difficulties in repaying debts, can be treated as examples of partnership between public and private sector while implementing social innovation (Kabus, Dziadkiewicz, 2022). The authors also present an interesting insight into the social innovations implemented by the Częstochowa City Commune, which focus on a number of problematic issues faced by residents in terms of public housing resource management. The solutions include, for example, activities taken to increase the safety of young and elderly people, carbon monoxide and natural gas detectors which are installed in apartments in multi-family buildings, the "Work for rent" program designed for people who were facing difficult financial circumstances (Kabus, Dziadkiewicz, 2023).

The examples provided of social innovations implemented in Polish and foreign public organisations give an overview of the difficulties faced by contemporary societies. At the same time, particular attention should be paid to the scope of the activities of the public sector aimed at reducing the negative factors affecting the inhabitants of a particular administrative division and focussing on their needs, which so far have not been met partially or fully. In addition, it is important to emphasise the cooperation of public entities with the private sector and nongovernmental organizations, because it not only gives more access to target groups to meet their needs, but also spreads implementation innovations that may inspire other entities.

3. Methodology

To identify the theoretical basis of the question under discussion in this study, the literature review method was used as a research method. This method can generally be described as a form of collecting and synthesizing past research (Tranfield et al., 2003), that's why it can reveal what is still not yet recognised by the scientists. It also identifies research gaps and, in the next phase, enables the deduction of research hypotheses (Czakon, 2020).

There are several stages of literature analysis distinguished by researchers, as shown in Figure 3.

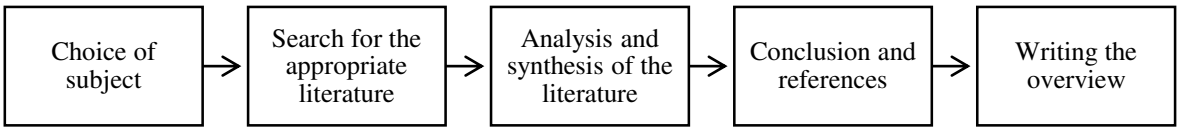

Figure 3. Literature analysis stages.

Source: Own study based on Cronin et al, 2008.

The first phase of literature analysis is to choose the topic to be studied. The next step is to search for the literature related to the topic. Today's databases available on the Internet are necessary and extremely useful, allowing searches to be carried out by selecting variables that can greatly facilitate the research process, such as keywords of interest to researchers or scientific publications' time spans. The next stage is to analyse and synthesize the literature sources selected, and then write an overview of the themes that have been studied. The final step of literature analysis are conclusion and references (Cronin et al., 2008).

The research process conducted by the author consisted of the following stages: literature analysis, gap identification, formulation of research hypotheses and their verification through literature review.

4. Results and discussion

The analysis of literature allows to conclude that social innovation is defined by researchers from the perspective of different criteria that they consider crucial. Some authors have developed definitions for the purpose of social innovation, focusing on noun "innovation" that enables analysis of this definition in the context of the theoretical innovation framework and innovation system (e.g., definition by Degelsegger, Kesselring, 2012); a "social" adjective that is derived from the perspective of social sciences (e.g. definition by Howaldt, Kopp, 2012); an adjective and noun "social innovation" that defines social innovation as an activity aimed at solving social problems (Howaldt, Swarz, 2010). The definitions of social innovation presented in this division can be further divided into broad and distinctive definitions. A broad definition includes activities at different sectors and levels of society, thus broadening the concept of social innovation in this definition (e.g., definition by Hochgerner, 2012). Similarly, distinctive definitions include innovations to meet social needs and focus on improving the quality of life of the population to achieve these goals (e.g., definition by Olejniczuk-Merta, 2014).

Despite the popularity of social innovation phenomena, there is no universal and widely accepted definition of this construct. Considering the definitions of social innovation provided in this article, it should be concluded that a social innovation can be considered a new solution aimed at satisfying social needs that have not been completely or adequately satisfied so far. In this context, the cooperation of public entities with other sectors and the relationships that are developed within it are also emphasized.

The results of the literature review have allowed to find gaps in research in the current state of knowledge. Social innovations in the context of public institutions are important and current issues, because the problems affecting modern societies affect not only their quality of life, but also have impact on their satisfaction with the actions of public institutions in promoting the aid provided. Studies have shown that there is not enough literature sources combining social innovation and public institutions issues. There is also a lack of sources aimed at public organizations' staff to improve knowledge of social innovations, as well as the need for their implementation and cooperation with other entities.

The challenges faced daily by modern societies should lead to greater awareness among public sector institutions of the importance of implementing social innovation. In this regard, attention should be drawn in particular to the impact of social innovation in public institutions on improving the living conditions of citizens in a particular administrative unit, since the objective of its implementation is to achieve long-term results to meet the needs of society that have not yet been adequately or fully met.

However, innovative solutions can also have a positive impact on the functioning of those who implement them, who will be respected by the population and increase their efficiency. In this regard, it is necessary to emphasise the cooperation of public sector organisations with

private and non-profit sectors, creating new relations and increasing the chances of social innovations being spread and new ideas being implemented.

Analysis of the examples of social innovation implemented in public organisations in Poland and abroad leads to the conclusion that public entities are aware of the problems that currently affecting members of society. In addition, mentioned examples of social innovation implemented in public organisations in selected countries address various social problems, what is connected with different problems faced by societies in these areas. Moreover, public entities are currently trying to reach out to citizens through the use of the Internet, social networks, and artificial intelligence, also in order to improve the quality of public services offered. It is also important to highlight the role of members of the public involved in the social innovation, as the actions taken can strengthen the relationship between citizens and the state and influence the level of public satisfaction resulting from the activities undertaken by public entities.

5. Conclusions

The analysis of literature on the subject leads to the conclusion that social innovation plays an essential role in public organisations. First, they positively affect the public by satisfying their needs, which is the most important issue in this regard. Second, it has the effect of creating positive perceptions of the public organisations that implement them by residents and creating relationships with other entities that can contribute to new innovative solutions, including in other areas.

This article aimed to draw attention to the role of social innovation in public organisations. The essential values of this research are the following:

a) at the theoretical level – emphasizing the important role of social innovation in public institutions and its effects on society and on the public entities themselves;
b) on a practical level – the possibility of using the given examples of implemented social innovations in selected countries by public entities that are looking for solutions, as they face similar problems.

Interesting part of the research appears to be examples of social innovation implemented in selected countries' public institutions, demonstrating the interest of public organisations in social problems and showing actions to meet the needs of residents. The results of the research can be further used by public institutions employees because mentioned examples of social innovation implemented in public institutions in other countries may inspire a similar solution in the environment of a particular organisation. Furthermore, the research could even more increase public institutions' awareness of the problems facing the inhabitants of their administrative areas. However, the results of the research cannot be considered comprehensive.

The main limitation of the study is that it treats social innovation from a general point of view and does not consider specific examples of community problems. This may lead to less interest in public institutions seeking solutions to specific problems. In this regard, it seems that it would be better to limit the study to the specific problems faced by contemporary societies, which can be useful for public institutions seeking solutions in this area.

It is important to emphasise the need to conduct further research on social innovation in public organisations in the future, both in general and in particular cases. In addition, more detailed approaches to social issues are also crucial for public organisations to better plan and implement social innovation at different levels. Therefore, taking into consideration the constant change in the organisational environment, it seems reasonable to continuously analyse the issues that relate to social needs and the solutions that may be crucial to meet them.

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ON THE IMPORTANCE OF A "DIPLOMA" ON THE JOB MARKET

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Purpose: The purpose of this article is to contribute to the ongoing discussion on the role of higher education in the job market by analyzing the risk of unemployment for individuals with higher education, the wages they receive, as well as qualitative aspects such as personal development and self-fulfillment, in the context of evolving attitudes towards the concept of lifelong learning.
Design/methodology/approach: In the article an analysis of the literature on the subject and selected methods from the field of descriptive statistics were used. During analysis, data from public surveys, such as Labor Force Survey and Survey of Wage Structure by Occupation, as well as from the Polish Graduate Tracking System, were used. The analysis considered the time series from 2010 to 2020.
Findings: The risk of unemployment is notably influenced by a person's level of education. College degree holders face the least risk, with job search duration influenced by the level and field of study, and work experience gained during studies. Individuals with higher education earned more than the average market economy wage over the observed period. However, an analysis of these wages relative to the average market wage and a comparison of wage growth dynamics against minimum wage growth reveal unfavorable trends. When assessing the significance of higher education in the labor market, it's important to consider also elements tied to broadly defined well-being or personal happiness. HEIs are formal education institutions which foster general cognitive and transferable competencies. Additionally, they facilitate non-formal and informal education for students. Such approach in current world is essential for young people to be on the way of self-improvement, self-realization and create personal well-being.
Originality/value: The article contributes to the discourse on higher education's role in the labor market, analyzing unemployment among college graduates and their wage trends, with special attention to the graduates' situation. It also highlights the positive impact of the educational process on personal well-being and happiness. The paper is addressed to all interested in higher education policy and management of higher education institutions.

Keywords: higher education, higher education institutions, labor market.

Category of the paper: research paper.

1. Introduction. Modern Labor Market

The labor market is a dynamically changing environment encompassing all aspects of employment and unemployment. Numerous interdependent factors influence it, and they cannot be evaluated in isolation.

Notably, demographic changes present significant challenges. Negative trends such as depopulation, a decreasing working-age population, and a sharply increasing demographic burden[1] result in dwindling labor market resources and an increasing worker deficit in certain sectors (specifically healthcare, the TSL sector, construction).

Shifts in economic and technological paradigms, such as the knowledge based economy, sharing economy, inclusive growth, Industry 4.0, and digital transformation, signify a move from an industrial civilization to an information-technology civilization. This new civilization is built on information, knowledge, innovation, and continuous education. Consequently, the value of today's workers is determined in the labor market across three dimensions: cognitive, technological, and social. Employers expect specific competencies related to a given industry and profession, as well as transferable competencies such as communication skills, conscientiousness, teamwork, analytical thinking, and organizational skills. These competencies are integral to an employee's effectiveness in a variety of professional contexts, with their key characteristic being transferability. This means they can be applied and utilized across different employers, sectors, or industries.

In evaluating changes in the labor market, it is also important to consider phenomena related to the COVID-19 pandemic (e.g., issues related to the Great Resignation and Great Rotation), the Russian-Ukrainian conflict (the influx of migrants into the Polish labor market), or high inflation (which causes a decrease in real wages for workers). Concurrently, we are observing deep social transformation and cultural change. Researchers refer to a VUCA-type reality or its extension, the BANI world, to define the current human condition and associated challenges (e.g. Jeruszka, 2023). Frequently observed phenomenon among young people is also the so-called prolonged transition, i.e. delaying decisions characteristic of the period of maturity (Maksim, 2021, p. 9).

Young people often encounter difficulties when planning their educational and professional careers as they struggle to fully anticipate the consequences of their decisions and remain uncertain about the validity of their educational choices. They frequently question established truths and cause-and-effect relationships. Common questions they pose to themselves and others include: is self-education worthwhile, is pursuing studies beneficial, and what is the value of a higher education degree in the job market?

[1] From 2020 to 2022 alone, the total age dependency ratio increased from 68.3 to 70.4; comparatively, in 2010 it was 55.2 (GUS, BDL).

Longstanding media narratives like "Polish higher education institutions educate the unemployed" (e.g. Guza, Klinger, 2010), "Polish higher education institutions do not know why and for whom they educate" (Dudzik, 2011), and "studies are becoming less and less profitable" (INN Poland, 2021) exacerbate this problem. This topic often comes up in family discussions[2] and forms the questions prospective college applicants ask their senior peers.

In scientific research and analytical works by various institutions, this issue is addressed in terms of the so-called higher education premium (e.g., Goraus-Tanska, Osika, 2020; NBP, 2015; Rocki, 2021), indicators of graduates' success in the labor market (e.g., Pacuska, 2014), the impact of characteristics of HEI on the situation of graduates on the labor market (Grotkowska, Gaik, 2019; Rocki, 2022) or factors differentiating the wages of college graduates (e.g., Rocki, 2018). Researchers strive to determine the relationship between education and wages (level, number of years of education) and the rate of return on higher education. Survey research, in contrast, attempts to chart long-term trends relating to the factors influencing young people's educational decisions — the type of high school completed, the financial status of the family, the size of the town or city the candidate hails from, parental influence and educational background, or the candidate's self-esteem (e.g. CBOS, 2017; CBOS, 2019).

The purpose of this article is to contribute to the ongoing discussion on the role of higher education in the job market by analyzing the risk of unemployment for individuals with higher education, the wages they receive, as well as qualitative aspects such as personal development and self-fulfillment, in the context of evolving attitudes towards the concept of lifelong learning. In the article data from public surveys, such as the annually conducted Labor Force Survey (LFS) and the biennial Survey of Wage Structure by Occupation, as well as from the Polish Graduate Tracking System (ELA) were used. The ELA system, developed and maintained by the National Information Processing Institute - National Research Institute on behalf of the Ministry of Education and Science, provides annual data on the status of graduates of Polish universities in the job market. Importantly, this system relies on data from administrative sources (POL-on and the Social Insurance Institution records[3]), not opinions, ensuring the reliability and accuracy of the data. The analysis considered the time series from 2010 to 2020 (the most recent year with available data for most metrics). In the article an analysis of the literature on the subject and selected methods from the field of descriptive statistics were used.

[2] According to a CBOS survey, about 80% of young people frequently or occasionally discuss their educational plans with their mothers; this percentage is slightly lower for discussions with their fathers, at less than 60% (CBOS 2019, p. 4).

[3] The results of this study are reported at t+2 years.

2. The risk of unemployment among people with higher education

As highlighted in the introduction, demographic factors primarily shape the labor market and, concurrently, the functioning of higher education institutions (HEIs). Since 1989, Poland has experienced a consistent decline in the fertility rate, falling below the level necessary to ensure generational replacement. This leads to population decrease and unfavorable changes in the structure of biological and economic age groups within Polish society. A drop in the population aged 20–24, the age generally associated with entering higher education, has been observed since 2006. According to the official demographic forecast, this statistic is projected to decrease by over 100,000 by 2040 compared to 2022 (GUS, BDL). Despite the decreasing number of students in Poland[4], the gross enrollment rate at the tertiary level, often used as a measure of educational universality, has been stable and hovering around 50% for a considerable time (Figure 1). This trend is also apparent in survey results. According to a 2018 CBOS survey, 62% of students planned to pursue further studies in their chosen fields after completing their current level of education. This figure was slightly lower in 2013 and 2018 at 59% (CBOS, 2019). Some labor market experts interpret these data as the massification of education and the subsequent devaluation of a university degree. However, this perspective is overly simplistic and doesn't align with the developmental priorities of modern societies and economies. Indeed, tertiary enrollment rates are included in many composite indexes on the development of human capital (GUS, 2021), quality of life, or general well-being (e.g. OECD), treating them as stimulants of the aforementioned processes and phenomena. As A. Murawska highlights — in modern societies, education is not just a private affair for individuals; the level and type of education in a society impacts the economic, cultural, or political development of a country (2017).

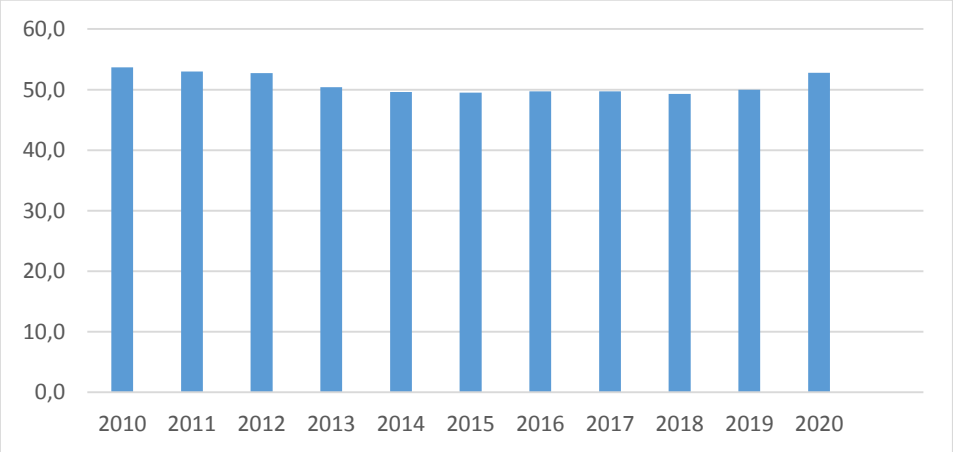

Figure 1. Ratio of students to population aged 19-24 from 2010 to 2020.

Source: own elaboration based on BDL, GUS.

[4] The number of students per 10,000 population in Poland has decreased from 472 to 319 in the analyzed time series (GUS, BDL).

Even though the unemployment rate in Poland has progressively decreased[5], a certain segment of the population remains unemployed and seeking work. The risk of unemployment is notably influenced by a person's level of education. Those with higher education are least at risk (Figure 2). The unemployment rate (according to LFS) among people with tertiary education in 2020 was 1.9%, 3 p.p. lower than among people with general secondary education.

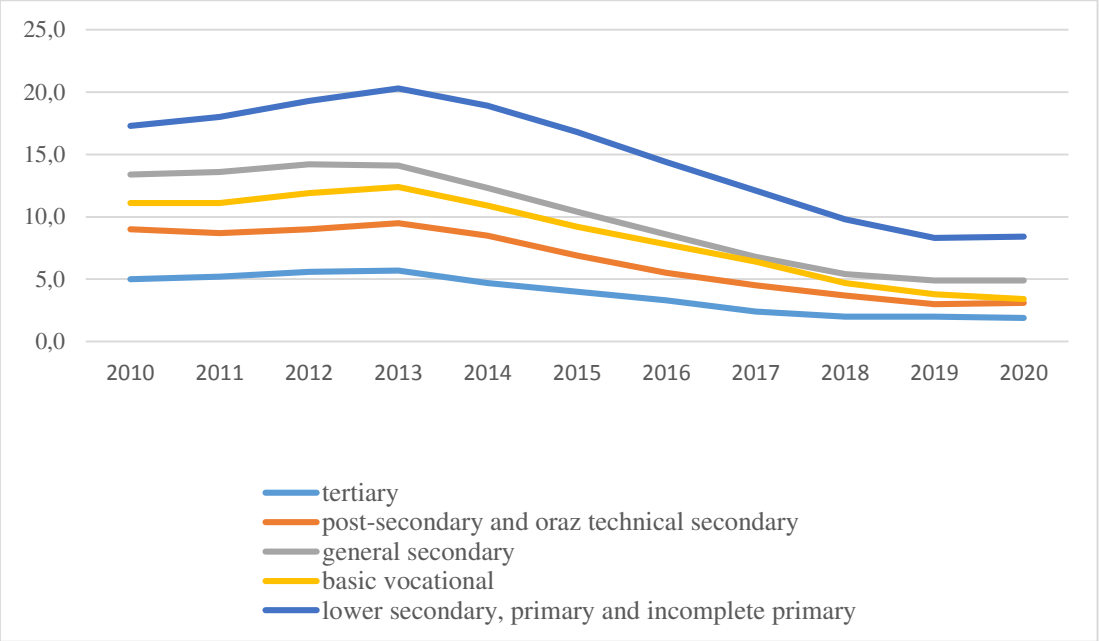

Figure 2. Unemployment (LFS) rate by education level from 2010 to 2020.

Source: own elaboration based on data: GUS, BDL.

The risk of unemployment among college graduates is significantly determined by their field of study. Despite the widespread availability of information on occupations in demand in the labor market, popular university campaigns (e.g., “Girls to Technical Universities”, “Girls to the Sciences”) and the apparent rationalization of young people's educational preferences (in terms of labor market demand), there are still young people who choose “easier” or locally “available” fields of study. This choice often aligns with the financial capabilities of the prospective student and their family.

The ELA survey provides data on the unemployment risk of college graduates by field of study in relation to their place of residence. The study introduced the so-called relative unemployment rate (RUR). This represents the average value of the quotient of a graduate's unemployment risk and the registered unemployment rate in the graduate's country of residence. The interpretation of this indicator is straightforward — RUR values below 1 imply that, on average, the risk of unemployment among graduates was lower than the unemployment rate in their countries of residence during the survey period. The lower the RUR values, the better. For 2020 graduates from virtually all groups of study fields, RUR values were below 1.0 (Figure 3). The notably lower values for bachelor's degree programs are influenced by the fact

[5] Poland's registered unemployment rate fell from 12.4% to 6.3% in the analyzed time series (BDL, GUS).

that many graduates proceed to second-degree programs. Within this group, graduates of theology[6], life sciences, humanities, and medical and health sciences fared the best. On the other hand, the lowest RUR among second-degree graduates was observed in the fields of engineering and technical sciences, and medical and health sciences.

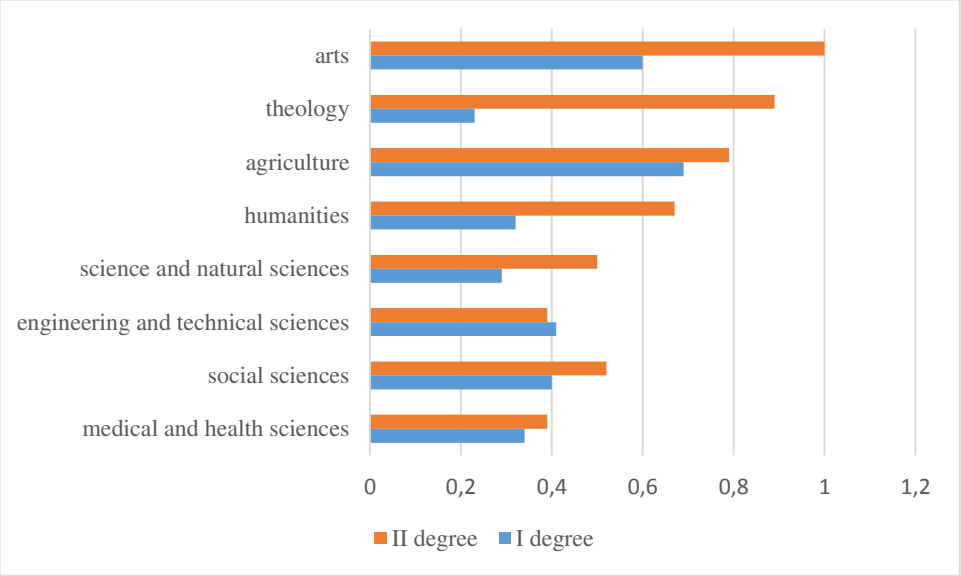

Figure 3. Relative unemployment rate of 2020 graduates[7] by field of study.

Source: own elaboration based on data: ELA, 2020.

The ELA survey also provides information on the average time it takes graduates to look for a job[8]. Second-degree graduates typically secured full-time jobs faster than first-degree graduates. 60% of undergraduates found a job within 4 months, 20% within 4 to 18 months, and 20% took longer than 18 months. In contrast, among level II graduates, 60% were already employed, 20% found a job within 3 months, and 20% took 3 months or longer. The duration of the job search was strongly influenced by previous work experience (Table 1).

Table 1.

Average time to secure a contract job post-graduation for 2020 graduates (in months)

Degree of study	Experience of full-time employment or self-employment before obtaining a diploma	
	yes	no
I degree	3,47	13,8
II degree	1,44	6,76

Source: own elaboration based on data: ELA, 2020.

First-degree graduates who worked based on an employment contract or were self-employed during their studies typically took an average of four times less time to find a full-time job compared to graduates without such experience. For level II graduates, this disparity was even greater.

[6] However, it should be noted that the graduates in this group constituted a small collective (N = 73).
[7] In the second year after obtaining the diploma.
[8] For this edition, the study covers the period up until 12/31/2022.

3. Wages of individuals with higher education

Wages of individuals with higher education play a critical role in the analysis of the value of higher education in the labor market. Considerations include wage levels, wage growth, and relationships to relative quantities (like minimum wage or average wage in the market economy). The drive to gain material benefits from skill improvement is undeniable and serves as the primary motivator.

Throughout the studied time series, the average salary of college-educated individuals has risen and remained significantly higher than the minimum wage. However, the growth rate was notably lower compared to the minimum wage (Figure 4). This disproportion was particularly evident during the 2018-2020 period. It's worth noting that in Poland, the minimum wage is growing faster than the average wage in the market economy. In 2010, the minimum wage was 40.8% of the average wage, and a decade later, it was 50.3%.

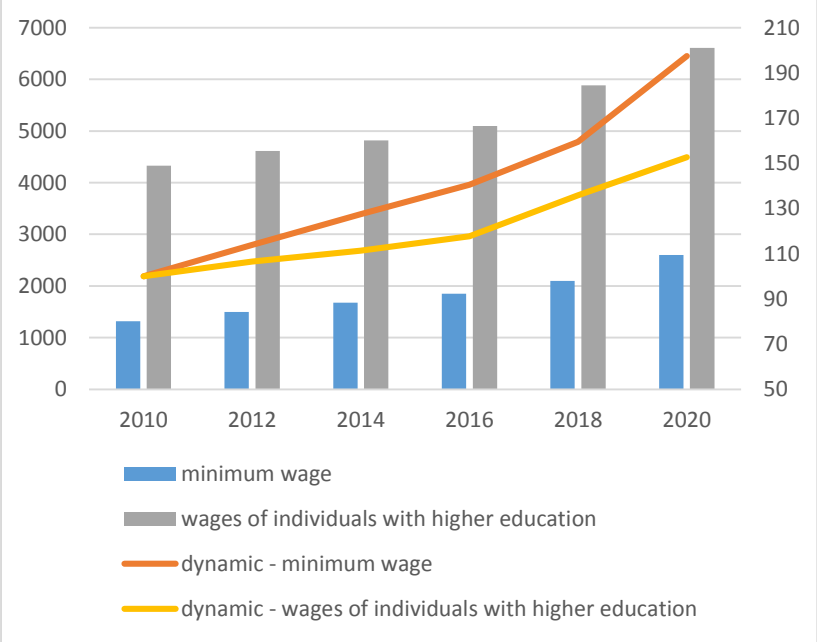

Figure 4. Level (left axis, in PLN) and dynamics (right axis, 2010 = 100) of the average gross salary of individuals with higher education and the minimum salary from 2010 to 2020.

Source: own calculations and elaboration based on data: GUS, BDL.

Therefore, it's worth analyzing the relationship of the salaries of workers with higher education to the average salary of workers in the national economy, in comparison to the average salaries of people with other education levels (Figure 5).

Analysis of statistical data from 2010 to 2020 reveals that the average salaries of individuals with higher education consistently exceeded the average salary in the market economy. However, the ratio of the average gross salary of college-educated workers to the average salary in the market economy (= 100) fell from 122.2 in 2010 to 115 in 2020. This implies that by 2020, the average salary of individuals with higher education was only 15% higher relative to

the average salary in the market economy. A similar downward trend is observed concerning the salaries of individuals with post-secondary, general secondary, and secondary vocational education.

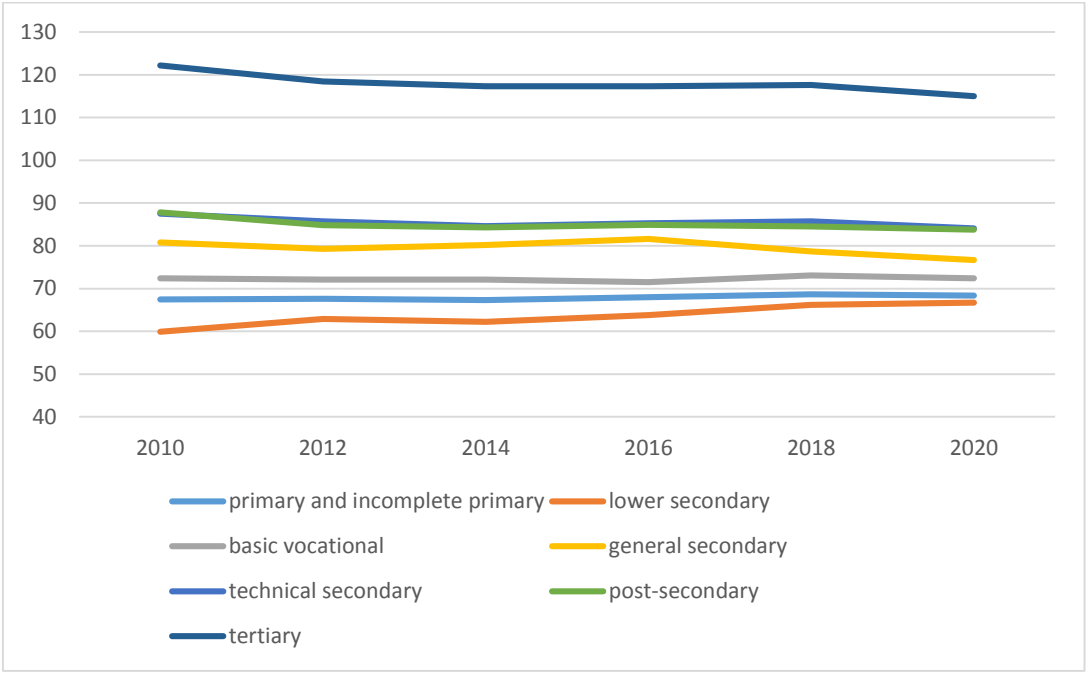

Figure 5. Relation of the average gross salary of employees by specific education levels to the average salary of employees in the national economy from 2010 to 2020.

Source: own elaboration based on data: GUS, BDL.

The ELA survey provides information on the salaries of college graduates by field of study in relation to the graduate's place of residence. The study introduced the so-called relative earnings index (REI). This index represents the average value of the ratio of the graduate's average monthly salary to the average monthly salary in their county of residence. Interpreting this index is straightforward: REI values above 1 imply that, on average, the salary level of graduates exceeded the average salaries in their counties of residence during the survey period. Hence, the higher the REI values, the better. For 2020 graduates from each group of majors, the REI showed higher values for second-degree graduates (Figure 6), suggesting that continuing education is associated with higher post-graduation salaries.

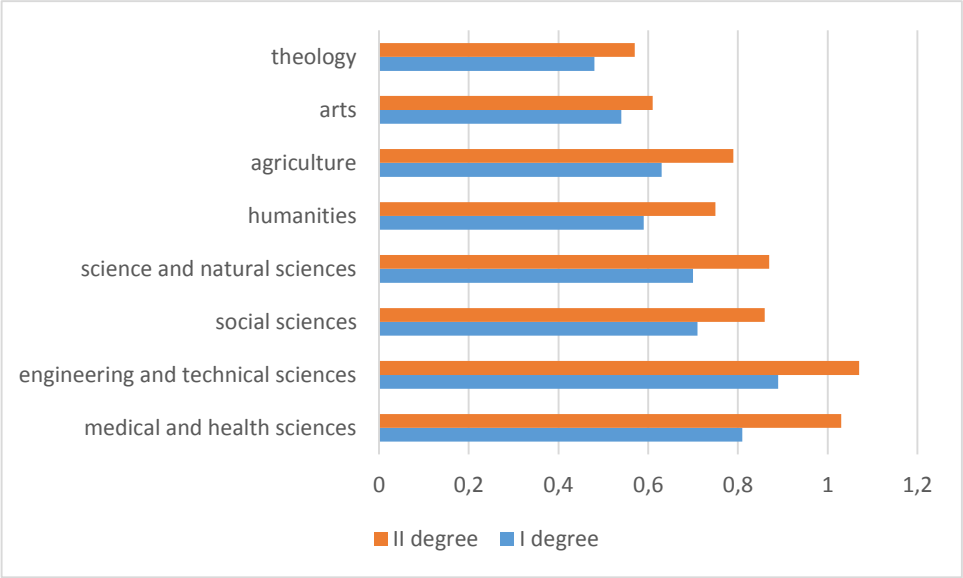

Figure 6. Relative earnings rate of 2020 college graduates[9] by field of study.

Source: own elaboration based on data: ELA, 2020.

Regarding bachelor's degree programs, the most successful graduates were those from engineering, medical and health sciences, and social sciences. Among second-degree graduates, the highest REI values were observed in the fields of engineering and technical sciences and medical and health sciences (REI above 1).

4. College education and the concept of lifelong learning

The transformations mentioned at the start of the article have led to changes in the approach to lifelong learning. This shift has moved from education aimed at supplementing, improving, or changing one's qualifications to learning throughout the life cycle for conscious self-realization and improved quality of life.

When assessing the significance of higher education in the labor market, it's vital to consider not only quantifiable aspects but also elements tied to broadly defined well-being (including mental well-being) or personal happiness. Z. Niśkiewicz contends that mental well-being is crucial in human life, asserting that a sense of fulfillment and satisfaction is developed throughout our lives across six dimensions: purpose in life, personal development, self-acceptance, positive relationships with others, autonomy, and mastery over the environment (2016, p. 149). The accumulation of knowledge and wisdom plays a significant role in this process, gained through expanding our knowledge, interacting with others, and observing our own and others' behaviors in various contexts. A. Mirski viewing well-being as a social and economic category, points to studies that confirm the indisputably positive

[9] In the second year after obtaining the diploma.

impact of education and employment on an individual's sense of happiness (2009, p. 179). According to the latest research – psychological and social well-being for young people are extremely important. More than half of them think that individual well-being is more important than high earnings (PwC, Well.hr, Absolvent Consulting, 2022, p. 4).

HEIs are formal education institutions. They primarily foster general cognitive competencies, providing a foundation that graduates continually broaden with additional skills needed in the job market, acquired through other non-formal or informal learning activities. Formal education can be viewed as a baseline, not a process with a definitive end. Transferable skills such as collaboration, punctuality, work organization, and patience are also honed during higher education.

Additionally, HEIs facilitate non-formal and informal education for students. While non-formal education may not alter educational achievement levels, it fosters the development and acquisition of skills relevant to various professional and social aspects of life. Commonly conducted through courses, training (like micro-certification or certification programs), instruction, seminars, conferences or lectures (like open lectures), it also encompasses distance education, such as webinars. Furthermore, personal growth through social interactions is crucial. This includes interactions with lecturers, fellow students, administrative staff, or internship supervisors. This aspect is part of non-formal education, a lifelong process that unfolds intentionally and unintentionally.

In curricula, alongside directional and specialized modules designed to prepare students for specific professional roles, general education subjects exist. Interestingly, students sometimes call these as “fillers”. These subjects aid students in their learning journey and personal development. In essence, these subjects are intended to help young individuals understand themselves, set and achieve not only educational but also “life” goals, manage stress, connect with their environment, and foster their overall well-being.

5. Conclusions

The labor market and education are intricately linked. HEIs' educational endeavors largely cater to the needs of their two main beneficiaries — students and employers. The labor market presents a growing array of challenges for HEIs, but it's important to note that changes in the education system usually lag behind those in the labor market (Jeruszka, 2023).

This article contributes to the discourse on higher education's role in the labor market, analyzing unemployment among college graduates and their wage trends, with special attention to the graduates' situation. It also highlights the positive impact of the educational process on personal well-being and happiness.

The risk of unemployment is notably influenced by a person's level of education. College degree holders face the least risk, with job search duration influenced by the level and field of study, and work experience gained during studies. A review of statistical data shows that individuals with higher education earned more than the average market economy wage over the observed period. However, an analysis of these wages relative to the average market wage and a comparison of wage growth dynamics against minimum wage growth reveal unfavorable trends.

When assessing the significance of higher education in the labor market, it's important to consider also elements tied to broadly defined well-being or personal happiness. HEIs are formal education institutions which foster general cognitive and transferable competencies. Additionally, they facilitate non-formal and informal education for students. Such approach in current world is essential for young people to be on the way of self-improvement, self-realization and create personal well-being.

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TANGIBLE AND INTANGIBLE MOTIVATIONAL FACTORS IN IT PROJECTS: REMOTE COLLABORATION ENVIRONMENT

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Purpose: This study aimed to identify critical motivational factors in remote teams in the IT industry.
Design/methodology/approach: 72 members of project teams from different organizations in the IT industry that provided work in a remote environment participated in the research. Using a survey questionnaire, we examined which of the proposed 29 motivational factors (15 tangible and 16 intangible) are used by IT companies and experienced by their employees, and which are of the greatest importance to their employees (members of project teams).
Findings: Based on the results obtained using the survey questionnaire, 5 critical motivating factors from the tangible group were specified (adequate base rate for the position and experience, access to modern technologies and equipment, annual discretionary bonuses, additional training or paid extramural studies, paid overtime) and 6 critical incentives from the intangible group (opportunity to reconcile professional duties with private life, job security, learning opportunities, flexible working hours, working in a "good" team, autonomy in decision-making). This analysis revealed that intangible motivators are as important as tangible ones, because in most cases the respondents indicated that intangible factors are also very important to them.
Originality/value: The paper presents the first analysis of motivators relevant to project team members working remotely within the IT industry.

Keywords: motivators in project management, remote working, IT projects, tangible and intangible motivational factors, project teams.

Category of the paper: research paper, case study.

1. Introduction

Current changes in the labor market have caused a radical change in the perception of employment by employees. It turns out that work can be done at home as effectively as in the employer's office. This is confirmed by recent research, which shows that about 56% of

companies work remotely, and 52% of employees work from home at least once a week (Labs, 2018). These changes are also strongly visible in the IT industry, which has rapidly adapted to the recent transformations in the labor market and is facing the growing importance of digital and hyper-competitive business environments (Bitzer et al., 2020). It should be emphasized that a significant part of these companies, adapting to these changes, uses a project approach in their activities and the possibilities of remote cooperation. This is related to the widespread agreement among scientists and practitioners that cooperation in teams generates positive work results, especially in the context of innovative projects (Walker et al., 2017) which are certainly projects implemented in the IT industry. Effective cooperation between team members is seen here as a key success factor in projects (Vaaland, 2004) and is associated with effective coordination and communication, which result from a common understanding of the context and assumptions of the innovation project (Chiocchio et al., 2011).

Hence, people working in project teams need appropriate skills, motivation and opportunities to work effectively (Dasí et al., 2021), especially if this work takes place in a remote environment and concerns IT projects which are often highly innovative and modern. As it is emphasized in the research (Schmidt et al., 2001), the lack of required knowledge and skills among project personnel is one of the five greatest threats that may affect the success of an IT project.

However, as indicated by researchers (e.g. Dasí et al., 2021) in the literature on project management, a limited number of studies take into account issues related to Human Resources Management, including issues of motivation (Sharp et al., 2007). In addition, although there is a fairly rich literature on remote projects, the literature related to the implementation of remote projects in specific industries is still small (Dybå, Dingsøyr, 2008; Hossain et al., 2011). There are studies in the literature on the possibility of working in a remote environment in individual industries (e.g. Adams-Prassl et al., 2022), but they do not directly relate to project management and project implementation. In the work, these strands are combined, and this gap in the literature is filled by providing the first analysis of motivators relevant to project team members working remotely within the IT industry. To identify critical motivators (tangible and intangible) in remote project teams, respondents are asked in the survey to indicate what motivators they expect, whether they are used in their workplaces and how important they are to them. We conducted the research from April to May 2022 on a sample of 72 members of project teams from the IT industry working remotely in Poland.

The article is organized as follows. The first part describes project work in a remote environment and motivations in project management. Chapter 3 describes the methodology of empirical research. The results are presented in Chapter 4, and the Discussion in Chapter 5. The summary includes theoretical and practical implications.

2. Theoretical background

2.1. Remote project work

Dynamically developing ICT technologies affect the type and nature of performed work, which is why more and more often in various areas it can be seen that work is provided in locations other than the office (Hoeven, Zoonen, 2015; Ratti, Claudel, 2016; Stiles, Smart, 2021; Zdonek et al., 2017) which is interchangeably called remote work, telework or distributed work (Allen et al., 2015). Remote work can be treated as a special case of flexible work where the employer is primarily interested in the effects of work, and not on detailed control of its course. When working remotely, employees work remotely and are connected to the company's organizational structure via ICT (Battisti et al., 2022). In conclusion, it can be said that remote work is a flexible work organization that allows an employee to work from a remote location outside of corporate offices or production plants, without personal contact with colleagues, but with the possibility of communicating with them using information and communication technologies.

The growing interest in remote teamwork met with the interest of many researchers, who in particular tried to answer the question of how remote work can be carried out in an optimal way for employees and the organization itself (Messenger, Gschwind, 2016). Moreover, the researchers' analyzes were also associated with the effects of such cooperation indicated in the literature, including increased productivity (Choudhury et al., 2021) and employee engagement (Perry, 2019), as well as work-life balance (Lattemann et al., 2017). In particular, the fact how the transition to remote work affects productivity has long been in the practical interest of organizations considering increasing the use of remote work (Karnowski, White, 2002), or human-computer interaction (Olson, Olson, 2000), IT and engineering (Neufeld, Fang, 2005), management (Choudhury et al., 2021), economics (Bloom et al., 2015), and more. Research results in this area often indicate that the opportunities for employees to engage in remote work largely increase productivity and efficiency (Gajendran et al., 2015). It should also be noted that despite the benefits of remote work, it can also bring a wide variety of personal challenges for individuals, such as blurred lines between home and work life, reduced support and feedback, feelings of isolation and struggles with detachment from work (Charalampous et al., 2019; Eddleston, Mulki, 2017). Moreover, working in a remote environment requires from employees personal skills that allow them to organize and perform work without any form of direct supervision and an appropriate approach from the organization itself, which would have a culture that supports and encourages remote work (Baruch, 2000).

As (Desilver, 2020) noted, knowledge-intensive jobs are particularly well suited to remote work. Computer and math jobs, for example, have a high share of home-based jobs, as do jobs in the information and communications industry, where programmers, for example, can do about 89% of their tasks remotely (Adams-Prassl et al., 2022). This can also justify the growing

popularity of remote work during the implementation of IT projects that require highly specialized competences and the ability to manage their own work from the teams that create them. In addition, remote IT projects are mostly implemented using agile practices that are considered lightweight, flexible and self-organizing, but also facing challenges related to maintaining the continuous interaction between team members required in IT projects (Dorairaj et al., 2010). This is because an agile approach allows IT project teams to respond to emerging needs in a timely manner (Dreesen et al., 2020; Hennel, Rosenkranz, 2021; Recker et al., 2017), and meet rapidly changing customer preferences and available technologies (Podgórska, 2022), but precisely at the price of continuous and effective communication between members of the entire project team.

Howe and Menges (2021) suggest that the future of remote work should include careful consideration of the psychological factors associated with the experiences of remote workers. Understanding beliefs about remote work and their role in adapting can help organize remote work and support employees to maximize employee well-being and productivity. It can also help ensure that technological progress which enables employees to work from anywhere will benefit both employees and organizations.

2.2. Motivational factors in project management

Motivation can be defined as the reason an individual works to achieve a goal (Robbins, 1993). One may be motivated by work, pay, promotion, relationships with colleagues and other factors that can influence the attitudes and behavior of individuals, as well as determine their level of commitment, passion, participation or concentration (Crossman, Abou-Zaki, 2003). In other words, motivation is a factor that creates reasons for action, motivates people to work actively and efficiently, and helps them be as creative as possible (Phan et al., 2020).

Motivation is one of the key factors influencing the effective work of teams, and thus the success of the project (Schmid, Adams, 2008). Clark (2003) emphasizes that motivation and commitment to the project influence process efficiency as strongly as hard project management practices. Whereas (Collins, Smith, 2006) indicate that a high level of team motivation affects its trust and cooperative behavior and causes individuals to strive to achieve joint results. In turn, (Liang et al., 2007; Liu et al., 2011) point out that a low level of motivation is associated with the fact that team members trust each other less or are not committed to the project's goals, causing conflicts in relationships and poorer results.

According to (Peterson, 2007): four key elements that can strengthen team motivation and are related to the area of project management are: authority of a team member, planning and allocation of qualified resources, dissemination of correct information, and responsibility for completing the task. The literature also presents a division into tangible and intangible motivational factors, e.g. (Meder et al., 2018). Tangible factors refer to those that have specific, visible and easy to measure characteristics, such as financial remuneration and promotions. Intangible awards are relatively less observable and measurable, and mostly come from other

subjects in the social environment. Intangible factors include social approval, verbal praise and recognition from co-workers or management (Yoon et al., 2015).

In this context, it should be noted that research on motivational factors (Carnahan et al., 2017) shows that intangible factors that refer to employees' preferences in intellectual challenges, recognition, work-life balance, and opportunities to contribute to society can motivate action and positively impact work outcomes. Researchers emphasize here that the key theoretical mechanism explaining better work performance through intangible factors is the existence and fulfillment of "motives", i.e. individual preferences similar to the characteristics of employees in relation to these intangible benefits. (Sauermann, Cohen, 2010) treat "motive" as "employee's preference for incentives", and "incentive" as "conditional benefits provided by the company". In addition, research results indicate that different types of intangible benefits have a different impact on individual employees, depending on their motives (Agarwal, Ohyama, 2013; Sauermann, 2018), and stronger preferences for a specific intangible benefit increase the marginal utility of the benefit, leading to increased effort (Sauermann, Cohen, 2010).

Moreover, it should be noted here that, the very character of the project team differs from the "traditional" team, which will also require the use of different motivational factors than in the case of traditional teams. Project teams consist of employees with diverse competences, i.e. knowledge, experience and skills, who work together throughout the project to achieve a common goal (Chiocchio, 2015). What makes project management different from management in general is that it evolves around a temporary team under the guidance of temporary project manager. However, the temporary and intermittent nature of projects may become a barrier to effective collaboration if skills, capabilities and motivations are not properly managed (Bartsch et al., 2013). Therefore, understanding the motivators which have the greatest impact on team members is particularly important, especially given the increasing performance pressures faced by project managers (Zimmerer, Yasin, 1998). It is worth adding here that motivation is equally influenced by the project manager and the entire organization. That is why it is so important that both the project manager and the organization create a culture of high motivation for project teams.

Taking into account the above considerations, the following research questions were formulated in the paper:

RD1: What motivators do employees of remote IT project teams consider important?

RD2: Which of the tangible factors are the most important for remote IT project teams?

RD3: Which intangible factors are the most important for remote IT project teams?

RD4: Are tangible factors more important to members of remote project teams than intangible ones?

3. Methodology

The research sample was an industry target group in the field of motivation in project management. It was a "transitional" sample, which is defined as a set of people over 30 and under 100. The research is an introduction to further in-depth research on the motivation of remote project teams from the IT industry from the perspective of success achieved by these teams. At the beginning, pre-pilot activities were carried out and a questionnaire was sent to 3 people for critical analysis from the perspective of different individuals. This allowed for the optimization of the survey in terms of layout and content, as well as for the appropriate clarification of questions and the addition of missing ones, listed by the respondents, and a reference to the surveyed population.

The respondents were employees from the broadly understood IT industry sector - people who mainly use information technologies in their daily work and carry out their tasks based on them, but also employees who work remotely. People referred to as remote workers are employees who mostly work outside the company's offices, using mostly home space. The respondents were searched to be employees of various companies from the IT sector. This made it possible to reduce the error caused by the tendency of employees of one company to specific motivators. The research was conducted over a period of two months; from the beginning of April to the end of May 2022. The survey was constructed in such a way that the time to complete it oscillated between 15 and 20 minutes. The appropriately short time of completing the questionnaire was to ensure the credibility of the answers and that the respondents would not feel discouraged to make well-thought-out answers after too long time required to complete the questionnaire.

The group of surveyed people included 13 project managers/executives, 41 members of the project team, 7 business specialists and 11 people holding other posts. 46 men and 26 women joined the study.

The respondents included 23 people aged 18-25, 22 people aged 26-30, 16 people aged 31-40, 8 people aged 41-50 and 3 people aged 50+.

The form of employment of the surveyed persons is: 53 persons employed under an employment contract, 10 persons employed under a B2B form, 8 persons under a contract of mandate, 1 person employed in a different form and no persons employed under a contract for specific work.

The current approach of the respondents to project management is the Scrum approach for 40 people, extreme programming for 3 people, Kanban for 7 people, waterfall for 10 people, and other forms of project management for 12 people.

As for the experience of the respondents, 11 respondents had experience in the range of 0-1 years, 17 people in the range of 2-3 years, 13 people 4-5 years, 15 people 6-10 years and 16 people had experience of over 11 years.

The research was conducted online, and the survey was carried out using the Microsoft Forms application. The survey was divided into three groups in order to properly determine the tangible and intangible motivational factors as well as basic information about the respondents. The surveys were mostly sent directly to the respondents after initial verification of their form of work on social networking sites, i.e. LinkedIn, in order to properly fit into the form of remote work and the IT industry. They were also sent to Project Management associations, such as the Silesian Regional Group IPMA.

The obtained results of the survey were developed in order to obtain appropriate statistical results which will allow to identify the key tangible and intangible motivational factors. An analysis was carried out to properly determine the specific deviations of the respondents depending on gender, age, experience and form of employment.

The first group of questions regarding tangible motivators involved determining whether the given motivators are used in the current workplace, whether the person has experienced a given motivator, and what is the significance of a given motivator. There is also a gap for entering particularly important tangible motivators not presented in the list.

For the group of questions related to intangible motivators, the question of their application to individual employers was also provided, and the question was whether the employee had experienced the motivator and how they assessed the importance of individual motivators. The survey included sixteen questions about intangible motivators. There is also a gap for entering particularly important intangible motivators not presented in the list.

For questions regarding the use of a given motivator, simple answers on a 3-point scale are provided, i.e. "Yes", "No" and "I don't know". For questions related to the importance of a given motivator, a 5-point Likert scale was used, i.e. "Very important", "High importance", "Medium importance", "Low importance" and "Irrelevant".

The survey also includes the metrics of the surveyed people, detailing the position in which the surveyed person works, the currently used approach to project management, form of employment, gender, age, and education.

The prepared survey allowed to obtain relevant information from the survey respondents in order to specify key motivational factors in remote teams from the IT industry.

4. Results

First, the results of the use by employers and the experience by members of project teams from the IT industry of tangible motivational factors were presented (Figure 1). Next, the most important tangible factors for the respondents were presented (Figure 2). Sequentially, the intangible motivating factors used by employers and experienced by project team members (Figure 3) and their importance for the respondents (Figure 4) are presented.

As can be seen from Figure 1, in the case of the first motivator **(TF1) - the basic rate adequate to the position and experience** is used in 79% of cases, in 14% of cases it is not used, and only 7% of respondents do not know whether it is used. As for the experience of this factor by the respondents, 78% of the respondents have experienced it. It can therefore be indicated that the application of an adequate base rate to the position and experience is both used by employers and experienced by team members. As regards **access to private medical care (TF2)**, it can be seen that it is used by as many as 86% of employers and 13% do not use it. When it comes to experiencing this motivator by the respondents, 75% of the respondents experienced it, while 25% did not. The third motivator **(TF3)**, i.e. **additional training fully paid by the employer, access to training platforms or paid extramural studies**, are used in 79% of the companies surveyed, and in the case of 17% it is not used. Taking into account the experience of this motivator by the respondents, 67% of people answered that they had experienced this motivator. Another analyzed motivator was **the possibility to participate in conferences during working time (TF4)**. In this case, the vast majority of surveyed companies (79% of respondents) use the given motivator and 64% of the respondents answered that they had experienced this motivator. Another motivator - **additional insurance (TF5)** is used by 75% of employers of the surveyed persons, by 17% it is not used, and 8% do not know whether the company uses it. When it comes to the respondents' experiences, only 58% have experienced this motivator. The next motivational factor examined were **integration meetings with team members and company employees paid for by the company (TF6)**. In 76% of cases, this motivator is used by their enterprises and as many as 78% of the respondents have experienced this motivator. Another intangible motivator is **free access to sports facilities (TF7)**. In this case, it is used by 58% of employers, 31% do not use it, and 11% do not know whether it is used in their company. In turn, 49% of the respondents have experienced this motivator. **The opportunity to learn foreign languages funded by the employer** is **TF8**. Figure 1 shows that in 69% of cases this motivator is used by the surveyed companies. In addition, 51% of the respondents have experienced the given motivator. Another intangible factor examined were **additional privileges, e.g. a company car, a mobile phone (TF9)**. In this case, 52% of the enterprises in which the respondents work do not use the given motivator, 40% do, and 8% do not know whether it is used. What is more, 65% have not experienced using this motivator. The tenth motivator examined was **the use of annual discretionary bonuses (TF10)**. The motivator is used in 61% of enterprises, but as many as 50% of respondents have not experienced the use of annual discretionary bonuses. The next examined motivator was **access to modern technologies and equipment (TF11)**. In 76% of cases, this motivator is used by the surveyed enterprises. In turn, 69% of respondents have experienced this motivator, and 31% stated that they had not experience it. Using a motivator in the form of **additional social benefits, e.g. vacation, getaways, cultural events** is **TF12**. This motivator is not used in 45% of the enterprises of the surveyed team members. Figure 1 also shows that 63% of the respondents have not experienced TF12. Another

factor, **additionally paid overtime (TF13)** is used by 61% of the surveyed enterprises, 29% of employers do not use it, and 10% of respondents do not know whether it is used. In terms of experiencing TF13 by respondents, 50% have experienced it. Another examined motivator were **material rewards (TF14).** In this case, 58% of companies where project team members worked do not use this factor. In turn, 76% of respondents have not experienced this motivator. The last examined motivator in the group of tangible factors were **pension programs (TF15)**. In the case of 38% of the respondents, the motivator is not used in their company. In turn, as many as 78% of respondents have never experienced this motivator.

The importance of tangible motivational factors for the respondents is shown in Figure 2. And so, it can be noticed that out of all 15 analyzed factors, the surveyed members of remote teams in the IT industry considered the following to be of key importance to them: (1) adequate base rate for the position and experience – TF1, (2) annual discretionary bonuses – TF10, (3) access to modern technologies and equipment – TF11, (4) additional training paid in full by the employer, access to training platforms or paid extramural studies – TF3, (5) additionally paid overtime – TF13. In the field with additional motivators, the respondents also specified the possibility of paying extra for additional days off and the use of "workation", i.e. the possibility of going on vacation and simultaneously working and resting during free time. In addition, the possibility of using cafeteria bonuses as thanks to other employees of the company, who are not members of a given team and are not subordinate to project managers, was specified.

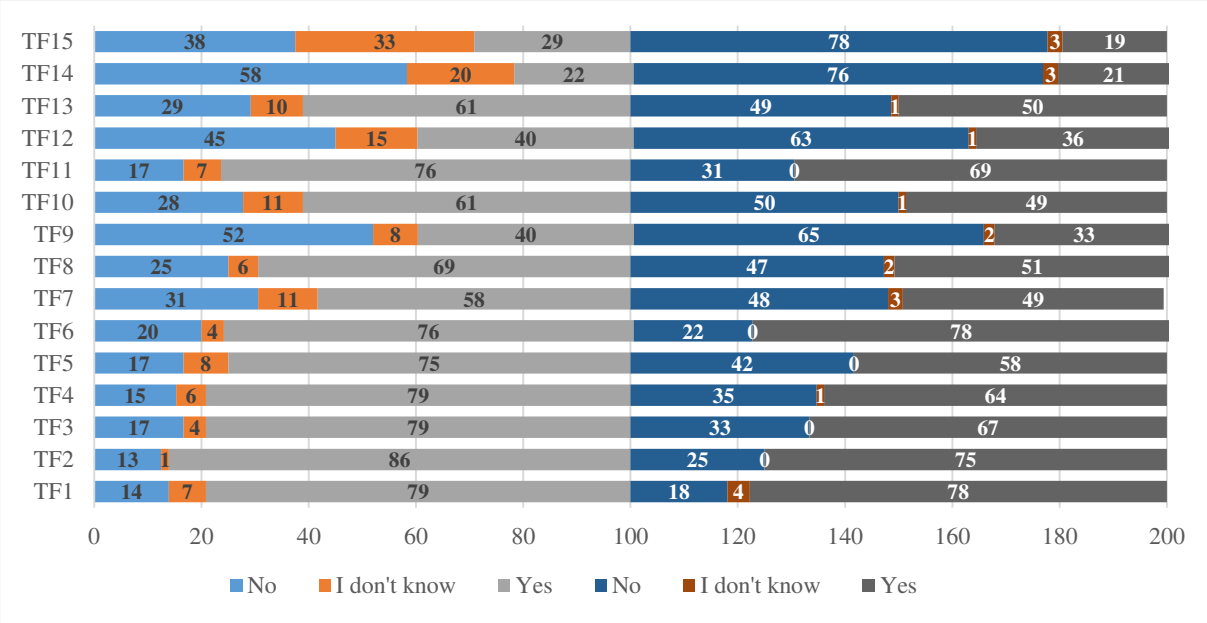

Figure 1. The use of tangible motivational factors by employer vs. The respondent's experience in applying given tangible motivational factors.

Source: Own elaboration.

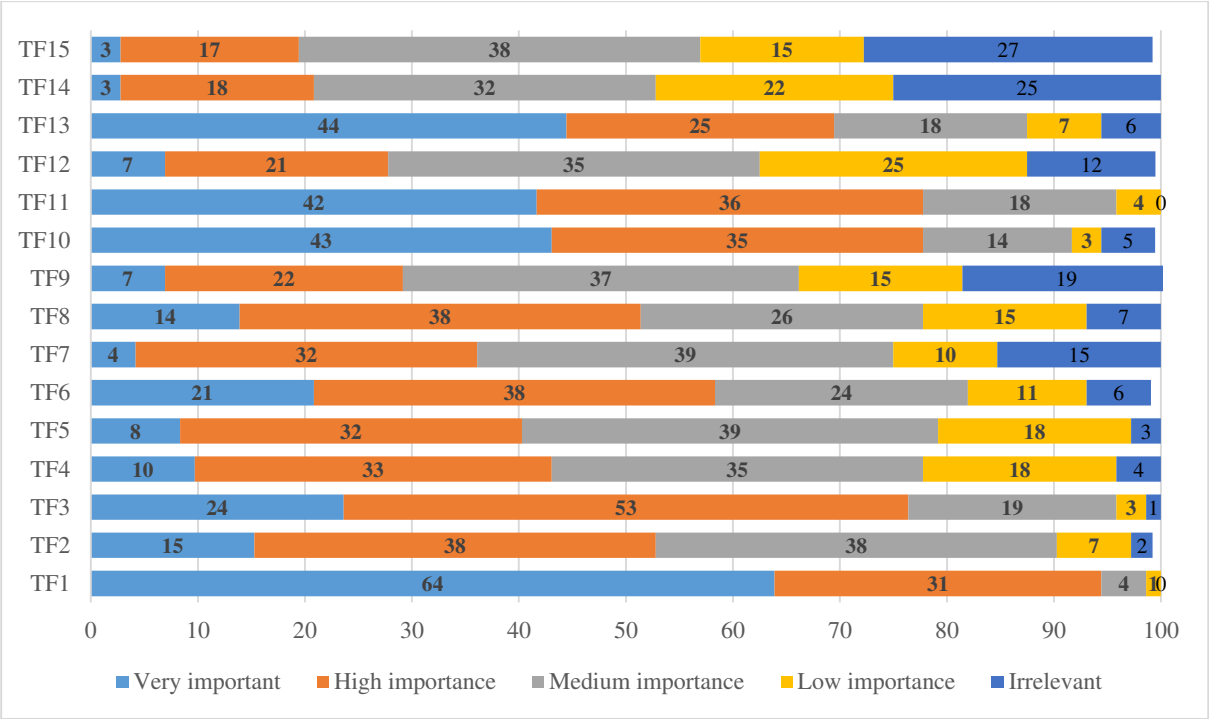

Figure 2. Results regarding the importance of tangible motivators.
Source: Own elaboration.

Figure 3 refers to the use of intangible motivation factors by the surveyed companies and their experience by project team members. As shown in Figure 3, in the case of the first motivator - **implementation independence and decision-making autonomy (IF1)** - 78% of employers use the given motivator, 18% do not use it, and 4% do not know whether the company uses it. As for the experience of this factor by the respondents, 81% of team members experience the above motivator. As far as **the possibility of reconciling professional duties with private life (IF2)** is concerned, it can be noted that it is used by as many as 90% of employers, 4% do not use it, and 6% of respondents did not know whether the employer uses it. When it comes to experiencing this motivator by the respondents, 92% of the respondents have experienced it. The third motivator, i.e. **having a mentor supporting career development (IF3)**, is used in 50% of the surveyed companies, in 39% it is not used, and 11% do not know whether the company uses it. Taking into account the experience of this motivator by the respondents, 53% of people answered that they had experienced the use of this motivator. Another analyzed motivator was **the freedom to express opinions and views (IF4)**. In this case, the vast majority of surveyed companies (93% of respondents) use the given motivator. When it comes to the experience of the respondents in this regard, the results here are consistent with the use of this motivator by enterprises. Another motivator - **clearly defined goals and a competency development plan (IF5)** is used by 63% of employers of the surveyed persons. As far as the respondents' experiences are concerned, only 60% have experienced this motivator. The next intangible factor examined was **the lack of discrimination by colleagues (IF6)**. In as many as 92% of cases, this motivator is used by their enterprises. In terms of experiencing this motivator by the respondents, as many as 90% of the respondents have

experienced this motivator. **IF7** means **no discrimination by superiors**. In this case, 90% of employers use the selected motivator, and as many as 94% respondents have experienced this factor. The eighth intangible motivating factor is **the principles of employee evaluation based on quantitative criteria - criteria with a specific score (IF8)**. In this case, it is used by only 40% of employers, 38% do not use it, and 22% do not know whether it is used in their company. In turn, only 35% of the respondents have experienced this motivator. **The principles of employee evaluation based on qualitative criteria (descriptive evaluation prepared by the immediate supervisor) are IF9**. Figure 3 shows that 31% of employers do not use it, 47% use the selected motivator, and 22% do not know whether the company uses it. In addition, 44% of the respondents have experienced the given motivator.

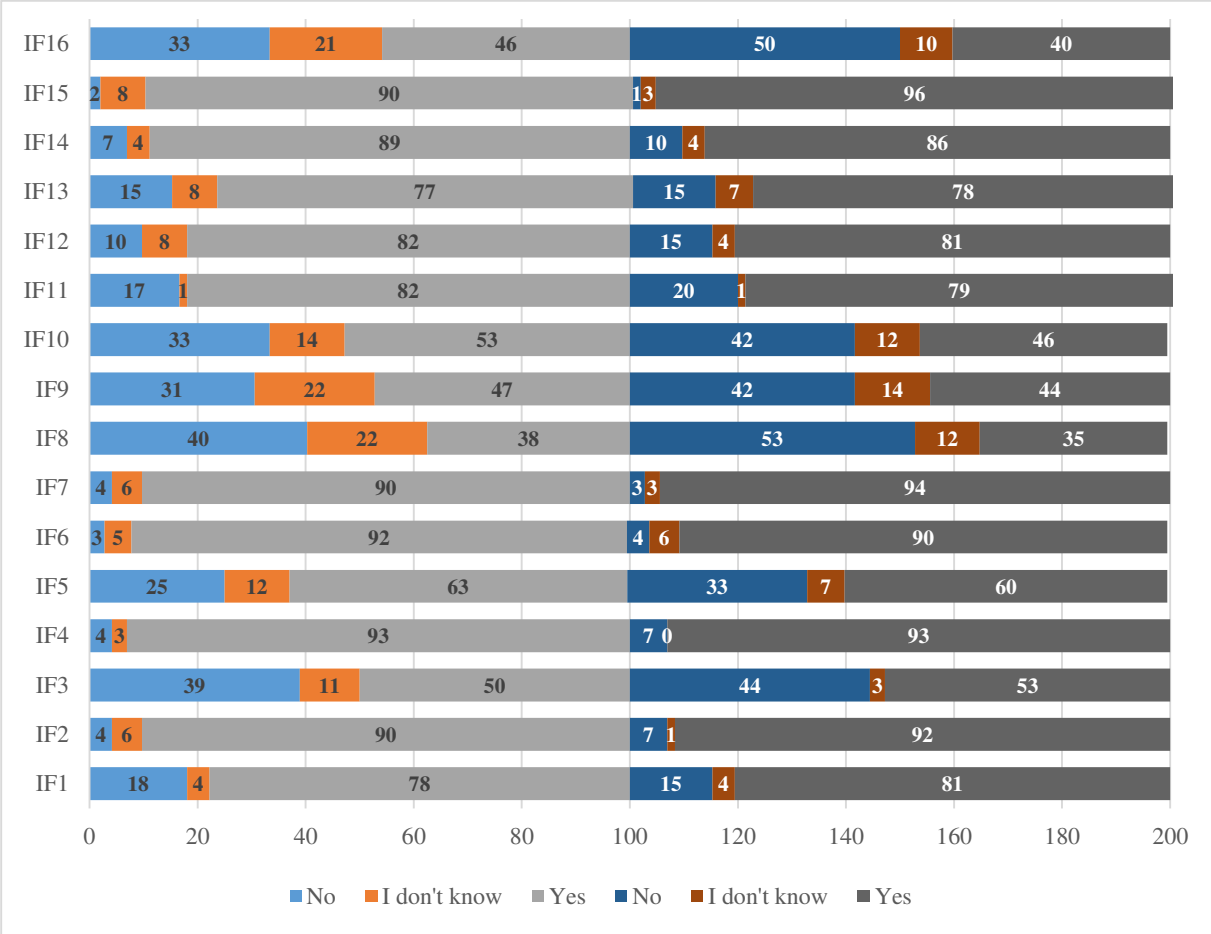

Figure 3. The use of intangible motivational factors by employer vs. The respondent's experience in applying given intangible motivational factors.
Source: Own elaboration.

Another examined intangible motivator was **the opportunity to work in a project that solves significant problems in the context of social development, the environment and solving complex problems (IF10)**. In this case, it can be seen that 53% of the surveyed employers use the given motivator. However, 46% of respondents have experienced it and 42% have not experienced it. The next examined motivator from the group of intangible ones was **flexible working hours (IF11)**. And so, it is used in 82% of the surveyed enterprises, 17% do not use this motivator, and 1% do not know whether it is used. The experience of this motivator

by the respondents is similar. The twelfth intangible motivator **(IF12)** was **the opportunity to experiment and learn**. 82% of the surveyed employers use it, 10% do not use it, and 8% of the respondents do not know whether it is used in their company. The results in terms of experiencing it are almost identical. Another factor, **the use of praise and recognition (IF13)** is used in 77% of the surveyed enterprises, in 15% of employers they are not used, and 8% of the respondents do not know whether they are used. The experience of this motivator by the respondents is similar. Another examined motivator was **working in a "good" team (IF14)**. 89% of respondents answered that it is used in their company. In turn, 86% of people have experienced this motivator, 10% have not experienced its use, and 4% do not know if it is used. The fifteenth examined motivator from the intangible group was **job security (IF15)**. In this case, 90% of the respondents answered that their company uses IF15. In terms of experiencing this factor, 96% of people claimed that their employment was certain. The last examined motivator in the group of intangible factors was **the possibility of choosing the project in which they wanted to participate (IF16)**. According to the respondents, 46% of employers provide such an opportunity, 33% do not provide such an opportunity, and 21% do not know whether the employer uses the given motivator. In turn, when it comes to experiencing this motivator, 50% had no choice.

The importance of intangible motivational factors for the respondents is shown in Figure 4. And so, it can be noticed that out of all 16 analyzed factors, the surveyed members of remote teams in the IT industry considered the following to be of key importance to them: (1) the ability to reconcile professional duties with private life – IF2, (2) job security – IF15 , (3) the ability to experiment and learn – IF12, (4) flexible working hours – IF11, (5) working in a "good" team – IF14, and (6) independence in implementation and autonomy in decision-making – IF1. In the field concerning other intangible motivators, the respondents also indicated the possibility of horizontal promotion, i.e. changing the career path within the same organization, as important.

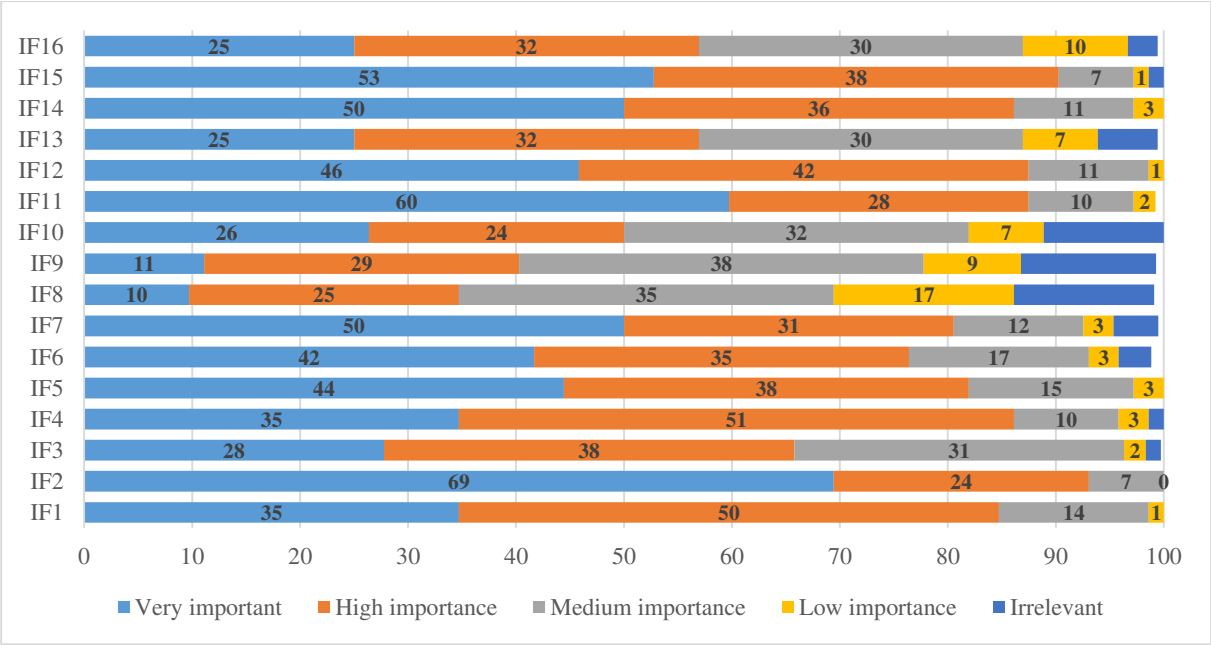

Figure 4. Results regarding the importance of intangible motivators.
Source: Own elaboration.

5. Discussion

The article poses four research questions related to the importance of motivational factors for members of remote teams from the IT industry. Referring to the first research question, it can be stated that the members of remote teams from the IT industry as the most important motivational factors out of all 31 factors surveyed considered: (1) the ability to reconcile professional duties with private life, (2) an adequate base rate for the position and experience, (3) flexible working hours, (4) job security, (5) working in a "good" team, and (6) the opportunity to experiment and learn. It can therefore be concluded that among the most important motivational factors for the respondents were both tangible and intangible ones, i.e., answering the fourth research question, tangible motivators are not more important than intangible ones, on the contrary - intangible factors are equally important for the respondents. This is in line with other previous studies presented in the literature, e.g.(Daniel, Metcalf, 2005; Silverman, 2005) emphasizing that organizations that use both tangible and intangible motivators will perform better, and thus the effectiveness of their teams will be better. Admittedly, the results of some studies, e.g. (Al-Nsour, 2011) show that tangible motivators have a greater impact on motivation compared to intangible ones, but the same research shows a significant relationship between tangible and intangible factors and team performance. In addition, it should be noted that tangible motivators require additional financial outlays and

intervention at the level of senior management, while intangible motivators are most often used at the level of lower management.

Furthermore, the division of motivational factors into tangible and intangible ones allows for their balanced selection and adjustment to the needs of project team members. This is also confirmed by other researchers, e.g. (Lawler, 2003) pointing out that employee motivation can be increased by offering better and more tailored reward and recognition programs that will increase the effectiveness of undertaken projects.

In addition, the research revealed that the respondents considered the base rate adequate to the position and experience as the most important tangible motivating factor. This result is not surprising, because in research conducted in this area, (Baddoo et al., 2006) it is indicated that financial remuneration is one of the most valuable factors for employees. Annual discretionary bonuses also turned out to be an important factor in this group. In this context (Amstrong, 2003) emphasizes that if financial rewards are related to the performance of individual team members, they provide a form of feedback on their performance. Moreover, it indicates that employees are motivated only when performance is linked to rewards. In the group of tangible factors, the respondents also indicated additional training paid in full by the employer, access to training platforms or paid extramural studies. The importance of this factor is also confirmed by research (Seiler et al., 2012), although their authors emphasize that motivational factors related to learning opportunities are more important for younger than older employees.

In turn, taking into account intangible motivating factors, the most important in this area turned out to be the ability to reconcile professional duties with private life, job security and the opportunity to experiment and learn. Regarding job security, (Dwivedula, Bredillet, 2010) note that until recently, organizations have not focused on ensuring the continuity of employment for their project employees. This resulted in a high turnover rate in some industries, in particular in the IT industry. Therefore, organizations wanting to retain their employees had to change their strategies in this area. In the context of opportunities for experimentation and learning, (Dwivedula, Bredillet, 2010) emphasize that project-based organizations, due to their structure and requirements, should create a culture conducive to taking up challenges and experimenting. Employees of remote teams in the IT industry have also shown flexible working hours as a leading motivator. This is consistent with previous research, e.g. (Fuller, Hirsh, 2019; Jonek-Kowalska et al., 2020) in which it was emphasized that flexible working time is a key resource that helps to cope with competing requirements in various industries. In addition, independence in implementation and autonomy in decision-making tuned out to be important for the respondents. The importance of this factor is also emphasized by (Dwivedula, Bredillet, 2010) according to which the project team should be granted autonomy at the stages of project implementation, and this effort should be rewarded for results. They add that ensuring autonomy in action along with meeting the needs respect of the project staff, will lead to further good team performance.

The most serious limitation of our study was the relatively small sample size. It should be noted, however, that there were both industry restrictions - (IT industry), as well as the nature of work (remote work), which limited the surveyed population quite strongly. The continuation of this research may be its repetition in different contexts, in organizations from other industries and from other countries. Research on motivational factors in teams implementing projects in non-profit or production organizations could be cognitively interesting. This would allow for a comparison of motivators in project teams from different industries, and shed more light on the clear challenges and prospects associated with working in remote teams. This study may also be limited by not separating motivators into those that the team expects from the organization, and which are expected from the supervisor, i.e. the project manager. Approaching this issue from such a perspective would allow organizations to target their activities in the area of team motivation even more. It would also be worth paying attention to the issue of intrinsic motivation in future research, which also seems to be important in this case.

6. Conclusions

The results of this study have implications for both research and practice. While previous research looked at the different skills required from IT professionals, little attention was paid to the motivation of project team members, including those working remotely. This study is one of the first to address this issue, thus contributing to management science in the field of project management and human resource management from the perspective of the motivation of remote project teams from the IT industry and raising the argument for focusing more attention on building motivation systems based on tangible and intangible factors, tailored to the needs of a specific group of employees.

For practitioners, the results of the study can be immediately used in many ways. First, organizations in the IT industry increasingly need to take various types of actions to properly maintain the motivation of members of their organization's project teams. Their offer must be attractive to draw new employees' attention. The results of this study show the key motivational factors that are worth adjusting to the expectations of current and future members of remote project teams in the IT industry.

With regard to the first key tangible motivation factor - an adequate base rate for the position and experience, organizations should ensure that the remuneration received is adjusted to the role performed in the team, responsibility and competences that a given team member represents. They should also provide an additional budget to adjust the base rate to the current role. In terms of guaranteeing modern equipment and technology for remote team members in the IT industry, it is worth introducing a specific process of replacing equipment at a certain

fixed period of time so that employees do not feel neglected and do not leave for competition due to negligence in this area. In terms of the annual bonus system - it is worth preparing an appropriate plan for monitoring the involvement of team members and a strategy that will be the basis for calculating the bonus. The annual bonus system can also encourage constant commitment throughout the year of work and guarantee motivation for the next years of work on the project. Enabling team members to develop competences through training, access to training platforms or extramural studies will allow members for constant development tailored to the needs of projects implemented in the organization, and ensuring an overtime remuneration system clearly defining the benefits that result from performing additional work, will allow to ensure the continuity of work "in difficult periods" in the project, requiring additional work.

In the case of intangible motivators, organizations should show greater interest in this group of factors and use them in their incentive systems. In this case, the respondents put the possibility of reconciling professional duties with private life in the first place. Therefore, duties for team members should be selected so that they do not have to work in their free time and beyond their capabilities. The right scope of duties will make employees much more motivated, which can result in more effective work, increased quality and greater commitment. Job security ranked second. It is therefore worth guaranteeing employees the right type of contract during the recruitment process, as well as bearing in mind that team members are often sensitive to situations that may suggest problems in the organization. In terms of the opportunity to experiment and learn, team members who will be given the opportunity to try and perform experiments, resulting in a reduction in the time required to perform tasks or an increase in the quality of the final product, will be more likely to be involved in the daily life cycle of the project. Defining the scope and opportunities for experimenting and learning can have a positive impact on the entire project team, which is focused on innovation, especially in this industry. As for flexible working hours organizations should guarantee such an opportunity and define the appropriate scope of tasks without detailed planning of the time in which they will be performed, in order to allow individual employees to perform work at the most convenient time for them, taking into account the fixed daily schedule team work. In the context of working in a "good" team it should be pointed out that the selection of members according to their personality types is crucial in this matter. Identical personalities should not be selected for the team, but it is worth monitoring the attitude of its individual members towards each other. It is worth pointing out here that organizations during the team recruitment process should use popular personality tests that allow to identify the roles that best suit the given employees and select the team in a complementary way. In the case of the last key IF, i.e. implementation independence and autonomy in decision-making, project team members should be gradually granted freedom in performing tasks and making decisions, monitoring the effects of their work so as to ensure good results.

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INFORMATION BEHAVIOURS OF YOUNG ADULTS IN THE AREA OF ENVIRONMENTAL PROTECTION ACTIVITIES – A PILOT STUDY

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Purpose: Analysing the information behaviour of young adults in the field of environmental action and looking for implications for improving communication in this area.
Design/methodology/approach: 1) A literature review on the information behaviour of young adults and their attitudes and behaviour in the area of environmental care. 2) Qualitative research carried out using an online survey sheet. The respondents - students at two Krakow-based universities (540 completed questionnaires). An analysis of tables multi-divisional tables with different cross-sections.
Findings: Young adults say that their lifestyles are environmentally friendly despite not engaging in the environmental activities mentioned in this paper. They are also not interested in expanding their knowledge in this area with the help of environmental organisations. The study found that nearly half of the respondents (48.9%) never look at the social media profiles of pro-environmental organisations, and only 5.9 systematically look at the websites of these organisations (47.2% never go there). They believe that their style is environmentally friendly ('definitely yes' – 5.4 % and 'rather yes' – 44.3 %), although, for example, almost 70 % of respondents have never supported such an initiative with a financial contribution. And nearly 60 % have never taken part in an environmental demonstration.
Research limitations/implications: The research involved young adults studying at universities, which naturally limits the generalisation of conclusions drawn to the entire population of this group of young people. The next stage should extend the research to groups not yet represented in the described research process.
Practical implications: It is necessary to facilitate collecting and verifying information on human impact on the environment and develop programmes to improve young adults' knowledge of methods of caring for environmental well-being.
Social implications: Supporting young adults in seeking, selecting, assessing and learning about the principles of supporting the environment will ultimately result in an improved environment.
Originality/value: Analysing the information behaviour of young adults from universities in Kraków in environmental action and contrasting it with their chosen behaviours from this area. Identifying implications for educational educators to help develop the information behaviour of young adults and help increase their involvement in environmental action.

Keywords: information behaviours, environmental protection, young adults.

Category of the paper: research paper.

1. Introduction

The need to engage in pro-environmental behaviour is becoming more and more natural in modern societies. More and more people declare that they would like to do something for the good of the environment. For example, respondents of the research presented in this paper mostly believe (63.1%) that pro-environmental activities are necessary in today's climate situation. At the same time, it is noticeable that most of us find it difficult to assess how specific human behaviour affects the environment daily. Choosing the more environmentally friendly option requires specialised knowledge, e.g., the composition of the products we buy, the technological processes used to manufacture them and the possibility of recycling them afterwards. A knowledge that everyone should learn to reach for on their own. Educational programmes implemented on a mass scale will be very helpful but will not solve the problem. Everyday consumer decisions involve many issues, and market participants need quick access to information on different topics. The ability to correctly identify and verify information sources should be developed in every member of society to use them independently, intuitively and safely.

The discussion presented here aims to analyse the information behaviour of young adults in the area of environmental concern and to look for implications for improving communication in this area.

The starting point of the research process was a literature review on the information behaviour of young adults and their attitudes and behaviour in the area of environmental concern. The basis for the inference was a qualitative study conducted using an online survey sheet (Google Forms). The survey covered students at two universities in Kraków, from whom 540 completed questionnaires were obtained. The collected data was analysed using multi-divisional tables with different cross-sections.

2. Literature review

Access to information, skilful verification of its reliability and professional management is the basis for functioning in today's market reality (Kolbusz, 1993; Gregor, Kalicińska-Kula, 2014). Knowing information behaviour allows you to get the right message across more quickly to stakeholders and to maintain constant contact with them, enabling you to influence their attitudes and behaviour and analyse the results of these actions (Groff, Jones, 2014; Włodarkiewicz-Klimek, 2016). In contemporary terms, information behaviour encompasses the various activities of seeking and generating information. It also includes the factors influencing these processes and their results (more comprehensive in Rogala, 2017). Since the state of

knowledge about the possibilities of satisfying needs strongly influences the market decisions of buyers, bidders of goods and services systematically analyse the information behaviour of other market participants (Davenport, Prusak, 1998). The continuous development of ways and tools of communication and the potential readiness to use them in society influences the development of information competencies of market participants and necessitates their systematic study. Therefore, it becomes natural to constantly update the results of this research to isolate changes in preferences in the choice of information sources and communication tools. It becomes crucial in an era of information oversupply when many messages mean that some of them go unnoticed (Kaczmarek, Walczak, 2009). And the large amount of information makes verifying their credibility impossible. Selecting the channels used and optimising the content communicated is necessary (Dawson, 2014). Through these processes, it is possible to increase the effectiveness of information flows.

Young adults are very proficient in the online environment and find the information they need relatively quickly. However, they rarely ask questions about the reliability of the information they find. Some researchers note, however, that young people often tend to uncritically reproduce the information they obtain, which creates the danger of spreading opinions and advice that are not in line with ecological principles (Mooradian et al., 2006). In today's reality, analysing the reliability of information sources is becoming a key competence for all market users (Kotler et al., 2021). Consumers' decision-making is significantly influenced by the knowledge stored in their memory (Brucks, 1985; Hristov, Kuhar, 2015).

An important question becomes whether and how young adults are increasing their knowledge of the impact of their attitudes and behaviour on the environment. Understanding these processes will make it possible to create an information system to equip people with the knowledge to disseminate pro-environmental behaviour and avoid the duplication of environmentally damaging information (Budzanowska, Proszowska, 2022). However, the different nature of individual market decisions also makes the need for information different. Sometimes information is objective and quantitative, associated mainly with data, while at other times the term is understood as subjective and qualitative (Madden, 2014).

Web browsing can serve functional and recreational purposes (Xia, 2010). Experience and knowledge gained from browsing influence decision-making and subsequent online information behaviour (Xia, 2010). The popularity of online communication and sales channels is perceived as facilitating these processes and increasing the level of uncertainty accompanying them. (Chiou et al., 2017). The problem for Internet users is that too many sources of information are contained therein (Broilo et al., 2016). The website's credibility and data quality are significant for business-to-business (B2B) customers. They expect information confirming a website's trustworthiness and a supportive service when using it (McLean, 2017). Information demand is growing in the face of aggregate market uncertainty (Geiger et al., 2022). Asynchronous social search, the search for information by a group of collaborators acting non-

concurrently, is also trendy. They independently collect information and immediately verify its relevance, which helps to reduce information overload in the system (Buijs, Spruit, 2017).

The importance of credibility for a positive image of online services is also highlighted by research (Hoffman et al., 1998; Grant, Waite, 2003). Some industries, such as tourism, already have procedures for collecting, systematising and verifying offer information (Almeida-Santana et al., 2020). Wealthier and better-educated people are more likely to use online sources of information and are more likely to share them using sharing economy platforms (Almeida-Santana et al., 2020).

The process of obtaining information from the Internet is significantly influenced by the involvement of this channel in the implementation of advertising campaigns (Klein et al., 2020).

The global climate situation makes environmental concerns the focus of many studies and programmes, and young adults, as the future beneficiaries of these measures, are the subject of them (Lisowski et al., 2021). Some studies confirm that the state of the environment is essential for young adults, and, at a declarative level, they are willing to engage in action to protect it (Bernaciak et al., 2021; Sun et al., 2022). However, everyday market decisions are often very complex and making pro-environmental choices requires knowledge of the subject (Khan et al., 2021). A detailed analysis of the mechanism of these decisions will make it possible to determine the natural willingness of young adults to engage financially and organisationally in environmental action (Beatson et al., 2020). Altaher (2013) noted that girls are likelier to have higher environmental awareness and willingness to develop it.

Young adults are aware that the costs of environmental degradation will inevitably be borne by younger generations (Lisowski et al., 2022). They are, therefore, willing to get financially involved in environmental projects, mainly if they affect their local community (Wu et al., 2018; Dardanoni, Guerriero, 2021). However, the oversupply of information and the lack of tools to verify it means that they do not have sufficient knowledge to engage in environmental action more widely (Johnstone, Tan, 2015). It was therefore considered essential to analyse the information behaviour of young adults in this area.

3. Methodology of the research process

The presented results are a piece of a broader study on the pro-environmental behaviour of young adults, conducted among students at the Cracow University of Economics and the AGH University of Cracow on a sample of 540 respondents. (Lisowski et al., 2022). The research used an online questionnaire made available to respondents via Google Forms between 15.12.2021 and 30.01.2022. The survey research was preceded by focus interviews with selected groups of students, which were used to develop the actual research questionnaire.

The central survey was preceded by a pilot study, which made it possible to verify the correctness of the prepared questionnaire.

In the process of analysing the results, the analysis of multivariate tables in different cross-sections using Pearson's Chi-square statistic and Cramer's V coefficient was used, which made it possible to extract statistically significant relationships between selected the surveyed variables and to create strategic implications for those who wish to influence the attitudes and pro-environmental behaviour of young adults (the relationships identified are presented in the paper (Lisowski et al., 2022); this material is a continuation of the analysis cited).

In the sample population, almost 55% were women, and the remaining respondents were men. Undergraduate students were the most numerous group (51.30%), engineering students accounted for 43.15% and master's students for 5.55%. They were mainly full-time students (76.11% of respondents). Almost 85% of them were born after 2000. Most respondents were dependent on their parents (70.93%). 29.26% lived in towns with up to 5,000 inhabitants, 52.22% of respondents lived in towns with more than 50,000 inhabitants, and 18.52% lived in other cities. They most often lived in rented accommodation (45.18% of respondents). The paper (Lisowski et al., 2022) includes detailed characteristics of the surveyed population.

4. Research results and discussion

The main aim of the research was to identify and analyse selected information behaviour of young adults in environmental activities. The specific area of research interest was primarily to determine whether respondents use information distributed by pro-environmental organisations and whether this translates into their involvement in activities in the form of participation in environmental demonstrations or financial support for initiatives of this kind. In this context, it was also an interesting research problem to find out how the respondents assess their attitudes towards the environment and what information behaviours they implement to develop themselves in this area. The distribution of respondents' answers is included in Table 1 and Table 2.

The respondents claim (Table 1) that their lifestyle is relatively environmentally friendly. At the same time, juxtaposing information about their relatively low interest in knowledge distributed via the Internet by pro-environmental organisations, it can be presumed that this conviction is not supported by too much activity to broaden environmental knowledge. Only a few per cent of the surveyed respondents declare systematic browsing of such websites and portals. Pro-environmental organisations' actions in social media are more likely to be monitored by women born after 2000.

Table 1.
Distribution of respondents' answers on their information behaviour in the area of environmental activities

Do you think your current lifestyle can be considered environmentally friendly?							
Rather not		Sometimes yes and sometimes no		Rather yes		Definitely yes	
Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications
34	6.30%	238	44.07%	239	44.26%	29	5.37%
Do you monitor the activity of pro-environmental organisations (individuals) on social media?							
No, I never look in		Yes, I observe a few		Yes, I watch and actively comment on their posts		Yes, and I also run a social media channel	
Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications
264	48.89%	266	49.26%	9	1.67%	1	0.18%
Do you monitor the websites of pro-environmental organisations or individuals working on this issue?							
No, I never look at such websites		Sometimes I go to them		Yes, I systematically check several of them			
Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications		
255	47.22%	256	47.41%	29	5.37%		

Source: own research.

Among those convinced that their lifestyle is environmentally friendly (answers "yes" and "rather yes"), 45.15% do not look at the profiles of pro-environmental organisations (persons) on social media at all, 47.76% do not monitor the activity of pro-environmental organisations (persons) in social media at all. One wonders where they get the information that supports them in developing their declared attitudes.

The young adult generation is very active on the Internet (Gao et al., 2022; Ågren et al., 2023; Lopez-Fernandez et al., 2023). However, pro-environmental organisations do not seem to notice this and are not using the full potential of online tools to connect with their audiences. Attracting Internet users to this topic through edutainment activities (including gamification) would help to keep recipients in this thematic area and encourage them to develop their knowledge on the subject (Chermakani et al., 2023). Pro-environmental organisations are mainly NGOs without significant support from governmental bodies. The observed negative climate change makes it increasingly urgent for this topic to be a more common theme in the activities of countries and organisations.

The next stage of the analysis was to collate the respondents' opinions on the friendliness of their style towards the natural environment and their realisation of specific actions that would give credence to these opinions. It turned out (Table 2, Table 3) that the surveyed respondents hardly take part in demonstrations in support of the environment (59.63% do not do so, and it would never occur to them to do so) and do not financially support such initiatives (68.70% of respondents never allocate their money to this). They are only interested in the ecological dimension of the production process of the products they buy, "by the way" (Table 5). Men most often notice this information but do not take it into account, while women find it pleasant when the chosen product "is organic", but it is not necessary for them.

Table 2.
Distribution of respondents' answers to the question, 'Do you participate in marches and demonstrations in support of the natural environment?'

Listing	Do you participate in marches and demonstrations in support of the natural environment?									
	No, it never crossed my mind.		No, but I insert positive comments, e.g. under such information on social media.		I had planned to participate, but I have a lot of other activities and have been unable to make it happen.		I have taken part (a few times at most) and more for the company than out of any real need to manifest my views.		Yes, I often take part in such demonstrations.	
	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications
sum	322	59.63%	107	19.82%	78	14.44%	19	3.52%	14	2.59%
1	**18**	**62.07%**	3	10.34%	5	17.24%	1	3.45	**2**	**6.90%**
2	**142**	**59.41%**	50	20.92%	34	14.23%	6	2.51	**7**	**2.93%**
3	136	57.14%	53	22.27%	35	14.71%	6	2.52	8	3.36%
4	26	76.47%	1	2.94%	4	11.77%	1	2.94	2	5.88%

Due to volume constraints, the first column uses a symbolic notation of information: it lists the categories within the respondents' answers to the question "Do you think your current lifestyle can be considered environmentally friendly?": 1 - definitely yes; 2 - rather yes; 3 - sometimes yes and sometimes no; 4 - rather no. The percentage of indications shows the percentage distribution of values in the rows.

Source: own research.

Table 3.
Distribution of respondents' answers to the question, 'Do you engage financially in pro-environmental activities?'

Listing	Do you engage financially in pro-environmental activities?							
	No, I never donate my money to such causes		I donate sporadically during direct can collections		Yes, from time to time, I financially support actions that I consider important		Yes, I very often (even systematically) contribute to environmental actions and activities	
	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications
sum	371	68.70%	106	19.63%	60	11.11%	3	0.56%
1	**14**	**48.28%**	6	20.69%	9	31.03%	0	0
2	**154**	**64.44%**	50	20.92%	33	13.89%	2	0.84%
3	175	73.53%	46	19.33%	16	6.72%	1	0.42%
4	28	82.35%	4	11.77%	2	5.88%	0	0

Due to volume constraints, the first column uses a symbolic notation of information: it lists the categories within the respondents' answers to the question "Do you think your current lifestyle can be considered environmentally friendly?": 1 - definitely yes; 2 - rather yes; 3 - sometimes yes and sometimes no; 4 - rather no. The percentage of indications shows the percentage distribution of values in the rows.

Source: own research.

The only activity out of those mentioned in which they engage more than average (more than 80% of respondents collect sometimes or more often) is collecting plastic bottle caps (Table 4). Women and residents of medium-sized cities are more willing to collect plastic bottle caps.

Table 4.
Distribution of respondents' answers to the question, 'Do you collect plastic bottle caps?'

Do you collect plastic bottle caps?								
Listing	I haven't heard you can collect them and do something with them afterwards.		I have heard about this action but don't want to collect them.		Yes, sometimes I try to remember not to throw them away but to collect them.		Yes, I collect all used plastic caps.	
	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications
sum	10	1.85%	77	14.26%	**241**	**44.63%**	212	39.26%
1	0	0	7	24.14%	7	24.14%	**15**	**51.72%**
2	2	0.84%	26	10.88%	**108**	**45.19%**	103	43.09%
3	8	3.36%	33	13.87%	110	46.22%	87	36.55%
4	0	0	11	32.35%	16	47.06%	7	20.59%

Due to volume constraints, the first column uses a symbolic notation of information: it lists the categories within the respondents' answers to the question "Do you think your current lifestyle can be considered environmentally friendly?": 1 - definitely yes; 2 - rather yes; 3 - sometimes yes and sometimes no; 4 - rather no. The percentage of indications shows the percentage distribution of values in the rows.

Source: own research.

Table 5.
Distribution of respondents' answers to the question, ' Are you guided in your purchasing decisions by the manufacturers' ecological approach to the production process?'

Are you guided in your purchasing decisions by the manufacturers' ecological approach to the production process?										
Listing	I don't notice such signs, and I never take them into account.		I note the existence of such information and designations, but I do not take them into account.		I see such information, and it is nice when I shop for 'organic' products, but it is unnecessary.		Only for nutritional products because this directly affects my health.		Yes, I am always looking for such information, and the lack of it causes me to abandon the purchase.	
	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications	Number of answers	% of indications
sum	88	16.30%	111	20.55%	**218**	**40.37%**	102	18.89%	21	3.89%
1	4	13.79%	7	24.14%	**8**	**27.59%**	3	10.34%	7	24.14%
2	34	14.23%	41	17.16%	**104**	**43.51%**	54	22.59%	6	2.51%
3	40	16.81%	56	23.53%	92	38.65%	42	17.65%	8	3.36%
4	10	29.41%	7	20.59%	14	41.18%	3	8.82%	0	0

Due to volume constraints, the first column uses a symbolic notation of information: it lists the categories within the respondents' answers to the question "Do you think your current lifestyle can be considered environmentally friendly?": 1 - definitely yes; 2 - rather yes; 3 - sometimes yes and sometimes no; 4 - rather no. The percentage of indications shows the percentage distribution of values in the rows.

Source: own research.

As part of a more precise analysis of the information behaviour of young adults, the attitudes and behaviour of young adults convinced that their current lifestyle could be considered environmentally friendly ("rather yes" and "yes" answers) were analysed. There were 268 people in this group (236 people, or 44.26% of respondents - "rather yes" answers; 29 people, or 5.37% of respondents - "yes" answers). Activities requiring organisational or

financial commitment to the environment (participation in manifestations, contributions to this cause) are not popular among young adults (Table 2, Table 3). They never participate in demonstrations of this kind 59.70% of this group and 62.68% of them never contribute to a cause of this kind. Their "environmental friendliness" is expressed in occasional activities that do not require much commitment. They are only convinced to collect bottle tops (Table 4) because shopping may or may not be 'bio' (Table 5). In this context, this "pro-environmental lifestyle" can be seen more as a good-sounding declaration than an actual commitment in this area. Unfortunately, even less interest is in the mentioned environmental activities among those who do not declare an environmentally friendly lifestyle (Table 2-5).

Obviously, the presented summary is only a selection of information on the attitudes and behaviours of respondents. Still, it crucial signals that environmental concern is uncommon among young adults. It is more of a fashionable declaration than actual activity. Young adults do not seek information on this subject, i.e. they are not quite ready to make conscious decisions in this area and for these decisions to benefit society. It would be further confirmed by the fact that the same study also found that respondents save electricity and water primarily for financial rather than environmental reasons.

5. Conclusions

The most relevant to the future state of the environment are the attitudes and behaviours of young adults who are just entering adulthood and will be making critical decisions about the state of the environment in the future. The subject of the research described in this publication was to determine to what extent young adults consider their life activity to be pro-environmental and how they seek information that will help make pro-environmental decisions. The analysis of the behaviour of young adults made it possible to assume that the Internet is the space where they will look for the information they need to make pro-environmental decisions. Therefore, the analysis covered the behaviour of young adults related to this market area.

The study found that nearly half of the respondents (48.9%) never look at the social media profiles of pro-environmental organisations. On the other hand, when it comes to the websites of these organisations, only 5.9% systematically look at them, and 47.2% never go there. At the same time, the same group believes that their style is environmentally friendly ('definitely yes' - 5.4% and 'rather yes' - 44.3%). However, almost 70 % have never financially contributed to such an initiative. And nearly 60 % of this group have never participated in an environmental demonstration.

In summary, the juxtaposition of the results of the research of selected opinions, attitudes and behaviours in the area of pro-environmental actions indicates the urgent need to monitor the information behaviour of young adults and educational activities among this group to

increase their activity in searching for information that will help make their actions more beneficial to the environment. A higher level of knowledge on the subject among market participants should also contribute to reducing the popularity of greenwashing.

The research described is a pilot study. It covered young adults studying at universities, which naturally limits the generalisation of the conclusions drawn to the entire population of this group of young people. The next step should be to extend the research to groups not yet represented in the described research process.

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LONG-TERM IMPACT OF PANDEMIC RESTRICTIONS ON CONSUMER BEHAVIOR IN POLAND

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Purpose: The purpose of the article is to present the results of research on the long-term impact of SARS-CoV-2 pandemic restrictions on the marketing environment and consumer behavior in Poland. Two surveys conducted during the 1st lockdown and after the official end of the epidemic emergency made it possible to compare and evaluate phenomena that have perpetuated or had a potential longitudinal effect.
Design/methodology/approach: The comparative research used literature studies, analysis of reports and online publications, and an online quantitative survey; conducted in 2 phases, i.e. in 2020 and 2023 on a similar group of respondents, allowed to achieve the research objectives.
Findings: Research confirmed that many of new consumer attitudes and behaviors remained in the post-pandemic period, including increase in online shopping, greater acceptance of electronic payments, VOD subscription surge, new working time arrangements, and more sustainable consumer choices.
Practical implications: The paper provides insights into the attitudes and behaviors of consumers in Poland that have been perpetuated by long-lasting restrictions, which will help enterprises shape marketing strategies, tailored to the characteristics of post-pandemic consumers.
Research limitations: In the 1st stage of research, the snow-ball method of sampling, which has its own limitations, was adopted.
Originality/value: An important novelty of the work is the comparative research which was done with a similar survey questionnaire to assess whether the new shopping habits and behaviors observed during the pandemic remained present after it ended. An additional value is the synthesis of the changes in the marketing environment that most affected consumer behavior.

Keywords: consumer behavior, pandemic, Poland, comparative study.

Category of the paper: research paper.

1. Introduction

The SARS-CoV-2 virus confronted regulatory agencies and governments with the difficult task of reaching a balance between public health and economic protection. Restrictions imposed have resulted in increased economic risks, including customer and revenue loss for many companies. The waves of the pandemic's spread in Poland affected the health care system, the economy, education, and the daily lives of residents (Plebańska et al., 2021). During the first wave, which lasted from March to May 2020, the full lockdown featured border closures, rigorous constraints on social mobility, a decrease in the operation of shopping malls, the shutdown of gyms and fitness clubs, swimming pools, museums, libraries, theatres, and cultural institutions (Serwis RP, 2020).

As a result of the second wave, which occurred between September and November 2020, the economy experienced another downturn, and many companies were forced to reduce their workforce. After the second wave subsided, the action taken by the government was to enter the "Stage of Responsibility" (Golinowska, Zabdyr-Jamroz, 2020). Stores and services in malls were restored, and some cultural institutions were re-opened. Unfortunately, the recovery did not last long, as again a national quarantine was established, which lasted until January 2021 (Polityka Zdrowotna, 2020).

During the third and fourth waves of the pandemic (Spring and Autumn 2021, respectively), a renewed increase in infections and deaths caused by new variants of the virus was registered, again spurring restrictions that affected both businesses and consumers (Ministerstwo Zdrowia, 2021). Throughout the last fifth wave of the pandemic (2022), Poland tried to return to normal, restrictions were lifted and those businesses that survived the hardest moments began to rebuild their operations. The most significant changes affecting citizens include the abolition of the requirement to wear masks in enclosed public spaces, and the discontinuation of isolation and quarantine in March 2022. Online forums also mentioned 6^{th} and 7^{th} waves of Sars-CoV-2, but these were unofficial terms. Ultimately on July 1, 2023, the state of epidemic emergency imposed in Poland due to SARS-CoV-2 viruses was canceled.

Restrictions on the functioning of the economy, such as the closure of certain sectors and limitations in social mobility, resulted in a decline in demand for many services and products. Due to lockdowns, many companies were forced to temporarily close their operations or operate in a limited capacity. In addition, entrepreneurs faced changing customer preferences and behaviors as a result of the pandemic. Remote working and learning, travel restrictions and health concerns have caused consumers to change their purchasing habits (Długosz, 2021).

Many entrepreneurs had to take quick and strategic action to survive the difficult times. These included shifting operations to the virtual space, creating loyalty programs, investing in digital marketing and building relationships with customers online. While the pandemic restrictions were still in place, researchers and practitioners were considering the extent to

which new consumer buying patterns would be established, requiring changes in corporate strategy and the adaptation of business practices to the new conditions.

The own study was conducted during the period of the most restrictive epidemic restrictions, with the main goal of determining how these limitations influenced consumers' purchasing behavior and decisions. To verify whether the observed changes in buying behavior persisted, the survey was conducted again, after the cessation of pandemic restrictions. The research was conducted in 2020 and 2023 on a similar group of respondents using literature studies, analysis of reports and online publications, and online quantitative surveys. It was found that acceptance for online exchanges and electronic and mobile payments has increased, similarly to the share of some consumer goods (such as pets' accessories and food) in online shopping. Respondents indicate that a favorable change is the ability to work remotely and hybrid work, although this mainly applies to those under 40. The survey results show changes in buyer attitudes that were initiated during the pandemic restrictions. The article includes a presentation of original survey research conducted by the author and a synthesis of source materials and academic publications - especially in the area of studying changes in the marketing environment.

2. Research methodology

The study on the impact of pandemic restrictions on consumers in Poland during the SARS-CoV-2 virus pandemic and after its cessation was conducted in 2 stages. To empirically confirm to what extent the changes in Polish consumers' shopping behavior caused by the SARS-CoV-2 virus pandemic have been perpetuated, surveys were conducted during the pandemic lockdown (2020) and after all restrictions were removed (2023).

The 1st part of the study was designed and conducted in the period March-May 2020, when the first lockdown was still in progress. This stage of the research was exploratory in nature, and it tried to describe a new phenomenon: a global pandemic that affected almost all spheres of the marketing environment, the operations of businesses and consumer behavior. The aim of the study was to determine the impact of pandemic restrictions on consumer purchasing behavior and decisions.

The methodology of the study included the measurement of secondary sources of information, including online publications and reports from the Statistics Poland, because at the time, scientific publications on this new phenomenon were not yet available (Bedgood, 2020; Deloitte, 2020; Drozdowski et al., 2020; Gorzelany-Dziadkowiec, 2020; GUS, 2020a; 2020b; McKinsey & Company, 2020; Alfonso et al., 2021).

Primary sources were measured through an online survey based on an originally designed survey questionnaire. 301 respondents participated in the survey.

Part II of the survey was conducted after the cancellation of the pandemic emergency in Poland in June 2023, to determine whether the perceived changes in consumer behavior, such as a change in shopping routines, a slower and more sustainable lifestyle, and an increase in online shopping, have been perpetuated in the long term. A research assumption was that all of the changes in consumer behavior observed in the first part of the study would be sustained.

Pandemic restrictions have affected many spheres of social and economic life. Therefore the analysis covered the economic environment, online exchange and electronic currency, the labor market and working conditions, the socio-cultural environment, including attitudes toward remote work, sustainable consumption, new consumer behaviors, and the environmental impact of the pandemic.

The aim of the study was to determine how consumers' experiences during the Covid-19 pandemic, the threat of an epidemic and the cessation of pandemic restrictions affected their purchasing behavior and decisions. The crucial task was to identify changes in the marketing environment, which provided a framework for studying new consumer behavior. The assessment was conducted on the basis of secondary sources e.g.: available scientific studies, reports and statistical data on the impact of pandemic restrictions on the economic domain, socio-cultural trends, technological and environmental aspects.

In addition to studying secondary sources of information, changes in consumer behavior were verified empirically through an online survey. A modified survey questionnaire from 1st part of the study was used. 209 respondents participated in the study.

The subject of the research was the impact of the marketing environment on consumer decisions, the balance between work and leisure, the organisation of purchases in households, and the patterns of shopping in conventional and online stores.

During the first stage of surveys, due to their pioneering nature and the specific limitations of lockdown time, the snowball method was used in selecting the sample, while during the second part of the survey, the same contact channels were used to reach a similar group of respondents (Table 1).

Table 1.
Sample structure in research 2020 &2023

Sample structure by age					
	up to 19 yrs	**20-26 yrs**	**27-39 yrs**	**40-59 yrs**	**over 60 yrs**
Survey 2020 (n = 301)	2%	43,5%	17,6%	26,2%	10,6%
Survey 2023 (n = 209)	3,8%	60,6%	17,3%	11,5%	6,8%
Sample structure by place of residence					
	rural areas	**town of up to 30,000 inhabitants**	**city of 30,000-100,000 inhabitants**	**suburban areas**	**city of more than 100,000 inhabitants**
Survey 2020 (n = 301)	23,6%	6,0%	14,3%	6,3%	49,8%
Survey 2023 (n = 209)	7,21%	8,65%	22,11%	12,01%	50,0%

Source: Prymon-Ryś, Galarowicz, 2021 & own study.

In the sample, 26.9% of respondents indicated that they had participated in research focused on shopping and consumer decisions during the pandemic, while the majority said they could not recall such research (58.2%).

3. Overview of pandemic-related changes in the marketing environment based on secondary studies

The long-term impact of pandemic restrictions on consumer purchasing behavior was considered in the context of trends in the marketing environment. Among the most important determinants of consumer decisions were changes observed in the economic environment, evolution of employment conditions and work arrangements, the increased role of online exchanges, and new social trends related to sustainable consumption and a strong focus on safety (safety obsession) and health care (Długosz, 2021).

3.1. Economic environment

In response to the pandemic, the Polish government responded by seeking to offset the negative consequences of both the virus infection and the restrictions introduced at the same time. The government legislated act that were called "Anti-Crisis Shields", consisting of a package of solutions to protect the Polish state and citizens from the crisis caused by the coronavirus pandemic (Koman, Syta, 2022).

The cost of all the Anti-Crisis Shields estimated by the Polish government was more than PLN 312 billion, the largest part of which was support in the form of, among other things, non-refundable loans to companies, tax changes in PIT and CIT settlements, exemptions from Social Security contributions, and suspension of tax payments (Serwis RP, 2021). Approx. 30 billion was allocated to subsidize public investment in areas such as infrastructure, modernization of schools and hospitals, energy transition, digitization, biotechnology and pharmaceuticals, and environmental policy. Another 30 billion has been earmarked for worker security, preserving jobs through initiatives such as wage subsidies of up to 40% of average monthly wages, assistance for the self-employed through Social Security benefits, supplementary care allowance, loan deferment and reductions in non-interest costs for consumer loans. For health care, mainly in terms of COVID-19, 7.5 billion was allocated. This amount also included the digitization of the health care system, the construction of day care homes or the expansion of the Patient Telephone Hotline (Polski Fundusz Rozwoju, 2021).

Decisions to increase demand at the expense of new investments have boosted consumer spending. However, many people changed their purchasing preferences, switching to cheaper brands or local products. During the COVID-19 pandemic, many people experienced a drop in income or financial uncertainty, which forced them to change their shopping preferences.

They began to look for cheaper alternatives to their existing products and paid more attention to local brands and products (Korzeniowska et al., 2023).

The Act on Special Arrangements for Preventing, Countering and Combating COVID-19 provided support to Polish entrepreneurs whose turnover was reduced by 15% or 25% (depending on the period used for calculation) during the pandemic (Żelazowska, 2020).

Thanks to the law, entrepreneurs were able to reduce wages paid by up to 50% during the shutdown and receive subsidies for reduced wages equal to 50% of the national minimum wage. They were also authorized to reduce the time of those employed to 20% and receive wage subsidies of up to 40% of the average, national wage.

It may be stated that through such interventions an overwhelming number of entrepreneurs, despite the threat of closure of their businesses, have demonstrated the ability to resilience, adapt, take advantage of state aid or make plans that reach beyond the crisis period.

According to economists' predictions, the effects of the pandemic will be experiences up to 5 years. Steadily rising prices are the result of the disruption caused by the pandemic and will be felt in the long term. The main reason for the negative market sentiment related to the economic collapse during the pandemic has become rising inflation, which at the same time worries people the most of all factors that threaten the development of the economy (Hamulczuk, Idzik, 2022).

3.2. Electronic payments

Long-term effects of pandemic-related changes are (Kubiczek, 2022):

- growth of e-commerce and technologies supporting remote communication and online exchange,
- high degree of acceptance of these IT solutions,
- change in consumer payment habits.

One of the more significant changes brought about by the pandemic has been the circulation of money by consumers. The payment market has changed dramatically over the past decade or so due to the increasing use of credit and debit cards at many points of sale, making it possible to make payments via payment terminals. In the year affected by the pandemic, the number of purchases paid for with cash declined by more than 30% (Kaźmierczak et al., 2021).

Not only has the number of electronic transactions among different age groups increased, but also the use of the newest of the common types of payment - BLIK. After the pandemic explosion, the share of this form of cashless payment increased from 24% to 39%. It has become the most popular method of paying for purchases and services among the youngest age group (18-34) - who, on average, spend smaller amounts, which is typical of BLIK payments. The older-than-mentioned age group, having given up cash during the pandemic, were more likely to switch to payment cards or start using fast payment operators such as PayU or BlueMedia.

The main reasons for the increase in cashless transactions are the increasing presence of payment terminals in Poland, the possibility to pay with BLIK - also using smartphones/ smartwatches, the increase in widespread trust in these forms of payment, low commissions for merchants for processing such transactions (Kubiczek, 2022).

The high degree of acceptance of online exchange and electronic payments, also among people who previously used the Internet to a limited extent, has influenced the consolidation of these shopping habits. The surge in online shopping during the pandemic is one of the most persistent phenomena that has persisted after the cessation of pandemic restrictions (Amsari, Sari, 2022), as also confirmed by the results of the surveys conducted (see section 4).

3.3. Labour market

The coronavirus pandemic proved to be an exogenous shock to the economy and to the labor market. The external factor has disrupted labor markets and has long-term consequences for the economic performance of companies (Radlińska, 2020).

In Poland, the number of new jobs has steadily increased since 2015, at the same time the number of jobs lost has remained at a similar level. 2020 turned out to be the first year in the period under review, the number of newly created jobs fell below 500,000. The moment of the market collapse was the first wave of the pandemic - the period from March to May 2020 (GUS, 2020a). The relatively rapid introduction of restrictions by the government, which most companies did not anticipate and for which they did not prepare safeguards, led to internal crises. So, many companies have decided to cut staff and stop recruiting new employees. In order to limit staff cuts, quite a few companies decided to remodel their organizational structures and make internal redeployments of employees (Witkowska-Pertkiewicz, 2020). As a result, changes in the labor market manifested themselves in, among other things, a reduction in employment, an increase in part-time employment and, to a some extent, an increase in unemployment.

Several support programs were introduced by the government including the Anti-Crisis Shield, as a response to the main problems arising from the pandemic (Polski Fundusz Rozwoju, 2021). However, the restrictions introduced, albeit for the safety and health of citizens, led to the collapse of many businesses.

The Anti-Crisis Shield was a set of assistance programs aimed at workers and entrepreneurs. It was based on five pillars (Departament Rynku Pracy, 2020):

- job protection and worker security,
- financing for entrepreneurs,
- health care,
- strengthening the financial system,
- public investment.

Compensation in the form of support programs has certainly been essential and has been a kind of "last lifeline" for many companies. The possibility of taking advantage of subsidies, tax breaks, refinancing and a number of other measures made it possible to avoid the closure of many companies, and thus saved jobs, so vital in the context of the unemployment phenomenon.

Despite the substantial assistance, however, the labor market has not returned to its full pre-pandemic condition, and assessing the long-term impact of the pandemic restrictions is hampered by the outbreak of war in Ukraine and related ongoing changes in the labor force structure.

3.4. Work-time arrangements and job attitudes

In the early days of the pandemic, in many companies the ability to continue working could only be done remotely. Employees performed their duties from a home office. This solution has many advantages like optimization of rental costs for the employer or a flexible work mode for the employee. Taking advantage of this mode, employers often placed greater emphasis on monitoring working hours and properly securing company data.

At the same time, some companies have decided to strengthen the competencies of hired employees by organizing training courses conducted by internal and external trainers and e-learning platforms. A great number of developmental forms were created that employees could take advantage of (Dolot, 2020):

- online training,
- remote coaching,
- e-conferences
- e-learning,
- webinars,
- experience-sharing forums.

It can be concluded that the pandemic generally did not have a negative long-term impact on the course, quality and outcomes of the HR processes in enterprises. This is supported by the results of partial studies and practitioner insights.

The pandemic did not contribute to the reduction of the number of applications offered, companies hiring during the pandemic coped with the new reality by taking care of relationships with candidates, providing them with the help they needed at every stage of the recruitment process, to the extent that they were positively assessed by candidates through the prism of an organized process.

According to forecasts for the next few years, remote work will become a permanent part of the operation of enterprises, most likely in a hybrid mode that will allow for both flexible work modes and the ability to control the progress of work among employees (Muster, 2022).

3.5. Safety and sustainability

One of the main drivers of public life during the pandemic was safety and reducing the risk of infection. Governments and regulators introduced several measures to protect public health and prevent the spread of the SARS-CoV-2 virus. Companies were obliged to make changes to their operations and procedures to comply with new requirements for stricter hygiene rules and the provision of disinfectants.

The impact of the COVID-19 pandemic on human health and safety has made health awareness a key factor in the choice of products and services. Consumers have begun to review ingredients and manufacturing processes more carefully in an effort to avoid substances harmful to health. There has been a growing interest in products with disinfectant properties that can help reduce the risk of infection (Hamer, Baran, 2021).

In addition, customers paid more attention to hygiene in public places and preferred establishments that took extra precautions. Restaurants and cafes, for example, were rated by customers for adherence to sanitary guidelines, such as disinfecting surfaces, maintaining social distance and having access to hand sanitizers (Polityka Zdrowotna, 2020). As a result, companies have had to adjust their procedures and marketing strategies to reflect these changing customer preferences and ensure that customers feel safe.

The pandemic caused by the SARS-CoV-2 virus also had a significant impact on consumer awareness (Długosz, 2021). Many people have noticed how drastic changes in traffic and production have affected the environment. As a result, there has been an increased interest in local products that generate a smaller carbon footprint and support local communities. Consumers were looking for farmers, artisans and producers in their immediate vicinity to reduce CO2 emissions associated with transportation and support the local economy. There has also been a growing interest in organic products that are sustainably produced and minimize environmental impact (Maciejewski, 2023).

The pandemic has caused consumers, for example, to gradually reduce their spending on clothing, guided by the reflection that they own too many clothes or by reducing purchases altogether due to their deteriorating financial situation (Pang et al. 2022).

3.6. Pandemic restrictions vs. environmental pollution

The assessment and analysis carried out on the impact of the pandemic on reducing emissions of climate change-inducing pollutants allowed us to confirm that the pandemic did not significantly affect emissions of the pollutants in question into the atmosphere (Stryjek, 2021).

Analyzing the juxtaposition of concentrations of, among others, PM2.5 and PM10 particulate matter, nitrogen dioxide, benzo(a)pyrene and carbon dioxide in 2016-2020 in Poland, the highest decreases occurred at the beginning of the epidemic and the time when the restrictions associated with it were most restrictive. However, these trends were not long-lasting

and returned to pre-restriction values after a short period. This is mainly because the majority of emissions come from the municipal and residential sectors. Thus, it can be assumed that the restriction of automobile traffic in the long term would not significantly affect the reduction of emissions of hazardous substances into the atmosphere, since the largest emitter is and will be the agricultural sector and the energy sector (the total impact of the volume of emissions of about 25-30% each). Transportation (road air, sea and rail) accounts for about 10% share of total greenhouse gas emissions and is likely to remain unchanged (IOŚ, 2021).

It may be stated that pandemic restrictions have had a bilateral impact on the natural environment. On one hand, the lockdowns and travel restrictions reduced human activities, leading to temporary improvements in air and water quality in some areas. However, there were negative effects as well. The increased use of disposable personal protective equipment (PPE) led to more waste, including plastic pollution. The pandemic also disrupted waste management systems in some places, causing improper disposal of medical waste. Additionally, conservation efforts and eco-tourism suffered due to travel restrictions, affecting funding for wildlife protection and local communities.

4. Results of the comparative study of pandemic influence on consumer decisions

During the lockdown, consumers were forced to change their daily habits and routine activities. This was related to taking on additional duties (19.9% of responses) or more responsibilities at work. (16.9%).

Some of the respondents (15.6%) said they had more free time, which they used for their own interests, study and personal work or helping other people (Galarowicz, Prymon-Ryś).

During the second part of the survey, respondents were asked to compare their current commitments (2023) with the pandemic period. The vast majority declared that they were devoting more time to work (37,5%) and additional family duties (36%). The percentage of people who now declare they have more leisure time decreased to 10,1% (Table 2).

Table 2.
Impact of Covid-19 restrictions on post-pandemic time organization (2023)

Time organization characteristics	Respondents' responses				
	strongly agree	**agree**	**neither agree nor disagree**	**disagree**	**strongly disagree**
Professional work takes up more of my time	37,5%	25,0%	17,3%	12,0%	8,2%
I have additional duties, e.g., with children, caring for seniors, etc.	36,1%	23,1%	22,1%	11,1%	7,7%
I devote more time to helping others	26,9%	17,8%	22,1%	20,2%	12,9%
I have more free time	10,1%	19,2%	30,3%	26,4%	13,9%
I spend more time cultivating personal hobbies	10,1%	14,9%	27,9%	26,4%	20,6%
I devote more time to self-study	8,2%	12,0%	10,1%	36,1%	33,6%

When asked about the impact of the COVID-19-induced pandemic on their shopping habits, the majority of respondents (64,1% in total) declared that their previous shopping habits had changed, 21,1% declared that they had not changed their shopping habits and 14,8% could not determine whether a change had taken place. The majority of respondents after the pandemic is over do not plan to return to the shopping habits they manifested before the outbreak (60,26% in total). A large group could not determine whether they would stay with current trends or return to shopping mainly in offline sales channels (33,9%), while the fewest respondents said that after the pandemic ended, they plan to return to the habits they manifested before the outbreak situation (5,4%).

Among the changes caused by the lockdown that were observed during Part I of the survey, the most significant was that consumers repeatedly made purchases online (67,8%). They made more purchases in terms of the amount of goods purchased (58,5%) and value of purchases (47,8%) but, in general, they spent less money (43,5%). The respondents preferred electronic payments (47,5%) and reduced time spent in the store (43,5%) (Galarowicz, Prymon-Ryś).

Some of the cited changes observed during the first wave of the pandemic have solidified, as confirmed by the results of our own research. First and foremost, consumers say they are more likely to shop online (a total of 87,5% of strongly positive and positive indications) and more likely to make electronic payments (Table 3). Customers say they spend more money when shopping and buy more products during one-time purchases - it's hard to say conclusively whether this is the result of pandemic habits or a general change in customer income.

Table 3.
Impact of Covid-19 restrictions on post-pandemic time organization (2023)

Buying behavior characteristics	Respondents' responses				
	strongly agree	**agree**	**neither agree nor disagree**	**disagree**	**strongly disagree**
I shop online more often	66,3%	21,2%	10,4%	2,1%	0,0%
I make payments by card, BLIK or electronically more often	50,6%	31,3%	9,6%	5,3%	2,4%
I spend more time shopping in the store	46,0%	27,0%	14,3%	10,4%	2,1%
I buy more items of products at once	27,0%	23,0%	23,5%	17,0%	7,7%
I generally spend less money	26,2%	29,1%	37,0%	5,3%	0,9%
I spend more money during one-time purchases	26,2%	22,2%	35,6%	6,7%	4,8%
I go shopping alone more often, without company	5,0%	11,0%	43,2%	21,2%	18,3%

However, the structure of the most frequently ordered products online has changed. Since the outbreak of the pandemic, customers were most likely to buy clothing and footwear this way (58% and 49% of respondents, respectively) due to the wide range of products offered by online stores, as well as easy and efficient return options.

Compared to the 2020 survey, among purchases made online there was an increase in games and multimedia (up from 24,7% to 58,0%) and pet products and accessories (up from 20,2% to 30%). Among the other groups of products surveyed, respondents' indications did not change significantly, with the exception of food items, where online purchases of these products fell from 14,4% to 5,8%, and medicines and personal care products, where a decrease from 14,8% to 4,8% was observed.

Another change caused by the pandemic has become the determinants of choice. Previously, customers pointed to the price of the product, the convenience of the transaction and the store's credibility as key factors (Amsari, Sari, 2022). In 2023, credibility has overtaken convenience in the classification due to the fear that an online store might not fulfill the contract and simply not ship a given order after it has been paid for. While large e-commerce platforms have systems in place to protect the buyer, smaller online stores set their own rules and regulations and are often not audited, with the added likelihood of defaulting on a consumer contract. A new feature considered by the customer has become the type of delivery and its cost.

During the lockdown, several commercial offers were introduced to provide an incentive for consumers to stay home (Olszanecka-Marmola, 2021). Obviously, many of these "real-time-pandemic-related" offers are no longer available. However, consumers accustomed to free delivery and free returns on online purchases strongly prefer them. The increase in the availability of offers from streaming channels and VOD platforms can also be counted among the long-term effects of pandemic. There is a noticeable increase in subscriptions to these platforms of almost 35% compared to the 2020 survey.

5. Discussion

During and after the cessation of the pandemic there were many studies and scientific publications on the phenomenon, including those concerning the Polish market. However, a significant novelty of the work is the comparative research which was done with a similar survey questionnaire to assess whether the new shopping habits and behaviors observed during the pandemic remained present after it ended. An additional value is the synthesis of the changes in the marketing environment that most affected consumer behavior.

The research substantially confirms the findings of other researchers, particularly regarding the increase in online shopping, greater acceptance of electronic payments, VOD subscription surge, new working time arrangements, and more sustainable consumer choices (Gorzelany-Dziadkowiec, 2020; Alfonso et al., 2021; Hamulczuk, Idzik, 2022; Pang et al., 2022; Maciejewski, 2023).

Furthermore, the survey outcomes provide insights into the attitudes and behaviors of consumers in Poland that have been perpetuated by long-lasting restrictions, which will help enterprises shape marketing strategies, tailored to the characteristics of post-pandemic consumers (Hamer, Baran, 2021).

Moreover, thanks to the research, it was possible to identify the positive changes that the pandemic caused in social and economic life in Poland. While it is common in the public space to mention the pandemic as a traumatic experience for citizens (Długosz, 2021), it has also brought innovations to support customer service and positive effects on the economy.

Considering the research, the positives include omnichannel distribution: now most companies that previously operated only in stationary stores have online sales channels. Stores are trying to make shopping as easy as possible for customers (e.g., return policy and free delivery, chat-bots and virtual consultants, VR visualizations of products or clothing sizing calculators - i.e., the customer gives his or her measurements and the system gives the right size). All these solutions allow building a relationship with the customer, and also increase the chance that a given customer will return in the future. An additional convenience for e-consumers is a wider range of products compared to a traditional store, this is since there is no need to have the product at the point of sale, and the offered products can be stored in an external warehouse. Many companies order a product from a distributor only when a customer order is received.

So-called last-mile logistics services (e.g., courier services, parcel machines, etc.) are developing rapidly.

Other positive effects after the cessation of pandemic restrictions in the perception of consumers are:

- possibility to work remotely, greater work flexibility,
- dissemination and improvement of teamwork tools (e.g. MS Teams, Zoom, Click meeting, etc.),
- availability of online services e.g. “medical tele-consulting”,
- greater acceptance of electronic payments, BLIK,
- hybrid work - new solutions in this area in the Labor Code,
- studying or lecturing remotely - ease of reconciling work with studies,
- more opportunities for online shopping, new forms of stores,
- e-commerce improvements and development of e-commerce tools that can increase sales efficiency.

During the COVID-19 pandemic, there was increased interest in shopping via mobile apps (Amsari, Sari, 2022). As a result, there has been increased interest and demand for apps that allow remote shopping, ordering take-out food, virtual business meetings, or online learning.

Research assumptions were not confirmed for all changes observed in consumer behavior. Some of the declared behaviors appeared to be specific only to the lockdown period, such as more leisure time, or certain purchasing routines. Some consumers do not continue online purchases of food, medicines, and hygiene products. In the case of the macro-environment, some changes, e.g. the rise in unemployment, proved to be short-term, although it is important to note the significant impact of other variables here e.g. the war in Ukraine, migration, remote work possibilities (Radlińska, 2020; Muster, 2022; Pozniak, 2023).

6. Conclusions

An important contribution of the work was the comparative research carried out during the pandemic lockdown and after all pandemic restrictions were removed. This made it possible to assess whether the new shopping habits and behaviors observed during the pandemic continued after the pandemic had ended. Synthesizing the changes in the marketing environment that most influenced consumer behavior was an added value. Considering the impact of restrictions related to the SARS-COV-19 virus, during and outside of the epidemic emergency in Poland - on the marketing environment and, consequently, on consumer purchasing behavior allowed to identify several lasting changes.

Among the most important factors is the growth of electronic payments and online trading. Research confirms increased online shopping and greater acceptance of electronic and mobile payments than before the pandemic.

In Poland, these are currently not only popular and easily accessible, but also widely accepted by customers. With regard to online shopping, customers expect free delivery, shipping and convenient return policies, as well as other e-commerce support solutions.

In scope of the survey, the categories of goods purchased online have changed: including a significant increase in online purchases from the categories of “clothing and footwear”, “games and multimedia” and “pet supplies”, while online purchases from the “food products” and “medicines and personal care products” categories have decreased compared to the lockdown survey. This may be related not only to post-pandemic social trends, but also to other socio-cultural changes that the pandemic restrictions have only exacerbated and accentuated.

Another change was the continued subscription to VoD services and streaming platforms. This, combined with new forms of remote or hybrid work, is influencing consumers' greater propensity to “#stay at home” (Olszanecka-Marmola, 2021).

Other observed changes in consumer behavior that have persisted beyond the pandemic period include working time arrangements, with respondents reporting more time spent at work and consequently less time for hobbies.

A desire for security - in the realm of both health and household finances - was observed in consumer behavior. A positive change is the greater inclination of consumers to recognize the environmental impact of their purchasing decisions and to consume more sustainably. Today's consumers are more aware, considerate and demanding of suppliers. This, too, can be counted among the positive changes brought about by the pandemic.

Both secondary sources and the results of our own research confirm that many of new consumer attitudes, behaviors, and buying habits remained in the post-pandemic period.

Whatever the root causes of the Covid-19 pandemic, it can be assumed that, in the realm of consumer behavior, they have contributed to a society that is more open to technological innovation (Amankwah-Amoah et al., 2021), better adapted to changes in e-commerce and, at the same time, more aware of its buying power. Consumers now have more tools to make prudent choices and meet their needs effectively, which in Poland could be a strong impetus to overcome the crisis caused by the pandemic and other political and economic changes.

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RESPONSIBLE LEADERSHIP: BIBLIOMETRIC ANALYSIS USING SCOPUS DATABASE

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Purpose: This study aims to explore the concept of Responsible Leadership (RL) and identify patterns and dimensions within the field of RL, allowing for a better understanding of how the concept has evolved over time. Another purpose of this study is to contribute to the scholarly discourse on RL by providing quantitative insights into the development of the concept.
Design/methodology/approach: We use bibliometric analysis to identify trends, influential authors, prominent keywords, significant journals, and nations contributing to RL research. Our study examines 185 articles that were published in the Scopus database between 2019-2023 to investigate the responsible leadership concept. The methodology was developed using VOSviewer software.
Findings: The results show that responsible leadership is becoming more and more important in academic research. The evaluation shows how responsible leadership research is distributed among various countries, highlighting those that have contributed substantially to the concept. The results list the authors who have made substantial contributions, demonstrating major participants. The investigation also reveals patterns of cooperation between academic researchers, illustrating linkages that support research on responsible leadership. Our study also presents a bibliometric analysis of co-authorship, co-citations and preferred journals that have published articles in this particular field.
Originality/value: The originality and value of this study can be identified through several key aspects of the research. The methodology offers a systematic and quantitative way to analyze the vast body of literature on RL, providing a unique perspective on the evolution and impact of the concept. The identification of key researchers in RL concept not only acknowledges their contributions but also guides other scholars in the field by highlighting whose work has had significant influence. The global perspective of research broadens the understanding of RL's impact beyond a specific geographic area and highlights the international nature of responsible leadership.

Keywords: responsible leadership, bibliometric analysis, Scopus, index, Vosviewer, global perspective.

Category of the paper: Literature review.

1. Introduction

The idea of Responsible leadership (RL) is widespread in today's organizations. It refers to the way in which a company's leaders conduct themselves and make decisions. It involves considering the long-term impact of their actions, being accountable and prioritizing the interests of all stakeholders. It is a multi-dimensional concept that includes ethical, sustainable and socially responsible behaviors (Waldman S. S., 2020). Responsible leaders are those who consider the impact of their actions in ways that are consistent with their values and the organization's mission. It has become important in recent years as businesses have faced growing pressure to consider their impact on society and environment. Due to a growing awareness of firms' social impacts in recent times, it has drawn more and more interest. RL involves "the integration of ethical, social, and environmental considerations into the decision-making processes of organizations" (Waldman S. , 2008). This requires leaders to take a more holistic approach to their responsibilities and to consider long-term impact of their actions. One of the key elements of responsible leadership is transparency and accountability. It involves willingness to disclose information about their organization's activities and to accept responsibility for any negative consequences that may result from those activities (Zueva-Owens, 2020). This requires leaders to be open and honest with their stakeholders and to prioritize the interests of the wider community over short-term financial gains. Another important aspect of RL is a commitment to sustainability. Addressing current requirements without sacrificing potential of subsequent generations to satisfy their own desires is a key component of sustainable business strategies (Székely, 2005). This requires leaders to consider long-term impact of their decisions and to take proactive steps to reduce their environmental footprint. In modern age, where both shareholders and customers alike are calling for an ethical and environmentally friendly method of doing company operations, it is also an important idea for firms to take into account. By prioritizing transparency, accountability and sustainability, RL can help to create a more equitable and sustainable future for all stakeholders.

However, given how many articles have been issued, assessing and evaluating scientific publications in RL is challenging. Researchers feel that it is now appropriate to conduct a systematic review of publications published by bibliometric analysis because it may help leadership body with expertise become more organized (Vijayakumar, 2018; Marques, 2019) . Even though Science Citation Index (SCIE), Social Sciences Citation Index (SSCI) and Web of Science (WoS) may have a strong correlation with indexed journals (Khudzari, 2018). This study seeks to encompass and broaden queries that may not be available on SCIE, SSCI and WoS as explored by using Scopus database searches up until recent years of 2023.Scopus is acknowledged as the largest abstract and citation database of rigorously reviewed literatures. It may offer insights that another database did not address. Therefore, this research examines scientific output of RL as represented in Scopus index (2019-2023).

The goal of study is directly tied to its motivation. By doing this, we will be able to determine its research patterns and dimensions in this field, which may serve to broaden audience for subject matter and help scholarly society to better understand how RL theme has developed. The concept of RL was first defined in a journal as "a relational and ethical phenomenon, which occurs in social processes of interaction with those who affect or are affected by leadership and have a stake in purpose and vision of leadership relationship" (Pless, 2006). This definition only included societal dimension of RL. The research over the years has broadened the theme of RL and included other stakeholders such as environmental dimension. The research looks at bibliometric assessment and its significance in comparison to earlier studies' approaches. The main aim is to identify keywords, journal names, groups, authors, and nations with largest scientific production in order to comprehend RL trends in scientific literature. Several crucial components identify uniqueness and significance of this study. The methodology gives a methodical and quantitative means to examine substantial database of RL literature, offering a distinctive viewpoint on the concept's development and influence. By identifying those whose work had a substantial impact, designation of prominent academics in RL concept acknowledges their achievements and also provides guidance for other scholars in field. Research from a global perspective emphasizes universal nature of responsible leadership and widens awareness of RL's impact beyond a particular geographic location. Key terms, authors, research activities and countries are only few of signs this study cites as supporting shared occurrence. We have also shown precise bibliometric analysis of keyword's distribution.

2. Theoretical Overview

RL refers to ethical and sustainable practices of leaders in various organizations including businesses, non-profits and governments. It emphasizes importance of accountability, transparency and social responsibility in decision-making processes. There has been a significant amount of academic research on RL in recent years. The purpose of this literature review is to examine and explore concept of responsible leadership and its implications for organizations. Some recent academic papers have discussed importance of RL (Ur Rehman, 2023; Zhao, 2023). A study by Elkhwesky (2022) provides a comprehensive review of RL literature, highlighting key themes and challenges in field. There is also a study which proposes a multi-level conceptual model of RL and CSR, highlighting role of leaders in promoting sustainable practices within their organizations (Zhong, 2022).RL is critical for creating a sustainable future and proposes a framework that emphasizes importance of ethical values, stakeholder engagement and long-term thinking. Recent papers provide a systematic review of RL literature for social innovation, highlighting importance of social entrepreneurship and sustainable practices in creating positive social impact (Păunescu, 2022; Uysal, 2022).

These studies provide valuable insights on importance of RL and its role in promoting sustainable practices and social responsibility within organizations.

Consumers and investors increasingly demand a more ethical and sustainable approach to business which makes RL an important factor for businesses to consider in today's world. By prioritizing their obligations on ecological and social matters, leaders can help to create a more equitable and sustainable future for all stakeholders while also driving long-term business success. Recent studies have highlighted importance of responsible leadership for organizational performance and long-term sustainability (Castro-González, 2022). It is positively related to employee well-being and job satisfaction which in turn leads to higher levels of organizational performance. Corporations must change to meet ever-changing requirements of stakeholders. They should address challenges posed by sustainability and social responsibility (Moqbel, 2023). Several factors have been found to affect RL. For example, organizational culture and climate play a significant role in promoting RL behaviors (Akhtar, 2023). Similarly, leadership development programs can enhance RL skills and behaviors (Mau, 2022).

The current corporate environment is marked by extreme complexity and change dynamics. Businesses are attempting to deploy an increasing number of novel ideas and techniques in order to acquire a sustainable competitive advantage. One of the concepts deployed by companies for gaining competitive advantage is idea of responsible leadership (RL). Its characteristics demonstrated by managers affects CSR which in turn leads to a balance between different dimensions of business activity. A study by Hąbek and Wolniak (2016) highlights importance of quality of CSR reports and its relationship with managerial practices. The quality of CSR reports prepared by managers affect Triple Bottom Line of corporations. Therefore, responsible leadership at manager's end is necessary for maintaining overall sustainability of any business. Leaders are also responsible for ensuring that international private regulations are accommodated in framework of an organization. Self-regulation in field of CSR plays a key role in ensuring effectiveness of international private regulations, however, different factors (legal, economic, social and behavioral) affect CSR so a multi-dimensional approach is necessary to ensure its effectiveness (Alavi et al., 2016). It is also one of behavioral factors that affect effectiveness of CSR initiatives in framework of a business. Hence, responsible leadership at manger's end is also necessary to ensure effectiveness of international private regulations in the field of CSR.

Despite benefits of responsible leadership, there are also challenges associated with its implementation. Leaders face a trade-off between responsible leadership and short-term financial performance which can lead to conflicts between stakeholders. It can be hindered by power dynamics and organizational politics. Hence it is a multi-dimensional concept that is increasingly recognized as important for organizational performance and sustainability. Various academic papers have highlighted its importance, factors that affect it and challenges associated with its implementation. To promote RL, organizations should foster a culture of

ethics and sustainability, provide leadership development programs and address trade-offs between RL and short-term financial performance.

3. Methodology

Statistic evaluation has been performed on the data taken from the Scopus database for current study. The data was extracted using Scopus databases. The fact that this database is acknowledged as largest abstract and citation database of reviewed literature may help to justify the choice. The co-authorship analysis, co-occurrence analysis, bibliographic coupling of journals, bibliographic coupling of countries, bibliographic coupling of authors, bibliographic coupling of publications has been discovered for network analysis using VOS viewer. It is one of the most well-known software tools for bibliometric data visualization (van Eck, 2010; Waltman, 2010; Van Eck, 2011).

Bibliometric assessment has been used for data interpretation and analysis (Md Khudzari, 2018). The outputs of the academic literature database are used in bibliometric evaluation, an analytical method to identify global research trends in a certain area. Utilization of data forms serves as a foundation for achieving precise conclusions based on well-chosen methods in bibliometric analysis. This study methodology has identified various indications that were utilized to connect various components in a bibliometric study using a map.

For this analysis, 185 publications regarding RL published between 2019 and 2023 were selected. The studies on RL are discussed. What are different journals and how research into RL has grown over time? This study also lists well-known authors who have made contributions to this topic and details numerous associations that have been made. The search mainly focused on articles with the term "responsible leadership*" in the abstract and title, using the query string TITLE-ABS (responsible leadership*). Since there hasn't been much research on RL, it's critical to provide a clear framework and guidelines for RL. There has been a lot of discussion about it but very little systematic research has been done, therefore more thorough and systematic studies are required (Leung, 2017). To do this, a scientific assessment of a relevant body of knowledge on RL has been conducted. Numerous searches have been conducted to produce a thorough output. "Responsible leadership" TITLE-ABS-KEY AND (LIMIT-TO (SUBJAREA, "BUSI") OR (SUBJAREA, "SOCI") OR (SUBJAREA, "ECON") OR (SUBJAREA, "PSYC")) AND (LIMIT-TO (PUBYEAR, 2019) OR (PUBYEAR, 2020) OR (PUBYEAR, 2021) OR (PUBYEAR, 2022) OR (PUBYEAR, 2023). Additionally, (LIMIT-TO (LANGUAGE, "English")). Notably, only papers that comply with and meet rigorous specifications of the journal standards are picked in order to assure quality of searches and articles chosen for analysis.

4. Findings

4.1. Documents Published per Year

According to data available on a year-by-year basis, 185 scientific papers were published between 2019 and 2023. There were 24 publications that were related to year 2019. There are indications of an increase in the number of publications on RL starting in 2020. However, there was a decline in publications in 2021. There was an increase in publications after 2021. Following that, number of articles published grew in 2022 as shown in (Table 1). The record for the most articles written is set in 2022 with number of 70 publications. The most recent year with 18 or fewer publications is 2023. Figure 1 illustrates yearly publication and increase in publications year over year. Consequently, it is anticipated that annual publishing would grow even more as 18 publications have already been published in just first half of year 2023.

Table 1.
Annual publications on responsible leadership

Year	Publications
2023	18
2022	70
2021	31
2020	42
2019	24

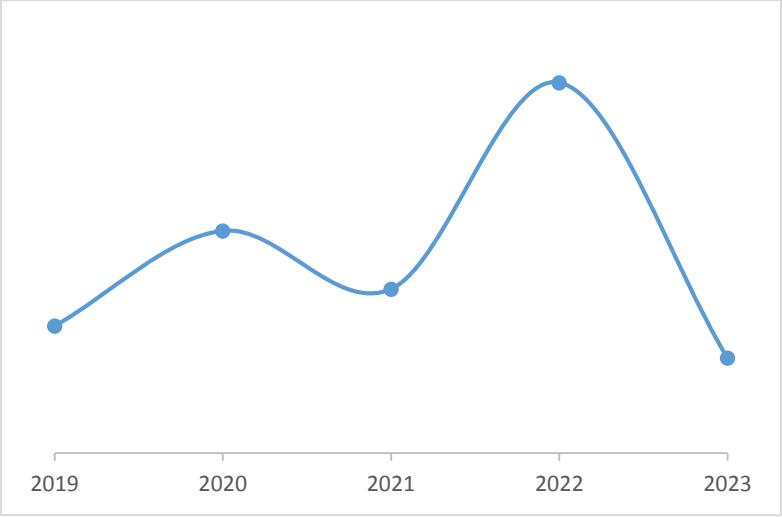

Figure 1. Annual publishing of articles on RL.

4.2. Papers published by Subject Area

Business management and accounting made up majority of subject areas in current study, accounting for 137 articles, followed by economics and econometrics with 66, social sciences with 62, environmental science with 25 articles and psychology with 18. All other subject areas are also listed in Table 2 with a total of 185 articles published.

Table 2.
Papers published by subject area

Subject Area	No of Documents
Business, Management and Accounting	137
Economics, Econometrics and Finance	66
Social Sciences	62
Environmental Science	25
Psychology	18
Arts and Humanities	13
Energy	11
Medicine	9
Engineering	7
Computer Science	7
Decision Sciences	4
Nursing	2
Mathematics	2
Multidisciplinary	1
Materials Science	1
Health Professions	1

4.3. Documents by Source

As per the documents by year source there were 11 documents in Sustainability Switzerland, 10 documents in Frontiers in Psychology, 9 documents in Journal of Business Ethics and so on. Top sources are listed (Table 3).

Table 3.
Documents by source

Source title	No of Documents
Sustainability Switzerland	11
Frontiers In Psychology	10
Journal Of Business Ethics	9
Corporate Social Responsibility And Environmental Management	7
Leadership And Organization Development Journal	5

The Most Cited Sources

It is demonstrated that RL should be among investigator's assets and comprehensive analyses of their material aid in developing their research perspective (Figure 2). The sources with most significant highest number of citations are journal of business ethics with 198 citations and Sustainability Switzerland with 193 citations. Table 4 includes number of documents and sources which helps to comprehend most often mentioned sources. The researcher in field of RL must carefully analyze these sources especially in terms of learning intensity or recurrent reliance on the study as they are concentrated in orange desert areas and have big circles in network (Figure 3).

Table 4.
Most cited sources

Sources	No. of documents	Citations
journal of business ethics	9	198
sustainability Switzerland	10	193
Leadership and organization development	5	109
Journal of Business Research	2	88

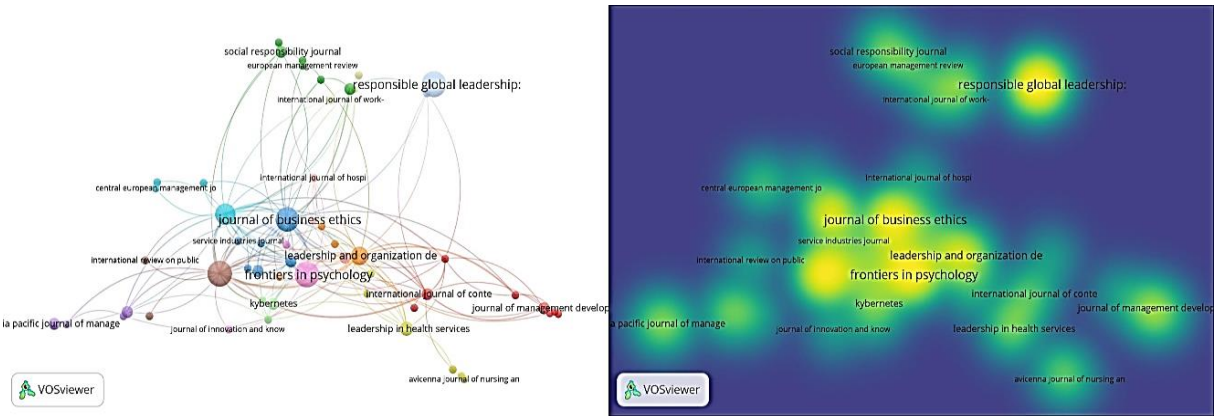

Figure 2. Network and density of most cited sources.

4.4. Documents by Country

Table 5 shows scientific papers published by countries. China has published more documents on RL counted to 36. UK has 26 number of papers whereas Australia has published 19 papers. Pakistan is also listed in countries who has published documents in RL accounted to 18. Least number of papers are published by Poland, South Korea and Vietnam.

Table 5.
Documents by country

Country	No. of Documents
China	36
United Kingdom	26
Australia	19
Pakistan	18
Austria	10
Canada	10
Malaysia	8
Portugal	8
Poland	1
South Korea	1
Viet Nam	1

The Most Cited Countries

In this pursuit for comprehension, researcher should consult results of most referenced countries, investigations and citations which are presented and analysed (Figure 3). The world's most prosperous nations are shown which is causing a rise in RL work (Table 6). About half of global publications came from China and Pakistan, indicating that these two nations are crucial to the development of RL. China is most active country in terms of research with 481 citations

and Pakistan is placed second with 338 citations. Australia received 245 while UK has 172 citations. Figure 3 has a list of all other nations. Researchers working in field of RL should refer to countries that show up as huge circles in pattern of orange and yellow gaps in density illustrated (Figure 3). They can use research to further their work and can use successful results as models for future research. They can offer these countries as models for their own nations. These nations are categorized in terms of RL. They are ranked which supports validity of these findings and efficiency of the VOSviewer program.

Table 6.
The most cited countries

Country	Citations
China	481
Pakistan	338
Australia	245
United Kingdom	172
United States	108
Thailand	91

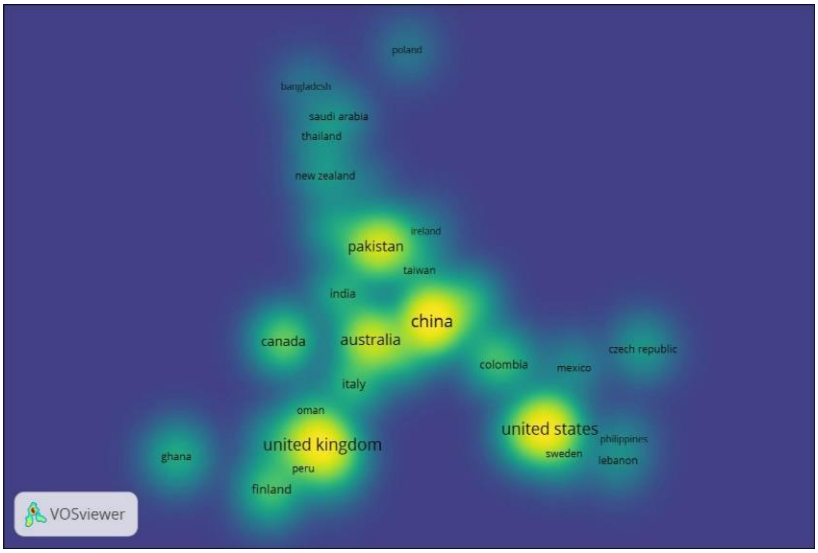

Figure 3. Density of most cited countries.

4.5. The Most Frequently Occurring Keywords

According to extent of accessibility in database, network, overlay and intensity, keywords are shown (Figure 4). It contains prior concepts and crucial words that might be regarded as keywords. The term "responsible leadership" is used 99 times, followed by "corporate social responsibility" 14 times and "leadership" 12 times. It displays each keyword that was used in RL field. The research fields that any researcher should choose in this instance of a topic of study are shown in clusters by VOSviewer. The lines connecting keywords signify that they appeared together in same research project. For instance, phrase "responsible leadership" is a component of corporate social responsibility, social learning theory, sustainable development, and environmental apathy. Research has connected line's strength that joins these words to a net. They serve as another factor in determining the areas of study that a researcher pursues.

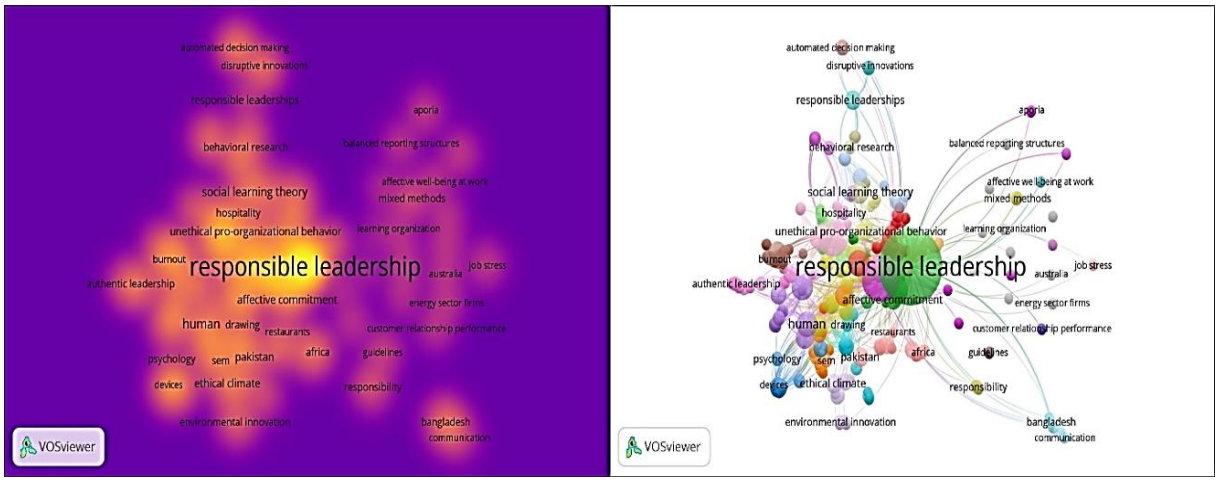

Figure 4. Network and density of appearance of keywords in responsible leadership.

4.6. Popular Authors

The most popular author in this field is Haque, A. who has written 8 papers and Mousa, M. he has also written 6 papers. The other top authors are Stahl G.K., Akhtar M.W., Javed M., Caputi P. and Fernando M.

Table 7.
Most popular authors

Author name	No of Documents
Haque, A.	8
Mousa, M.	6
Stahl, G.K.	6
Akhtar, M.W.	5
Javed, M.	5
Caputi, P.	4
Fernando, M.	4

The most cited authors

Scholars can understand expertise of most important researchers in field through study of previous investigations. The most significant authors in field of RL are shown (Table 8). In this area, researcher ought to depend on their assumptions and ideas. It is advisable to rely on other researchers who are situated in orange or yellow ocean (Figure 5), particularly in RL, as they are well-known in this discipline.

Table 8.
The most cited authors

Author	Citations
Haque, A.	190
Javed, M.	174
Caputi, P.	145
Fernando, M.	145
Ali, H.Y.	135
Hussain, G.	120

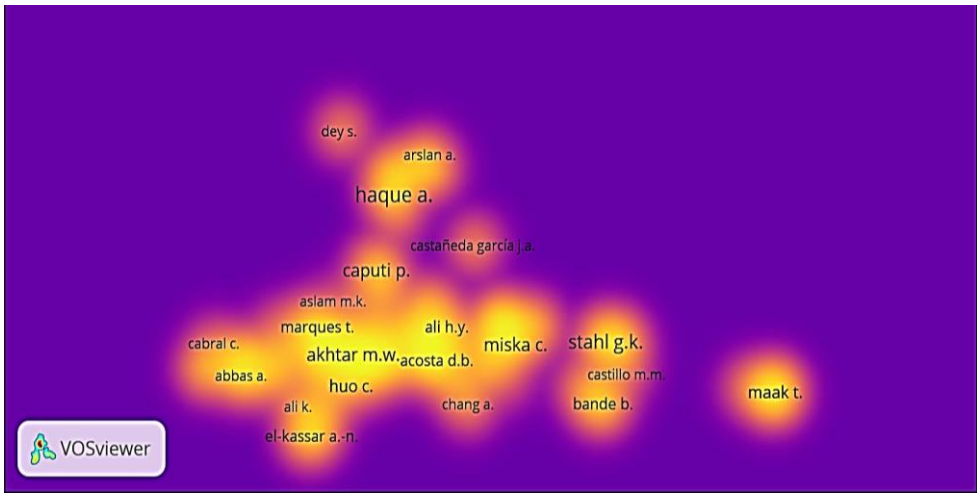

Figure 4. Density of most cited authors.

4.7. Bibliometric analysis of co-authorship and countries

The closer two countries are to one another in VOSviewer, more significant and powerful their relationship. China, United Kingdom, Pakistan, United States, Italy and Australia have most contributors to a paper. Co-authorship research revealed that China had strongest associations overall with a total of 27 links. Pakistan shows 19 links, UK (23 links) and USA with 13 links were on list (Figure 6). We discovered that Javed M., Akhtar M.W., Stahl G.K., and others have contributed to notion of RL through examination of co-authorship. All authors who participated in co-authorship analysis are listed (Figure 7).

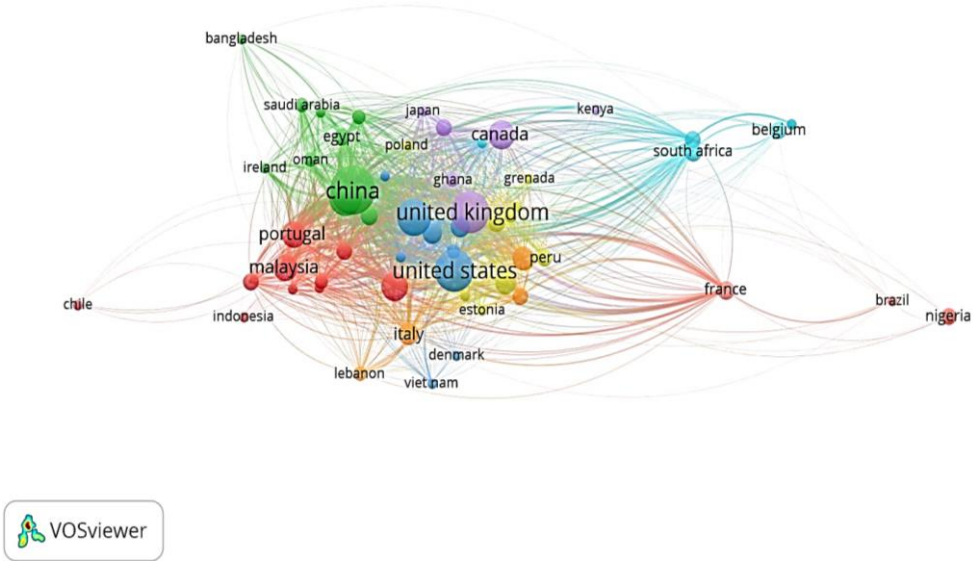

Figure 5. Bibliometric analysis of countries.

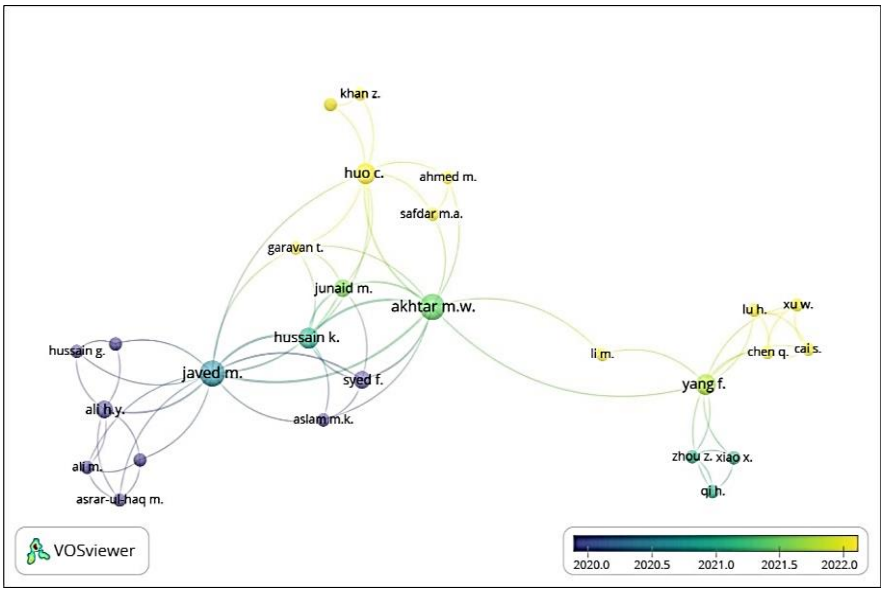

Figure 6. Bibliometric analysis of co-authorship.

4.8. Co-citation Analysis of Authors

This is what VOSviewer offers, where researchers can learn this through cooperative citation. The cognitive organization of information source in RL has been shown through author's co-citation analysis. This was done using VOSviewer, which generated an author's co-citation map showing connections between researchers who were often mentioned in this body of literature. The most significant authors in field of RL are shown (Figure 8). In this area, researcher ought to depend on their assumptions and ideas. It is advisable to rely on other researchers who are situated in orange or yellow ocean (density Figure 8), particularly in RL, as they are well-known in this discipline. Results are shown (Figure 8).

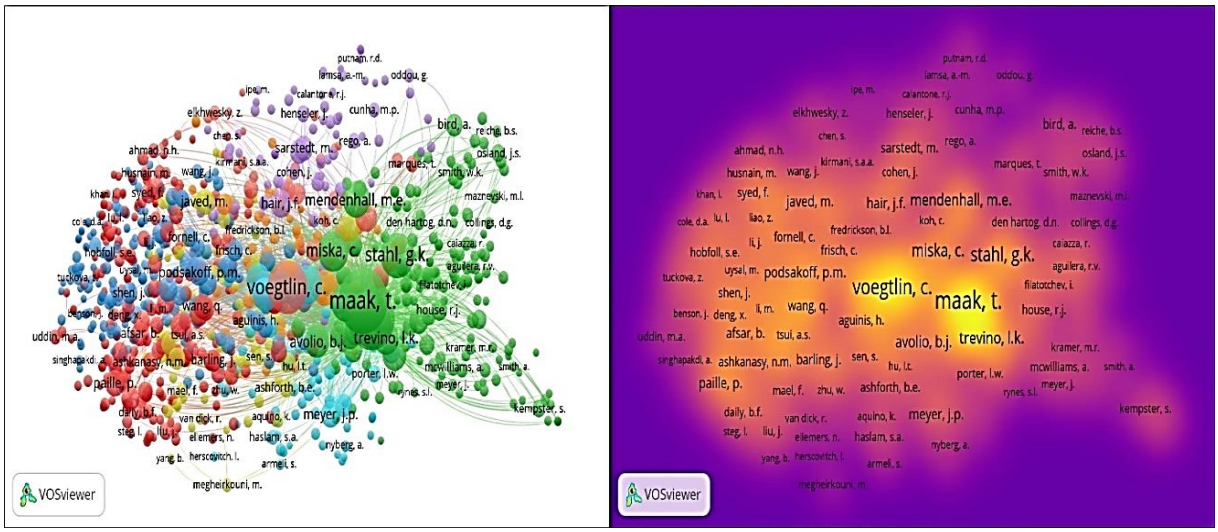

Figure 8. Co-citation analysis of authors.

5. Limitations and Future Research Directions

There may be a drawback to limiting the search term to titles and abstracts that contain (responsible leadership*). The search results might not cover every subject connected because different terms and words may be used in different studies. The data generated by this study extends up to the year 2023 and data gathering began on June 10 of that same year. Following this, additional research on RL may have been released which could have increased sample size and strengthened connections between keywords. Future studies may use different databases for accessing bibliometric data, even though we are convinced that our sample provides an accurate representation of the topic. In order to build a wider view of the area, supplementary evaluations may also include thorough searches in non-indexed journals, proceedings, dissertations, and books. It is advised that comparable parameters in future studies must be compared with those in other databases such as ScienceDirect and Web of Science. A variety of leading publications that are present in these databases may produce connections and linkages of varying quality. We have also excluded studies that were written in languages other than English. It is crucial to investigate what RL means in different countries.

6. Discussion & Conclusion

Our study covers bibliometric analysis of RL topic in the period of 2019-2023. The phases and procedures of bibliometric study cover RL relating to the emergence of terms, most significant scholars in this area, significant research output, reference sources and reference nations. The VOSviewer network, density software outputs, research findings, and recommendations are used by academic institutions. An illustration of an investigation's expertise and research effort with bibliometric analysis is performed on RL using VOSviewer software. The most critical researchers on this topic are also discussed along with citations. The results of bibliometric analysis which concur with those of Baporikar's (2021) study, stated that it is necessary to cite some significant research papers, citations, most influential researchers and key terms on subject of RL. This aids in formulation of RL theoretical frameworks. Bibliographic analysis is crucial for future research paths as it helps in recognizing terminology, most important researchers, papers, sources and nations.

The article has looked into theoretical analysis of numerous bibliometric analysis concepts and has discussed RL. By using the Scopus database, we are able to overcome bias and filter selection issues. We are able to achieve outcomes in bibliometric analysis when compared to traditional approaches. The approach of the investigator's choosing supports bibliometric analysis techniques but cannot take place of conventional approaches of reviewing theoretical

literature. The bibliographic analysis is useful for defining important terminology, most important scholars in the subject, research papers and nations. The researchers' bibliometric analysis reveals that Haque, A. (2021), Stahl, G.K. (2014), Akhtar, M.W. (2021), Javed, M. (2020), Caputi, P. (2021) and Fernando, M. (2021) are the most significant scholars in RL. The researchers should rely on them to conceptualize this topic and support their theories with remarkable depth of research. The most important scholars in this area have taken over research on RL. The bibliometric study of citations in following international journals should serve as foundation for reference materials on RL: Corporate Social Responsibility and Ethical Leadership, Journal of Business Ethics and Sustainability journal. These are the sources that researchers in this area need to have. China, Pakistan, Australia and the UK are nations that have been the subject of most cited research regarding RL. Researchers will benefit from this study's understanding of criteria and identification of trends in RL. The rising understanding that RL has a significant influence on society is furthered by this study. This is further supported by the trajectory of RL literature development, the multidisciplinary nature of its structure, the diversity of fields presenting its material, calibre of journals and academics involved in this field. The concept of RL was first defined as relational phenomenon that describes responsibilities leaders have in relation to society. Research by academics has broadened this concept and included various stakeholders in the field of RL, such as research by Ur Rehman (2023) focuses on financial and environmental dimension of RL. RL literature development trajectory shows evolution of multidisciplinary nature of RL. All in all, theme of RL has developed over years owing to extensive research in this field by academics.

The research evaluates literature development trajectory of concept of responsible leadership and highlights contributions of researchers in field of RL. New researchers can benefit from this research as study provides an overview of credible publications in the field of RL. However, our study only focuses on publications in English language which is a limitation of this research. Another limitation of the study is that even though it highlights the multi-disciplinary nature of RL, it only focuses on publications till June 2023. Publications after June 2023 are not included in study. Future research could include bibliometric analysis of publications in other languages and also those which are published after June 2023. All in all, this study analyses literature development in the field of RL and showcases how the concept of RL has evolved from a relational phenomenon to a multi-disciplinary phenomenon over time.

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FINANCIAL SURPLUS AS A SOURCE OF FINANCING IN POLISH AND SELECTED MULTINATIONAL ENERGY COMPANIES. A COMAPRISON

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Purpose: The paper aims at a comparative analysis of the ways in which Polish energy companies and selected international corporations manage their financial surplus.
Design/methodology/approach: The paper is theoretical and analytical. It presents a critique of pertinent literature dealing with the essence of the financial surplus and its place in the theory of capital structure determinants. The empirical data used in the calculations were taken from a Reuters database. Based on data for the years 2010-2021, relationships were calculated showing the specificity of the energy industry and the use of financial surplus to finance operating activities, investments in tangible fixed assets and the possibility of debt repayment.
Findings: The research led to the conclusion that Polish energy companies and their international counterparts are characterized by a high share of long-term assets in their total assets, which means that the rate of return on assets is relatively low. Polish energy companies manage their financial surplus employing methods that are not fundamentally different from the same in their international counterparts. Only the ability to repay debt from the surplus is higher in Polish companies than in the corporations used for comparison. This is due to the lower level of Polish companies indebtedness, which results from Poland's interest rates which are higher than in the economies of the corporations selected for the comparison. In addition, foreign companies used the surplus to finance development to a greater extent than the Polish companies.
Research limitations/implications: The energy transformation of the Polish economy is going to need large investments. Further research should determine the extent to which they can be covered from the financial surplus, and to what extent from capital raised on the financial market. The research presented in the paper is based on historical published data. Future research can attempt to compare forecast values. Polish companies have to implement a number of investments in the area of renewable energy sources, modernization of transmission lines and construction of nuclear power plants. In order to meet the needs, they must select rational financing sources. To finance these investments they should use their surplus more extensively, while at the same time limiting its use to finance operating activities.
Practical implications: The results of the research can be used by the managerial staff of Polish energy companies to take action and use their surplus to finance various areas of activity based on patterns positively tested in international corporations. The results of the research can also be used by doctoral students and students conducting their own research and writing papers.

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Social implications: The results of the research may increase awareness of the need for energy transformation and rational selection of financing sources.
Originality/value: The results of the research show stakeholders interested in the industry how Polish energy companies used the financial surplus. The value of the surplus reflects the company's ability to repay its debt, and thus its ability to raise external capital to finance its investment. It also shows whether Polish energy companies will be able to finance the implementation of the energy mix and cope with challenges arising from the Fit for 55 package.

Keywords: specificity of the energy sector, financial surplus, growth financing.

Category of the paper: Research paper.

1. Introduction

In the free market economy, companies aim mainly to increase shareholder value. In the case of a joint-stock company, it is usually assumed that its long-term aim is to increase its market capitalisation. This formulation of the company's aim clearly puts a premium on long-termism and consequently the need to analyse the impact of time and risk on the decision-making process and the need to use appropriate decision-making methods. This creates the need to formulate a long-term action strategy and to seek a compromise between short-term and long-term goals (Jajuga, Jajuga, 2015). The above is of extreme importance in energy companies which are undergoing transformation to address climate protection needs. While defining financial management objectives, it is now emphasised that an increase in a company's value as a shareholder-oriented objective must balance the objectives of all stakeholders: employees and trade unions, suppliers and customers, budgets as well as the natural environment. The achievement of the company's objectives depends on a rational choice of financing sources. To finance operating and development activities companies use equity and debt capital. Equity capital offers a stable basis for the operation of enterprises. It has a critical impact not only on liquidity, but above all on the very development of business entities. It is basically the use of financial surplus (sum of net profit and depreciation/amortization) that facilitates tapping external capital. Indeed, capital providers pay attention to the capital structure and the share of equity in the structure. In order to determine to what extent financial surplus is used to finance company activities, an empirical study was conducted, and an attempt was made to verify three research hypotheses.

In order to determine to what extent financial surplus is used to finance corporate activities, an empirical study was conducted in ten energy entities, four of which are Polish and six are foreign. The research used economic relationships based on financial surplus and compared the performance of Polish entities to that of foreign entities. The aim of the comparison was to determine to what extent the use of financial surplus in Polish companies differs from the approach in foreign companies whose energy production has been undergoing transformation

over the last few years. Polish companies need to move in a similar direction, they need to restructure their operations, move away from coal-based power generation to nuclear power, power generation from gas, hydrogen and to greater use of renewable energy sources. This means that they should use their financial surplus mainly to finance investments and to a lesser extent to finance their operations.

Based on the research carried out, an attempt was made to verify three research hypotheses.

H1. In energy companies, part of the generated financial surplus is used to finance operations.

H2. The degree of debt coverage by financial surplus is higher in Polish companies than in foreign companies.

H3. The degree of coverage of capital expenditure on tangible assets by means of financial surplus in Polish companies varies in a way which is similar to the same in foreign companies.

To date, there are no studies showing whether the use of surplus funds in Polish energy companies is similar to the same in multinational corporations. It is also important to determine whether the surplus generated can be used to a similar extent to implement the energy transition in the same way as in multinational corporations.

2. Literature Review – the Shape of Financial Surplus and Its Impact on Capital Structure

Companies' objectives can be achieved by using internal sources of finance or by raising external funds. Internal financing sources include financial surplus, funds generated by the transformation of assets into cash or disposal of redundant long-term assets, acceleration of the circulation of capital or the management of reserves and funds. To ensure stability of the financial situation in the short term, i.e., the ability to settle liabilities on time and ensure growth in the long term, enterprises should make extensive use of financial surplus. For companies, it is the most readily available source of financing. At its narrowest, financial surplus is the sum of retained earnings and depreciation/amortization. Each year the owners decide at the Annual General Meeting what percentage of the generated net profit will remain in the company and how much will be consumed by way of management and supervisory board remuneration, staff bonuses, social benefits fund contributions or other allocations. The level of retained earnings shapes the size and structure of equity in companies. In broader terms, financial surplus is the sum of net profit and depreciation/amortization.

A company’s retained earnings represent the owners' contribution to the growth of equity, thereby increasing the profit potential of business entities. Such actions promote companies’ financial standing, supporting future profitability growth. Additionally, retained earnings can

be used as a financing source whenever a company generates a financial surplus (Mądra-Sawicka, 2017). In countries with developed market economies, the level of self-financing is considered to be high if the share of an entrepreneurial company's own funds in financing its needs reaches 70% or more (Baranski, 2018). Retained earnings can be used to finance companies' operating and development activities. Indeed, they can feed into net working capital and prevent the loss of short-term financial equilibrium, or they can be used to finance investment projects.

Reserves created by an organization may be the source of their internal funds. They represent retained earnings at the balance sheet date and are intended to settle future liabilities. Reserves are charged to other operating expenses or financing cost. Funds originating in reserves remain at the company's disposal only during the time between the creation and release of the reserve. In the event of a contingency, reserves offer a liquidity cushion to the company. Of all long-term reserves, reserves for employee pensions are of particular importance. They offer a double benefit to the company. On the one hand, they are treated as a tax-deductible expense that reduces the tax base, and on the other, they are available to the company for the entire period of the employee's employment (Sierpińska, 2016).

In addition to retained earnings and reserves, sources of internal funds include depreciation/amortization. Depreciation/amortization is an expense, but it does not result in a current cash outflow from the company. It reduces the tax base and tax payables as a non-interest tax shield. Depreciation funds are not just an expense, they are also capital used to finance the purchase of long-term assets. The funds released from long-term assets return to the company and increase the value of its tangible assets. Consequently, funds originating in accumulated depreciation are funds from the transformation of assets. Depreciation capital can be reinvested in fixed assets or accumulated to finance investments. Financing from the released depreciation capital is called the capital return effect or the capital release effect (Iwin-Garzyńska, Adamczyk, 2009).

The Accounting Act governs the way in which depreciation/amortization is accounted for in the balance sheet and profit and loss account. It allows business entities to autonomously determine depreciation rates and choose the depreciation method. The Income Tax Act determines the rules underlying determination of depreciation for the purpose of calculating income tax more restrictively, as it introduces, inter alia, restrictions on setting individual depreciation rates and making the depreciation period dependent on the initial value of fixed assets. The tax cost of depreciation must also meet the condition of a cause-and-effect relationship between the depreciation cost of a given fixed asset and the income derived from its use. The separation of accounting and tax depreciation is due to the fact that the rules for determining tax income are determined solely by the provisions of tax law (Iwin-Garzyńska, 2018).

The financial surplus generated has numerous advantages as a source of financing of the company's operations:

- in times of an economic downturn and tight money, it can be used to finance day-to-day business operations and help maintain liquidity,
- it increases the company's debt capacity and improves its creditworthiness,
- it reduces the risk of changes in ownership structure, as in the event of a shortage of funds there arises the need for a new share issue,
- it reduces financial risk.

However, drawing on funds originating from financial surplus has disadvantages:

- the high volatility of the financial surplus can limit access to debt capital,
- lower return on equity against an increase in this capital originating from retained earnings,
- higher cost of capital in the absence of a tax shield,
- limited effect of leverage and tax shield.

The process of financing companies' economic activities is extraordinarily complex in nature, and the capital used for this purpose has a specific origin, as it can be generated by the company or obtained from other sources. The main types of financing sources utilized by an economic entity are its net profit, depreciation and amortization (Kowalik, 2021).

According to the theory of the hierarchy of financing sources, companies should first reach for internal sources of financing, i.e., the financial surplus, as it is more easily accessible than external sources. If companies primarily finance their activities using internal resources, the share of debt in the financing structure may decrease in conditions of increased liquidity levels (Aydin, Kiraci, 2018). The positive impact of the liquidity indicator on the debt level and the wider use of retained earnings are also presented, inter alia, in the research conducted by Sibindi (2016).

According to theory of the hierarchy of financing sources, higher profitability presupposes lower debt, as investment projects can be financed from the profit generated by the entity. This is confirmed by a study conducted by Barowicz (2013) on a group of 39 joint-stock companies covering years 2000-2006. On the other hand, according to the signalling theory, a high share of debt in companies' capital structure indicates their good financial health. In pertinent literature, one can encounter the approach proposing that earnings volatility is linked to the size of financial leverage. Research has confirmed that when profits are above or below average, financial leverage imitates the movements. Thus, companies with stable profits should have lower financial leverage volatility (Jerzemowska, 1999). It follows from the research carried out by DeAngelo and Masulis (1980) that a company which is able to establish higher depreciation/amortization provisions should use less external capital to finance its operations. External capital is replaced by depreciation capital. Hence, the optimal capital structure arises because of the adopted system solutions governing the depreciation of fixed assets, which shape the tax depreciation capital (Gay, Hatfield et al.).

The extent to which financial surplus is used to finance business activities is undoubtedly industry specific. This is due to the company's asset structure. This is because depreciation is linked to the specific nature of the industry in which the company operates and the size of its assets and their structure. The higher the share of depreciable tangible and intangible assets in the company's long-term assets, the higher the value of depreciation/amortization. In her research conducted in companies from 70 countries belonging to the commodity industry, Kurronen (2018) presents evidence that this industry has less debt than other non-financial companies. The research also shows that debt levels in the surveyed companies do not increase with company size, as is the case for business entities in other sectors, and that high profitability does not depress debt ratios. The higher the level of depreciable assets, the higher the financial surplus and the higher the level of cash flow generated.

Internal funds generated by companies do not suffice to finance their development. Companies must resort to external funds by issuing new shares or taking loans, making bond issues or using leasing. However, any change in the capital structure carries a risk. Before taking any decision in this area, the financial situation of the economic entity should be closely analysed and the long-term effects of a change in the capital structure should be determined.

3. Information Sources and Research Methods

Four Polish corporates and six large international groups operating in different markets were selected for the study of the structure of financing sources of energy companies. The Polish corporates Energa, Enea, PGE and Tauron are listed on the Warsaw Stock Exchange. The financial statements of these companies for the years 2010 to 2021 retrieved from a Reuters database were used to calculate the application of financial surplus to finance operating and investing activities. The data contained therein are comparable as they are prepared in accordance with IAS and IFRS. The comparability and uniformity of the economic relationships facilitates the inference and positioning of companies according to a specific relationship. At PGE, the level of depreciation/amortization reported for the needs of global statistics also included impairment losses on assets. Between 2016 and 2019, large write-downs were made to revaluate assets in use, which distorted the comparability of the analysed relationships. To ensure data comparability, this amount was excluded from calculations. Depreciation/amortization was adjusted for impairment losses on long-term assets and the adjusted figure was used to calculate its contribution to operating cash flows.

The Polish companies selected for the study generate and supply energy to consumers throughout Poland. A small percentage of consumers, mainly in Warsaw, use energy supplied by Innogy. Iberdrola S.A. is a Spanish energy group that is now a global energy leader, a leading producer of wind energy and one of the largest energy companies in the world. It is firmly

committed to energy transformation through its sustainable business model based on renewable energy, smart grids, large-scale energy storage and digital transformation (www.iberdrola). SSE PLC is an energy company that operates and invests in the UK and Ireland. It invests in renewables and modern energy infrastructure. Tokyo Electric Power Company Holdings Incorporated (Tokyo Inc.) is a Japanese energy holding company that produces wind, hydro and thermal power (oil, coal, geothermal) and distributes it to consumers with international offices in Washington DC and London. It is a founder and member of strategic energy innovation consortia (www.tepco).

The American NextEra Energy, Inc. is an energy company operating in the United States and Canada. It is the largest energy holding company by market capitalisation. It invests in modern energy infrastructure and renewable alternatives to coal-fired power. Valero Energy Corp. is the largest US producer of renewable fuels, producer of energy from renewable sources promoting a sustainable energy future. Xcel Energy Inc. provides energy to millions of homes and businesses in eight states in the western and midwestern United States (Johnstone, 2023).

Several indicators were used to verify the hypotheses formulated in the introduction. The first two relationships were used to show the specificity of the energy industry, the structure of assets and the return on assets calculated based on financial surplus. These are:

- the share of long-term assets in the total assets of the companies,
- the ratio of the financial surplus to the value of assets – this indicates the rate of return on the company's assets financed, among others, with the generated net profit and depreciation/ amortization.

The following three ratios provide information on the application of financial surplus:

- the ratio of financial surplus to operating cash flow. It shows the extent to which the financial surplus generated was used to finance companies' operating activities,
- the ratio of financial surplus to total debt – this shows how much of the debt the company could repay from the financial surplus generated in a given year,
- degree of coverage of investment outlays from the amount of financial surplus established as a relationship of the sum of net profit and depreciation/amortization to investment outlays on tangible fixed assets incurred in a given year.

The data used to calculate the above ratios were mainly taken from the companies' balance sheets and cash flow statements. The total capital expenditure in a given accounting year was sourced out from their cash flow statements.

4. Specificity of Companies from the Energy Industry

The electricity industry is highly capital-intensive. The investment cycle takes an average of three to five years. The production and distribution of electricity requires a large commitment of capital on tangible fixed assets. Table 1 shows the structure of the assets used by the energy companies.

Table 1.
Asset structure of the surveyed energy companies in 2010-2021, %

Company name		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Energa S.A.	FA	70.9	71.0	71.7	74.0	73.1	75.2	77.7	70.9	74.9	77.6	82.6	86.0
	CU	29.1	29.0	28.3	26.0	26.9	24.8	22.5	29.1	25.1	22.4	17.4	14.0
Enea S.A.	FA	68.1	71.7	74.9	75.8	79.2	79.2	79.4	78.0	76.9	81.6	72.8	64.6
	CU	31.9	28.3	25.1	24.2	20.8	20.8	20.6	22.0	23.1	18.4	27.2	35.4
PGE	FA	85.8	75.6	77.0	78.6	78.8	80.9	80.1	86.8	78.0	83.8	81.5	74.5
	CU	14.2	24.4	23.0	21.4	21.2	19.1	19.9	13.2	12.0	16.2	18.5	25.5
Tauron Polska Energia	FA	70.9	81.9	81.6	85.3	81.5	87.7	87.1	86.5	87.7	83.6	80.5	84.5
	CU	19.1	18.1	18.4	14.7	18.5	12.3	12.9	13.5	12.3	16.4	19.5	15.5
Iberdrola	FA	80.5	83.7	83.5	88.0	87.9	88.6	90.0	87.5	88.2	88.9	87.8	84.2
	CU	19.5	16.3	16.5	12.0	12.1	11.4	10.0	12.5	11.8	11.1	12.2	15.8
NextEra Energy Inc.	FA	90.1	90.8	91.9	91.6	90.7	91.8	91.8	92.7	93.7	93.7	94.2	93.4
	CU	9.9	9.2	8.1	8.4	9.3	8.2	8.2	7.3	6.2	6.3	5.8	6.6
SSE PLC	FA	60.1	58.6	64.6	65.6	66.1	61.7	72.5	69.2	70.2	68.7	83.4	79.1
	CU	39.9	41.4	35.4	34.4	33.9	38.3	27.5	30.8	29.8	31.3	16.6	20.9
Tokyo Inc.	FA	92.6	80.3	85.3	81.7	82.0	83.0	82.9	83.8	82.3	83.5	85.0	87.0
	CU	7.4	19.7	14.7	18.3	18.0	17.0	17.1	16.2	16.2	16.5	15.0	13.0
Valero Energy Corp	FA	64.1	62.7	63.0	59.2	63.5	66.2	63.6	61.5	64.7	64.8	69.4	63.4
	CU	35.9	37.3	37.0	40.8	36.5	33.8	36.4	38.5	35.3	35.2	30.6	36.6
Xcel Energy Inc.	FA	90.0	89.9	91.6	90.5	90.9	92.5	93.1	93.1	93.3	93.8	93.9	92.7
	CU	10.0	10.1	8.4	9.5	9.1	7.5	6.9	6.9	6.7	6.2	6.1	7.3

Note: SSE PLC balance sheets and Tokyo Inc. are prepared as at 31 March, hence the data for each year covers the period starting on 1 April of the relevant year until 31 March of the following year.
FA – long-term assets; CA – current assets.

Source: own calculations based on data retrieved from surveyed companies' balance sheets on Reuters database.

Energy companies are characterized by a remarkably high share of long-term assets in total assets, with this share trending to be on the increase. At Energa, the share of long-term assets increased between 2010 and 2021 from 71% to 86%, with a similar trend notable at Tauron. Such large increases in long-terms assets were not ascertained at Enea and PGE. The Spanish company Iberdrola and the Japanese company Tokyo Energy had an asset structure like that of the Polish companies Enea and Tauron. The US company Valero had a relatively stable asset structure in the period under review, with the share of long-term assets oscillating around 65%. NextEra and Xcel Energy on the other hand had an exceptionally high share of long-terms assets at over 90%.

In most of the companies, an increase in the share of long-term assets in total assets is conspicuous. However, it should be borne in mind that with the ongoing processes of financialization of companies and globalisation of national economies, the share of financial investments in long-terms assets is on the increase. In corporates, these are shares in

subsidiaries. The increase in long-term assets necessitates long-term sources of financing, most often in the form of equity. Due to the high volatility of value occasioned by market factors, shares have a lower pledge value than the tangible assets which are needed for bank borrowing. However, corporates are better positioned to place corporate bonds on the debt market. The Polish market is characterised by a significant potential for the increase in green corporate and municipal bond issuance, mainly in the energy and transport sectors (Supernak, 2023). The key barriers to the development of this market are currently the additional costs of organising the issue related to the preparation of the green bond framework and external verification, as well as challenges of an operational nature. Additionally, the question of a lower cost of capital for green issues is not so clear cut.

Table 2 presents returns on energy companies assets based on financial surplus, which show the return on assets used to generate current profit. The return on profit invested in tangible and intangible assets in past periods is through depreciation/amortization. Rates of return on assets illustrate the role of financial surplus in running a business. The higher the level of this indicator, the more efficient the company is because of the reinvestment of funds originating in internal financing sources. The preference for these sources over external capital is driven by the need to maintain a rational debt level and reduce debt service expenses. This approach improves the liquidity of business entities.

Table 2

Return on assets based on financial surplus in the surveyed companies from 2010 to 2021, %

Company name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Avg
Energa S.A.	11.0	11.4	9.0	10.2	11.6	10.7	16.1	9.4	8.9	1.5	4.2	11.1	9.6
Enea S.A.	10.1	11.0	9.9	9.0	9.0	1.7	8.0	8.3	7.3	6.4	(2.1)	9.6	7.4
PGE S.A.	13.5	15.1	12.1	13.2	11.5	13.2	10.6	10.2	8.0	8.5	6.0	10.4	11.0
Tauron Polska Energia	11.2	10.5	11.6	10.5	9.5	(1.1)	6.5	9.8	6.0	4.7	(1.1)	6.9	7.1
Iberdrola	7.2	6.9	7.0	7.0	7.1	7.2	6.7	6.3	7.5	7.6	7.9	8.0	7.2
NextEra Energy Inc.	7.1	6.1	5.3	6.5	7.2	7.2	7.1	8.1	9.6	6.7	5.2	5.0	6.8
SSE PLC	9.0	9.3	4.3	5.1	5.0	5.7	5.7	12.9	10.4	9.6	9.1	15.7	8.5
Tokyo Inc.	7.7	(0.2)	(0.4)	(0.2)	7.5	7.8	5.9	5.8	7.1	6.3	4.1	5.0	4.7
Valero Energy Corp	12.5	8.5	8.2	9.4	11.9	13.4	9.3	12.2	10.8	9.3	2.4	6.4	9.5
Xcel Energy Inc.	5.9	5.9	5.9	6.0	5.9	5.7	6.2	6.4	6.6	6.5	6.6	6.7	6.2

Note: AVG-Average.

Source: own calculations based on data retrieved from surveyed companies' balance sheets on Reuters database.

In Polish energy companies, just like in their foreign counterparts, the rate of return on total assets varied significantly in the years under review. In 2010, the highest rate of return on assets was reported by the Polish company PGE. Prior to 2017, Polish companies achieved higher rates of return than their foreign counterparts. In 2018-2020, there was a significant deterioration in performance because of rising energy prices. In 2021, rates of return improved significantly in nearly all companies (except NextEra), with the highest rate of 15.7% reported

by the UK company SSE PLC. Over the twelve-year period, the highest average rate of return on assets was achieved by Polish companies PGE, Energa and US company Valero. Returns at Xcel Energy showed the lowest volatility.

Given the high capital intensity of the energy sector and the higher level of accrued depreciation than in other sectors, it can be concluded that rates of return are relatively low. This confirms the correlation highlighted in the pertinent literature which asserts that highly capital-intensive industries have lower rates of return on assets employed.

5. Study Results

Financial surplus can be used during operations to maintain liquidity, repay debts and as a source covering capital expenditure. The extent to which financial surplus is used in the above areas is shown in the subsequent tables. Table 3 shows the relationship between the amount of financial surplus and operating cash flow. This relationship indicates what level of funds generated in the form of net profit and depreciation/amortization was used to finance operating activities, with the remainder being used to finance the company's growth. Ratios higher than 100% indicate that the sum of net profit and depreciation/amortization was higher than the cash generated through operating activities, meaning that part of this surplus was used to finance operating activities, to cover the need for additional net working capital. Ratios lower than 100% indicate that the financial surplus was augmented by funds released from current assets either through a decrease in inventories and receivables or by an increase in current liabilities (excluding short-term borrowings).

Table 3
Ratio of financial surplus to operating cash flow in the surveyed companies from 2010 to 2021, %

Company name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Energa S.A.	117.6	105.0	101.1	86.8	108.0	122.7	168.7	90.5	103.3	25.5	44.0	64.2
Enea S.A.	101.3	106.7	117.6	87.2	146.8	17.7	80.8	91.5	90.2	97.4	(20.1)	60.6
PGE S.A.	104.8	127.9	102.6	100.9	120.6	118.9	111.7	92.3	119.3	97.0	47.5	124.5
Tauron Polska Energia	103.8	134.5	103.2	83.6	125.9	(10.5)	70.0	97.0	108.2	90.1	(10.4)	55.5
Iberdrola	85.4	109.9	96.5	109.7	97.8	108.4	105.8	123.0	111.1	134.8	116.2	140.5
NextEra Energy Inc.	98.2	85.7	85.9	88.3	97.5	97.5	100.7	123.9	150.5	96.4	83.7	93.2
SSE PLC	96.5	116.4	48.3	53.6	43.7	67.5	58.4	119.1	139.7	207.4	146.9	186.1
Tokyo Inc.	103.2	(2.5)	(19.0)	(12.2)	173.9	126.4	76.0	103.5	118.2	158.9	160.0	251.1
Valero Energy Corp	154.8	89.7	69.3	79.9	127.4	105.9	89.4	112.0	124.0	91.1	131.2	63.0
Xcel Energy Inc.	90.2	72.7	92.2	79.3	82.0	73.8	83.8	88.2	97.4	100.4	124.8	176.0

Source: own calculations based on data retrieved from surveyed companies' balance sheets on Reuters database.

Prior to 2016, the funds generated in the form of net profit and depreciation/amortization by the Polish companies were mostly used to finance current operations. Between 2017 and 2021, the Polish energy companies generated cash flows exceeding their financial surplus. In 2021, only PGE consumed the entire surplus through operating activities, and the financing needs in these activities were more than 24% higher than the funds generated.

In most of the global companies surveyed, the opposite trend occurred. Prior to 2016, with a few exceptions, these companies had a financial surplus lower than their cash flow from operating activities and therefore part of this cash flow was covered from funds released from inventories and receivables and from an increase in current liabilities. In the subsequent period covering 2017 -2021, their financial surplus was higher than the operating cash flow, except in NextEra. At SSE PLC, surplus was more than twice as high as cash flows. This means that the global companies had no need to inject external funds to finance operating activities and could use part of the surplus to repay debts and invest.

A different approach to the management of funds originating in financial surplus manifests itself in the relationship of this surplus to the debt levels of foreign energy companies as illustrated by the data in Table 4.

Table 4

Ratio of financial surplus to total debt in the surveyed companies from 2010 to 2021, %

Company name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Energa S.A.	24.7	26.6	18.6	19.8	22.0	20.3	30.2	16.9	17.0	2.7	7.6	20.9
Enea S.A.	43.3	43.3	38.5	30.3	26.9	3.4	15.9	15.5	13.8	11.4	(3.6)	16.1
PGE S.A.	48.2	49.3	39.3	46.1	35.6	38.4	28.8	27.2	20.8	18.7	12.5	22.4
Tauron Polska Energia	30.0	23.4	24.2	22.7	19.8	(2.2)	12.9	19.4	11.8	8.3	(1.8)	11.8
Iberdrola	10.5	10.5	10.7	11.3	11.4	10.1	10.2	9.5	11.3	11.0	11.1	11.2
NextEra Energy Inc.	9.8	8.3	7.1	8.8	9.7	10.0	9.7	11.4	14.3	8.3	7.3	6.8
SSE PLC	10.9	12.3	5.5	7.0	6.7	7.7	7.4	17.4	13.4	12.5	11.7	22.7
Tokyo Electric Power	9.5	(0.2)	(0.4)	(0.2)	8.4	9.1	7.1	72	8.9	8.1	5.4	6.7
Valero Energy Corp	20.9	13.7	13.8	16.0	21.7	24.9	16.5	21.8	19.0	15.7	3.8	9.4
Xcel Energy Inc.	8.5	8.7	8.3	8.4	8.1	7.8	8.5	8.7	9.0	8.8	9.0	9.1

Source: own calculations based on data retrieved from surveyed companies' balance sheets on Reuters database.

Between 2010 and 2014, Polish energy companies were very well positioned to repay their debts from their financial surplus. PGE and Enea were able to repay their debt within 2-3 years, while Energa and Tauron were able to do so within a slightly longer period of 3-5 years. The ability of Polish companies to repay their debts deteriorated significantly between 2015 and 2021. In 2020, Enea and Tauron generated losses exceeding the value of their depreciation/amortization. At Tauron, for example, the loss totalled PLN 2 374 million and depreciation/amortization stood at PLN 1 954 million. In 2021, Tauron's net profit totalled PLN 675 million and depreciation/amortization stood at PLN 2,100 million. At Enea, the net

loss in 2020 amounted to PLN 2,234 million. In 2021, the performance of the Polish energy companies improved, which increased their ability to repay debts from the financial surplus. Energa and PGE were able to repay their debts from financial surplus in less than five years. Only the UK company SSE PLC had a ratio of financial surplus to total debt like that of the Polish companies. The other international energy companies were able to settle 6-9% of their debt in 2021, meaning that they would have been repaying this debt over a period of 11-17 years.

The data in Table 5 show the extent to which energy companies were able to cover shortfalls in investing activities with funds generated from financial surplus.

Table 5.
Ratio of financial surplus to capital expenditure on tangible assets in the surveyed companies in 2010-2021

Company name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Energa S.A.	129.4	105.9	74.3	110.2	143.5	122.8	73.5	154.3	117.2	x	51.6	87.8
Enea S.A.	151.6	128.5	81.7	73.2	63.9	13.7	72.9	114.6	111.0	100.6	x	174.9
PGE S.A.	153.3	196.4	159.6	173.5	119.8	93.7	90.0	120.6	111.6	95.7	82.2	198.3
Tauron Polska Energia	91.8	129.3	109.7	86.7	95.1	8.9	58.6	102.5	63.0	55.6	x	105.9
Iberdrola	121.9	147.7	150.4	160.4	186.5	165.9	141.7	109.3	132.7	167.0	165.9	164.6
NextEra Energy Inc.	127.7	86.7	70.4	137.2	153.1	154.0	150.5	146.0	165.1	33.1	99.1	100.0
SSE PLC	159.3	178.8	43.4	65.4	57.8	83.2	65.0	138.7	155.0	155.1	157.8	287.2
Tokyo Electric Power	161.0	x	x	x	184.9	194.4	125.0	126.4	158.2	129.2	88.6	100.4
Valero Energy Corp	103.9	153.8	124.7	209.7	250.9	367.3	337.3	445.4	309.5	252.7	69.6	221.8
Xcel Energy Inc.	73.4	79.3	71.9	60.3	67.9	60.6	78.6	83.1	76.9	77.5	66.2	90.8

x - negative financial surplus, depreciation/amortisation lower than net losses.

Source: own calculations based on data retrieved from surveyed companies' balance sheets on Reuters database.

In Polish capital groups from the energy industry, the level of coverage of capital expenditure from financial surplus varies due to fluctuations in the profit/loss and the method of calculating depreciation/appreciation. In 2012 -2016, Enea used external funds to finance its growth. In the next years, its financial surplus was higher than the level of capital expenditure. It did not generate a financial surplus in 2020 as a result of losses incurred, as did the Tauron group and Enea itself in 2019.

1 January 2019 saw changes to the method of calculating depreciation under IFRS16. In accordance with the legal solutions in the energy companies, resources used by the companies under operating leases are accounted for in the balance sheet and in the calculation of depreciation. In addition, leases came to include (Sierpińska, 2021, p. 101):

- perpetual usufruct of land - both purchased and received in kind, or received free of charge on the basis of an administrative decision,
- land and transmission easements,

- lease and hire agreements, etc. related to the location of line and technical infrastructure (heating nodes, transformers),
- hire and lease agreements, etc. of office premises,
- hire and lease agreements etc. of buildings, structures and technical equipment.

The value of assets was most significantly affected by the recognition of perpetual usufruct of land and land rental/lease agreements, which, prior to the entry into force of IFRS 16, were reported as operating leases not recognised in the balance sheet. Not all agreements though were treated as subject to the provisions of IFRS 16. For example, following an analysis, PGE decided that agreements for the occupation of the roadside for the placement of energy infrastructure, for which a significant right of substitution was established, and agreements for the lease of lines/fibres/cable ducts were outside the scope of IFRS 16. (PGE Consolidated Financial Statements, 2021, p. 38).

In 2021, capital expenditure in Polish energy companies was lower than the financial surplus they generated. At PGE, the financial surplus totalled PLN 9,283 million and capital expenditure stood at PLN 4,682 million. The relationship between financial surplus and capital expenditure in the global companies selected for the study varied, just like in Polish energy companies. In the Spanish company Iberdrola, capital expenditure was lower than the level of financial surplus throughout the entire period under study. This means that part of this surplus was either used to repay debts or to cover other net working capital requirements arising from financing of the company's operating activities. At NextEra, in only four years of the period under review was capital expenditure higher than the financial surplus and in 2020-2021the entire financial surplus was spent on investment. At Tokyo Electric Power, capital expenditure did not show much changeability over the period under review and was in the range of 550-650 million yen. The varying share of financial surplus in capital expenditure resulted from changing bottom line. In 2011-2013, the company generated losses exceeding depreciation/amortization, which resulted in a negative financial surplus. In 2015, its net profit was 479 million yen versus 69.3 million yen in 2020, which is seven times less. Valero made a loss in 2020, but it was less than the accrued depreciation. Capital expenditure was similar to that of the previous year, but the level of financial surplus was four times lower than in the previous year. In 2019, the company reported a net profit of $2,784 million followed by a loss of $1,107 million the following year. While in 2017 Valero's financial surplus was 4.5 times higher than its capital expenditure, in 2020 the shortfall in surplus funds needed to cover capital expenditure equalled 30%. The only company among those surveyed in which each year’s capital expenditure exceeded the financial surplus was Xcel Energy. During the period under review, Xcel’s surplus covered an average of 74% of its capital expenditure. The remaining expenditure was covered by share and bond issues as well as loans (data taken from the financial statements).

6. Discussion and Conclusion

In summary, the results of the theoretical and empirical considerations show that the energy industry ranks among highly capital-intensive sectors of the economy. The share of long-term assets in total assets exceeds as much as 90% in some of the entities studied. In Polish energy companies, this share averages 80%. The increase in the share of long-term assets in total assets continues to show. Indeed, globalization is giving rise to large, diversified business entities. Following series of mergers and acquisitions, financial investments in the form of shares in subsidiaries appear in the long-term assets portfolio. This leads to an increase in the share of long-term assets in total assets, which determines the choice of financing sources. Polish energy companies have less diversified business activities than the foreign entities studied.

Rates of return based on financial surplus are relatively low and show considerable fluctuations over time, reflecting changes in the level of profit/loss due to market changes affecting energy carriers and the increase in amortization/depreciation. In Polish energy companies, changes in the rules for calculating depreciation/amortization and the increase of the same led to an increase in the financial surplus, which had an impact on the increase in rates of return on total assets.

Company managers adapt the sources of financing of operations to the internal circumstances of the company and to the signals from the environment. One of the most readily available sources of financing is financial surplus. The way in which it is used in business entities is truly varied.

As part of procedure aimed at verifying hypothesis one, the research period 2010 -2021 was divided into two sub-periods. In the 2010 – 2016 period, the financial surplus in Polish companies was used to finance current operations. In their foreign counterparties, financial surplus was used for investment and debt repayment. Energy transition processes started there much earlier than in the Polish companies studied. In 2017 -2021, funds generated by Polish energy companies from operating activities exceeded their financial surplus, which allowed them to use the funds for investment purposes. The same trend occurred in most of the foreign companies studied. Hence, hypothesis one was confirmed. In energy companies, part of the financial surplus generated is periodically used to finance operating activities. In Polish energy companies, however, the degree of utilization of financial surplus to finance operating activities was higher than in their multinational counterparts.

The results of the research allowed confirming the second hypothesis. The degree of debt coverage by financial surplus is higher in Polish companies than in their foreign counterparties. Polish energy companies were able to repay debt using from their financial surplus in up to five years, compared to over ten years in the foreign companies.

Throughout the period under review, foreign companies revealed much lower ability to repay debt out of their surplus than their Polish counterparts. Foreign companies are able to use debt financing more widely than their Polish counterparts thanks to lower interest rates on loans than in Poland and they are also more able to tap the debt market. In April 2023, the interest rate in the euro area stood at 3.75%, in Switzerland at 1.50%, the UK at 4.25%, the US 5.25%, Norway 3.25%, Japan 0.10%, the Czech Republic 7.0 % and Poland 6.75% (Kozieł, 2023). Polish companies are less indebted than their foreign counterparties (Kowalik, 2021). This is on the one hand due to the higher cost of debt, and on the other to the limited possibility of obtaining loans under the restrictive credit policy of Polish banks. There are also fewer opportunities to place bond issues on the debt markets. The capacity of the Polish debt market is limited and limited opportunities to use foreign debt markets result from exchange rate risk. In conditions of lower interest rates, foreign companies generate lower costs of debt financing, which increases their net profit.

However, the investment needs of Polish energy companies are much greater than those of the foreign companies. In Poland, electricity produced from coal increases CO2 emissions into the atmosphere. Restructuring the energy sector and the economy towards a change in the structure of consumption of energy carriers and a reduction in energy consumption will require huge outlays. It is estimated that by 2040, expenditure on power generation capacity alone will amount to PLN 726.4 billion. This is related to Poland's need to adapt to the EU's energy and climate policy. Investments in renewable and nuclear energy sources, as well as gas sources accounts for 86% of that amount. An update of Poland's Energy Policy until 2040 shows that within 17 years Poland's coal-fired electricity generation will be reduced from the current 77% to just 8%. Hard coal would account for 7.5% and lignite for 0.8% of the foregoing. Instead, energy production from so-called renewable sources will increase sharply. In 2040, RES are expected to cover almost 51% of Poland's electricity needs and nuclear power 23%. Gas is expected to generate 15% of Poland’s electricity (Cukiernik, 2023). Poland’s energy policy until 2040 assumes the construction of three nuclear power plants. It is estimated that a total investment outlay of PLN 1.5-2.0 trillion is needed for the transformation of Poland's energy sector and elimination of obsolete coal blocks. Some of the funds will come from various types of funds including the Modernisation Fund, the Energy Transformation Fund, the Innovation Fund, the EnIKS Fund, ReactEU and funds from the National Reconstruction Fund (Skłodowska, 2021). Energy companies will use their financial surplus as well as bank loans and green bond issues to finance this transformation.

The third hypothesis was also positively verified. The degree to which expenditure on tangible assets was financed varied, in both Polish and foreign companies. However, foreign companies used their surpluses more extensively to finance growth than their Polish counterparts. The varying share of financial surplus in capital expenditure resulted from fluctuating profit/loss. Such changes are influenced by a number of macroeconomic factors, including the economic situation, fluctuations in the price of energy carriers and their

availability. The size of the financial result is also significantly affected by internal factors, including changes in energy carriers, the level of indebtedness of companies and the burden of interest on the companies' profit/loss, the structure of long-term assets and the share of depreciable components therein, the rate of implementation of innovations reducing costs of energy production, etc.

In conclusion, it should be noted that the results of this study may be a seed for further research and an attempt to answer the question of the extent to which the surplus will finance the energy industry's restructuring processes and further what part of the funds must be raised on the domestic and international debt market. The way in which the financial surplus is used by international companies and the pace of restructuring can provide a benchmark for Polish energy companies helping them to minimize erroneous decisions in the area of using the financial surplus.

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CONTEMPORARY CHALLENGES FOR SUBSIDIARIES MORE AUTONOMY OR RESTRICTIONS

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Purpose: The purpose of the study is to identify the level of decision-making autonomy of subsidiaries of multinational automotive companies located in Poland and to determine whether this level will increase or decrease? Around the main objective formulated in this way, the following specific objectives were established: (1) to recognize the current level of decision-making autonomy of subsidiaries; (2) to determine the direction of change (increase/decrease) in the level of decision-making autonomy of subsidiaries.
Design/methodology/approach: The survey method and the method of content analysis of source materials were used. The electronic questionnaire was answered by the directors of subsidiaries, who make up the so-called local management. The survey was conducted in the second quarter of 2023 on a sample of 32 subsidiaries.
Findings: Subsidiaries show an average level of decision-making autonomy in functional areas (1.85 on a 3-degree scale). Subsidiaries have the highest level of autonomy in the technical and personnel areas and the lowest in the marketing and sales sphere. This indicates the manufacturing nature of the subsidiaries with a strongly developed personnel function.
Research limitations/implications: The research was limited to thirty-two automotive subsidiaries. The results presented should serve as a starting point for research on a larger research sample.
Practical implications: The results and conclusions presented in the article can be used by headquarters managers, including those in other sectors, when designing the level of autonomy of subsidiaries. Changes in the level of autonomy of subsidiaries should take into account the opinion of subsidiary managers, and therefore not just one but two sides.
Originality/value: Demonstrate the existing level of decision-making autonomy of subsidiaries with particular emphasis on functional areas, strategic decisions made, decisions made in key areas of the division. To indicate the directions of changes in autonomy taking into account the Covid 19 pandemic and the contemporary challenges facing organizations.

Keywords: Subsidiary, parent company, decision-making autonomy.

Category of the paper: Research paper

1. Introduction

Among the areas that can and should be shaped by the enterprise is the modeling of the organizational structure, ensuring that it is up-to-date with the needs of the enterprise, as well as an adequate degree of formalization (Lichtarski, Grzesik, 2018, p. 265). The organizational structure is one of the areas for improving the management system of modern organizations (Czekaj, 2013, p. 8). It is one of the basic components of an organization and is of great importance for its functioning (Lichtarski, 2011, p. 13). As a rule, the structure is temporary in nature. It works well at a certain time and under certain environmental conditions. According to A. Zakrzewska-Bielawska, the environment is one of the key structuring factors, which means that it influences the creation of the organizational structure and the changes occurring in it (Zakrzewska-Bielawska, 2015, p. 106). In recent years, we have seen significant changes in the economic space. Among them can be mentioned the challenges of limited access to workers, remote work, the development of electromobility, the increase in the price of energy resources, the effects of the Covid-19 pandemic. These, but also many other challenges affect the contemporary shape of the organizational structure. Its dimensions are being modified, including centralization. In the trend toward centralization of management, subsidiaries are being stripped of their decision-making rights. Their role is to implement decisions made at the parent company. According to J. Karpacz, an environment dominated by command and control limits employees' independence to make decisions and take on new challenges. Individuals operating in such an environment quickly learn that thinking and acting is pointless by which they fail to take initiatives (Karpacz, 2013, p. 108). When new challenges arise, they are unable to react quickly. On the other hand, increasing the decision-making powers of subsidiary managers promotes decentralization of management. Thus, it increases their involvement in business processes and imposes on local boards of directors to take more responsibility for the performance of the entire group (conglomerate). Decentralization is conducive to increasing the position of the individual in the group, who is given additional powers. Greater autonomy of the individual in the organization leads to greater motivation, increased creativity, faster development and, as a result, greater staff stability (Stańczyk-Hugiet, 2012, p. 14). Decentralization is a trade-off between the higher knowledge of local managers and the loss of control at headquarters (Acemoglu, Aghion, Lelarge, van Reenen, Zilibotti, 2007). According to Hamermesh and White, subsidiary autonomy refers to the degree to which business unit managers can make decisions independently of other parts of the company, especially corporate headquarters Hamermesh and White (1984, p. 104).

The issue of subsidiary autonomy is one of the more difficult problems in both management theory and practice. The apparent disorder in this topic is caused, among other things, by problems in measuring certain variables, such as subsidiary autonomy (Gorynia, Samelak, 2013, p. 17). The purpose of this study is to identify the level of decision-making autonomy of subsidiaries of multinational automotive companies located in Poland and to determine whether this level will increase or decrease?

2. Research methodology

The research conducted among foreign subsidiaries[1] of multinational corporations located in Poland was aimed at recognizing their level of decision-making autonomy. Answers were sought to the following questions: what is the level of decision-making autonomy of the subsidiaries? and whether this level will increase or decrease? Decision-making autonomy and its changes were identified based on the implementation of the following research tasks:

Task 1. Identify the current level of subsidiary decision-making autonomy in terms of functional areas.

Task 2. To identify the influence of the local board of directors on strategic decisions concerning the entire group and the subsidiary.

Task 3. Identify the influence of the local management on decision-making in key areas of the subsidiary.

Task 4. Identify changes implemented in the organizational structure of the subsidiary (within the last year).

Task 5. Identify the scope of functions implemented in the subsidiary and their importance in achieving its goals.

Task 6. Identify the impact of the Covid 19 pandemic on the level of decision-making autonomy over the various functional areas of the subsidiary.

Task 7. Identify contemporary challenges shaping the subsidiary's decision-making autonomy.

The sample for the study was selected in a purposive manner. This was due to several considerations. The first, which the researcher usually has to deal with and accompany him in the research process, is generally due to the reluctance of the top management of organizations (in this case, subsidiaries) to engage in any research, which consequently affects the high degree of refusal of managers to participate in research processes. Hence, the electronic survey questionnaire was made available to respondents after prior discussion with them and their acceptance to participate in the study. Secondly, the business subordination of the local management of the company's headquarters has its consequences in decision-making. Obtaining permission to take part in a survey usually has to be approved by headquarters, which in turn may not be interested in involving its units in any research. Third, purposive selection reduces time in data acquisition and generates lower costs compared to random selection.

The questionnaire was answered by plant directors, who make up the so-called local board. They had extensive knowledge of the plant's operation, including its decision-making autonomy. The questionnaire, consisting of closed-ended questions, was prepared in electronic form and the link to it was sent by email only to those respondents who agreed to take part in

[1] Subsidiaries of multinational corporations located in Poland participating in the survey have limited liability company status.

the survey. The survey was conducted in Q2 2023 on a sample of 32 subsidiaries[2]. Although an effort was made to reach 70 subsidiaries, 40 of them were not interested in taking part in the survey. The collected empirical material from closed questions was presented in the form of tables, figures. The choice of purposive sampling for the study has limitations. It does not ensure representativeness. Thus, the results and conclusions of the study presented in the following section apply only to the participating companies. Any generalization of the results to the entire automotive sector is unauthorized.

3. Characteristics of subsidiaries

The study involved 32 subsidiaries of multinational corporations located in Poland representing the automotive sector (Table 1). Their main business is the production of automotive components for the internal and external markets. The companies participating in the study perform a wide range of technical and market functions.

Table 1.
Characteristics of subsidiaries participating in the study

Characteristics of subsidiaries	Number of subsidiaries	% of responses
(1) Size of the organization		
More than 500 employees	20	62,5
251 - 500	4	12,5
50-250	8	25
Less than 50	-	-
(2) Business object		
Production for internal and external markets	20	62,5
Production for the external market	12	37,5
(3) Country of origin of the company's headquarters		
Countries within the European Union	24	75
Countries outside the European Union	8	25

Source: own elaboration based on questionnaires.

Subsidiaries with more than 500 employees represented the largest sample. They accounted for 62.5% of the total surveyed organizations participating in the study. The second group of companies in terms of size were subsidiaries with 50 to 250 employees. They accounted for 25% of the total number of surveyed organizations. The least numerous group of companies were those with 251 to 500 employees. They accounted for 12.5% of the total number of surveyed organizations. The sample was dominated by companies that produce for the group's internal needs and for the external market (62.5% of indications). On the one hand, they perform certain operations in the group's (concern's) production chain, such as producing components (details) or finished products and selling them to other branches of the group for the next phase

[2] Number of companies in the sector: 342 firms (Manufacture of motor vehicles, trailers and semi-trailers, firms with more than 49 employees). Source: https://www.paih.gov.pl/sektory/motoryzacja, 31.07.2023.

of processing, assembly, on the other hand, they produce components (details) or finished products and sell them to companies outside the group. The remaining 37.5% of subsidiaries produce automotive components only for the external market. The largest number of companies had headquarters located in European Union countries (75% of indications). Outside the EU, 25% of the surveyed subsidiaries were located.

4. Results and conclusions of the study

Based on the assumptions made in the earlier part of the paper (research methodology), a research procedure was carried out to identify the current level of decision-making autonomy of subsidiaries and its directions of change. The results and conclusions of the research are presented in the order of the research tasks set.

Task 1. Identification of the subsidiary's existing level of decision-making autonomy in terms of functional areas.

Identification of the existing level of decision-making autonomy consisted of assigning the functional areas of the analyzed subsidiaries a scale from 0 to 3, where 0 means no decision-making autonomy, 1 - low level of decision-making autonomy, 2 - medium level of decision-making autonomy and 3 - high level of decision-making autonomy. The results of the study are shown in Table 2.

The analysis of the results shows the average level of decision-making autonomy of the branches in terms of functional areas (1.85). Branches have the highest level of decision-making autonomy in production (3), maintenance (3), logistics (2.87), quality control (2.5) and human resources (2.25). A moderate level of autonomy was identified in finance (1.75). Moderately low levels of decision-making autonomy were identified in purchasing (1.25), IT (1.25) and R&D (1.12). Low levels of autonomy were identified in sales and marketing (0.62 and 0.75, respectively). In the area of sales and marketing, there is a fairly high level of centralization within the internal policies of the group (headquarters). This is also evidenced by the fact that in half of the surveyed branches no decisions are made in these functions. Lack of decision-making freedom was also recognized in twelve branches in R&D, purchasing and IT. This testifies to the full centralization of decisions in these functions.

The results presented here indicate the typically manufacturing nature of the subsidiaries, which, in order to carry out day-to-day tasks and respond quickly to changes in the production sphere, must be equipped with the necessary authority for functions of a technical character.

Table 2.
Decision-making autonomy of subsidiaries in functional are

Functional areas of subsidiaries	Overall level of autonomy	Number of subsidiaries declaring lack of decision-making autonomy (N = 32)
Production	3	0
Maintenance	3	0
Logistics	2,87	0
Purchasing	1,25	12
Sales (Product Management)	0,62	16
Marketing	0,75	16
Human Resources	2,25	4
Finance	1,75	4
IT	1,25	12
Quality control	2,5	0
Research and development	1,12	12
Level of autonomy of subsidiaries	**1,85**	

Source: own elaboration based on questionnaires.

Task 2. Determine the influence of the local management on strategic decisions concerning the entire group and the subsidiary.

The influence of the local board of directors on strategic decisions is shown in Table 3. All of the subsidiaries participating in the survey have an influence on strategic decisions concerning their operations. Including half of them, they participate in strategic decisions concerning the entire group. Thus, their level of decision-making autonomy is higher than that of the other companies, as they can influence the group's development directions.

Table 3.
Influence of subsidiaries on strategic decisions

Influence of local management on strategic decisions concerning	Number of indications	% of responses
the entire group	16	50%
subsidiary	32	100 %

Source: own elaboration based on questionnaires.

Task 3. Recognize the influence of the local management on decision-making in the subsidiary's key areas.

The place of decision-making in the seventeen selected key areas of the subsidiary is shown in Table 4. Only in the area, staffing of executive positions, the vast majority of subsidiaries (24 indications) make decisions on their own. In the remaining areas, decisions are made by the parent company or jointly with the subsidiary. Key areas dominated by the headquarters include new product launches (24 indications), approval of the branch's budget (24), negotiating terms of sale of products/services (24), finding new customers (20), and marketing activities (20). Key areas within which joint decision-making dominates are: product modernization (24), creation of new business units (24), introduction of new technology (20), staffing of local management positions (20), staffing of director positions (20), investment in machinery, equipment, the purchase of which exceeds monthly net turnover (20).

When examining the key areas of a subsidiary, it can be seen that as the rank of a job position decreases, their participation in self-determination regarding staffing increases. A large percentage of surveyed subsidiaries declare joint decision-making in increasing the size of the organizational structure as a result of separating new cells, departments, organizational divisions. While the rationale (comments) of the company's branch managers can be taken into account in the design of new organizational units, their de facto influence on increasing the freedom of action of the entire company branch is limited. As evidenced by the other results of the study.

Table 4.
Decision-making place in key areas of subsidiaries

Decisions in key areas of the subsidiary	Decision-making place (N = 32)		
	Parent Company	Subsidiary	Together
Introduction of a new product	26		6
Modernization of products	8		24
Introduction of new technology	12		20
Staffing of local management positions	12		20
Staffing of director positions	12		20
Staffing of executive positions	16		16
Staffing of executive positions		24	8
Creation of new organizational units (cells, departments, divisions)	8		24
Selection of funding sources	16		16
Investment in real estate (e.g., construction of a new production hall)	16		16
Investment in machinery, equipment, the purchase of which exceeds the monthly net turnover	12		20
Search for strategic suppliers located close to the branch	16		16
Determining the volume of production in a given year	16		16
Approve the branch's budget	24		8
Negotiate terms of sale of products/services	24		8
Searching for new customers	20		12
Marketing activities	20		12

Source: own elaboration based on questionnaires.

Task 4. Identify changes implemented in the organizational structure of the subsidiary.

Identified changes implemented in subsidiary companies over the past year are shown in Table 5. The results indicate that both expansion, slimming down and adaptation of existing organizational solutions were taking place in the surveyed subsidiaries. In the majority of the company's subsidiaries, job responsibilities were increased (20 indications), organizational procedures (20), the degree of use of information systems in the subsidiary, product offerings (20 indications each, respectively) and the number of organizational units (16). Director positions (12) and managerial positions (8) were singled out. These changes were conducive to increasing the size of the structure of the subsidiaries and the corporation as a whole.

Increasing job responsibilities may be indicative of problems in recruiting employees with the right skills and burdening existing staff with new responsibilities. On the other hand, the increase in the use of IT systems in subsidiaries has its origins in the Covid-19 pandemic, when, due to the reduction of direct contacts between employees, IT began to be used more

extensively in day-to-day work. This trend continues in most subsidiaries and can be assumed to extend to more and more functional spheres of the companies. Increasing the subsidiary's product offerings (through the implementation of new automotive projects in the companies) has its origins in production costs. They are lower in the host country (Poland) than in the home country. Hence, headquarters are inclined to transfer existing or new projects to subsidiaries for implementation. While this is not a new way for head offices to operate, this direction may deepen due to strong competition in the automotive market, the introduction of electric cars which will consequently force managers to look for places where the production of automotive components or finished cars will be as cheap as possible.

Table 5.
Changes implemented in subsidiaries during the last year

Changes implemented at subsidiaries over the past year	Direction of change (N = 32)		
	Increased	No change	Decreased
Product offerings	20	12	0
Management levels	8	16	8
Director positions	12	20	0
Managerial positions	8	20	4
Executive positions	12	12	8
Responsibilities of job positions	20	12	0
Organizational cells	16	6	10
Organizational documents	12	20	0
Organizational procedures	20	12	0
Degree of use of information systems in the subsidiary company	20	12	0

Source: own elaboration based on questionnaires.

Task 5. Determining the scope of functions performed in the subsidiary and their importance in achieving its goals.

Identification of the importance of functional areas in achieving the goals of a company branch consisted in assigning a scale from 0 to 3 to the functional areas of the analyzed company branches, where 0 means an unimportant functional area, 1 - a functional area of little importance, 2 - a medium degree of importance of a functional area and 3 - a high degree of importance. functional area. The research results are presented in Table 6. The analysis of the results indicates an average high degree of importance of functional areas in achieving the goals of the subsidiary (2.45). In turn, the analysis of individual functional areas allows the following conclusions to be formulated:

- the greatest importance was assigned to the functions production (3.0), maintenance (2.87), logistics (2.75), finance (2.75), quality control (2.62), human resources (2.37), IT (2.37) and R&D (2.37),
- medium importance was assigned to the functions purchasing (2.12), sales (2.12), marketing (2.0),

- marketing is a functional area of little importance in achieving the company's goals in half of the surveyed companies (in 16 companies), R&D (in 8), purchasing (4), sales (4), human resources (4) and IT (4),
- none of the companies indicated an invalid functional area.

The results regarding the importance of functions are consistent with the results of decision-making autonomy in the case of the following functions: production, maintenance, logistics, quality control and human resources. Local companies have the greatest decision-making independence in the above-mentioned functions and at the same time attach the greatest importance to them. This indicates the typical production nature of subsidiaries in which technical functions play a leading role compared to market functions, i.e. marketing and sales. Managers are aware of the role and importance of marketing and sales in the process of generating company turnover, assigning medium importance to these areas. They receive strong support for these functions from the group's Shared Services Center (Table 7). This also shows that the development of the marketing and sales function at the branch level is limited. This is justified by the results of decision-making autonomy. Subsidiaries have the least decision-making independence in the field of sales and marketing.

Table 6.
The scope of functions performed in the subsidiary and their importance in achieving its goals

Functional areas of subsidiaries	Overall level of importance
Production	3,0
Maintenance	2,87
Logistics	2,75
Purchase	2,12
Sales (Product Management)	2,12
Marketing	2,0
Personnel	2,37
Finances	2,75
IT	2,37
Quality control	2,62
Research and development	2,37
The level of importance of functional areas in achieving the goals of subsidiaries	**2,45**

Source: own elaboration based on questionnaires.

Table 7.
Implementation of the marketing and sales function by the Shared Services Center

Support in the implementation of the marketing and sales function by the group's Shared Services Center	Number of indications	% of responses
Tak	28	87,5%
Nie	4	12,5%

Source: own elaboration based on questionnaires.

Task 6. Identifying the impact of the Covid 19 pandemic on the level of decision-making autonomy in individual functional areas of the subsidiary.

Identification of the impact of the Covid 19 pandemic on the level of decision-making autonomy consisted in assigning the functional areas of the analyzed subsidiaries on a scale from 0 to 4, where 0 means no impact, 1 - the scope of decision-making autonomy was reduced, 2 - the scope of decision-making autonomy was slightly increased, 3 - to a medium extent the scope of decision-making autonomy has been increased to a large extent, 4 - the scope of decision-making autonomy has been significantly increased. The research results are presented in table 8. The analysis of the results shows a low level of increase in the autonomy of subsidiaries (0.49) under the influence of the Covid 19 pandemic. The highest increase in autonomy was observed in the field of IT (1.12), purchases (1.12), production (0.75), maintenance (0.75) and quality control (0.75). The smallest in terms of sales (0.12). Quite a large percentage of respondents declare that the Covid 19 pandemic has not changed their level of decision-making independence. In general, it can be seen, against the background of all the analyzed functional areas, that in every second company surveyed after the impact of the pandemic, autonomy in the field of purchasing and IT increased slightly. As a result of the pandemic, supply chains were interrupted. The implementation of central production assumptions was subject to significant fluctuations. Companies limited production due to shortages of materials and raw materials. Local staff were involved to a greater extent than before the pandemic in searching for new suppliers (including for strategic raw materials), equipping them with additional decision-making powers. In turn, the development of remote work and the use of IT in almost every functional area of the branch contributed to increasing decision-making independence in this function.

Table 8.
The impact of the Covid 19 pandemic on the level of decision-making autonomy of subsidiaries

Functional areas of subsidiaries	**The impact of the Covid 19 pandemic on the level of decision-making autonomy**		
	Overall level of increase in autonomy	**Number of subsidiaries declaring no influence**	**Number of subsidiaries declaring a reduction in decision-making autonomy**
Production	0,75	20	0
Maintenance	0,75	20	0
Logistics	0,375	24	0
Purchase	1,125	16	0
Sales (Product Management)	0,125	28	0
Marketing	0	28	4
Personnel	0,5	24	0
Finances	0,375	20	4
IT	1,125	16	0
Quality control	0,75	20	0
Research and development	0,5	20	0
Increased level of autonomy of subsidiaries	**0,49**		

Source: own elaboration based on questionnaires.

Task 7. Identification of contemporary challenges shaping the decision-making autonomy of subsidiaries.

According to the majority of managers of subsidiaries, the increase in their autonomy may be influenced by problems with access to executive employees (20 indications), problems with access to highly qualified engineering staff (24 indications) as well as the challenges of remote work (16 indications) – Table 8. The challenges indicated here shape the current operating policy of companies whose main task is to maintain continuity of production and on-time deliveries. Employment fluctuation, problems with hiring employees with appropriate qualifications or lack of employees will pose a big challenge for local managers. In their opinion, meeting them requires increased freedom of action. | In turn, a significant number of branch managers indicate that the increase in competitiveness in the industry (32 indications), the search for new markets (28), the increase in the prices of products for individual customers (28), electromobility (28) or restrictions in access to rare raw materials (28) will not increase the autonomy of subsidiaries in the future. It can therefore be concluded that these are challenges that head office managers will have to face.

Table 8.
Contemporary challenges shaping the decision-making autonomy of subsidiaries

Challenges of modern times	**Direction of change in decision-making autonomy (N = 32)**		
	It will increase	**Without changes**	**Will get smaller**
	Number of subsidiaries		
Reconstructing disrupted supply chains after the Covid-19 pandemic	4	24	4
Restrictions on access to raw materials needed in production processes (e.g. lithium, cobalt, aluminum)	4	28	0
Energy crisis	8	20	4
Electromobility	0	28	4
Problems with access to executive employees	20	12	0
Problems with access to highly qualified engineering staff	24	8	0
Price increases for products for individual customers	4	28	0
Remote work	16	12	4
Reducing operating costs	12	20	0
Increased product innovation	12	20	0
Searching for new sales markets	0	28	4
Increased competitiveness in the industry	0	32	0

Source: own elaboration based on questionnaires.

5. Conclusion

The research results presented in the study allow us to learn about the opinions and arguments of managers of subsidiaries of international corporations from the automotive sector participating in the research. It should be clearly emphasized here that this was a one-sided study. Only managers of subsidiaries, not headquarters, participated in it. The participation of

top management in the research could verify the findings of the local management of the surveyed companies, whose views (including assessments) are subject to some subjectivity. Managers assessed decision-making autonomy and its directions of changes having knowledge about their companies (their needs) and general knowledge about the functioning of the entire concern. If it turns out that the arguments of the headquarters prevail in terms of the level of branch autonomy, and their views on this matter formulated from the point of view of the entire organization are different from the position of branch managers, one would have to agree with them. Branch headquarters should learn the position (opinions) of the management of local companies regarding their level of decision-making autonomy. Even if it turned out that it would not be taken into account in the design of increasing or decreasing their freedom of action.

When considering the current level of autonomy of the examined subsidiaries and its directions of change, several basic conclusions can be formulated:

- subsidiaries demonstrate an average level of decision-making autonomy in functional areas (1.85 on a 3-point scale). Companies have the highest level of autonomy in technical functions, such as production (3), maintenance (3), logistics (2.87), quality control (2.5) and in the personnel function (2.25). At the same time, they attribute the greatest importance to these functions compared to the others. In turn, companies have the least freedom of action in the field of sales and marketing. This proves the typical production nature of the branches with extensive independence of operation in the production sphere and central support in the field of market functions (marketing, sales);
- branch managers have influence on strategic decisions regarding their operation, half of them also have influence on decisions regarding the entire group;
- decisions regarding key areas of operation of subsidiaries are made independently by the parent company or with its participation. Only when it comes to filling executive positions, the vast majority of companies make decisions on their own;
- in the last year, companies did not provide new functions that would allow them to obtain new authorizations and thus increase their autonomy. There was a tendency to burden employees with new tasks, increase the product offer and use IT systems on a larger scale than before;
- the Covid-19 pandemic did not change their level of autonomy in most branches. And its slight increase by 0.49 on a 3-point scale was recorded in a smaller number of surveyed companies in the area of purchasing and IT,
- in the future, the autonomy of companies may increase due to problems with access to executive employees and highly qualified engineering staff, as well as due to the development of remote work. It can be assumed that the importance of the personnel function at the level of local branches will increase.

To sum up, it should be stated that in the examined subsidiaries the production sphere is very important, within which managers have considerable freedom of action. It determines the level of autonomy of companies. It can be assumed that the headquarters will strive to expand the production area of the branches by assigning additional authorizations, which will ultimately contribute to increasing their autonomy. Also, the personnel function, which currently plays an important role in the surveyed branches, will play an increasingly important role in the future. The strong support the branches receive in the areas of, among others: sales and marketing from the Shared Services Center, indicates a tendency to move away from developing these functions at the level of local companies, but may also exclude their location in new branches in the future.

The author is aware that limiting the study population to 32 companies does not fully illustrate the ongoing changes in autonomy. However, it shows a certain direction of changes that may occur in other subsidiary companies, especially in the automotive industry.

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COMPARISON OF THE FINANCIAL SITUATION OF CITIES WITH POWIAT RIGHTS IN POLAND AND MUNICIPALITIES IN THE YEARS 2010-2021

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Purpose: The aim of the article is to identify and assess the financial situation of cities with poviat rights in Poland and urban, urban-rural and rural communes against the background of the entire country in the years 2010-2021.
Design/methodology/approach: The article identifies and assesses the financial situation of cities with poviat rights in Poland and urban, urban-rural, and rural communes against the background of the entire country in 2010-2021. The empirical material of the article concerns both the entire country and all cities with poviat rights in Poland, as well as all urban, urban-rural and rural communes. The figures come from the Local Data Bank of the Central Statistical Office in Warsaw and concern the years 2010-2021. The empirical material collected and ordered was developed in a descriptive, tabular, and graphical form, using the method of comparative analysis, with comparisons made in time and space. In addition, all diagnostic features illustrating the financial situation of cities with poviat rights in Poland and urban, urban-rural and rural communes against the background of the entire country for the years 2010-2021 were assessed, which is a new approach to the research problem addressed in the article.
Findings: The analysis of statistical data confirmed the research hypothesis, which assumes that the presence of a city, especially a larger one, is an important factor that positively and permanently affects the financial situation of local government units in Poland, hence cities with poviat rights are characterized by a better financial situation compared to municipalities.
Originality/value: The originality of the work lies in the approach to the analysis of the research issues undertaken. The point assessment of the financial situation of the surveyed local government units was carried out in the context of the country. The work is addressed primarily to local government officials responsible for public local government finances, as well as for the conditions, opportunities, and directions of local socioeconomic development of cities with poviat rights in Poland and urban, urban-rural, and rural communes.

Keywords: cities with poviat rights in Poland, urban, urban-rural and rural communes, financial situation, changes in 2010-2021.

Category of the paper: research paper.

1. Introduction

Today, highly developed countries and their societies are moving towards the implementation of the concept of sustainable development, which is also related to the idea of sustainable finance. The analysis of the components of the sustainable development process shows that its effective implementation also depends on the extent of the involvement of the financial system. In addition, the idea of sustainable finance is gaining importance these days. The Nobel Prize winner Shiller confirms its relevance, legitimacy, and topicality, pointing out that the implementation of this concept should contribute to the improvement and growth of the broadly understood well-being of society. It should be added that public sector units, including local government units, are financially sustainable when they can generate sufficient income to perform basic functions and tasks and provide services at an acceptable level (Shiller, 2012; Alińska, Frydrych, Klein, 2018; Cyburt, Gałecka, 2020).

Local government is a key institution responsible for the implementation of many tasks that serve to meet the needs of primary importance for residents, as well as creating socioeconomic development in the regional and local system. The effectiveness of the implementation of tasks by local government units is largely dependent on effective financial management, and the guarantee of their implementation is the appropriate economic potential. Therefore, the quality of the local government finance system, considered as a set of institutions, legal norms, and tools defining the principles of local government financial management and used for its management, is of great importance in this regard (Grzebyk, Sołtysiak, Stec, Zając, 2020; Kata, Czudec, Zając, Zawora, 2022).

Cities are local government units of exceptional importance and influence on supra-local and even regional development, because it is in them that potentials, activities, and entities deciding on its course are concentrated. The measure of the city's strength is primarily its ability to shape development in the qualitative aspect, i.e., to generate new solutions and processes characterised by innovation and creativity. The pace, directions, possibilities, and nature of the development of modern cities are determined both by their ability to unconventionally use their potentials to achieve breakthrough ideas and by the skills and competences of functioning in various cooperation networks (Wrana, 2013).

One of the main criteria for evaluating the effectiveness of actions undertaken by city governments is the ability to compete. The successful competition for a significant investor, the location of an important institution, a prestigious event, or for new residents is a tangible and often spectacular testimony to the success of the policy implemented by local government authorities. Competing is also a process that motivates various entities to increase the effectiveness of their own activities or implement innovations. Competition between cities leads to the strengthening of cities themselves, as well as to the strengthening of the regional structure. However, the importance of cooperation as a competence that determines the rank of

the city and the possibilities of its development is being revealed with increasing force. Therefore, today one of the most important factors determining the development of a city is its social potential, which is usually identified by: 1. an efficient leader, able to formulate a long-term vision of the development of a given local system, able to gather the local elite around him; 2. the local elite, bringing together the most active and creative actors; 3. the functioning of local institutions stabilising the leader's actions and stimulating local development; 4. the activity of the local community joining projects initiated by local government authorities or initiating development themselves; 5. willingness of local governments to cooperate between communes; and small and medium-sized enterprises strengthening the local entrepreneurial fabric. Attributing a key role in the development of the city to the aforementioned factors results from many reasons, but the most important of them lies in the statement that the way of using the values and resources of the local environment is ultimately always the responsibility of the human factor, which, through its actions, can either create a development factor out of them, or a limiting barrier (Wrana, 2013; Tuziak, 2014; Kulawiak, 2016).

The financial management of local government units is a complex process, conducted in compliance with legislative requirements within the local government budget. Ensuring the efficient and correct operation of this specific economy, which consists primarily of cash and assets, requires strict compliance with many legal acts, standards, as well as budgetary principles. As part of the financial management of local government units, various public tasks and financial operations are carried out, relating to individual public finance departments, and various legal and financial methods and instruments are used (Chojna-Duch, 2003; Kosek-Wojnar, Surówka, 2007; Sołtyk, 2017; Sołtysiak, 2017; Sołtysiak, Suraj, 2018; Sołtysiak, Zając, 2023).

The financial management of local government units consists in collecting revenues and revenues as well as in making expenses and outlays in order to perform own and commissioned tasks, while it determines their development and competitiveness and secures the fulfillment of current and future needs of residents. When assessing the income side of the budget of local government units, it is important to study the status and changes in the level of income, its dynamics and structure, as well as spatial differentiation. On the other hand, the analysis and assessment of the expenditure side of the budget allows to determine to what extent financial resources are allocated to solving current problems, and to what extent to the promotion, investments and development of local government units and to the improvement and increase of their competitiveness (Podstawka, 2005; Hybel, 2010; Błachut, Cierpiał-Wolan, Czudec, Kata, 2018; Sołtysiak, 2018; Grzebyk, Sołtysiak, Stec, Zając, 2020; Kata, Czudec, Zając, Zawora, 2022).

The financial management of public sector units, including local government units, should be conducive to rational spending of public funds and making appropriate decisions regarding the management of these funds. The primary objective in the financial management process should be maximizing the benefits from the resources held and minimizing losses and risks

associated with the undertaken activity, which is especially true for development projects, where benefits and costs are usually spread over time. Therefore, financial management should focus on: 1. shaping the size and structure of budget revenues and determining the ways and sources of their acquisition, 2. shaping the capital and property structure guaranteeing the maintenance of economic and financial balance, - in connection with the conducted current and investment activities, 3. influencing the level of risk accompanying the decisions taken, 4. monitoring and forecasting the financial and property situation, 5. ongoing assessment of the financial and property situation of the local government enabling the assessment of compliance of current, investment and financial activities with the accepted submissions, 6. assessment the impact of external conditions on investment and financial decisions, 7. formulating conclusions and recommendations regarding the conduct of business, 8. drawing up a financing strategy. A properly managed unit in the long term should develop the so-called "good indicators", i.e. those that prove its development. Particularly noteworthy is the concept of the financial situation of a local government unit interpreted as the ability of the local government to balance recurring expenditure needs with recurring sources of income, while implementing tasks resulting from the law, which are to serve to further multiply income and maximise public utility for its residents (Mrówczyńska-Kamińska, Kucharczyk, Średzińska, 2011; Adamczyk, Dawidowicz, 2016; Kowalska, Możyłowski, Śmietanka, 2019; Kata, Czudec, Zając, Zawora, 2022; Ociepa-Kicińska, Gorzałczyńska-Koczkodaj, Brzozowska, Pluskota, 2022).

When defining the financial situation of a local government unit, the following are most often emphasised: the possibility of financing services on a continuous basis, the complexity of healthy finances, the ability to repay liabilities, as well as maintaining the current level of services while maintaining resistance to the risk of changes over time. It seems that the most accurate is the interpretation of the financial situation of a local government unit, referring to its ability to meet its financial obligations on time and to maintain services provided to the local community (Filipiak, 2009, 2011; Dylewski, Filipiak, Gorzałczyńska-Koczkodaj, 2011; Wiśniewski, 2011; Kopyściański, Rólczyński, 2014; Zawora, 2015; Adamczyk, Dawidowicz, 2016; Kotowska, 2016; Natrini, Taufiq Ritonga, 2017; Ociepa-Kicińska, Gorzałczyńska-Koczkodaj, Brzozowska, Pluskota, 2022).

The financial situation of a local government unit is its financial condition in a specific period of time, which is the result of its income and its structure, expenses and their structure, the degree of use of repayable funds, activity, and effectiveness in obtaining extra-budgetary funds, as well as the efficiency of managing financial and material resources. Local authorities should care about the good financial situation of a given territorial unit, as it is a component of its competitiveness. In addition, it is evidenced, among others, the ability to perform tasks, achieve budget balance, increase property and to meet and meet the needs of residents. In addition, the good financial situation of local government units and the stability of public services they provide to residents undoubtedly have a clear and positive impact on broadly understood socioeconomic development, not only on the scale of a given local environment or

region, but even the entire country. Among a number of various conditions shaping the financial economy of a local government unit, including its financial situation, exogenous, endogenous, and mixed conditions are generally distinguished. In addition, some common categories can also be distinguished, which include social, economic, environmental, and spatial conditions, as well as institutional, legal, and political conditions. The catalogue of such factors is sometimes extended to include events whose effects cannot be predicted and which may fundamentally change the economic situation and the conditions of operation of local government units. Such an event in 2020 was the emergence of the coronavirus pandemic. It should be added that the analysis of the financial situation of a local government unit provides information about its current and future property and financial situation, and allows determining its possibilities and development prospects (Ossowska, Ziemińska, 2010; Zawora, 2015; Pedro Rodríguez Bolívar, Navarro Galera, Alcaide Muñoz, Deseada López Subires, 2016; Świrska, 2016; Bień, 2017; Standar, 2017; Stanny, Strzelczyk, 2018; Wójtowicz, 2018; Czudec, 2021).

2. Research aim, empirical material, and research methods

The aim of the article is to identify and assess the financial situation of cities with poviat rights in Poland and urban, urban-rural and rural communes against the background of the entire country in the years 2010-2021.

The article presents a research hypothesis, assuming that the presence of a city, especially a larger one, is an important factor that positively and permanently affects the financial situation of local government units in Poland, hence cities with poviat rights are characterized by a better financial situation compared to communes.

The empirical material of the article concerns both the entire country and all cities with poviat rights in Poland[1], as well as all urban, urban-rural and rural communes. The figures come from the Local Data Bank of the Central Statistical Office in Warsaw and concern the years 2010-2021. The collected and ordered empirical material was developed in a descriptive, tabular, and graphical form, using the method of comparative analysis, with comparisons made in time and space.

To identify and assess the financial situation of cities with poviat rights in Poland and urban, urban-rural, and rural communes, the following diagnostic features illustrating it were analysed in the years 2010-2021:

- total budget revenues of cities with poviat rights and communes per capita (PLN);
- own revenues of the budgets of cities with poviat rights and communes per capita (PLN);

[1] Excluding the capital city of Warsaw and its districts.

- share of own revenues in the total revenues of the budgets of cities with poviat rights and communes (%);
- total budget expenditures of cities with poviat rights and communes per capita (PLN);
- capital expenditures of the budgets of cities with poviat rights and communes per capita (PLN);
- share of investment expenditures in the total expenditures of the budgets of cities with poviat rights and communes (%).

The article evaluates all diagnostic features illustrating the financial situation of cities with poviat rights in Poland and urban, urban-rural and rural communes against the background of the entire country for the years 2010-2012, 2013-2015, 2016-2018 and 2019-2021. Individual diagnostic features were compared with the national average, which was assumed as 100 points, and their advantage or underweight was assessed accordingly in all cities with poviat rights and urban, urban-rural and rural communes. Then all points were summed up and the average was calculated (Figure 1). It should be emphasized that this is a new approach to the research problem addressed in the article.

3. Results

Among the cities with poviat rights in Poland, the smallest percentage, i.e. 18.5%, are units with the largest number of inhabitants, i.e. 200,000. and more. On the other hand, the percentage of cities with the smallest number of inhabitants, i.e. up to 100,000, is the highest, which amounts to 44.6%, while the percentage of cities with the number of inhabitants of 100-200,000 is 44.6%. they constitute 36.9% of all cities with poviat rights in Poland. On the other hand, among all communes without cities with poviat rights, rural communes constitute the largest percentage (61.5%). While urban-rural communes account for 26.3% of all communes without cities with poviat rights, the percentage of urban communes is by far the smallest and amounts to 12.2%.

The basic condition for effective and efficient performance by local government units of their statutory tasks is to ensure stable budget revenues, not only allowing for financing current expenses, but also enabling undertaking new investment tasks. In addition, the income system of local government units should ensure their fiscal stability, i.e. a relatively stable state in which local government authorities are able to provide a range of public services of appropriate quality, appropriate to the needs of the territorial community, and are able to stimulate socio-economic development. In turn, long-term fiscal stability creates the basis for the possibility of providing public services in a continuous and effective manner, as well as for settling related financial obligations (Wójtowicz, 2014a, 2014b, 2018; Poniatowicz, 2016; Czudec, 2021).

Table 1.
Total income of budgets of cities with poviat rights in Poland and urban, urban-rural and rural communes per capita against the background of the entire country in 2010-2021 (PLN)

Specification	Years			
	2010-2012	2013-2015	2016-2018	2019-2021
Poland				
Mean	3.448,3	3.944,1	4.970,2	6.576,2
Cities with poviat rights				
Mean	4.184,6	4.811,5	5.763,2	7.712,6
Coefficient of variation V (%)	17,2	16,4	13,7	15,5
Urban communes				
Mean	2.988,3	3.300,9	4.325,4	5.744,1
Coefficient of variation V (%)	56,4	34,6	24,3	20,1
Urban-rural communes				
Mean	2.971,7	3.283,9	4.306,3	5.708,8
Coefficient of variation V (%)	31,2	22,9	15,9	14,6
Rural communes				
Mean	3.097,5	3.423,1	4.455,3	5.974,1
Coefficient of variation V (%)	42,9	38,6	29,9	21,7

Source: Central Statistical Office in Warsaw.

As in the whole country, also in cities with poviat rights and in urban, urban-rural and rural communes, the average value of total budgetary income per capita increased in 2010-2021. In the analyzed period, the average value of total budgetary income per capita is higher in cities with poviat rights, compared to the national average. However, it is lower in communes and varies depending on their type, because it is the highest in the group of rural communes, while it is slightly lower and similar in the group of urban-rural and urban communes (Table 1).

It should be added that in the case of cities with poviat rights in Poland, the differentiation of this feature between individual cities is small in the analysed years, so its variability is low, which proves that these units are relatively homogeneous in this respect. However, in the case of communes, the differentiation of this feature between individual communes is greater and it is the smallest in the group of urban-rural communes. Furthermore, it decreases in the analysed years, so all the groups of communes become more homogeneous in this respect, especially in the group of urban-rural communes (Table 1).

Own income is a strategic element in the finance system of local government units, both from the point of view of the scope of financial independence, as well as in the context of the possibility of applying for funds from the European Union or other complementary sources of financing their activities, functioning, and development. In addition, a greater share of own revenues in total budget revenues allows local governments to manage financial resources more freely and creates the opportunity for them to conduct their own, uninterrupted economy and financial policy, aimed at improving the socio-economic situation and further development (Gołaszewska-Kaczan, 2005; Sobczyk, 2010; Sierak, 2015; Poniatowicz, 2016; Dziemianowicz, Kargol-Wasiluk, Bołtromiuk, 2018; Czudec, 2021; Szołno-Koguc, 2021).

In cities with county rights in Poland, the average value of their own budgets per capita increased in 2010-2021, similarly to the entire country and in urban, urban-rural, and rural communes. Cities with poviat rights are characterised by a higher average value of their own budgets per capita in 2010-2021, compared to the national average. While in communes it is lower and differentiated depending on their type, because it is clearly the highest in the group of urban communes, it is lower in the group of urban-rural communes, and definitely the lowest in the group of rural communes (Table 2).

Table 2.
Own revenues of the budgets of cities with poviat rights in Poland and urban, urban-rural and rural communes per capita against the background of the entire country in 2010-2021 (PLN)

Specification	Years			
	2010-2012	2013-2015	2016-2018	2019-2021
Poland				
Mean	1.824,9	2.179,1	2.536,3	3.208,6
Cities with poviat rights				
Mean	2.276,3	2.670,2	3.104,0	3.843,4
Coefficient of variation V (%)	29,0	25,2	26,2	23,7
Urban communes				
Mean	1.706,0	1.968,6	2.309,6	2.931,3
Coefficient of variation V (%)	75,5	48,4	38,4	36,2
Urban-rural communes				
Mean	1.292,2	1.539,4	1.789,2	2.380,7
Coefficient of variation V (%)	66,5	46,1	43,7	38,2
Rural communes				
Mean	1.097,1	1.357,2	1.567,3	2.154,8
Coefficient of variation V (%)	121,0	100,0	88,1	62,6

Source: Central Statistical Office in Warsaw.

It should be added that the differentiation of this feature between individual cities with poviat rights in Poland is rather small in the analysed years, i.e. these units are relatively homogeneous in this respect. On the other hand, in the case of communes, the differentiation of this feature between individual communes is large, with the greatest variation in the group of rural communes. In addition, it decreases in the analysed years, i.e. all groups of communes become more homogeneous in this respect, especially in the group of urban and urban-rural communes (Table 2).

In cities with poviat rights in Poland and in urban, urban-rural and rural communes, the share of own income in the total income of their budgets remains at a similar level in 2010-2021, i.e. the same as in the entire country. Cities with poviat rights and municipal communes are characterized by a similar share of own income in total income of their budgets in the analyzed years, as on average in the country. On the other hand, in urban-rural and rural communes, this share is lower compared to the whole country, but it is clearly the lowest in the group of rural communes (Table 3).

In addition, both in the case of cities with poviat rights in Poland and urban communes, the differentiation of this feature between individual units is small in the analyzed years, so its variability is low, which proves that they are relatively homogeneous in this respect.

On the other hand, in the group of urban-rural and rural communes, the differentiation of this feature between individual communes is greater, and this is especially true for the group of rural communes (Table 3).

Table 3.
Share of own revenues in the total revenues of the budgets of cities with poviat rights in Poland and urban, urban-rural and rural communes against the background of the entire country in 2010-2021 (%)

Specification	Years			
	2010-2012	2013-2015	2016-2018	2019-2021
Poland				
Mean	52,9	55,3	51,0	48,8
Cities with poviat rights				
Mean	54,2	55,3	53,4	49,7
Coefficient of variation V (%)	18,0	15,0	15,3	14,9
Urban communes				
Mean	56,3	59,0	52,7	50,3
Coefficient of variation V (%)	18,6	15,6	16,2	14,8
Urban-rural communes				
Mean	42,7	46,3	40,9	41,1
Coefficient of variation V (%)	31,8	27,2	28,2	24,5
Rural communes				
Mean	34,1	38,2	34,0	35,1
Coefficient of variation V (%)	40,1	34,4	35,6	30,3

Source: Central Statistical Office in Warsaw.

One of the basic elements of the financial policy of the state and local government is shaping the amount and structure of public expenditure, which is an important instrument for the implementation of many different political, economic, and social tasks. On the one hand, the amount of public expenditure depends on the current economic situation, on the other hand, it can be used, through the multiplier effect, to actively shape economic growth and reduce social inequalities. However, increasing public spending requires increasing public revenues or financing them from the budget deficit, which becomes impossible in a situation of limited economic growth and strong pressure to reduce the budget imbalance. Therefore, it is possible to optimise the structure of budget expenditures so that, taking into account the constraints resulting from the rigidity of many of them, it is possible to increase the share of expenditure categories that support the achievement of specific goals. In addition, to effectively influence the economy through public spending, it is necessary to take into account, apart from the level, its structure, efficiency and effectiveness, as well as the structure of taxes and budget constraints, because, as research shows, these factors are interrelated, and omitting one of them may weaken or distort the final effect (Owsiak, 2017; Gemmell, Kneller, Sanz, 2016; Ramey, 2019; Mikołajczyk, 2020).

The expenditure of local government units is the transfer of public funds for the implementation of their tasks, i.e. for meeting the collective needs of local and regional communities in the field of public utility. Therefore, the level and structure of these expenses are fully reflected in the directions of their activity. It should be added that the expenditure of

the local government sector is constantly growing, and this tendency has been observed in the law of constant increase in public expenditure, also known as the law of constantly increasing financial needs. On the other hand, among the reasons for the need to increase the expenditure of local government units, the following are distinguished: political, social, sociological and economic, many of which are complex and multifaceted in nature (Kańduła, 2010; Jastrzębska, 2012; Sołtysiak, 2017, Kata, Czudec, Zając, Zawora, 2022).

Table 4.
Total budget expenditures of cities with poviat rights in Poland and urban, urban-rural and rural communes per capita against the background of the entire country in 2010-2021 (PLN)

Specification	Years			
	2010-2012	2013-2015	2016-2018	2019-2021
Poland				
Mean	3.652,3	3.940,6	4.986,5	6.465,7
Cities with poviat rights				
Mean	4.428,8	4.903,9	5.774,6	7.717,4
Coefficient of variation V (%)	19,0	16,8	12,5	18,0
Urban communes				
Mean	3.108,3	3.279,5	4.347,8	5.586,3
Coefficient of variation V (%)	47,6	39,0	26,6	18,3
Urban-rural communes				
Mean	3.137,0	3.278,6	4.353,4	5.497,7
Coefficient of variation V (%)	31,7	29,4	16,7	15,4
Rural communes				
Mean	3.250,4	3.391,5	4.485,2	5.665,6
Coefficient of variation V (%)	34,1	35,4	28,5	23,2

Source: Central Statistical Office in Warsaw.

As in the whole country, also in cities with poviat rights and in urban, urban-rural and rural communes, the average value of total budget expenditure per capita increased in 2010-2021. In the analyzed period, the average value of total budget expenditure per capita is higher in cities with poviat rights, compared to the national average. However, it is lower in communes and varies depending on their type, because it is the highest in the group of rural communes, while it is slightly lower and similar in the group of urban-rural and urban communes (Table 4).

In the case of cities with poviat rights in Poland, the differentiation of this feature between individual cities is small in the analyzed years, so its variability is low, which proves that these units are relatively homogeneous in this respect. On the other hand, in the case of communes, the differentiation of this feature between individual communes is greater, and it is the smallest in the group of urban-rural communes. In addition, it decreases in the analyzed years, so all groups of communes become more homogeneous in this respect, especially in the group of urban-rural communes (Table 4).

The wealth of local government units clearly affects their investment opportunities, while units with higher budgetary income per capita, including their own income, usually also have a greater investment potential. On the other hand, the implementation of investments by local government units is one of their most important tasks, as it meets the needs of local communities

and contributes to their further socioeconomic development. Investment expenditures in the economy and financial policy of local government units, in addition to their own income, are therefore an important factor determining their prospects and development opportunities. It should be added that among the range of factors influencing the planning and implementation of local government investments, the most important are those included in the group of financial determinants related to the budgetary situation of local governments. Finance is therefore considered a key element and a basic determinant of the feasibility and success of each investment (Gołaszewska-Kaczan, 2005; Sobczyk, 2010; Filipiak, 2011; Dworakowska, 2013; Błachut, Cierpiał-Wolan, Czudec, Kata, 2018; Dziemianowicz, Kargol-Wasiluk, Bołtromiuk, 2018; Cyburt, Gałecka, 2020; Czudec, 2021; Szołno-Koguc, 2021).

In cities with poviat rights in Poland and in urban, urban-rural and rural communes, the average value of investment expenditures of their budgets per capita varies in the years 2010-2021, similarly as in the whole country, but it is the highest in 2019 -2021. However, cities with poviat rights are characterised by a higher average value of investment expenditures of their budgets per capita in 2010-2021, compared to the national average. On the other hand, in communes it is lower and varies depending on their type, because it is the highest in the group of rural communes, while it is slightly lower and similar in the group of urban-rural and urban communes (Table 5).

Table 5.
Investment expenditures of the budgets of cities with poviat rights in Poland and urban, urban-rural and rural communes per capita against the background of the entire country in 2010-2021 (PLN)

Specification	Years			
	2010-2012	2013-2015	2016-2018	2019-2021
Poland				
Mean	790,0	719,0	757,3	996,7
Cities with poviat rights				
Mean	943,2	936,9	812,0	1.265,4
Coefficient of variation V (%)	52,8	58,1	40,5	84,4
Urban communes				
Mean	696,8	535,0	684,1	860,9
Coefficient of variation V (%)	127,2	114,0	85,1	51,2
Urban-rural communes				
Mean	702,6	561,5	678,3	837,5
Coefficient of variation V (%)	78,5	97,6	52,4	52,8
Rural communes				
Mean	749,4	618,5	710,0	916,7
Coefficient of variation V (%)	66,6	84,2	72,3	62,4

Source: Central Statistical Office in Warsaw.

In turn, the differentiation of this feature between individual cities with poviat rights, as well as between individual urban, urban-rural and rural communes is usually large or even very large in the years studied, e.g. in the case of a group of urban communes in 2010-2015. It should be added that it clearly decreased in the group of urban-rural communes in 2016-2021 and in the group of urban and rural communes in 2019-2021. Thus, all groups of communes

without cities with poviat rights in Poland have become more homogeneous in this respect, especially in the group of urban-rural and urban communes (Table 5).

Table 6.
The share of investment expenditure in the total expenditure of the budgets of cities with poviat rights in Poland and urban, urban-rural and rural communes against the background of the entire country in 2010-2021 (%)

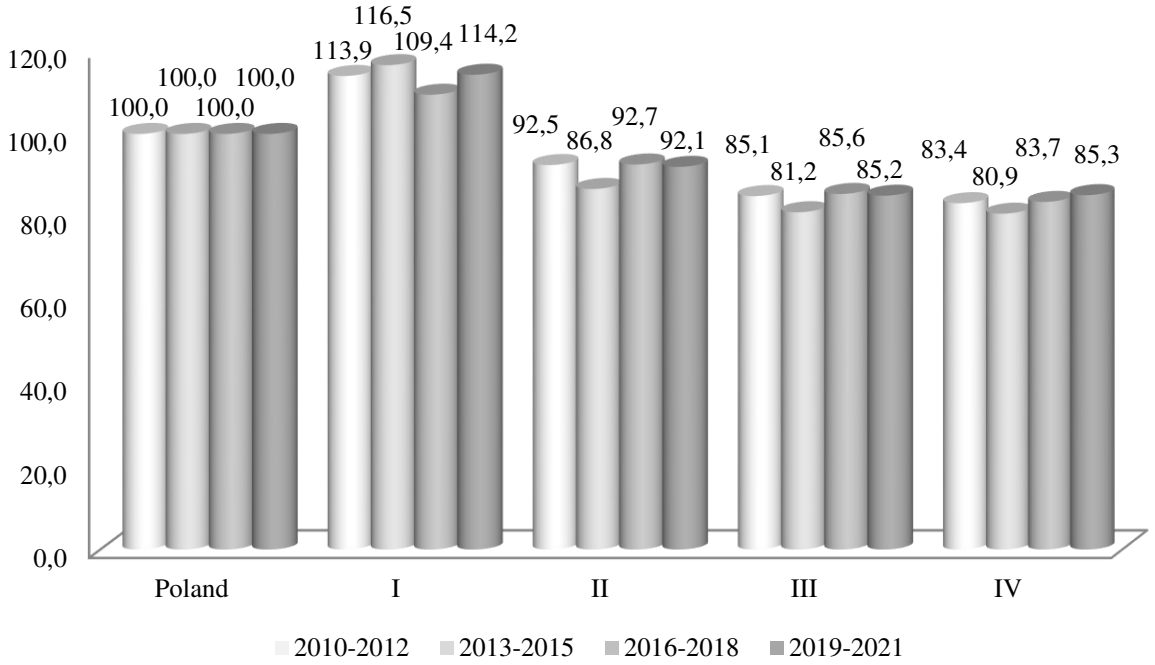
Specification	Years			
	2010-2012	2013-2015	2016-2018	2019-2021
Poland				
Mean	21,6	18,2	15,2	15,4
Cities with poviat rights				
Mean	20,4	18,2	13,8	15,4
Coefficient of variation V (%)	33,3	42,6	31,2	43,4
Urban communes				
Mean	20,6	15,1	14,8	14,9
Coefficient of variation V (%)	37,7	46,8	39,6	36,3
Urban-rural communes				
Mean	21,2	16,1	15,1	14,8
Coefficient of variation V (%)	36,7	44,4	40,8	39,6
Rural communes				
Mean	22,1	17,3	15,3	15,6
Coefficient of variation V (%)	36,8	43,7	41,9	40,6

Source: Central Statistical Office in Warsaw.

The share of investment expenditure in the total expenditure of the budgets of cities with poviat rights in Poland and urban, urban-rural and rural communes is very similar to the average for the entire country, but it decreased in 2010-2021. However, the differentiation of this feature between individual cities with poviat rights, as well as between individual urban, urban-rural and rural communes is quite large and remains at a similar level in the analyzed years (Table 6).

Evaluation and interpretation of the examined socio-economic phenomenon, using the point method of comparative analysis (e.g. on a scale from 0 to 100 points), using reliable numerical data, is an important instrument of the research apparatus, allowing to systematize and specify the results of the conducted analysis, and also for correct inference.

Figure 1 presents the results of the score assessment concerning the financial situation of cities with poviat rights in Poland and urban, urban-rural, and rural communes against the background of the entire country for the years 2010-2021. It should be noted that there are no major changes in this respect in the years analysed. Namely, cities with poviat rights in Poland in the entire period covered by the research are characterized by an average better financial situation compared to the average for the entire country, while communes have a worse financial situation, especially in the years 2013-2015. Moreover, there are no significant differences in terms of financial situation between urban, urban-rural, and rural communes. However, it should be added that the best financial situation in the analysed years is characterised by urban communes, and the worst by rural communes, with the exception of the years 2019-2021, where their financial situation is on average very similar or even slightly better than in urban-rural communes.



Explanations: I – cities with poviat rights; II – urban communes; III – urban-rural communes; IV – rural communes.

Figure 1. Score assessment of the financial situation of cities with poviat rights in Poland and urban, urban-rural and rural communes against the background of the country for the years 2010-2021 (Poland = 100.0 points)

Source: Own study.

All this therefore confirms the research hypothesis presented in the article, which assumes that the presence of a city, especially a larger one, is an important factor that positively and permanently affects the financial situation of local government units in Poland, hence cities with poviat rights are characterized by a better financial situation in compared to municipalities.

4. Summary and conclusions

Local governments of cities with poviat rights and urban, urban-rural and rural communes in Poland perform very important tasks and functions, both from the point of view of society and the economy, mainly by conducting an effective and efficient socio-economic development policy based on is responsible and rational financial management. It should be added that this is undoubtedly supported by the good financial situation of local government units, as well as the resulting high quality and stability of public services provided by them to the residents.

The analysis of statistical data showed that cities with poviat rights in Poland are, on average, in a better financial situation compared to urban, urban-rural and rural communes, as well as compared to the entire country in 2010-2021, and there are no major changes after that. compared to the entire study period. In addition, it was found that there are no significant differences in terms of financial situation between urban, urban-rural, and rural communes,

which are characterised by a worse financial situation compared to the average for the entire country, especially in rural communes.

Therefore, it allows us to confirm the research hypothesis, assuming that the presence of a city, especially a larger one, is an important factor that positively and permanently affects the financial situation of local government units in Poland, hence cities with poviat rights are characterized by a better financial situation compared to municipalities.

It should be added that the presented results of the analysis of statistical data provide relevant and up-to-date knowledge, which may be useful primarily for local government officials responsible for public local government finances, as well as for the conditions, possibilities, and directions of local socioeconomic development of cities with poviat rights in Poland and urban, urban-rural, and rural. At the same time, it justifies the need to continue similar research and analyses.

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KNOWLEDGE AND ACTIVITY OF THE YOUNG GENERATION OF POLES IN THE SCOPE OF THE FUNCTIONING OF LOCAL GOVERNMENT ENTITIES

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Purpose: The aim of the article is to identify and assess the level of knowledge related to the functioning and budget of local government units among representatives of the young generation of Poles (aged 18-25), as well as to determine the degree of their activity in the socio-political sphere of regional and local communities.
Design/methodology/approach: The article identifies and assesses the level of knowledge related to the functioning and budget of local government units among representatives of the young generation of Poles, and determines the degree of their activity in the socio-political sphere of regional and local communities. The empirical material of the article is the results of original surveys among 613 randomly selected representatives, studying representatives of the young generation of Polish residents aged 18 to 25 years. The research was conducted in 2023, using the CAWI (Computer Assisted Web Interview) method, via an online panel. The empirical material collected and organised was developed in a descriptive and graphical form, using the comparative analysis.
Findings: The analysis of the results of the author's survey research confirmed the research hypothesis presented in the article, which assumes that despite the fact that the young generation of Poles is open to the whole world, mainly via the Internet, they are also interested in problems on a regional and local scale, participating in their diagnosis and trying to solve.
Originality/value: The originality of the work consists in the presentation of the results of original survey research on the state of knowledge of the young generation of Poles about the functioning and budget of local government units and its activity in the socio-political sphere of regional and local communities, which significantly broaden the state of knowledge on this subject and reduce the research gap in this regard. The work is addressed primarily to local government officials responsible for the functioning and development of local government units and for public local government finances.

Keywords: knowledge and activity, the young generation of Poles, local government units and their functioning and budget.

Category of the paper: research paper.

1. Introduction

Local government is a key institution responsible for the implementation of many tasks that meet the needs of primary importance for residents and create socioeconomic development in the regional and local system. The essence and functioning of local self-government are related to the exercise of state power using administrative authority in the field of shaping public life in the commune, poviat, and voivodship. Local government units are nonstate and decentralized entities that have been granted tasks and competences in the field of public administration. Local government as a subject of public authority is the bearer of subjective rights assigned to it, and its essential function is to perform public tasks not reserved for other public law entities, i.e., primarily the state. The scope of tasks performed by the local government and their costs have a direct impact on the amount of financial resources it should have. Therefore, in order to carry out their tasks, local government units were equipped not only with their own property, but also obtained subjective rights to participate in public income according to the tasks assigned to them, to general subsidies and earmarked subsidies from the state budget, to determine the amount of taxes and fees, and to shape and implement public expenditure. In this context, one of the main aspects of the independence of the local government as a public authority entity is its financial independence, which means the right to independently conduct financial management. The limits of financial independence of local government units are determined by the scope of budgets and their competences in the field of shaping income and disposing of accumulated financial resources. Thus, financial independence understood in this way has an income and expenditure aspect as well as an aspect related to financial management based on the budget (Dębowska-Romanowska, 1995; Byjoch, Sulimierski, Tarno, 2000; Kotulski, 2000; Kornberger-Sokołowska, 2001; Glumińska-Pawlic, Sawicka, 2002; Jastrzębska, 2012; Grzebyk, Sołtysiak, Stec, Zając, 2020; Kata, Czudec, Zając, Zawora, 2022).

The basis for the financial management of a local government unit is, therefore, the budget. On the basis of its provisions, the unit implements the statutory objectives of its operation. Appropriate preparation of the budget, taking into account the social and economic needs of the local government unit, is the main duty of the commune head, mayor, or president. The basic rules and deadlines for the preparation and adoption of the budget, as well as its detail and necessary elements, are contained in the Public Finance Act. Regardless of statutory requirements, the preparation of the budget should take into account the principles of planning and management. Maintaining a purely administrative model of financial management is insufficient in light of the challenges faced by local government units. The appropriate analysis of the financial capabilities of a local government unit provides the basis for setting directions for its development and strategy of activities both in the budgetary perspective and beyond. The budget is the basic financial plan of a local government unit, combining income and expenses related to the implementation of both own and commissioned tasks. It is an act of

managing the financial management of a local government unit and, at the same time an instrument of implementing its policy (Dębowska-Romanowska, 1995; Gwoździcka-Piotrowska, 2012; Sołtysiak, 2017; Sołtysiak, 2018a; Sołtysiak, 2018b; Grzebyk, Sołtysiak, Stec, Zając, 2020).

Local authorities must look for ways to increase the conscious involvement of citizens in shaping the socio-economic decisions they make. One such way is the practical use of a form of participatory democracy developed three decades ago, which is the participatory budget. Participatory budgeting is defined as a tool for managing the budget of a local government unit, with the help of which members of the local community can decide or contribute to decisions on how to distribute all or part of the available public funds. Participatory budgeting is also understood as a special form of social consultations in which residents decide annually on a part of the budget expenditure of a given local government unit in a direct vote. Therefore, participatory budgeting is one of the forms of civic participation, which in relation to public finances refers to the involvement of members of the local community in activities in three areas, i.e., creating and analysing the budget, tracking public spending, and monitoring the implementation of public services. Participatory budgeting as a tool for activating the local community is not a one-time event, but a complex, multistage process. This process should be cyclical and should be included in the normal cycle of functioning of the local government unit. Its implementation is based on a participatory budget draught prepared in detail by local government units, which should contain detailed information on the requirements for the submitted projects, the rules for verifying the submitted projects, the consultation procedure, and the rules for voting, determining the results, and making them public (Ebdon, Franklin, 2006; Pordes Bowers, Bunt, 2010; Sołtysiak, 2017; Sołtysiak, 2018a; Sołtysiak, 2018b; Wampler, 2007a; Wampler, 2007b).

It should be added that in a civil society, the knowledge and activity of its members, including representatives of the young generation of Poles, in the field of functioning of local government units, i.e. communes, poviats, and voivodeships, are very important. It is important for citizens to have an appropriate level of knowledge about the activities of these units, and above all about the rules and regulations on the basis of which their budget is developed and implemented. The authorities of local government units, as part of the dialogue with residents, should therefore make special efforts to familiarize them with these issues and stimulate their activity in this regard, as well as try to involve as many residents as possible in the implementation of their tasks. A good example of action in this regard is the activation of the local community by enabling it to participate in the creation of a separate part of the budget of a local government unit under the so-called participatory (civic) budget (Sołtysiak, 2017; Sołtysiak, 2018a; Sołtysiak, 2018b).

In the second quarter of 2024, local government elections are planned in Poland, which will determine who will manage local government units and shape their development over the coming years. Selected representatives of local communities will be responsible for creating

appropriate infrastructure, an efficiently functioning social assistance system and securing a number of social needs related to, among others, education, health care and culture. All these tasks must be carried out on available and usually limited financial resources.

Every adult citizen can indirectly influence the functioning of these entities by participating in the elections of the president, mayor, or commune head and in the election of councillors who, on behalf of the local community, adopt the budget of the local government unit and supervise the proper functioning of these institutions. He can also actively participate in these works if he is elected by the local community, e.g. as a councilor (Sołtysiak, 2017).

Therefore, it is extremely important to examine the level of knowledge about the functioning of local government units, and in particular about issues related to the budget of these units, among the young generation of Poles, who will now have the opportunity to vote for the first time or will be able to vote for the first time. candidacies for these bodies. The representatives of this generation that in the future will have the opportunity in the future to actively participate in the management of local government units.

2. Research aim, empirical material, and research methods

The aim of the article is to identify and assess the level of knowledge related to the functioning and budget of local government units among representatives of the young generation of Poles (aged 18-25), as well as to determine the degree of their activity in the socio-political sphere of regional and local communities.

The article presents a research hypothesis, which assumes that despite the fact that the young generation of Poles is open to the whole world, mainly via the Internet, they are also interested in problems on a regional and local scale, participating in their diagnosis, and attempt to solve them.

The empirical material of the article is the results of original surveys among 613 randomly selected representatives, studying representatives of the young generation of Polish residents aged 18 to 25 years. The research was conducted in 2023, using the CAWI (Computer Assisted Web Interview) method, via an online panel.

The research group included 367 women (59.9%) and 246 men (40.1%). Respondents who participated in the study were divided into five segments based on place of residence, four segments based on income per family member, and four segments based on the field of study. The structure of the research group is shown in Figure 1.

The empirical material collected and organised was developed in a descriptive and graphical form, using the comparative analysis.

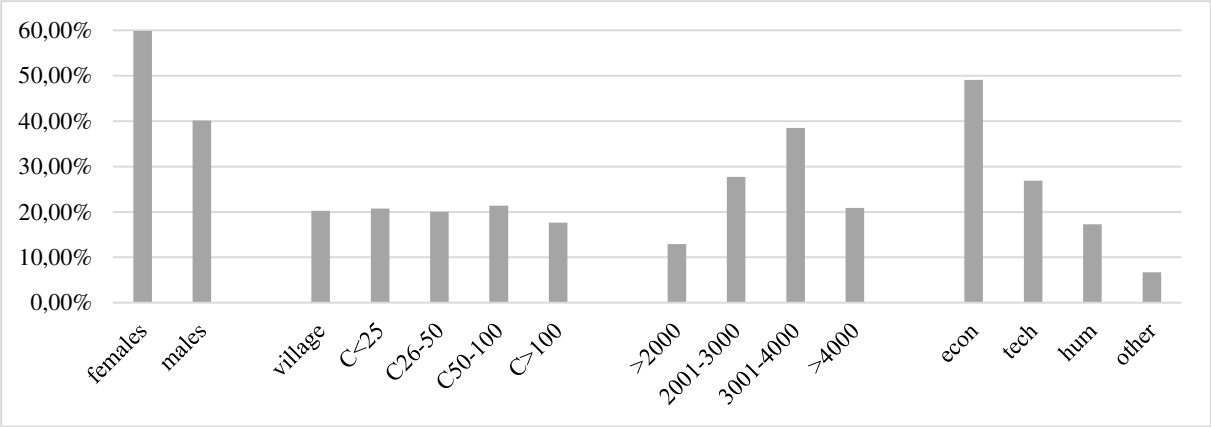

Figure 1. The structure of the research group.

Source: Own study.

It should be added that the results of the author's survey research presented in the article may be a supplement to the research conducted so far in this field. It should be emphasized that the research results presented in the literature on the subject concern primarily the analysis of the level of financial knowledge of employees of local government units (Skica, 2011; Analizy, 2012) or councilors (Nogalski, Kozłowski, 2013). To a limited extent, they concern the analysis of the level of knowledge of these phenomena in selected segments of Polish society (Sołtysiak, 2017; Sołtysiak, 2018a; Sołtysiak, 2018b). What is lacking, however, is the presentation of the research results, which would make it possible to assess the level of their knowledge among representatives of the young generation of Poles.

3. Results

The analysis of the survey results showed that only about 57% of the surveyed representatives of the young generation of Poles claimed that issues related to the functioning of local government units are not new to them. These declarations were made more often by women (59.6%) than men (53.7%). The largest percentage of respondents who believed they had knowledge on this subject was in the segments of residents of cities with more than 100,000 inhabitants (59.3%), respondents from families where the income per 1 family member was PLN 2,001-3,000 (62.4 %), respondents studying economics (69.1%).

It should be noted that these values were not confirmed during the self-assessment of the level of knowledge on the functioning of local government units (Figure 2). While doing so, only 34.1% of that respondents indicated the lack of knowledge was the answer, and 65.9% of the respondents (69.8% of women and 60.2% of men) chose a specific level of knowledge of these issues.

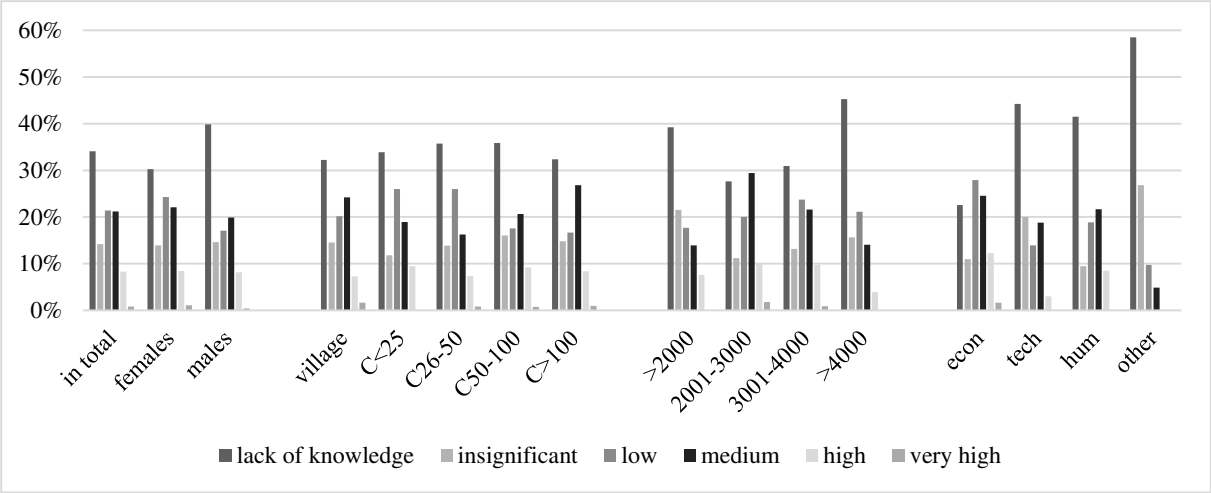

Figure 2. The level of respondents' knowledge on the functioning of local government units.
Source: Own study.

Analysing the level of knowledge on the functioning of local government units declared by the respondents, it should be stated that it was very low. 35.6% of the respondents (38.2% of women and 31.7% of men) indicated negligible and low answers. If we add to this the number of respondents who indicated lack of knowledge, it turns out that nearly 70% of the respondents (68.4% of women and 71.5% of men) do not have basic knowledge on this subject. The highest percentage of respondents indicating such a level of knowledge was in the segment of inhabitants of cities with 26-50 thousand inhabitants (75.6%), respondents with an income per family member of more than PLN 4,000 (82.0%) and respondents studying other faculties (95.1%).

Every fifth survey participant (22.1% of women and 19.9% of men) indicated an average level of knowledge about the functioning of local government units. This level of knowledge was most often declared by respondents belonging to the segments of inhabitants of cities with more than 100,000 inhabitants (26.9%), respondents with an income per 1 family member in the range of PLN 2,001-3,000 (29.4%), and respondents studying economics (24.6%).

The analysed research group also included approximately 9% of the respondents (9.5% of women and 8.5% of men) who considered themselves experts in the field of local government units and declared that they had a high or very high level of knowledge on this subject. The largest percentage of experts was found among residents of cities of 50-100 thousand (9.9%), respondents whose income per 1 family member was in the range of PLN 2,001-3,000 (11.8%), respondents studying economics (14.0%).

Another issue that was examined was to determine the level of knowledge on the principles of creating and implementing the budget of a local government unit. 23% of the representatives of the younger generation participating in the study claimed to have knowledge on this subject (Figure 3). It should be emphasised that such a declaration was made by every fourth woman and every fifth man who participated in the study. The largest percentage of those who believed they had knowledge about the budget of a local government unit was among rural residents

(26.6%), respondents with an income per 1 family member in the amount of PLN 2,001-3,000 (31.2%), respondents studying economics (29.6%). However, the smallest among residents of cities with more than 100,000 inhabitants (19.4%), respondents with an income per 1 family member above PLN 4,000 (12.5%), respondents studying other faculties (4.9%).

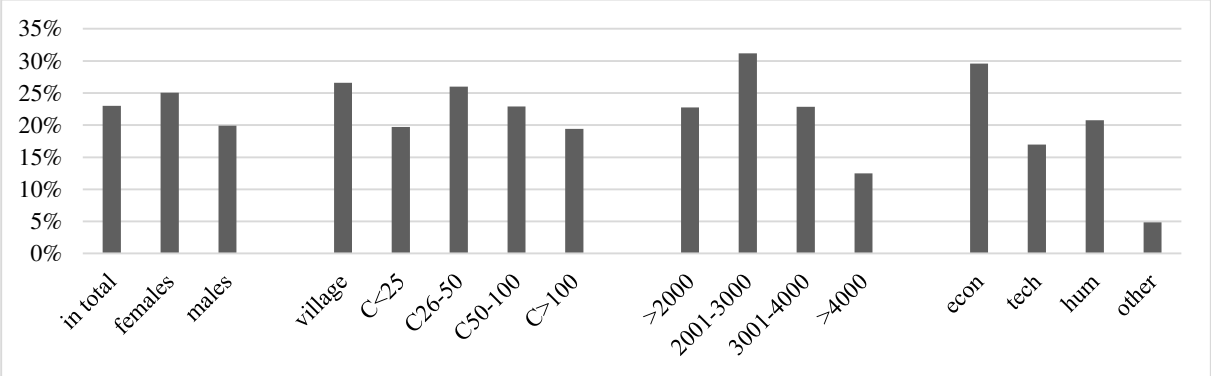

Figure 3. Opinions of respondents on having knowledge about the budget of local government units.
Source: Own study.

The survey participants who declared having knowledge about the budget of a local government unit made a self-assessment of their level (Figure 4). It should be emphasised that the knowledge of the respondents on this subject is very low - 77% of the respondents declared a lack of knowledge on this subject, 14.7% of the respondents (15.5% of women and 13.4% of men) indicated a negligible or low level, and a medium level was chosen by 5.2% of the respondents (5.7% of women and 4.5% of men). Only 3.1% of the respondents (3.8% of women and 2.0% of men) considered themselves experts in the field of local government budgets.

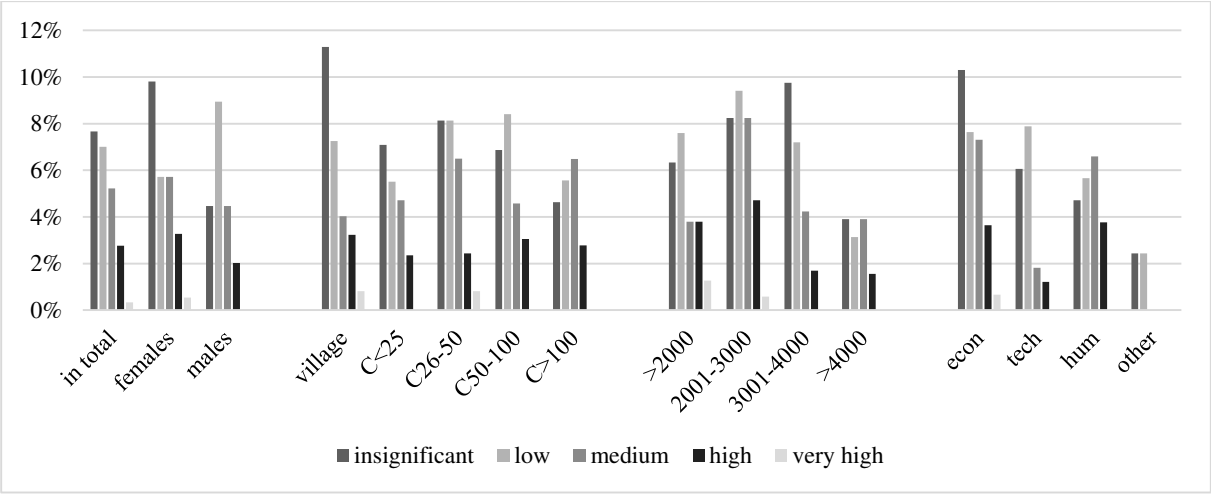

Figure 4. The level of respondents' knowledge about the budget of local government units.
Source: Own study.

It should be noted that 14.2% of the respondents (18.0% of women and 8.5% of men) believed that they knew the procedures for adopting the budget of a local government unit. The largest percentage of respondents expressing such an opinion was in the rural residents (18.6%), respondents with an income per 1 family member in the range of PLN 2,001-3,000 (18.8%), and respondents studying economics (22.3%).

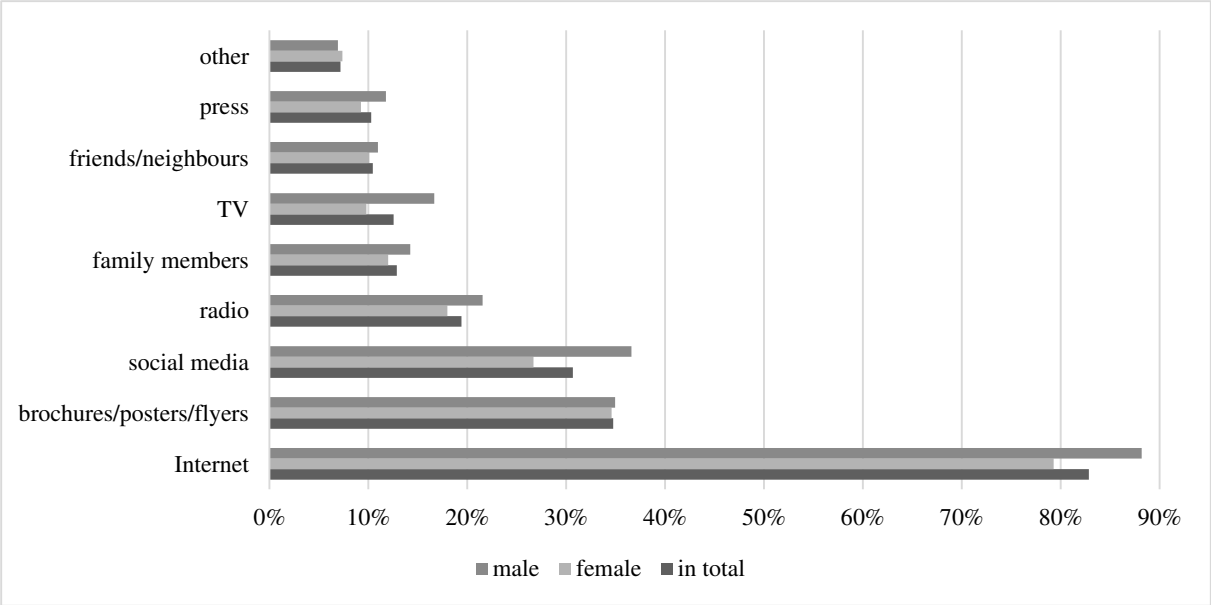

Figure 5. Sources of information obtained by respondents on the budget of local government units. Source: Own study.

During the survey, the respondents indicated the sources from which they obtain information on the budget of the local government unit (Figure 5). It should be emphasised that, as befits representatives of Internet generation, the main source from which they obtained information was the Internet. The Internet was indicated by up to 82.9% of respondents (79.3% of women and 88.2% of men). Most often, this source of information was used by respondents living in cities with 25-50 thousand inhabitants (90.2%), having an income per 1 family member in the range of PLN 3,001-4,000 (93.6%), studying economics (93.4%). Each third respondent (34.6% of women and 35.0% of men) broadened their knowledge on this topic on the basis of information contained in brochures or leaflets. More than 30% of the respondents said that they found information on the budget of a local government unit on social networking sites. This source of information was most often used by residents of cities with more than 100,000 inhabitants (36.1%), respondents with an income per family member below PLN 2,000 (31.7%), respondents studying other faculties (53.7%). It should be noted that the participants of the study less often sought information on this subject in the classic mass media, the radio (19.4%), television (12.6%) and the press (10.3%).

In order to verify the actual level of knowledge of the survey participants on the functioning of local government units, the respondents were asked to indicate the persons who, in their opinion, are responsible for the preparation, approval, and implementation of the budget of these units (Figure 6, Figure 7).

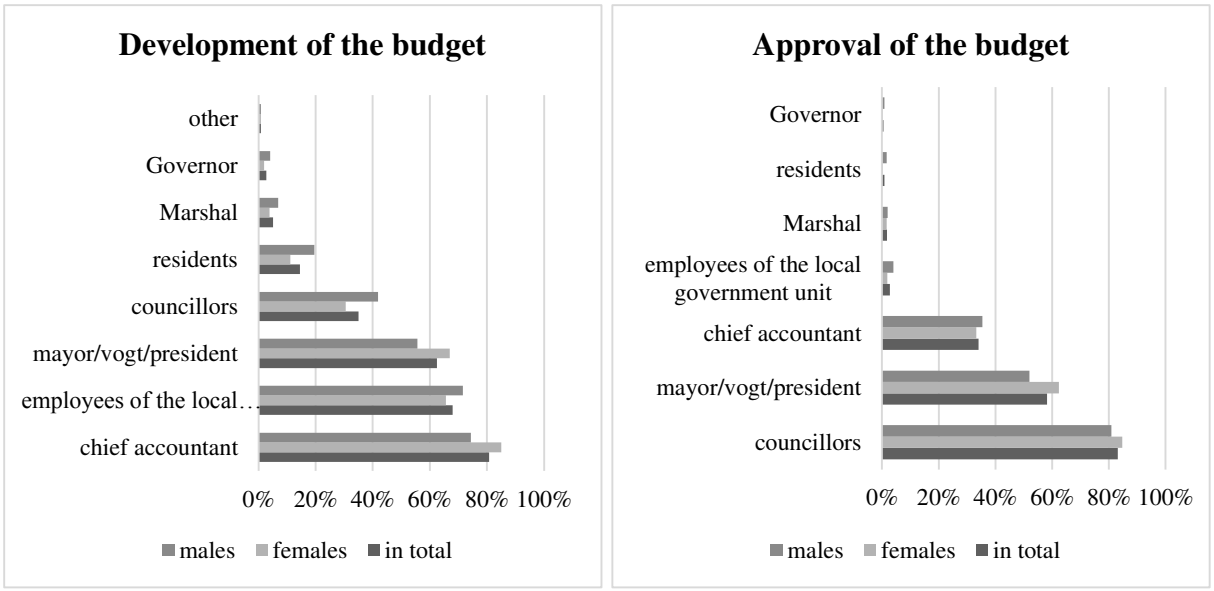

Figure 6. People responsible for developing the project and approving the budget of local government units in the opinion of the respondents.

Source: Own study.

The survey participants were of the opinion that the preparation of the draught budget is the responsibility of the chief accountant (80.8% - 85.0% of women and 74.4% of men) and employees of the local government unit (68.0% - 65.7% of women and 71.0% of 5% of men). Most often, such an opinion was expressed by respondents living in cities with 26-50 thousand inhabitants, respondents with an income per 1 family member in the range of 3001-4000, as well as respondents studying technical faculties. In the third place, the respondents placed the mayor/head of the mayor, he was indicated by 62.5% of the respondents (67.0% of women and 55.7% of men). It should also be noted that every third respondent (35.1%) was of the opinion that councillors participate in the work on drawing up the budget of a local government unit, and every seventh respondent (14.5%) that residents participate in these works. It is interesting that up to 26.9% of respondents living in cities with more than 100,000 inhabitants and 19.9% of those living in cities with 50-100,000 inhabitants indicated residents, and only 5.7% of rural residents and 6.3% of residents of cities up to 25 thousands of inhabitants. It may be related to the fact that in large and medium cities the idea of participatory budgeting in which residents participate has been used in practise for several years.

More than 83% of the respondents (84.7% of women and 80.9% of men) believed that approval of the budget of a local government unit is the responsibility of councillors. 58% of the respondents (62.4% of women and 52.0% of men) were of the opinion that this is the duty of the mayor, and 34% of the respondents (33.2% of women and 35.4% of men) combined this obligation with the chief accountant.

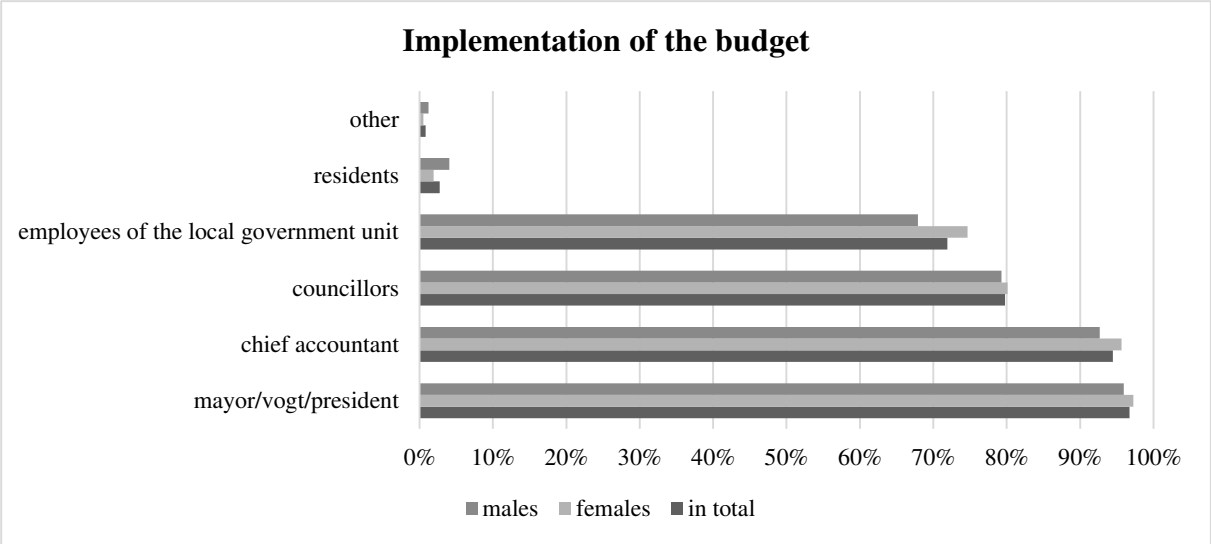

Figure 7. Persons responsible for the implementation of the budget of local government units in the opinion of the respondents.

Source: Own study.

However, the implementation of the budget of a local government unit, according to the respondents, is the task of the mayor/vogt/president and the chief accountant. 96.7% of the respondents (97.3% of women and 95.9% of men) indicated the mayor/head of office/president, and the chief accountant was indicated by 94.5% of the respondents (95.6% of women and 92.7% of men). The survey believed that this task is also the responsibility of the employees of local government units (79.8%) and the councilors (71.9%).

Then, the study participants determined from which sources the budget funds come from (Figure 8) and for what purposes they should be spent (Figure 9).

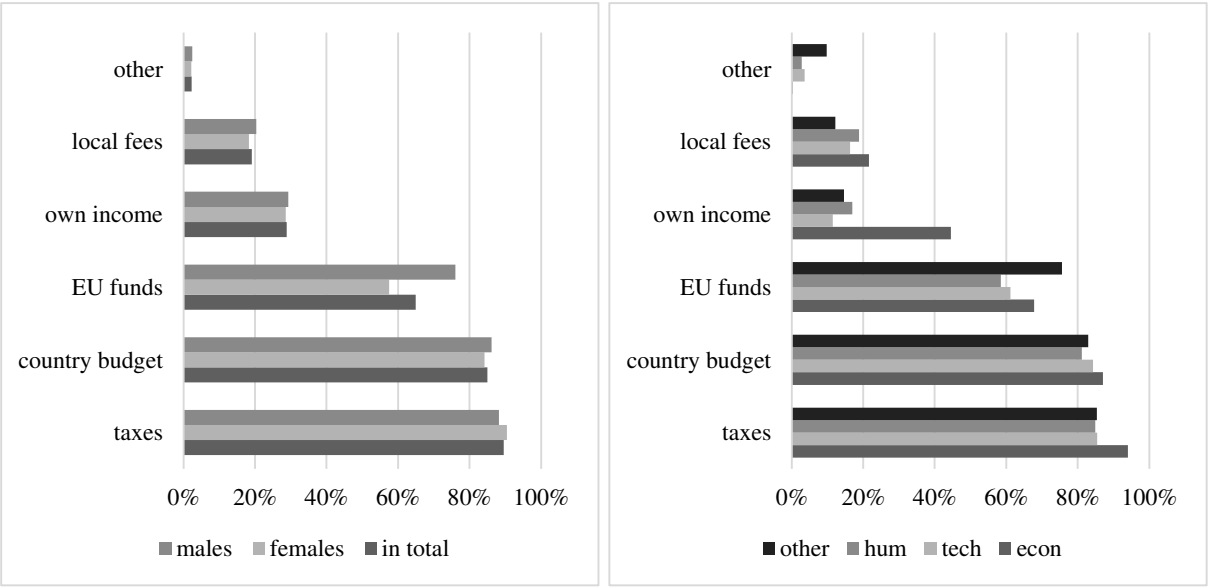

Figure 8. Sources of financial resources forming the budget of local government units in the opinion of respondents.

Source: Own study.

Representatives of the young generation of Poles believe that the funds forming the budget of a local government unit come from two main sources, i.e., from taxes and from funds provided by the state treasury. Taxes were indicated by 89.6% of respondents (90.5% women and 88.2% men), and the state treasury by 85.0% of respondents (84.2% women and 86.2% men). Both sources were most often indicated by respondents studying economics (94.0% and 87.0%, respectively). In third place, respondents will place funds from the European Union. They were indicated by 64.9% of the respondents. It should be noted that they were observed by 57.5% of women and up to 76.0% of men. They were most often indicated by residents of cities with more than 100,000 inhabitants (73.2%), respondents with an income per 1 family member below PLN 2,000 (67.1%), respondents studying other faculties (75.6%).

Almost 29% of the respondents (28.6% of women and 29.3% of men) were of the opinion that the budget of the local government unit is supplied with funds from their own income. And more than 19% of the respondents (18.3% of women and 20.3% of men) believed that they come from local fees. These two sources were most often indicated by respondents living in cities with a population of up to 25,000, respondents with an income per family member below PLN 2,000, and respondents studying economics.

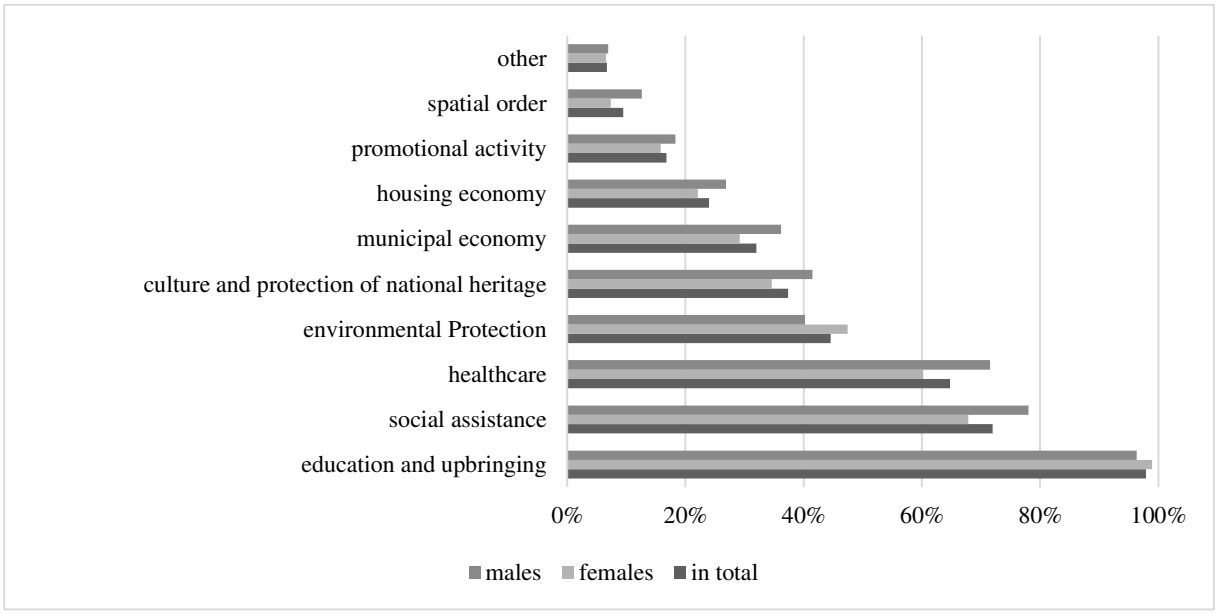

Figure 9. Objectives of allocating funds from the budget of local government units in the opinion of respondents.

Source: Own study.

Almost 98% of the respondents (98.9% of women and 96.3% of men) were of the opinion that funds from the local government unit's budget should be used to finance tasks related to education and upbringing. In second place, the respondents placed tasks in the field of social assistance. They were indicated by 71.9% of the respondents (67.9% of women and 78.1% of men). Most often, social assistance was indicated by residents of cities with more than 100,000 inhabitants (82.4%), respondents with an income per 1 family member below PLN 2,000 (89.9%), and respondents studying economics (74.8%).

Almost two-thirds of the survey participants (60.2% of women and 71.5% of men) were of the opinion that these funds should be spent on health care. Tasks from this group were most often indicated by residents of cities with 50-100 thousand inhabitants (67.9%), respondents with an income per 1 family member below PLN 2,000 (87.3%), respondents studying other faculties (82.9%).

More than 44% of the respondents believed that these funds should be used for environmental protection and over 37% of respondents would allocate them to finance tasks in the field of culture and national heritage. These tasks were most often indicated by residents of cities with more than 50,000 inhabitants, with an income per 1 family member in the range of PLN 2,001-3,000.

Every third participant in the survey believed that these funds should be used for tasks related to municipal management, and every fourth respondent for tasks related to housing management. It should be noted that men paid more attention to these tasks than women. Municipal management was indicated by 29.2% of women and 36.2% of men, and housing by 22.1% of women and 26.8% of men. It should be emphasised that the percentage of respondents who believed that funds from the budget of the local government unit should be allocated to housing economy increased with increasing size of the place of residence[1]. On the other hand, it decreased with the increase in the respondents' income per family member[2].

In the further part of the study, the activity of representatives of the young generation of Poles was analysed in terms of participation in the functioning of local government units.

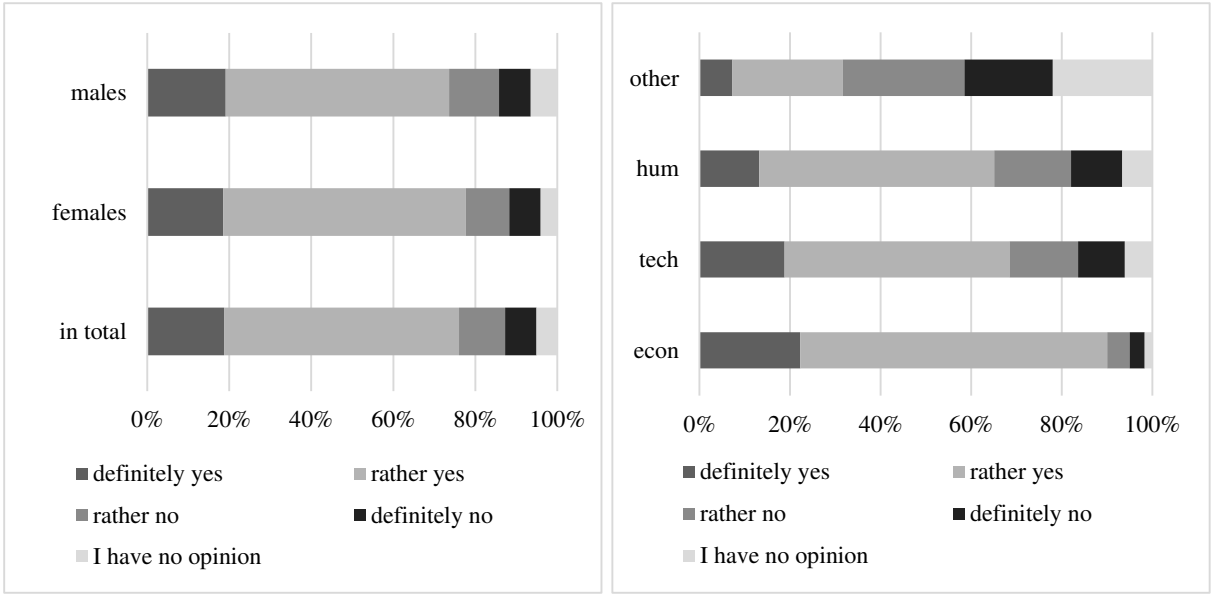

Figure 10. Opinions of respondents on the possibility of direct influence of residents on the budget of local government units.

Source: Own study.

[1] In the case of inhabitants of rural areas, it was 9.7%, and among inhabitants of cities over 100,000 inhabitants it was 37.0%.

[2] In the group of respondents with income per family member below PLN 2,000, it was 56.9%, and in the segment of respondents with income over PLN 4,000, only 7.0%.

At the beginning, it should be emphasised that 76% of the respondents (77.7% of women and 73.6% of men) were of the opinion that residents should have a direct impact on the budget of the local government unit in which they live (Figure 10). This opinion was most often expressed by respondents living in cities with 50-100 thousand inhabitants (80.2%), respondents with an income per 1 family member in the range of PLN 2,001-3,000 (82.9%), respondents studying economics (90.0%). On the other hand, the largest percentage of opponents of such an opinion was among residents of rural areas (23.4%), having an income per 1 family member below PLN 2,000 (25.3%), studying other faculties (46.3%).

In the analysed research group, 69% of respondents confirmed knowledge of the idea of participatory budgeting (Figure 11). It should be emphasised that knowledge of this idea was declared more often by men (71.5%) than by women (67.3%). The level of familiarity with this idea increased along with the size of the town inhabited by the respondents. This is probably due to the fact that in larger cities the idea of participatory budgeting has been used in practise for several years and information campaigns were conducted during this period. It is interesting that the highest level of knowledge of this idea was in the segment of respondents with income per 1 family member in the range of PLN 2,001-3,000 (74.7%) and the lowest in the segment of respondents with an income above PLN 4,000 (50.8%). Knowledge of the idea of participatory budgeting was most often confirmed by respondents studying humanities (70.8%) and economics (70.4%), and least often in other fields (65.9%).

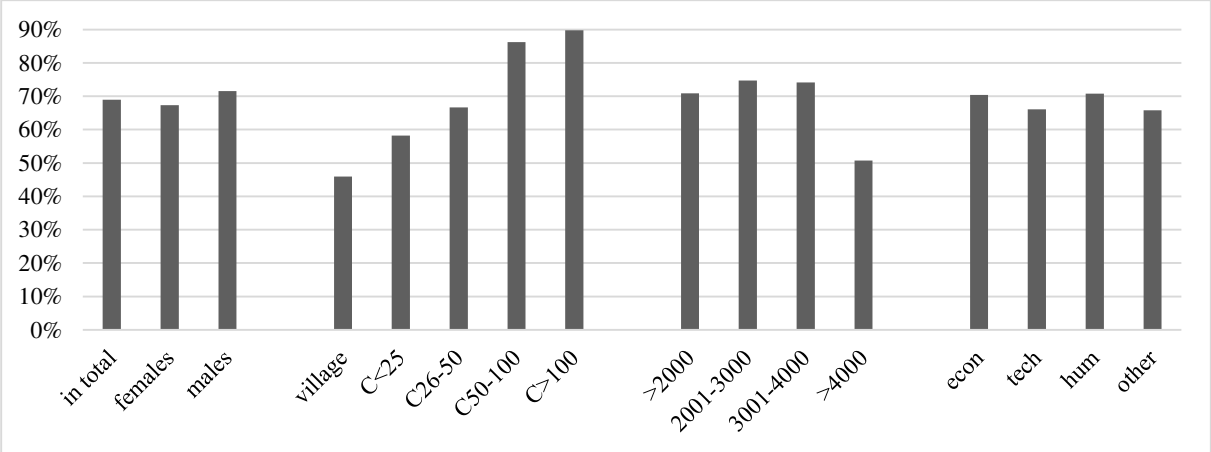

Figure 11. Opinions of respondents on the knowledge of the idea of participatory budgeting.
Source: Own study.

It should be emphasised that almost 69% of the respondents declared that more than 38% of the respondents (37.1% of women and 41.1% of men) declared that they had participated in previous editions of participatory budgeting organised by their local government units (Figure 12). The share of respondents who voted for this idea increased along with the size of the place of residence. This is due to the fact that in practice this idea is used by local government authorities in medium and large cities. However, what is interesting is the fact that the share of respondents who voted decreased along with the increase in their income per family member.

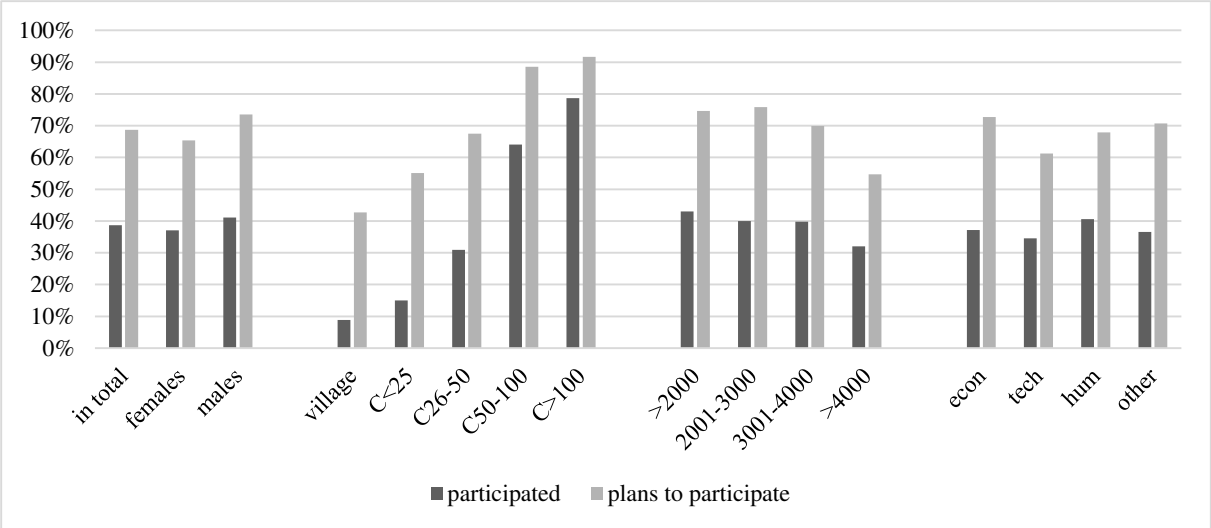

Figure 12. Participation of respondents in voting on the participatory budget.

Source: Own study.

It should be emphasised that almost 69% of the respondents declared that they would participate in future editions of the participatory budget. This declaration was made by 64.5% of women and 73.6% of men (Figure 12). The largest increase in interest in taking part in the vote, compared to people who had previously voted, was recorded among residents of cities below 25,000 inhabitants, respondents with an income per 1 family member in the range of PLN 2,001-3,000, students of economics.

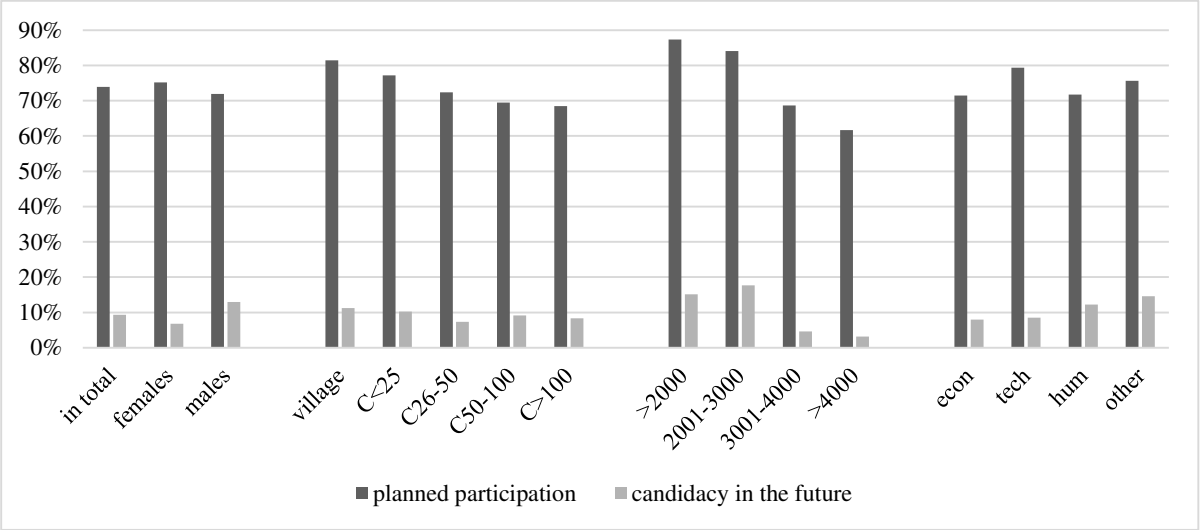

Figure 13. Planned participation of respondents in the next local government elections and willingness to run for councillor.

Source: Own study.

Almost 74% of the respondents declared that they planned to participate in the next local government elections (Figure 13). It should be emphasised that such declarations were made more often by women (75.2%) than by men (72.0%). It is also interesting that residents of smaller towns and respondents with a lower income per family member paid more attention to participation in local government elections. Among rural residents, 81.5% of respondents

planned to participate in local government elections, and 68.5% of respondents among residents of cities with more than 100,000 inhabitants. In turn, in the segment of respondents with an income per 1 family member below PLN 2,000, 87.3% declared their willingness to participate in the elections, and in the segment of respondents whose income was higher than PLN 4,000, 61.7% of respondents. It should also be noted that the highest percentage of those declaring planning to participate in elections was among students of technical faculties (79.4%) and the lowest among students of economic faculties (71.4%).

Among the representatives of the young generation of Poles participating in the survey, 9.3% of respondents who planned to run for councillor in the future. It should be emphasised that men (13.0%) declared higher activity in this respect than women (6.8%). The largest percentage of respondents interested in holding the mandate of a councilor lived in rural areas (11.3%) and in towns of up to 25,000 inhabitants (10.2%), had an income per 1 family member in the range of PLN 2,001-3,000 (17.7%) and below 2 thousand zlotys (15.2%), and also studied other faculties (14.6%) and humanities (12.3%).

4. Summary and conclusions

The respondents participating in the survey, i.e. representatives of the young generation of Poles (aged 18-25), belong to the generation referred to as the Internet generation. Its representatives are enterprising, have big plans for the future, are open to the whole world, and have a great need to change it and contacts with peers and the environment, and they gain knowledge mainly from the Internet.

Representatives of this generation are just entering the labour market and taking their first activities in the socio-political sphere. In a few years, they will constitute a significant social group deciding on the possibilities and directions of development of the local government units inhabited by them, i.e. communes, poviats, and voivodeships. However, in order to be able to fulfil their role in society well, they should have the necessary knowledge about the functioning of local government units and demonstrate a high level of activity in this area.

Knowledge is a resource, capital, an invaluable treasure, the key to success, not only on the market. Knowledge should be acquired, expanded, and deepened throughout life. Therefore, it is important to improve and improve the quality of education of young people, especially students, so that they can find themselves in the broadly understood society, both as its citizens and as employees or employers.

The research conducted showed that the issue of functioning of local government units is not yet a subject of interest among representatives of this generation. Although more than 60% of the respondents declare that they have knowledge of this subject, its level is very low. The situation is even worse in the case of knowledge about the budget of a local government

unit. More than 91% of the respondents either do not have it or declare that it is negligible or small. This leads to the conclusion that building a civil society in subsequent generations requires the introduction of content into the education system that will significantly increase the level of knowledge on this subject.

However, it should be emphasised that representatives of the surveyed generation of Poles declare their willingness to actively participate in the life of regional and local communities. More than 76% of respondents are of the opinion that decisions regarding the shape of the budget of a local government unit should be made by its residents. On the other hand, almost 39% of the respondents, despite their young age, have already cast their vote on participatory budgeting, and less than 69% of the respondents declare that they will do so in the future.

Furthermore, almost 74% of the respondents declared that they wanted to fulfil their patriotic duty by voting in the next local government elections. However, more than 9% of the respondents declared that in the future they want to be actively involved in the work of regional and local governments and plan to run for a councillor.

The conducted research allows us to confirm the research hypothesis presented in the article, which assumes that despite the fact that the young generation of Poles is open to the whole world, mainly via the Internet, they are also interested in problems on a regional and local scale, participating in their diagnosis and attempt to solutions.

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PRODUCTION OF GOODS: WHAT, WHERE, HOW, HOW MUCH AND FOR WHOM

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Purpose: Publications on the issues of justification for the selection of optimal production solutions are extremely numerous, but all of them have not been comprehensive, as they have studied in isolation different aspects of this, in fact, holistic problem. Therefore, the purpose of the article was to develop a systematic approach to justifying the choice of what to produce, where to produce, how to produce, how much to produce and for whom to produce.
Design/methodology/approach: Morphological analysis is used as the main research method.
Findings: The paper proves that the justification of "what, where, how, how much and for whom" to produce should be carried out comprehensively, interdependently and mutually coordinated, since all these 5 parameters are optimized together within the limits of one task. The proposed sequence of actions will provide a systematic approach to justifying the choice of what to produce, where to produce, how to produce, how much to produce and for whom to produce.
Research limitations/implications: In the further study of "what, where, how, how much and for whom" to produce, it is advisable to focus on the problems of the production range in the direction of the "set of goods", which should be produced in the appropriate places using the appropriate technologies, in the appropriate volumes, and for the appropriate sales markets.
Practical implications: The use of research results in practice will improve the quality of substantiating the choice of optimal production solutions (what, where, how, how much and for whom to produce). This will have a positive impact on business development.
Social implications: The results of the study can be used to improve state policy in the areas of spatial organization of the economy and technological development of the economy, which will have a positive effect on the quality of life of a society.
Originality/value: The value of the article lies in the development of a systematic approach to justifying the choice of what to produce (which goods), where to produce (which location), how to produce (with the help of which technologies in each place), how much to produce (in what volume in each place), for whom to produce (for which markets in each location). The article is addressed to entrepreneurs, scientists who deal with the issue of justifying the choice of optimal solutions for the production of goods, as well as state institutions in the field of economic development.

Keywords: Spatial-system approach, production of goods, placement of production, production technologies, production capacity, sales markets.

Category of the paper: Research paper.

1. Introduction

Business efficiency is determined by making the right decisions about what to produce (what goods), where to produce (locations), how to produce (with the help of which technologies), how much to produce (volume), for whom to produce (to which sales markets). Therefore, improving the rationale for choosing optimal production solutions has always been, is, and will always be an important scientific and practical task.

There are many interesting studies that offer economic justification methods for "what to produce?" (Alvarez, 2007; Fauziah, 2022; Graaf, 2020; Hjorth, 2015; Kier, 2018; Korsgaard, 2016; Leatherbee, 2020; Ott, 2017; Priem, 2018; Safitri, 2023; Squadrito, 2023). There are also plenty of highly professional studies on the economic rationale of "where to produce?" (Branco, 2019; Brown, 1979; Fujita, 2004; Krugman, 2010; Moses, 1958; Stadnicki, 2022; Venables, 1996). There is an extremely large amount of research on the economic justification of "how to produce?" (Andersen, 2018; Azzone, 1989; Beaves, 1988; Borgonovo, 2004; Dobrowolski, 2022; Fuss, 2008; Magni, 2010, 2023; Park, 2004; Proctor, 1992; Shank, 1996; Solow, 1957; Vlachý, 2017; Wiendahl, 2004). A whole layer of research is devoted to the problem of "how much to produce?" (Bueno, 2020; Cantamessa, 2000; Correia, 2021; Goswami, 2023; Ho, 2013; Mariel, 2015; Negahban, 2018). And research of the topic "for whom to produce?" can be found in many scientific papers that are devoted not only to economics and management, but also to marketing and logistics (Bernard, 2019; Daudin, 2011; Heijden, 2013; Li, 2022; Paul, 2020). Publications on the issues of justification for the selection of optimal production solutions are extremely numerous, but all of them are not comprehensive, as they consider different aspects of this influential problem separately. It is obvious that even in a study that is not complex, it is possible to obtain individual positive results (local optima), but a non-comprehensive study has no chance of a system optimum.

2. A systematic approach to justifying "what, where, how, how much and for whom" to produce

A comprehensive study of the integral problem of "what, where, how, how much and for whom" to produce is quite logical to begin with the answer to the question "what to produce?" However, at this initial stage, this answer will only be a declaration of intent, since the final answer whether this "what" is planned to be produced is really worth producing must be based on the answers to the other components of the investigated holistic problem: "where, how, how much and for whom" to produce.

The justification of "what, where, how, how much and for whom" to produce must be carried out interdependently in a harmonious sequence that will ensure obtaining a high-quality result. The proposed sequence of actions for substantiating "what, where, how, how much and for whom" to produce is given in the table 1.

Table 1.
The sequence of justification "what, where, how, how much and for whom" to produce

No.	Action content
1.	What is planned to be produced is determined (declaration of intentions)
2.	Outline of the space of possible placement of production
3.	Outline of potential sales markets and assessment of the demand for each of them
4.	Options for sales markets are formed from the potential sales markets, and calculation of the demand for each of them
5.	A list of production technologies is formed
6.	The factors of production location are identified
7.	Attractive places of production are identified within the space of possible placement
8.	The locally optimal production technologies are substantiated for each attractive place of production, while focusing on the appropriate options for sales markets
9.	A list of transportation technologies between each attractive place of production and all potential sales markets of the corresponding sales market option is formed
10.	Locally optimal transportation technologies between each attractive place of production and all potential sales markets of the corresponding sales market option are substantiated
11.	The locally optimal place of production and locally optimal production and transportation technologies from the set of its attractive production locations are determined for each option of the sales market
12.	Variants of potential systemically optimal places with potentially systemically optimal production and transportation technologies are formed from locally optimal places
13.	The choice of the best one, that is, the option of systemically optimal places with systemically optimal production and transportation technologies from the options of potential systemically optimal places is justified
14.	The expediency of implementing the optimal option "what, where, how, how much and for whom" to produce is evaluated.

Source: Author's development.

Further the positions of the given list of actions is described.

1. *What is planned to be produced is determined (declaration of intentions).* On this stage a specific good or a certain set of goods is meant. It is this initial action that is absolutely necessary, since all subsequent actions depend on it. In the end, as a result of the justifications, it may turn out that the declaration of intentions will remain only a declaration, since the justification will show the impracticality of the

planned production, but the declaration of intentions, which specific good or set of goods is planned to be produced, is a mandatory stage of the start of the procedure. If, indeed, the initial declaration of intentions remains only a declaration, then a new justification procedure will have to be started, again, with the formulation of some new declaration of intentions, which good or set of goods is planned to be produced.

2. *Outline of the space of possible location of production*. Here, to some extent, the answer to the question "where to produce?" is being formed, but at a fairly general level, since it is a relatively large space, within which there may be hundreds of specific places, among which it will be necessary to justify the choice of optimal ones. It can be a space from the global (the entire planet Earth and the outer space) to the local (for example, an administrative-territorial unit of the basic level or even its part). Choosing a global space of possible locations ensures that optimal locations do not lie outside of it, but such a choice will require a lot of calculations for a huge number of attractive production locations (production costs for different capacity options, transportation costs to various potential sales markets). Therefore, in a situation where the rejection of the global space of possible placement does not pose a threat to the correctness of the choice of optimal production locations, it is advisable to limit the space of possible placement taking into account the relevant factors: the properties of the "production" side (where aspects related to: what is produced are taken into account; production technology; necessary resources for production; pollution generated during production), and the properties of the "place" side (where various aspects related to the properties of the corresponding space are taken into account, in particular, legal, geographical, infrastructural, etc.).
3. *Outline of the potential sales markets and assessment of the demand for each of them*. Here, to some extent, answers to the question "for whom to produce?" and "how much to produce?", but at a fairly general level, since it is about the demand of individual markets and the general demand without reference to places of production. Orientation when justifying the optimal placement of production on potential sales markets is necessary, both from the point of view of taking into account the costs of transportation from the place of production to the places of consumption, and from the point of view of production capacity, since unit and total production costs depend on it. Taking into account the transportability of the good that is planned to be produced, it is expedient to aggregate potential sales markets: as transportability increases, the space for aggregating demand increases. Potential sales markets should be delineated taking into account the space of possible placement, which will allow identification of places that will require customs payments when exporting goods produced there, or places in the territory of states that are under various sanctions. The demand of each potential market has to be estimated using known methods.

4. *Sales market options are formed from the potential sales markets, demand for each of them is calculated*. Answers to the question "for whom to produce?" are also formed here and "how much to produce?", but already at a more specific level, since sales market options are separate potential sales markets and their combinations. Sales market options are formed and characterized by potential sales markets that are a part of these sales market options. The parameters of the sales market option are described by the coordinates of potential sales markets and demand (individual of each potential sales market and the total of all potential sales markets of the corresponding sales market option). It is obvious that individual potential sales markets can be part of several sales market options. The demand of the sales market option is defined as the sum of the demand of the potential sales markets included in its composition. It is the options of the sales market that will act as "units of demand", the orientation of which, when placing production, will determine the potential production capacity (and, accordingly, the unit and total costs of production), as well as the directions and volume of transportation (and, accordingly, the unit and total costs of transportation). Limiting the orientation when justifying the optimal location of production only by some individual option of the sales market (regardless of whether it will be formed from one or several potential sales markets) is erroneous, as it is not systematic and does not take into account competitive options. If there are even only two potential sales markets, three sales market options are possible: sales market option #1 is only potential sales market #1, sales market option #2 is only potential sales market #2, sales market option #3 is both potential sales market #1 and potential sales market #2. It is obvious that the increase in the number of potential sales markets leads to a significant increase in the number of sales market options. For each orientation, when placing production on the sales market option, the locally optimal location may be different.
5. *A list of production technologies is formed.* As a rule, a good can be produced by several interchangeable technologies: for example, production of paper from business wood and waste paper, production of gasoline from oil or coal, production of electricity at thermal power plants, nuclear power plants, hydroelectric power plants, etc. Forming a list of production technologies is a preparation for answering the question "how to produce?". In the future, the optimal production technologies will be selected from the created list. At the same time, various options for choosing optimal technologies from the list of potentially possible options will be possible: from one identical optimal technology to many different optimal technologies for each optimal place of production.

6. *Identification of the factors of production location*. Location drivers are reasons to consider when justifying or predicting future location (answering the question "where?") or explaining past or existing location (answering the question "why here?"). Production location factors are part of the properties of the following components of the "production" side: production technologies; resources that are necessary for production using the appropriate technology; negative effects on the environment (mainly pollution) that occur in the production process when applying the appropriate technology; of what is planned to be produced. Production location factors can be specific for each production technology, which can obviously lead to an increase in the number of attractive production locations, since there will be a change in three of the four components of "production" (technology, resources, negative impacts on the environment) and a corresponding change in production location factors, which will be able to cause a shift to more attractive places of production. Identification of factors of production location is a preparation for answering the question "where to produce?", because production will be in the optimal places where the relevant factors of production location will have the greatest impact.
7. *Attractive places of production are identified within the space of possible placement*. At the same time, there may be many options. One of them is that each orientation to the market option may have its own attractive places of production, because it is one thing to produce in a small volume for the market option with low demand (small producers have a lot of attractive places of production, since their requirements for various resources are limited), and another matter is powerful production, which will have significantly fewer attractive places of production.

   Not every attractive production location within the space of possible placement needs to be considered an attractive production location for every market option. Some attractive places of production within the space of possible placement may not be suitable according to the criterion of the volume of production (taking into account environmental restrictions, the volume of resource requirements) for the placement of a powerful production, i.e. one that is oriented to the option of a sales market with significant demand. It is clear that the focus on the option of the sales market with significant demand, which means a significant production capacity, will lead to a significantly smaller number of attractive places of production than the orientation on the option of the sales market with a small demand. This is because the small volume of production has smaller demands on various resources and has relatively less environmental restrictions.
8. *The locally optimal production technology is substantiated for each attractive place of production while orienting the location to the appropriate sales market options*. The locally optimal production technology is substantiated taking into account the previously formed list of production technologies. This is an important stage of

forming the answer to the question "how to produce?", since locally optimal production technologies and systemically optimal production technologies will be selected in the future. The substantiation of locally optimal production technologies is carried out with reference to the corresponding options of the sales market (to take into account the production capacity, which is assumed to be equal to the demand of the option of the sales market, on which unit and total costs depend) according to the criterion of minimum production costs. At the initial stage, production costs are calculated for each attractive production location in relation to the corresponding sales market option and the locally optimal production technology is substantiated. Since an attractive place of production can focus on several market options, the number of locally optimal production technologies in each attractive place of production will correspond to the number of market options. That is, the locally optimal production technology in an attractive place of production needs to be substantiated only for admissible variants of binding to the variant of the sales market. It should be emphasized that different production technologies may be optimal in different attractive production locations of each sales market option, and that, again, different technologies may be optimal in one and the same attractive production location when targeting different sales market options production.

9. *A list of transportation technologies between each attractive place of production and all potential sales markets of the corresponding sales market option is formed.* It should be emphasized that the transportation technology will be characterized by the transportation route, the type of transportation, and the volume of transportation. At the same time, it is necessary to take into account the possibility of transporting several or all portions of cargo on one flight (let's call it group transportation). This means that it is necessary to take into account not only the possibility of individual transportation between each attractive place of production and each potential sales market of the corresponding sales market option, but to implement a systematic approach, providing for the possibility of transporting several or all portions of cargo in one flight, if the number of potential sales markets in corresponding to the sales market variant exceeds one. Accordingly, each option of transportation between an attractive place of production and potential sales markets of the corresponding option of the sales market of the entire volume of production (which is equal to the demand of the option of the sales market) should be considered as a separate technology. Therefore, the following options will be separate technologies of transportation:
   a) an option that involves combining all only individual transportations between each attractive place of production and each potential sales market of the corresponding sales market option,

b) an option that provides for transportation on one flight between each attractive place of production and all potential sales markets of the corresponding sales market option,
c) options that provide for the combination of separate individual transportations between an attractive place of production and separate potential sales markets of the corresponding sales market option and group transportations so that the demand of all potential sales markets of this sales market option is satisfied.

Forming a list of transportation technologies is a preparation for the answer to the question "how to produce?", although with the help of the answer to the question "how to transport?", since when justifying locally optimal production technologies and systemically optimal production technologies, the costs of transporting the produced goods to sales markets are taken into account. In the future, the optimal transportation technologies will be selected from the created list.

10. *Locally optimal transportation technologies between each attractive place of production and all potential sales markets of the corresponding sales market option are substantiated.* Locally optimal transportation technologies are substantiated taking into account the previously formed list of transportation technologies. This is an important stage of forming the answer to the question "how to produce?", although with the help of the answer to the question "how to transport?", since when justifying the locally optimal production technology and systemically optimal production technology, the costs of the locally optimal technology of transporting the produced good to the sales markets are taken into account. The selection of the locally optimal transportation technology will be carried out according to the criterion of minimum transportation costs between an attractive place of production and potential sales markets of the corresponding sales market option in the amount of demand of each of these potential sales markets (the total demand for potential sales markets forms the demand for the corresponding sales market option). At the initial stage, the choice of the locally optimal transportation technology between each attractive place of production and potential sales markets of the corresponding sales market option is substantiated. It has to be noted that the binding to the sales market option affects the amount of transportation costs. Since an attractive production location can target all market options, the number of locally optimal transportation technologies in each attractive production location will correspond to the number of market options. If necessary, a locally optimal transportation technology in an attractive place of production can be justified not for all, but only for a part of the sales market options. If the fact, that different production technologies can be optimal for different attractive production locations of each sales market option, as well as the fact that different production technologies can also be optimal in one and the same attractive production location when targeting different sales market options. Also, the difference in optimal

transportation technologies between one and the same attractive place of production and potential sales markets of different sales market options is obvious.

11. *For each variant of the sales market, the locally optimal place of production and locally optimal production and transportation technologies from the set of its attractive production locations is determined.* At this stage, there is an approach to the final answer to the question - "where to produce?" and "how to produce?", because systemically optimal places will be identified among locally optimal places in the future, and systemically optimal technologies among locally optimal technologies. It should be emphasized here once again that when justifying the locally optimal production location for the sales market option, only attractive production locations that will be identified as attractive production locations for the corresponding sales market option can be taken into account. Among these attractive production locations of each market option, locally optimal locations will be selected by comparing their locally optimal technologies (production and transportation) according to an indicator that will take into account the total production costs in the demand volume of the market option and transportation costs between the attractive production location and potential markets sales of the corresponding variant of the sales market (in the amount of demand of the corresponding potential sales markets).

    As a result of such a comparison, the locally optimal technologies (production and transportation) of an attractive place of production with a minimum indicator of total costs are identified as locally optimal technologies when focusing on the appropriate sales market option, and the corresponding attractive place of production is identified as a locally optimal place of production when focusing on this sales market option. Each locally optimal place will be characterized by locally optimal technologies (production and transportation), as well as production capacity, which will be equal to the demand of the corresponding sales market option (that is, the production capacity at this stage is actually set by the demand of the sales market option). The result of the substantiation of optimal production and transportation technologies for individual options of the sales market will be a set of locally optimal technologies and locally optimal locations (each option of the sales market will have its own locally optimal location, although one location can be a locally optimal location for several options of the sales market) with production capacities, equal to the demand of the corresponding sales market options.

12. *The variants of potential systemically optimal places with potentially systemically optimal production and transportation technologies are formed from locally optimal places.* The formation of potential systemically optimal places with potentially systemically optimal technologies is the completion of preparation for the answer to the question "where to produce?" and "how to produce?", since systemically optimal places and systemically optimal technologies will be chosen precisely among potential

systemically optimal places with potentially systemically optimal technologies. The variant of the set of locally optimal locations, in which the total volume of production is equal to the total aggregate demand of all potential sales markets, is one of the variants of potential systemically optimal locations. With the system approach, variants of sets of locally optimal locations, the total production capacity of which is equal to the general (system) demand, will be compared. At the same time, the following options are possible:

a) an option that involves only one place of production in the amount of the total demand of all potential sales markets,
b) the option, which provides that the number of production sites will be equal to the number of potential sales markets, and the volume of production in each such site will correspond to the demand for potential sales markets on which the placement of the corresponding production was oriented (that is, for each potential sales market, production will be carried out by a separate manufacturer),
c) options that provide for the combination of individual manufacturers in the number of two to the number provided for by option (b) minus 1. It is clear that option (c) makes sense only when the number of potential sales markets is more than 1.

Each option of potential systemically optimal locations will be characterized by its set of potentially systemically optimal production and transportation technologies: these will be locally optimal technologies of locally optimal locations that form the corresponding option of potential systemically optimal locations.

13. *From the options of potential systemically optimal places, we justify the choice of the best one, that is, the option of systemically optimal places with systemically optimal production and transportation technologies.* This is the final stage of forming an answer to the question "where, how, how much and for whom to produce?". The variant of the set of locally optimal locations with the minimum total costs will be optimal and the locally optimal locations of this variant are identified as systemically optimal locations, in which it is necessary to locate production with the corresponding technologies, which are identified as systemically optimal technologies, and with the corresponding capacities, which are identified as systemically optimal capacities . That is, at this stage, competition will take place between locally optimal places with their corresponding locally optimal technologies, but the technologies of locally optimal places will not compete with each other directly, since their choice is determined by orientation to different options of the sales market. Variants of sets of locally optimal places (potential systemically optimal places) and production and transportation technologies corresponding to them will compete. Since each variant of the set of locally optimal places can have different production and transportation technologies, it is difficult to assess which of them ensured victory in the competition

of variants of sets of locally optimal places and the transformation of one of them (which will turn out to be optimal) into systemically optimal places.

The result of solving the problem will be information about 5 parameters of production and transportation - "where to produce?" (attractive production locations identified as systemically optimal locations) within the space of possible placement, "how to produce?" (systemically optimal production technologies in systemically optimal locations), "how much to produce?" (production capacity at each systemically optimal location), "for whom to produce?" (potential sales markets and the sales market options formed by them for each systemically optimal location), "how to transport?" (systemically optimal transportation technologies between systemically optimal locations and corresponding potential sales markets). That is, the result is a justification for choosing systemically optimal:

- places of production (from many attractive places of production),
- production technologies in each systematically optimal place of production,
- production capacities in each systematically optimal place of production,
- transportation technologies between each systemically optimal place of production and corresponding potential sales markets,
- sales markets (from a set of potential sales markets) for each systematically optimal place of production.

14. *The evaluation of the expediency of implementing the optimal option "what, where, how, how much and for whom" to produce.* The option of systemically optimal locations with systemically optimal technologies of production and transportation will be expedient to implement if its internal rate of return is greater than the corresponding normative indicator, which depends on the industry, type of investment, country and region.

    Thus, the justification of "what, where, how, how much and for whom" to produce should take place in four stages. At the first stage, a list of attractive places of production is formed and a selection for each attractive place of production is carried out with reference to the option of the sales market (to take into account the production capacity) of a locally optimal production technology from the list of possible ones (point competition of production technologies): as a result, for each attractive place of production with reference to the option of the sales market, only one (optimal) technology out of many possible ones is identified. If a specific attractive place of production is linked to several options of the sales market, then the locally optimal production technology should be selected from the list of possible ones every time (for each link to the option of the sales market). Theoretically, this can, under certain circumstances, determine the expediency of placing several enterprises producing the same products in one attractive place of production.

At the second stage, the choice of the locally optimal transportation technology between each attractive place of production and all potential sales markets of the corresponding sales market option is substantiated. At the same time, the costs of not individual transportation between each attractive place of production and each potential sales market are optimized, but the costs of system transportation between each attractive place of production and all potential sales markets of the corresponding sales market option (point competition of transportation technologies).

At the third stage, the choice for each sales market option (based on the indicator of the minimum total costs for production and transportation) is substantiated for the choice of locally optimal production technology (among competing locally optimal production technologies in attractive production locations of this sales market option) and transportation (among competing locally optimal transportation technologies between each attractive place of production and all potential sales markets of this sales market option) and thereby identifying the locally optimal location of production (local spatial competition of production technologies and transportation technologies). As a result, only one attractive place of production of each variant of the sales market becomes a locally optimal place and, accordingly, the locally optimal production technology at this attractive place of production will become the locally optimal production technology at the locally optimal place for the corresponding variant of the sales market, and the locally optimal technology of transporting the good between locally optimal place and all potential sales markets of this sales market variant - locally optimal transportation technology. That is, for each variant of the sales market, there will be only one locally optimal production technology in an attractive place of production, which will turn out to be a locally optimal place, among all locally optimal production technologies of attractive places of production of this variant of the sales market, and the corresponding technology of transporting the good (locally optimal) between the locally optimal location and all potential sales markets for this sales market option.

At the fourth stage, locally optimal technologies of locally optimal places will compete as components of options for potential systemically optimal places (systemic spatial competition of production technologies and transportation technologies). At the same time, competition of locally optimal places is theoretically possible not only with other locally optimal places, but also with itself in various variants of potential systemically optimal places, where there is a corresponding locally optimal place. At this stage, a choice is made among competing options of potential systemically optimal places of optimal production. As a result, the locally optimal technologies of the corresponding locally optimal places form an optimal system of production technologies and transportation technologies between the locally optimal places, which turned out to be systemically optimal places, and the potential sales markets of the corresponding sales market options. At the same time, the number of locally optimal locations can be from one (if production will take place in one place for all potential sales markets) to the total number of potential sales markets (if production will take place in a separate location for each potential sales market).

3. Conclusions

A spatial-systemic approach to justifying the choice of what to produce (what goods), where to produce (locations), how to produce (with the help of which technologies in each place), how much to produce (in what amount in each place), for whom to produce (sales markets in each place) is quite revolutionary, but its validity and, as a result, its correctness are not in doubt. The justification of "what, where, how, how much and for whom" to produce should be carried out comprehensively, interdependently and mutually coordinated, since all these five parameters are optimized together within the limits of one task.

In the further study of "what, where, how, how much and for whom" to produce, it is advisable to focus on the problems of the production range. This means the need to expand the study of the complexity of production in the direction of the "set of goods", which should be produced in the appropriate places using the appropriate technologies, in the appropriate volumes, and for the appropriate sales markets.

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ASSESSING THE IMPACT OF CYBER RISK PERCEPTION ON CYBER INSURANCE PURCHASE DECISIONS

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Purpose: The goal of this paper is to investigate how cyber risk perception influences medium and large companies' decisions to purchase cyber insurance.
Design/methodology/approach: The study collected data from 386 managers in medium and large Polish enterprises through a questionnaire. It examined managerial perceptions of cyber risk, considering firm attributes like size, age, and type. Various statistical methods, including Pearson's chi-square test, multiple correspondence analysis, and the random forests classifier, were employed for comprehensive data analysis.
Findings: The study highlighted the pivotal role that perceptions of cyber risk play in shaping decisions concerning cyber insurance. Managers' perceptions regarding the gravity and probability of cyber threats had a significant impact on the choices made by their organizations. Furthermore, the study identified the presence of the availability heuristic as a noteworthy factor influencing decision-making in the realm of cyber insurance. Moreover, specific determinants emerged as influential in a company's decision to invest in cyber coverage. These determinants encompassed the size of the employee base, annual turnover, the severity of previous cyber losses, and the frequency of successful cyber-attacks experienced by the firm over the preceding five years.
Research limitations/implications: The study recognizes potential biases, including non-response and sampling frame bias, as well as the limitations of self-reported data. However, it offers valuable insights for policymakers in enhancing cyber-attack resilience through cyber insurance. Future research should explore factors influencing cyber insurance purchases, examine the complexity of cyber risk perception, and consider context-specific studies and multidisciplinary approaches.
Practical implications: The outcomes of this research have practical implications for both businesses and policymakers. It provides insights into enhancing cyber-attack resilience through cyber insurance, helping businesses make informed decisions regarding risk management. This research can impact industry policy by guiding the development of tailored insurance offerings.
Originality/value: The article fills a gap in the literature concerning the analysis of the relationship between cyber risk perception and the decisions of medium and large companies regarding the purchase of cyber insurance in the Polish market. It provides valuable insights for policymakers, insurance providers, and businesses looking to improve their cybersecurity practices and resilience to cyber threats.

Keywords: cyber risk, cyber risk management, random forests, cyber insurance, cyber risk perception.

Category of the paper: research paper.

1. Introduction

Information technology, interconnectedness, and moving businesses to cyberspace are cornerstones of the modern digital economy. The digital realm not only presents tremendous opportunities, but also is a substantial source of cyber risks. Attacks are growing increasingly sophisticated, and the severity of their financial consequences has been profound. Privacy protection is among the major issues globally; media report data breaches almost every day (Munich Re, 2020). Cyber incidents can threaten the financial stability of national economies (DTCC 2020; Bank of Canada, 2021; Bank of England, 2022). Thus, cyber risk is of concern at both the micro- and macro-prudential levels; however, measuring the consequences of cyber risk on the overall financial system remains at an early stage (Brando et al., 2022).

The scale of financial losses resulting from cyber risk is illustrated by the SolarWinds case, which was one of the most serious incidents of its kind in the US. The costs for the US government alone amounted to hundreds of millions of dollars, even though the attack was likely not aimed at destroying IT infrastructure but instead was likely espionage (Nolan, Fixler 2021). Another example is the NotPetya malware infection in 2017, which is considered to have been the most destructive in history. It originally targeted Ukraine but spread to dozens of countries and contributed to losses estimated at $10 billion (Alladi et al., 2020).

Insurance can be considered as a risk management tool for cyber risk (Alladi et al., 2020). The cyber insurance market has been growing rapidly for a decade and is predicted to continue its 20-30% annual growth rate in the near future (Greenwald, 2020). Risk aversion determines the demand for insurance among individuals and small firms where the owner makes most decisions. For larger businesses, risk aversion among company owners and managers is considered insufficient to explain motivations for purchasing property insurance (Main, 1983; MacMinn, 1987; Mayers, Smith, 1990). Thus, other motives are being investigated, such as preserving a company's liquidity in case unfortunate events occur (Main, 1983); reduction of bankruptcy costs and financial distress (Main, 1982; MacMinn, 1987); tax optimization (Main, 1982); compliance with regulations, in some industries (Mayers, Smith, 1990); and demonstration of good corporate risk management practices (Main, 1982; Grace, Rebello, 1993). These motives can be represented by various characteristics of a given company, including size of employment, annual turnover, industry type, and legal status of a company; taken together, these characteristics can be considered to comprise a 'company profile' (Krummaker, 2019). Ultimately, two predominant factors may influence a company's decision

to purchase insurance: risk aversion of its owners or managers (which is the result of risk perception) and the company profile. The interplay of these forces in the real-life environment and their impacts on decisions to buy insurance policies is worth empirical investigation. A research gap remains in this area. Moreover, because cyber insurance is a relatively new product on the market, the factors associated with firms' decisions to purchase it have not been sufficiently investigated. This marks another research gap worth addressing.

Poland is a leading economy in the Central and Eastern European (CEE) region. The Polish insurance market is growing rapidly. The CAGR of the non-life insurance market for the 2013-2022 period is 6.15% (EIOPA, 2023). Poland's share of the non-life-insurance gross premiums written in the EU is the greatest in comparison with other post-communist countries that accessed the EU (EIOPA, 2023).

This explanatory study translates feedback from practice into theory. Our goal is to investigate how cyber risk perception influence medium and large companies' decisions to purchase insurance. As control variables, a range of features describing company profile are considered. More specifically, this study addresses two primary research questions:

- RQ1. Are cyber risk perception and company profile significantly associated with companies' purchase of cyber insurance? Which elements of risk perception and company profile are most influential in a multidimensional approach?
- RQ2. Is managerial cyber risk perception influenced by the availability heuristic?

The following section presents the literature review for theory-based development of hypotheses. Next, we specify the methodology of the questionnaire survey and the research methods utilized. The results acquired are then presented and discussed. The last section concludes.

2. Literature review for hypotheses development

Cyber risk perception refers to people's beliefs, attitudes, judgments, and feelings toward cyber risk, and incorporates the wider social and cultural values, as well as outlook, people adopt toward cyber threats (Van Schaik et al., 2017; Wei et al., 2021). According to Slovic (2000), individual risk perception can be an important factor in making decisions about risk. The dominant view in the literature on cyber insurance is a positive assessment of insurance as a form of corporate response to cyber risks. Talesh (2018) points to the growing role of insurance companies in supporting businesses in adapting to the world of cyber threats by providing insurance coverage and unique risk management services that affect how organizations comply with privacy regulations.

Notably, cyber risk has different characteristics in comparison to other insurance lines (Böhme, Kataria, 2006). First, cyberattacks directly or indirectly affect all users of a certain type of technology. Secondly, both the business continuity and information security of a single enterprise depend heavily on the efforts of other market players with which that enterprise interacts. Anderson and Moore (2006) have concluded that these considerations impede both the development and the application of cyber insurance.

Nevertheless, in prior literature, insurance companies are seen as bridging the gap for companies that see themselves as unprepared for the risks of data breaches or IT system compromises (Herr, 2019). Cyber insurance is pointed to as creating a strong incentive to invest in cybersecurity (Bolot, Lelarge, 2009). Partial cyber insurance can motivate reluctant insurance customers to invest more efficiently in self-defense (Pal, Golubchik, 2010), and cyber insurance premiums can thus be estimated more fairly (Herath, Herath, 2011).

Cybersecurity researchers also highlight the insurance industry's ability to create the attitudes that motivate customers to implement adequate cyber risk protection tools (Talesh, 2017). In this context, it is important that insurance companies can collect data on breaches and then compile and share insights on the factors shaping a risky environment, acting as a central repository of particularly relevant IT security-related data (Levite et al., 2018). As a result, the field of cyber insurance should be viewed in a much broader context than is the case for the traditional insurance market. In contrast, the literature also points out that although the transfer of cyber risk to insurance companies can be an effective tool for managing risk and is increasingly offered by global insurance carriers like AXA, Generali, and Allianz, the market remains in an early stage of development (Marotta et al., 2017).

In our research, we follow the approach of de Smidt and Botzen (2017) in studying individual risk perception and its covariates, particularly in developing the questionnaire. Thus, risk perception is broken down into three components: risk awareness, perceived probability of successful cyber-attack, and its impact. The proxy for cyber risk awareness is the question of how possible (or not possible) is a successful cyber-attack on the respondent's own company (variable PROB). Perceived probability is measured via a question that asks the respondent to estimate the frequency (which is the inversion of probability) of successful cyber-attacks on their own company (variable FREQ). Using frequency format instead of probability format is justified by the results of Schapira et al. (2001); they argue that using discrete frequencies in estimating risk magnitude provides greater salience and understanding, compared to probability format, in communication of probabilistic outcomes. Finally, the perceived financial impact of cyber risk is measured by a question that asks the respondent to choose from a range of estimated monetary cyber losses if a successful cyber-attack were to occur in their company (variable IMPACT). As Barberis (2013) argues, research on individual risk perception should not focus only on probability, but also on subjective estimation of potential losses in monetary terms. Both influence the protective behavior of an individual. Therefore, we hypothesize that:

H1. The purchase of cyber insurance is associated with individual cyber risk perception.

The over- or underestimation of risk can be explained by the so-called availability heuristic. According to this heuristic, people perceive hazardous events as high-risk if such events are easy to imagine, recall, or conceptualize the occurrence of (e.g., Tversky, Kahneman, 1973). In this respect, personal experience of risky situations becomes extremely important. Following de Smidt and Botzen (2017), salience of cyber threats determines the level of individual risk perception in the cybersecurity context. The proxy of this factor in the current study is a question regarding personal experience of a successful cyber-attack against the respondent's own organization in the last five years (variable COUNT). Therefore, we hypothesize that:

H2. The availability heuristic is related to cyber risk perception.

Finally, the current study includes a set of control variables characterizing a company profile, in order to investigate how specific features of a company are associated with its decision to purchase cyber insurance. Prior literature suggests that the following features of an enterprise are related to the demand for corporate insurance (Main, 1982; Mayers, Smith, 1990; Hoyt, Khang, 2000; Krummaker, 2019): firm size measured by employment and annual turnover as a proxy; firm age; type of business; the firm's legal form; origin of equity; share of intangibles in total assets; and the firm's share of equity in total liabilities (leverage). Therefore, we hypothesize that:

H3. The purchase of cyber insurance is associated with a company profile.

Hypotheses H1 and H3 address the research question RQ1, and hypothesis H2 addresses RQ2.

3. Materials and Methods

3.1. Survey design

Our survey was carried out in 2019 using the CATI method. The questionnaire comprises 17 questions covering cyber risk perception, cyber insurance, and key characteristics of the surveyed companies (the firm's size in terms of employment and annual turnover, the firm's type of business, the firm's age, the firm's legal form, the firm's equity structure, and the firm's origin). The research sample is a stratified random sample encompassing medium and large enterprises (MLEs) operating in Poland in multiple industries, excluding financial services and public administration. The stratified random sample method involves dividing the entire group into layers, and then randomly selecting independent samples from each layer; the size of each stratified sample is proportional to the size of its respective layer. The layers for the current study's sample were determined according to the industry type (which resulted in nine layers), size of business (medium or large), and headquarters location.

3.2. Research methods

First, we examine whether cyber risk perception and company profile are associated with cyber insurance purchases. The statistical method used is one-dimensional analysis that enables a description of basic relations between variables, using Pearson's chi-square test of independence.

Next, using multiple correspondence analysis (MCA), we attempt to answer the question which components of cyber risk perception and company profile influence decisions about insuring against cyber-attacks. MCA allows analysis of the pattern of relationships among several categorical dependent variables. Technically, MCA is obtained by using a standard correspondence analysis on an indicator matrix (i.e., a matrix whose entries are 0 or 1). MCA can thus define the structure of a particular data set and in this study's context, aid in identifying the significant contributing factors to firms' decisions regarding insurance purchase.

We also utilized the "random forests" method, which is essentially a generalization of the idea of decision trees and belongs to the so-called ensemble methods. Random forests work by performing classification using a group of decision trees. The final decision on classification is made by majority voting on the classes indicated by each decision tree. Each decision tree is constructed based on a bootstrap sample, which is formed by drawing with return N objects from a learning set of N items. In addition, at each node of a given tree, the division is made only on the basis of k randomly selected features. In addition to choosing the appropriate type of method, a necessary challenge is choosing an appropriate type of model. The data collected for the current study forms a complete set, so there are no problems with gaps, but the dataset is unbalanced in that there are many more uninsured than insured companies. The lack of balance issue warrants further analysis. In other words, the distribution of the variable representing the purchase of cyber insurance is uneven, and one class dominates in terms of quantity; in our case, far more companies do not have a cyber policy than have one. This is a skewed distribution and a predictive model may thus not be well fitted. There are two main approaches to solving this problem at the data level— methods that modify the available data to balance the dataset. The most popular methods are oversampling, which generates artificial occurrences of a less frequent class, and undersampling, which is the opposite approach and reduces the dominant observations to compensate for imbalances. In this study, both methods have been used, to find the optimal model fit. In general, random oversampling duplicates values that occur less frequently in the learning dataset and can result in over-fitting some models. Random undersampling, in contrast, removes values that occur more frequently and can result in the loss of in-formation that significantly affects the model. Optimal parameter values were assumed in the simulations: $N = 350$ for oversampling and $N = 100$ for undersampling.

Another issue is the selection of the optimal parameters for a given random forest model. In a random forest algorithm, two parameters are important: the number of decision trees used in the forest (parameter *ntree*) and the number of random variables used in each tree (parameter *mtry*). A common approach is to set *mtry* to a default value, in our case the square root of the total number of all predictors, and search for the optimal *ntree* value. To find the number of decision trees that satisfy a useful classifier, random forests with different tree counts were built. We built 10 classifiers of the random forest type for each value of the *ntree* parameter along with the OOB error rate. As a result, we obtained the number of trees, and hence the optimal number of predictors, in which the error rate stabilized and reached a minimum. For the selection of the final random forest model, a two-step approach was used. First, the most optimal set of random forest parameters was selected, and then - for this set of parameters - the standard model and the models with oversampling and undersampling were developed and compared with each other, selecting the model that yielded the best results. The data was split into two datasets: a training dataset and a test dataset, at a ratio of 75% to 25%, where the test dataset was used to verify the results obtained.

The next step in analysis is to evaluate the results for each model, which consists of comparing correctly and incorrectly matched results in a confusion matrix; identifying the variables that most affect the classification result; and finally evaluating the classifier's quality using ROC curves. The best classification models are those that maximize the parameters of the ROC curve: sensitivity and specificity. Sensitivity is the proportion of the model's accurate predictions of "ones" (indicating the occurrence of an event) to all the ones observed in a sample (the actual occurrence of an event).

To assess the quality of a model, the area under the graph of the ROC curve (denoted as AUC) can be calculated and taken as a measure of the goodness and accuracy of fit of a given model. The classification quality of a model is good when the curve is above the diagonal $y = x$, that is, when the parameter AUC has a value greater than 0.5. A general rule for assessing the classification quality of models is as follows (Hosmer, Lemeshow, 2000; Kumari, Rajnish, 2015):

- AUC = 0.5: classification is not good (it is comparable to a random classifier);
- 0.5 < AUC < 0.6: poor classification;
- 0.6 < AUC < 0.7: acceptable classification;
- 0.7 < AUC < 0.8: good classification;
- 0.8 < AUC < 0.9: very good classification; and
- AUC > 0.9: excellent classification.

Calculations and graphs have been done in RStudio v. 1.4.1717 software, equipped with the latest versions of the randomForest, h2o, and ROCR libraries.

4. Results and Discussion

4.1. One-dimensional analysis

The dataset collected through the survey is expressed in the form of qualitative variables. The categories of these variables are measured on a nominal or ordinal scale. Table 1 shows the structure of the received responses, where possessing cyber insurance (*INSURANCE* variable) acts as a grouping variable.

Table 1.
Structure of the sample grouped by the cyber insurance purchase criterion (n = 386)

Variable	Categories of variable and their codes	Does a firm have cyber insurance? (INSURANCE)		Total
		No	Yes	
TYPE	Manufacturing (1)	147	24	171
	Trade (2)	68	8	76
	Services (3)	114	15	129
EMPL	Up to 250 (1)	309	2	311
	More than 250 (2)	20	45	65
YEARS	Up to 10 years (1)	155	11	166
	More than 10 years (2)	174	36	210
FORM	Corporation (1)	238	39	277
	Other (2)	91	8	99
CPTL	Domestic (1)	301	32	333
	Foreign (2)	28	15	43
EQUITY	0-25% (1)	211	43	254
	26-50% (2)	50	4	54
	Above 50% (3)	68	0	68
TURN-OVER	Up to 50 (1)	284	14	298
	51-100 (2)	32	15	47
	More than 100 (3)	13	18	31
INTANG	Up to 25% (1)	289	41	330
	More than 25% (2)	40	6	46
COUNT	No (1)	274	4	278
	Yes (2)	55	43	98
PROB	Low (1)	30	2	32
	Medium (2)	245	20	265
	High (3)	54	25	79
IMPACT	Up to PLN 100k (1)	278	25	303
	More than PLN 100k (2)	51	22	73
FREQ	Less than once a year (1)	297	20	317
	Once a year or more (2)	32	27	59

Note: The numbers in parentheses next to the variable categories indicate the variable category codes used in the statistical analysis.

Source: the authors.

The size of a company, as measured by both its number of employees (*EMPL*) and the volume of annual revenue (*TURNOVER*), shows the strongest relationship with the purchase of cyber insurance. In terms of employment size, almost all medium-sized companies (50-250 employees) in our sample are uninsured (99.4%). In contrast, large companies have a high penetration of cyber insurance (69%) and only 31% of those surveyed are uninsured.

Turning to the second measure of company size, annual turnover, observations indicate that as the volume of turnover increases, the percentage of companies with cyber insurance increases.

While in the category up to PLN 50 million only 4.7% of respondents have insurance, in the turnover group of PLN 51-100 million the share of insured companies rises to 32%, and in the highest turnover category of over PLN 100 million 58% of respondents have purchased a cyber risk policy. These results are consistent with previous studies. Large organizations are more vulnerable to uncertain large losses caused by cyber-crime. This aspect of cyber risk motivates their decisions to prepare by buying related insurance (De Smidt, Botzen, 2017).

Another set of variables having a statistically significant association with buying cyber insurance are the probability of a successful cyber-attack on a company (*PROB*), the expected frequency of cyber-attacks on a company in the future (*FREQ*), and the potential losses resulting from a cyber-attack (*IMPACT*). These variables are based on respondents' subjective assessments of the scale of cyber threats and they are proxies for cyber risk perception. Their role is to measure the perception of cyber risk by an individual making key financial decisions in a company, including the decision to purchase insurance. The strongest association with the purchase of cyber insurance comes from the frequency of cyber-attacks (*FREQ*). In cases where respondents estimate that their company is likely to experience a cyber-attack no more than once a year (i.e., low frequency of incidents), the share of insured companies is only 6.3%. In contrast, when respondents expect cyber-attacks several times a year (i.e., high frequency of incidents), the percentage of insured companies is significantly higher, 45.8%. Subjective assessment of potential losses due to a cyber-attack on a company (*IMPACT*) is another factor differentiating whether a population of companies has cyber insurance.

Thus, in the group of respondents who believe that their company's maximum possible cyber loss will not exceed PLN 100,000, only 8% of companies are insured against cyber risk. If the anticipated losses are higher than PLN 100,000, the share of insured firms rises to 30%. When asked how respondents perceived the likelihood of their company becoming a victim of a cyber-attack in the future (*PROB*), 8.5% answered "low," 70.5% answered "medium", and 21.0% answered "high". However, the distribution of responses varies depending on whether a company has cyber insurance. Interestingly, in the group of insured companies, the percentages of individual responses are 0.5%, 5.3%, and 6.6%, respectively, while among uninsured companies the responses arranged as follows 8.0%, 65.2%, and 14.4%. These results confirm the fundamental principle that the propensity to purchase insurance is strongly influenced by risk aversion, as well as by subjective risk assessment (risk perception).

For insured companies, 14.4% of respondents perceived cyber risk as high, while among managers of uninsured companies half as many, 6.6% of respondents, indicated they perceived the highest assessment of this probability. Pearson's chi-square test of independence has been used to verify whether relationships between the purchase of cyber insurance and explanatory variables are statistically significant. Table 2 provides a summary of these results.

Table 2.
Pearson's Chi2 test of independence between the INSURANCE variable and selected explanatory variables

Description	Chi2 test statistic	p-value
H1: The purchase of cyber insurance is associated with the cyber risk perception of a managerial decision-maker in a company		
FREQ ↔ INSURANCE	73.73	Less than 0.0001
IMPACT ↔ INSURANCE	51.28	Less than 0.0001
PROB ↔ INSURANCE	48.86	Less than 0.0001
H2: The availability heuristic is related to cyber risk perception of a managerial decision-maker in a company		
COUNT ↔ FREQ	142.01	Less than 0.0001
COUNT ↔ IMPACT	18.78	Less than 0.0001
COUNT ↔ PROB	89.05	Less than 0.0001
H3: There are specific characteristics of a company that distinguish insured companies from uninsured companies against cyber risks		
EMPL ↔ INSURANCE	230.569	Less than 0.0001
YEARS ↔ INSURANCE	18.786	0.0009
TURNOVER ↔ INSURANCE	92.353	Less than 0.0001
EQUITY ↔ INSURANCE	15.550	0.0014
CPTL ↔ INSURANCE	26.371	Less than 0.0001
TYPE ↔ INSURANCE	0.7288	0.6946
FORM ↔ INSURANCE	9.0085	0.1155
INTANG ↔ INSURANCE	0.0524	0.9742

Source: the authors.

Regarding H1, findings indicate a strong association between cyber insurance purchase and cyber risk perception. How firm managers reported perceiving the probability and potential impact of a cyber-attack has affected their decision to insure against this risk. The same pattern applies to cyber risk awareness (i.e., the higher the anticipated possibility of a successful cyber-attack, the bigger the share of insured companies in the population of respondents). These findings align with De Smidt & Botzen (2017), who demonstrated that cyber risk perception is driven by risk awareness, perceived probability, and perceived damage.

Regarding H2, based on the assumption that the availability heuristic explains the risk perception of professional decision-makers, De Smidt & Botzen (2017) found that the experience of a successful cyber-attack positively impacts cyber risk awareness (PROB) and perceived cyber risk probability (FREQ), but is not associated with assessing the cyber risk's potential impact (IMPACT). Our results are partially consistent, indicating that the availability heuristic is related to cyber risk perception in all three aspects, thus confirming H2.

Findings indicate that firm size measured by employment and annual turnover, equity ownership, firm age, and leverage (the share of equity in total liabilities) are significantly related to existing cyber risk coverage in MLEs. Other factors, such as the type of business, a firm's legal form, and a firm's share of intangibles in total assets did not differentiate the population of insured and uninsured companies. In other words, these were not good indicators of a firm deciding to purchase cyber insurance. Hence, hypothesis H3 is confirmed.

4.2. Multiple Correspondence Analysis (MCA)

In this step, we investigate the factors that primarily influence cyber policy purchase decisions if all variables are analyzed jointly. In other words, we intend to create the profile of a company that insures against cyber risk. We have run MCA with three clusters in two dimensions. Table 3 presents the results of this analysis.

We applied a scaling method that combines MCA with dimension reduction, with k-means for clustering. Parameter *alpha_k* = 0.85 was set. This is a non-negative scalar to adjust for the relative importance of MCA (*alpha_k* = 1) and *k*-means (*alpha_k* = 0) in the solution. The chosen two dimensions explain 91.49% of the total inertia. If the analysis were expanded to three dimensions, only 0.08% more of the total inertia would be explained, but the ability to graphically present the results on a plane would be lost. Therefore, we decided to limit the analysis to two dimensions.

Table 3.
Multiple Correspondence Analysis results

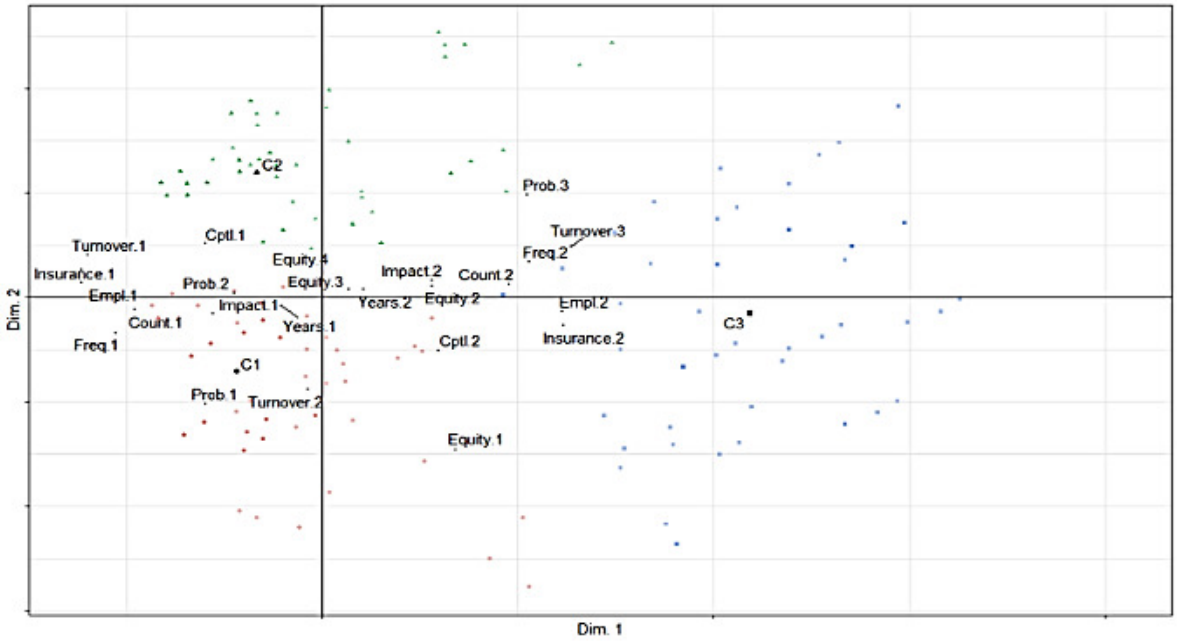
Dimension	**1**	**2**	**3**	
Singular value	0.327	0.025	0.020	
Eigenvalue	0.1071	0.0006	0.0004	Total inertia = 0.1446
Explained inertia (%)	91.11	0.38	0.08	
Cumulative explained inertia (%)	91.11	91.49	91.57	

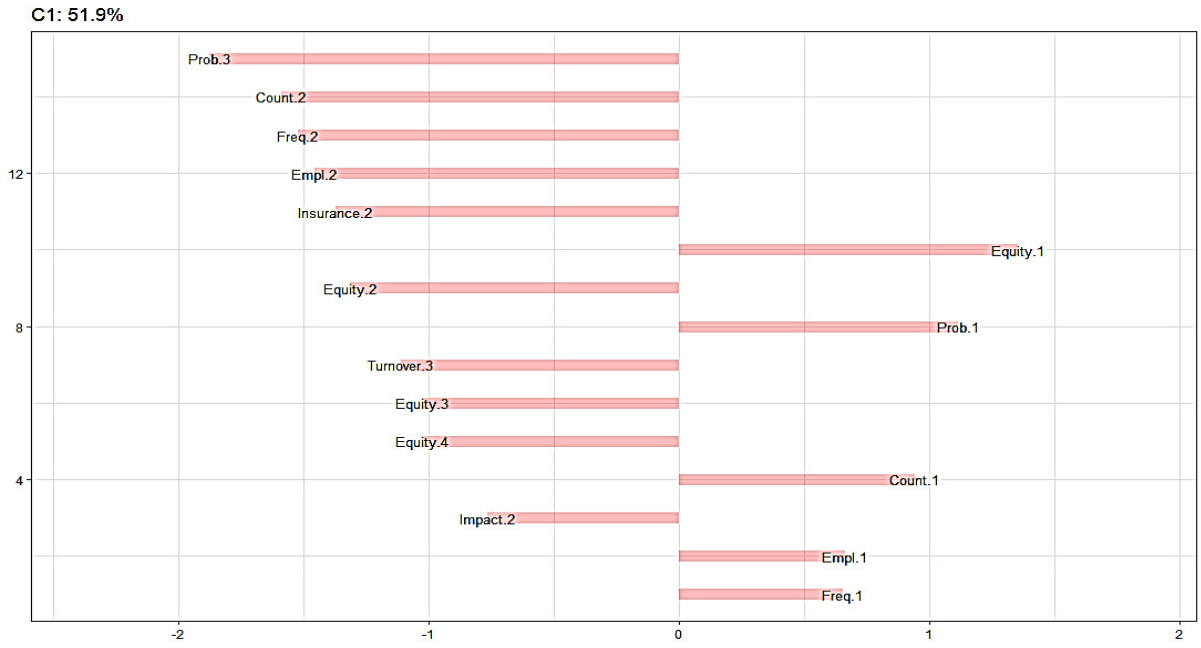
Source: the authors.

Fig. 1 presents the results of MCA in detail. The first graph shows a set of points representing all variables and their categories in a two-dimensional factor space. The points clearly arrange themselves into three groupings (clusters), denoted by points C1, C2 and C3. The other three bar graphs show the relative importance of the variable categories in each cluster. The longer the bar on the graph, the greater the impact of a given category of variable on forming a cluster, and the stronger relation with other variables in the cluster. The impact of a variable can be either positive (bar directed to the right) or negative (bar directed to the left). Cluster 1 (C1) includes 51.9% of objects, cluster 2 (C2) includes 33.2% of objects, and cluster 3 (C3) includes 14.9% of objects. C3 provides the most relevant insights into factors associated with the purchase of cyber insurance (*INSURANCE 2* variable category is the second most influential). They are as follows:

- business profile factors: employment above 250, annual turnover above PLN 100 million, and foreign equity capital;
- cyber risk perception: experience of at least one successful cyber-attack against the business in the last 5 years, high level of perceived frequency of cyber-attacks on the company "Once a year or more," high level of cyber risk awareness, and high anticipated impact of a cyber-attack on the company "More than PLN 100,000."

Thus, we have demonstrated that managerial cyber risk perception is associated with cyber insurance purchase decisions. Moreover, firm size and origin of equity are significant markers of firms deciding to insure against cyber risk.





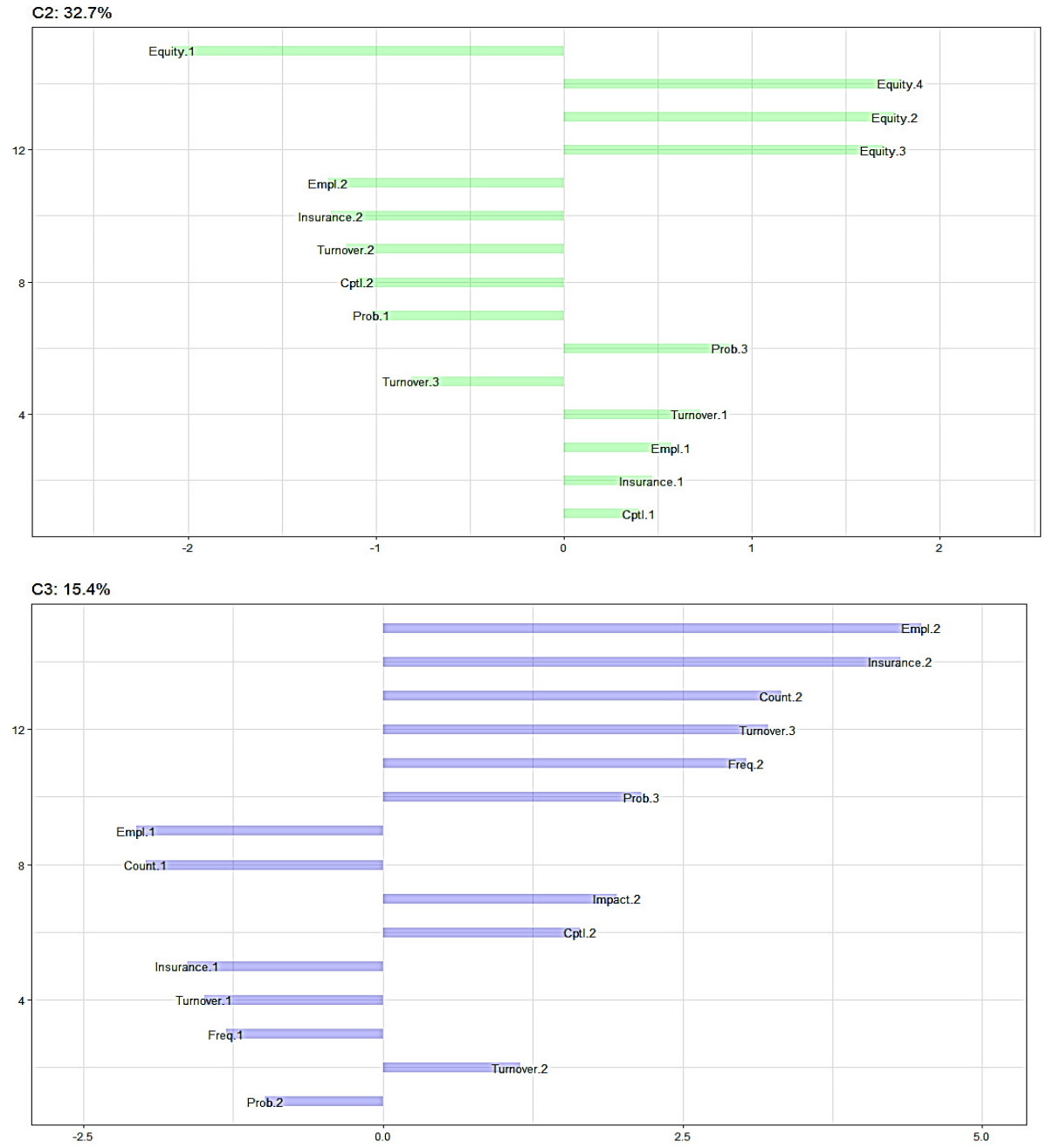


Figure 1. Clusters resulting from the MCA

Source: the authors

4.3. Random forests

Our purpose was to explore which elements of a company's business profile and cyber risk perception are related to having cyber insurance (so *INSURANCE* is a grouping variable). The analysis began with fitting an optimal set of random forest parameters, known as tuning. One hundred different parameter sets were tested. Table 4 shows the six best-fit models with their parameters.

Table 4.
Results of tuning the parameters of the random forest model – TOP 6 fitted models

Parameter *mtry*	Parameter *ntree*	Share of training dataset	Mean Squared Prediction Error (MSE)
2	200	0.75	0.0495
2	300	0.63	0.0498
2	500	0.80	0.0499
6	200	0.80	0.0499
6	300	0.75	0.0499
2	200	0.80	0.0504

Source: the authors.

Next, the parameter values were determined of the model that proved best in terms of minimizing MSE (*mtry = 2*, *ntree = 200*). Then, the accuracy of the model fit was com-pared using confusion matrices for the test dataset in three different variants: the baseline model (dataset unchanged, denoted STD), the model with oversampling (denoted OS), and the model with undersampling (denoted US). This step is shown in Table 5.

Table 5.
Comparison of confusion matrices of three variants of the data set of the selected model

Model	STD	OS	US
TP*	73	73	71
FP*	7	7	9
FN*	1	0	0
TN*	13	14	14
Accuracy	91.49%	92.55%	90.43%

Source: the authors.

The model with oversampling (OS) was chosen because it yields a maximum accuracy of 92.55%. Table 6 presents goodness-of-fit measures of this model. The model accurately identified companies with cyber insurance in most cases but was wrong in 7 out of 94 test data records.

Table 6.
Measures of goodness of fit of the estimated model

Parameter	Value
Accuracy = $\frac{TP+TN}{P+N}$	92.55%
Accuracy - 95% CI	(0.853; 0.970)
Sensitivity = $\frac{TP}{P}$	1
Specificity = $\frac{TN}{N}$	0.913
Negative Predicted Value = $\frac{TN}{TN+FN}$	1
Prevalence = $\frac{P}{P+N}$	0.223
Balanced accuracy = $\frac{Sensitivity+Specifity}{2}$	0.956

Notes: T - Positives (number of occurrences of an event), N - Negatives (number of non-occurrences of an event), TP - True Positives (number of correct indications of positive events), TN - True Negatives (number of correct indications of negative events), FP - False Positives (number of false indications of positive events), FN - False Negatives (number of false indications of negative events).

Source: the authors.

The high quality of the model fit to our dataset confirms the ROC curve (Figure 2). The value of the area under the curve (AUC) index is 99.6%, so the random forest with oversampling for the *INSURANCE* variable can be considered a very good classifier.

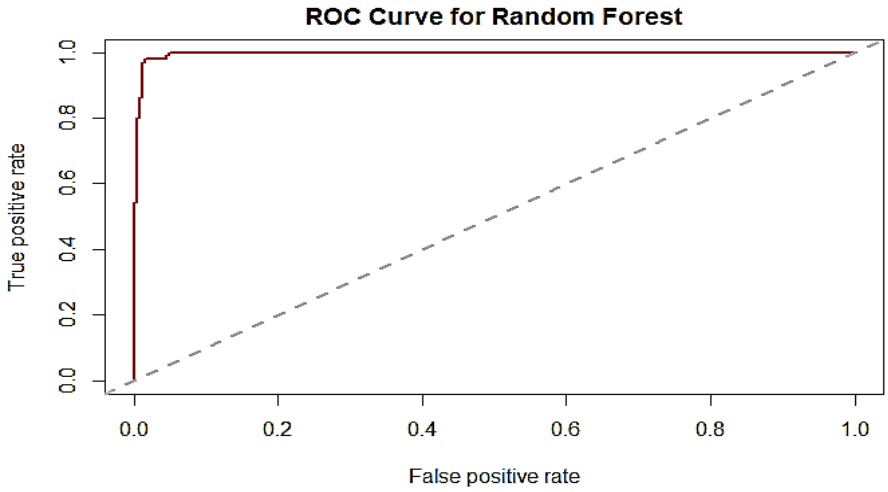


Figure 2. ROC curve.

Source: the authors.

The next step after the model estimation was to examine the impact of each variable on the classification result. The Mean Decrease Gini (MDG) was calculated for each variable. The higher the MDG, the greater the influence of the variable on the classification result. Figure 3 shows the highest influence of the *EMPL* variable. Moreover, the high impacts of *INC_MAXLOSS*, *COUNT* and *TURNOVER* are visible. Meanwhile, the variables *IMPACT* and *FREQ* have relatively lower impacts in the classification result.

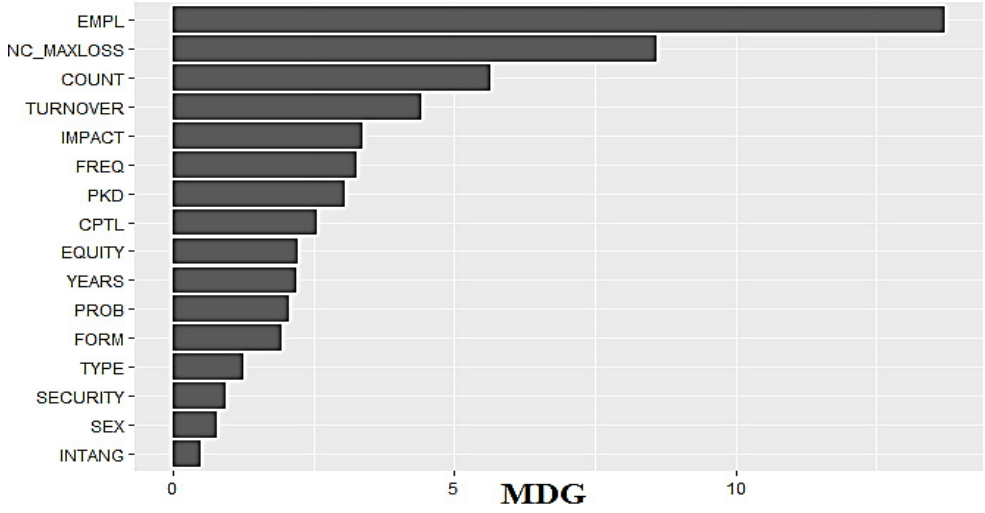


Figure. 3. MDG for explanatory variables in the estimated random forest model.

Source: the authors.

In other words, the factors that distinguish insured companies from uninsured ones in terms of cyber risk protection are primarily company size expressed as number of employees, and annual turnover. These are followed by the severity of experienced loss due to a cyber

incident, and the number of successful cyber-attacks experienced by a given company during the last 5 years. These are also the factors that make up a company's profile (i.e., the objective characteristics of an entity).

Lower on the list of factors influencing the decision to insure against cyber risk come cyber risk perception, that is, the expected negative consequences of a cyber incident and the subjectively perceived frequency of possible cyber-attacks in the future.

5. Conclusions

We found an association between managerial cyber risk perception and the decision to purchase corporate cyber insurance purchase. Negative experience with cyber threats, which shapes managers' risk perception, drives them to purchase insurance. Notably, the availability heuristic influences cyber risk perception. However, confidence in a manager's own company's cybersecurity capabilities does not affect their perception of cyber risk. Moreover, firm size, industry type, firm age, and equity ownership are significant markers of firms that have decided to insure against cyber risk. Therefore, we prove that the decision to purchase cyber insurance is also associated with some company profile elements.

Our MCA and random forests analyses show that decisions to purchase cyber risk coverage are mostly determined by factors related to company size, such as employment size and annual turnover. The number of successful cyber-attacks against a company, along with the maximum value of cyber losses a company has incurred in the last 5 years, are also important decision-making factors related to purchasing cyber insurance. This negative feedback from the past influences the cyber risk perceptions of company owners and managers, and thereby stimulates demand for cyber coverage.

Thus, we conclude that the propensity for company management to buy cyber insurance is driven by the interplay between cyber risk perception and company profile that defines firm-specific cyber risk exposure and insurance needs.

The reader should be aware of the potential biases and limitations of this study:

- Non-response bias: Despite efforts to reach a representative sample of individuals, it is always possible that individuals who did not participate in the survey are substantially different, in terms of their underlying beliefs, from those who completed the questionnaire.
- Sampling frame bias: The accuracy is based on contact information and the degree to which the list is representative of medium and large Polish enterprises that participated in the survey. We also acknowledge that the results may be biased by external events such as media coverage.
- Self-reported results: We are aware of the possibility that subjects may not provide accurate responses.

However, our study provides relevant feedback for policy-makers responsible for cyber security, particularly regarding incentives to improve cyber-attack resilience through cyber insurance. Moreover, the investigation of factors determining cyber insurance purchase can help insurance carriers target their offers on the market.

Cyber risk perception and insurance purchase decision-making are complex research-areas where both determinative factors and other cognitive processes can be influenced by each other. This can indicate that the dimensions differ across populations, industries and countries, creating grounds for further context-specific studies.

Further research may benefit from more multidisciplinary approach, and contextual studies within demand for cyber insurance can contribute to develop targeted tools for cyber risk management to enhance resilience of businesses and other organizations.

Acknowledgements

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SELECTED ASPECTS OF A PHOTOVOLTAIC INSTALLATION ANALYSIS FOR A SINGLE-FAMILY DETACHED BUILDING

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Purpose: Increased awareness of the society in the field of environmental protection and support programs addressed to prosumers encourage investment in renewable energy sources. This paper presents selected aspects of the operational, utility and economic analysis of a photovoltaic installation, based on the example of a selected single-family building located in a rural area of Mazowieckie Prowince.
Design/methodology/approach: The basis of the research was an analysis carried out in two variants of technical solutions, data obtained from the Photovoltaic Geographical Information System program and data from energy meter readings.
Findings: Photovoltaics covered 100% of the energy demand in the analyzed case and the actual energy production from photovoltaic panels (6,069 kWh) exceeded the theoretical yield (5,431 kWh). The analysis of energy collected from the power grid and that returned to the grid enabled making a balance, which, combined with the energy produced by the photovoltaic installation, was used to calculate the energy consumed by residents. It was therefore possible to present the relationship between the energy consumed and the energy supplied by the PV (photovoltaic) system in individual months.
Research limitations/implications: As part of the technical analysis for the case study, there were limitations in the selection of both a specific model of photovoltaic panels and the number of pieces thereof. This was due to the prosumer's participation in a program that supports the development of photovoltaics in a given area (the "Clean Air" Program implemented in 2018-2030).

Keywords: photovoltaics, renewable energy, return on investment, operation.

Category of the paper: research paper.

1. Introduction

The dynamic economic and technological development as well as the ever-growing population generate an increased demand for energy (Ahmad, Satrovic, 2023). The increase in

fossil fuel prices which results from the cumbersome processes of extraction, storage and transport as well as the issues of negative impact on the environment are the basis for the development of renewable energy sources (RES) (Wielewska, 2020; Xiong, Dai, 2023). These natural energy resources originate mainly from the earth, sun, water, wind, aside from being stored in biomass (Mackay, Probert, 2023). Their use is of great importance to reach the climate goal of the European Union (EU), which intends to achieve climate neutrality by 2050. In 2030, the share of energy from RES in the EU is to be 42.5 percent (Indeo, 2019).

The amount of electrical power installed in Poland for all types of energy sources (conventional and renewable) in May 2023 amounted to 62,574.522 MW, of which almost 40 per cent of electricity was produced from renewable energy sources (24,951.277 MW).

In the case of households, the most popular source of energy from the RES group is the solar radiation (Goraj et al., 2023). This is mainly due to the fact that the installation does not require large financial outlays, as is the case with energy from underground (heat pumps), hydropower (water power plants) or wind energy (wind turbines). The installed capacity of photovoltaics in May 2023 in Poland was 13,925.8 MW.

A photovoltaic installation is a set of properly selected devices and cables which make it possible to convert solar energy into electricity (photoelectric conversion) and transport it to a designated place (Kijo-Kleczkowska et al., 2022). The electricity generated in solar panels is transformed from direct current to alternating current through an inverter (Javeed et al., 2023). The main elements of the installation – the panels are made of modules, which in turn consist of individual cells. Photovoltaic panels fall into three basic generation categories, in which cells are made of different materials and characterized by a distinct structure (Ye et al., 2023).

Photovoltaic installations can be divided into two groups, depending on the method of connection: connected to the grid (on grid) and off-grid installations (Keiner et al., 2023).

In the on-grid installation, energy is used for the needs of electrical appliances in the household (Albatayneh et al., 2022). The unused energy excess electricity is sent to the power grid (prosumer) (Sabadini et al., 2021). The disadvantage of this system is that, in case of a power grid failure, the inverter disconnects the photovoltaic panels from the installation, which results in a complete power cut in the residential building (Guidara et al., 2020). The size of the on-grid installation depends, among others, on the area that is intended for the installation of panels, the selected type of solar batteries and the financial capabilities of the owner (Bahou, 2023). The percentage share of on-grid installations among all photovoltaic installations in Poland is about 70% (Dzikuć, et al., 2022).

In installations not connected to the power grid, the electricity generated by the photovoltaic panels is converted into alternating current by an inverter, and then used to power household appliances (Hassan, 2021). The excess energy is used to replenish the electricity in batteries (Ariztia, 2020). The stored energy can be used during a power outage (Navarro-Gonzalez et al., 2021). There is a regulator that is responsible for the appropriate level of battery charge (it also stops the charging when fully charged) as well as disconnection of all electrical devices as part

of protecting the battery against complete discharge (Li et al., 2023). The main advantage of an off-grid system is the energy independence of the household. Off-grid installations are usually installed in places where there are large distances from power grids or grids are not even intended to be constructed (Jamroen et al., 2023). The only downside is an off-grid installation is much more expensive than an on-grid one. The size of the off-grid installation depends on the demand for energy and the hourly demand distribution.

2. Research methodology

The object of the research was a detached home with a photovoltaic (on-grid) installation, which was used to conduct an operational and economic analysis. The building was located in a rural area of Mazowieckie Province. The household does not use a heat pump, air conditioning, electric water heaters or accumulation stoves. Also, no additional devices such as heat buffers, swimming pools, etc. were installed, which would increase own consumption.

For an analysis of a photovoltaic installation, natural factors are of great importance – especially sun exposure. The average annual sunshine for the town where the building is located is 1000 kWh/m^2.

2.1. Technical Assessment

The correct choice of installation devices and the estimation of yields that the installation is able to achieve in a specific latitude will be verified by calculations. They will also suggest the appropriate installation variant for a specific single-family building. The calculations were carried out for two variants of technical solutions of the installation.

In Variant I, the photovoltaic power plant is fitted on a single-family building and consists of 15 panels, 400 W each, which gives a total of 6,000 W of rated power. The choice of a specific model of photovoltaic panels as well as that of the number of pieces was conditioned by a program that supports the development of photovoltaics in a given area (the "Clean Air" Program, implemented in 2018-2030). The technical specification of the photovoltaic panel is included in the table below (Tab. 1). The area of the photovoltaic panels amounted to 31.5 m^2. A transformerless inverter with a rated power of 5kW was selected for the installation. Its main parameters are presented in Table 2. In the analyzed case, the voltage difference is about 0.1463V with every change of the temperature of the photovoltaic panel by 1° C. This means that the voltage changes by this amount, both when the temperature decreases and increases by 1°C. The maximum short-circuit current is 20.62 A. The voltage at high temperature is 268.3 V, and the voltage at low temperature is 448.52 V. The calculated low and high temperature voltages are in line with the design requirements of the fitted PV installation.

In Variant II, the photovoltaic installation consists of 18 panels with the power of 310 W each, which in total gives 5,580 W of the rated power of the installation. These panels were selected because they are monocrystalline cells, while the number of pieces was limited by the roof area of the selected building. The technical specification of the selected panel is presented in Table 1.

The area of the photovoltaic panels was 31.5 m^2. A 5 kW-rated power inverter was selected for the installation. Its main parameters are presented in Table 2. The voltage difference in variant II is about 0.1114 V with every change of the temperature of the photovoltaic panel by 1°C. The maximum short-circuit current is 19.78 A. The voltage at high temperature is 248.5 V, and the voltage at low temperature is 417.51 V.

Table 1.
Technical specification of the photovoltaic panel

	Variant I	Variant II
Electrical parameter STC		
Rated power [Wp]	400	310
Short-circuit current [A]	10.31	9.89
Open-circuit voltage [V]	48.75	40.82
Maximum current [A]	9.81	9.35
Maximum voltage [V]	40.86	33.18
Yield [%]	20.02	18.9
Electrical parameter NOCT		
Rated power [Wp]	295.8	226.1
Short-circuit current [A]	9.46	7.75
Open-circuit voltage [V]	39.05	36.29
Maximum current [A]	9.04	7.38
Maximum voltage [V]	32.71	30.64
Temperature parameters		
NOCT (800W/m2, 1m/s, AM 1,5, 20° C)	42±2° C	44±2° C
Temperature current coefficient	0. 027%/C	0.037%/C
Temperature voltage coefficient	-0.30%/C	-0.273%/C
Temperature power coefficient	-0.36%/C	-0.375%/C
Construction		
Front glass hardened	hardened 3,2 mm	hardened, anti-reflective 3.2 mm
Encapsulant	EVA foil	EVA foil
Rear layer	Multi-layer polyester	Multi-layer polyester
Frame	Anodized aluminium	Anodized aluminium
Cell type	BB N-TYPE Monocrystalline	Monocrystalline silicon
Cell dimensions	158.75x158.75	157x157
Number of cells [pcs.]	72 (6x12)	60 (6x10)
Socket resistance class	IP67, 3 By-pass diodes	IP67, 3 By-pass diodes
Wiring	1,100 mm, 4 mm^2	1,000 mm, 4 mm^2
Connectors	MC4 compatible	MC4 compatible
Mechanical parameters		
Length [mm[	1,990	1,650
Width [mm]	1,005	992
Thickness [mm]	40	35
Weight [kg]	22	18.5

Cont. table 1.

Application parameters		
Power tolerance	0/+4.99 Wp	0/+5 Wp
Application class	A	A
Safety class	II	II
Maximum system voltage	1,000/1,500 VDC	1,000VDC
Working temperature	-40/ +85°C	-40/ +85°C
Initial current protection	20A	15A
Certificates		
Maximum load	8,000 Pa (815 kg/m^2)	5,400 Pa (54 kg/m^2)
Maximum wind lift	5,400 Pa (550 kg/m^2)	5,400 Pa (240 kg/m^2)
Salt resistance	IEC 61701	IEC 61701
Ammonia resistance	IEC 62716	IEC 62716
Hailstone	Fi= 55mm, V= 33.9m/s	Fi= 55mm, V= 33.9m/s
PID effect resistance	IEC EN 60804	IEC EN 60804

Source: Own study based on JBG Product catalog.

Table 2.
Technical specifications of the inverter

		Variant I	**Variant II**
Catalog parameter	**Unit**	**Value**	**Value**
Input Data			
Number of MPP trackers	[pcs.]	2	2
Maximum input current	$I_{dc\ max}$[A]	16/16	12/12
Maximum short-circuit current	I_{max}[A]	24/24	18/18
DC input voltage range	$U_{dc\ min}$- $U_{dc\ max}$ [V]	150-1000V	80-1000
Rated voltage	U_{dc} start [V]	200	80
Rated input voltage	$U_{dc,\ r}$ [V]	595	710
MPP voltage range	$U_{mpp\ min}$- $U_{mpp\ max}$ [V]	163- 800	240- 800
Usable MPP voltage range	[V]	150- 800	80- 800
Number of DC connections	[pcs.]	2+2	2+2
Maximum PV generator power	$P_{dc\ max}$ [kWp]	10	7.5
Output data			
Rated power	AC ($P_{ac,\ r}$) [W]	5,000	5,000
Maximum Rated power	$P_{ac\ max}$ [VA]	5,000	5,000
Output current	AC ($I_{ac\ nom}$) [A]	7.2	21.7
Mains connection	$U_{ac,\ r}$ [V]	3~ NPE 380/220	1~ NPE 380/220
Voltage range	AC (U_{min}- U_{max}) [V]	150- 280	180- 270
Frequency	F_r	50/60 Hz	50/60 Hz
Frequency range	(f_{min}- f_{max})	45-65 Hz	45-65 Hz
Power factor	-	0.85-1	0.85-1

Source: Own study based on JBG Product catalog.

With the use of the Photovoltaic Geographical Information System for checking yields from photovoltaics, it was estimated that the selected installation with the power of 6 kW should produce 5,431 kWh per year (Variant I). These forecasts include geographical location, installation parameters, roof (panel) inclination angle and azimuth angle (deviation of panels in the horizontal plane). In the case of variant II, the selected installation with a capacity of 5.58 kW should produce nearly 5,051 kWh per year. Predicted monthly yields from installations in Variants I and II are presented in Table 3.

Table 3.
Predicted monthly yields from PV installations

Month	Predicted yield [kWh]	
	Variant I	Variant II
January	141.6	131.7
February	209.4	194.8
March	436.7	406.2
April	626.7	582.8
May	700.5	651.5
June	725.3	674.5
July	737.1	685.5
August	676.7	629
September	544	506
October	376	349.7
November	149.9	139.4
December	107	99.5

Source: Own study based on Photovoltaic Geographical Information System (PVGIS).

The values of energy production from a given installation in individual months presented in Table 3 were generated by the Photovoltaic Geographical Information System program. The database of this program consists of analyses of insolation yields from previous years. It should be emphasized that these are projected values, as the value of the sun exposure largely depends on the weather on a given day or in a given month. In addition, it is not known from which year the regional insolation values come from and when they were last updated.

The calculation results presented above indicate that the best solution in terms of the amount of energy produced are multicrystalline panels described in Variant I. For the location in question, their projected yields from the program simulation will amount to 5,431 kWh of energy. After the technical assessment of a given installation, it may be concluded that its basic elements have been selected correctly. The size of the inverter perfectly harmonizes with the power of the system. The results obtained from the calculations are within the ranges of values provided by the manufacturer, both for the inverter and the panels themselves. In addition, the yield simulation system shows that the fitted installation will work at a very good level, while generating significant amounts of electricity.

2.2. Settlement of energy collected and returned by the photovoltaic installation

Courtesy of the owner of the building being the subject of the research and the materials made available, it was possible to settle the electricity collected from the grid and returned to the grid, which came from surplus production (Fig. 1). This made it possible to analyze the amount of energy produced by the photovoltaic installation, and then compare the theoretical and actual yields.

After fitting the photovoltaic installation, the distribution system operator (electricity provider) is obliged to replace the traditional electric meter with a bidirectional meter. This way, the user of the installation can observe how much energy is drawn from the grid and how much is returned to the power grid as part of the production from the photovoltaic

installation. This also allows the owner to make payments for the electricity consumed. It is important to remember about the method of drawing energy from the grid with functioning photovoltaics. The PV installation (in the on-grid system) supplies the produced energy for the primary needs of the residents. Should these needs not be met, the energy is collected from the network and it is this energy that constitutes the value of the energy consumed on the meter. If, on the other hand, the energy produced by the PV system is not fully used to meet the energy needs, then it is returned to the grid, which is also recorded by the meter (returned energy).

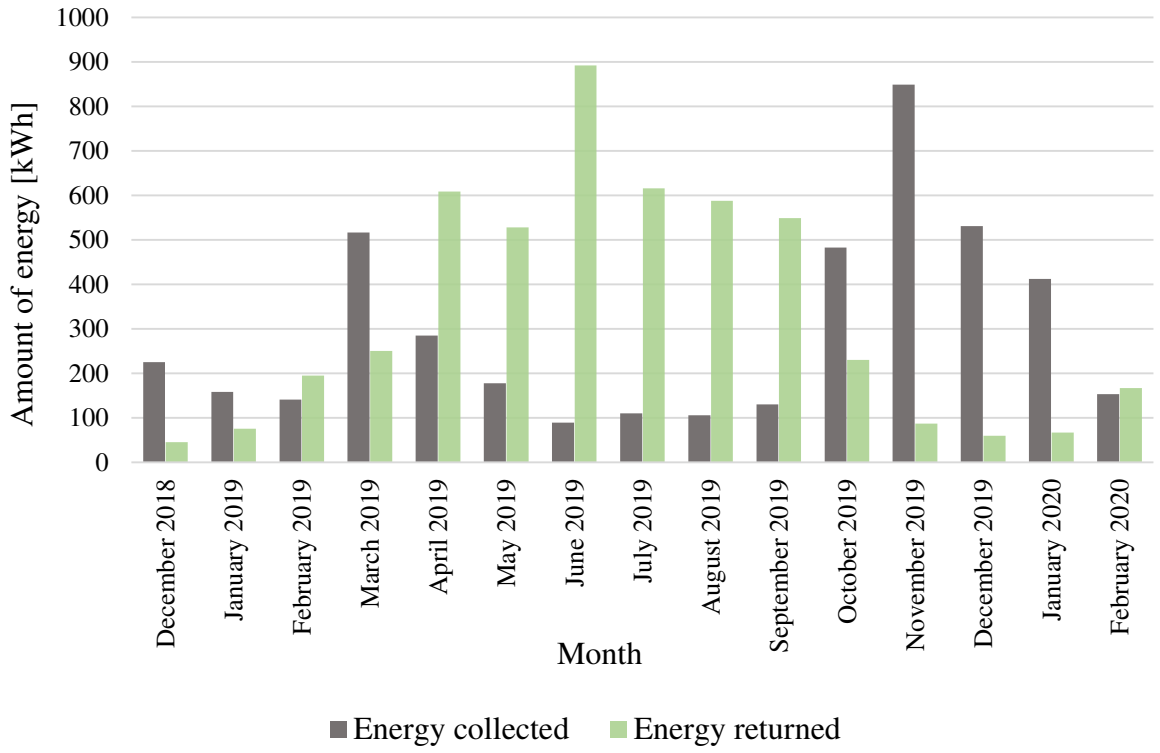

Figure 1. Comparison of the amount of energy consumed in relation to the energy returned.
Source: Own study.

2.3. Production of energy from photovoltaic panels

The fitting of a photovoltaic installation with all accessories makes it possible to track the energy produced from the sun. The yields for a given household after fitting the photovoltaic installation system for individual months (during its use) are presented in table 4.

Table 4.
Energy production for individual months

Month	Energy production [kWh]
October 2018	457
November 2018	172
December 2018	57
January 2019	107
February 2019	249
March 2019	475

Cont. table 4.

April 2019	819
May 2019	679
June 2019	996
July 2019	733
August 2019	730
September 2019	637
October 2019	391
November 2019	126
December 2019	127
January 2020	126
February 2020	220
March 2020	62

Source: Own study.

The highest yields of energy from photovoltaic panels in a given calendar year (2019) were recorded in June, which is typical for a specific latitude. The smallest production occurred in January, which is conditioned by weather conditions. The total energy produced during the year is 6,069 kWh, while the monthly average is 398 kWh. The energy production in individual months is shown in Figure 2.

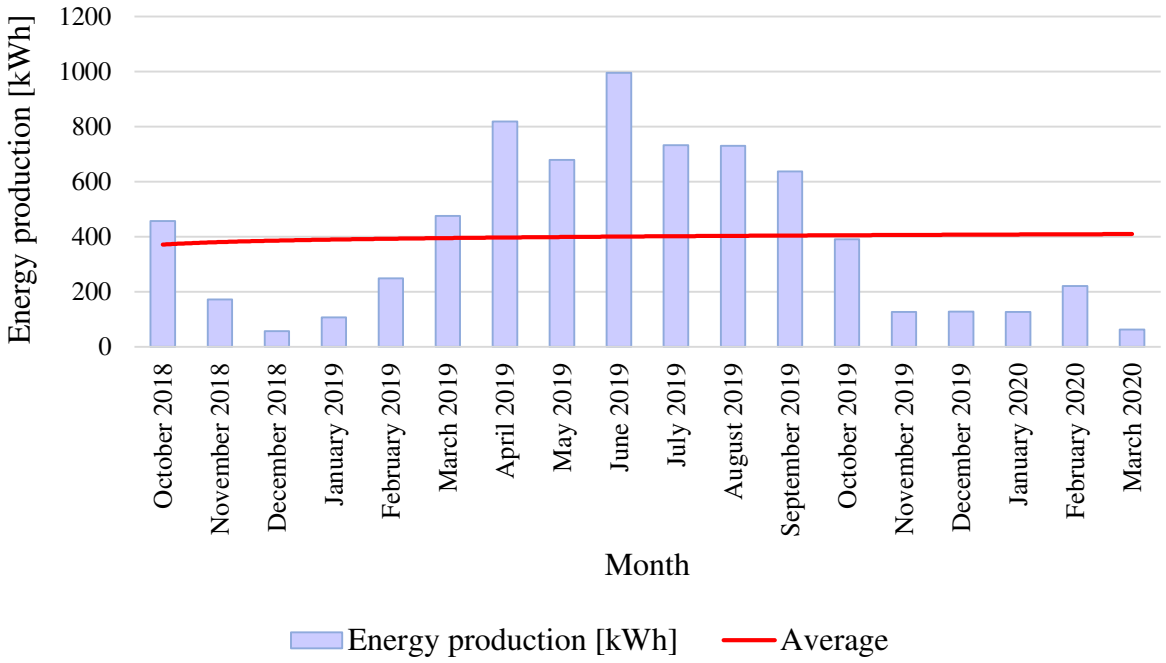

Figure 2. Energy production for individual months.

Source: Own study.

2.4. Comparison of theoretical and actual yields

The projected annual yields from a given photovoltaic installation were at the level of 5,431 kWh, while the actual production amounted to 6,069 kWh. This much better result certainly brought a lot of satisfaction to the prosumer. The comparison of the projected monthly yields from the photovoltaic installation with the actual yields is shown in Figure 3 (one full calendar year was selected).

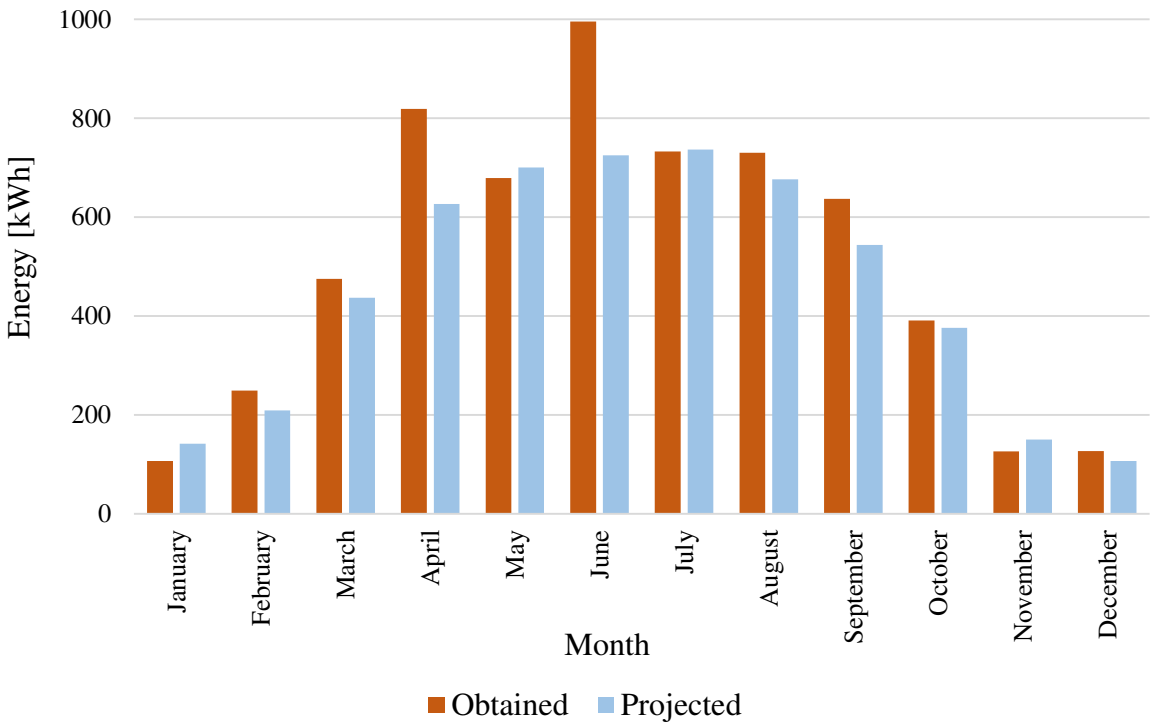

Figure 3. Projected vs actual yields.

Source: Own study.

2.5. Energy consumption by the users of the installation

With data on the energy fed into the grid, taken from the grid and produced by photovoltaic panels, the monthly electricity consumption in a household can be calculated. For this purpose, the following formula was used:

Energy consumption by users = energy collected from the grid + energy produced by PV panels – energy returned to the grid

Monthly electricity consumption values are presented in Table 5.

Table 5.
Monthly electricity consumption

Month	Monthly difference between energy collected and returned [kWh]	Monthly yield from the PV installation [kWh]	Monthly energy consumption (column 1 + column 2) [kWh]
December 2018	179.9	57	236.9
January 2019	82.8	107	189.8
February 2019	-53.4	249	195.6
March 2019	256.5	475	731.5
April 2019	-324.1	819	494.9
May 2019	-350	679	329
June 2019	-803	996	193
July 2019	-506	733	227
August 2019	-482	730	248
September 2019	-419	637	218
October 2019	253	391	644

Cont. table 5.

November 2019	812	126	938
December 2019	471	127	598
January 2020	345	126	471
February 2020	-14	220	206

Source: Own study.

The annual energy consumption (in the calendar year 2019) amounted to 5,007 kWh. The electricity consumption values in the table above are sometimes very diverse. This is due to the very careful management of energy by the owner of the household. The host conscientiously keeps a spreadsheet, calculates the balance of energy produced, while taking into account the appropriate coefficient (0.8) for energy storage by the operator. It is therefore known how much energy can be taken back from the grid yearly, so that the photovoltaic installation works only for the needs of a given building. The surplus energy collected back from the grid is usually used in transition periods for electric home heating. Hence, in March and November, the highest energy consumption can be observed, so that in the annual settlement the balance of energy produced from PV to electricity consumption stays at the lowest possible level.

The summary of the values from Table 5 made it possible to present a graph of the relationship between the energy consumed and the energy produced in individual months. It can therefore be seen when there was overproduction and when there was a shortage of energy (Fig. 4).

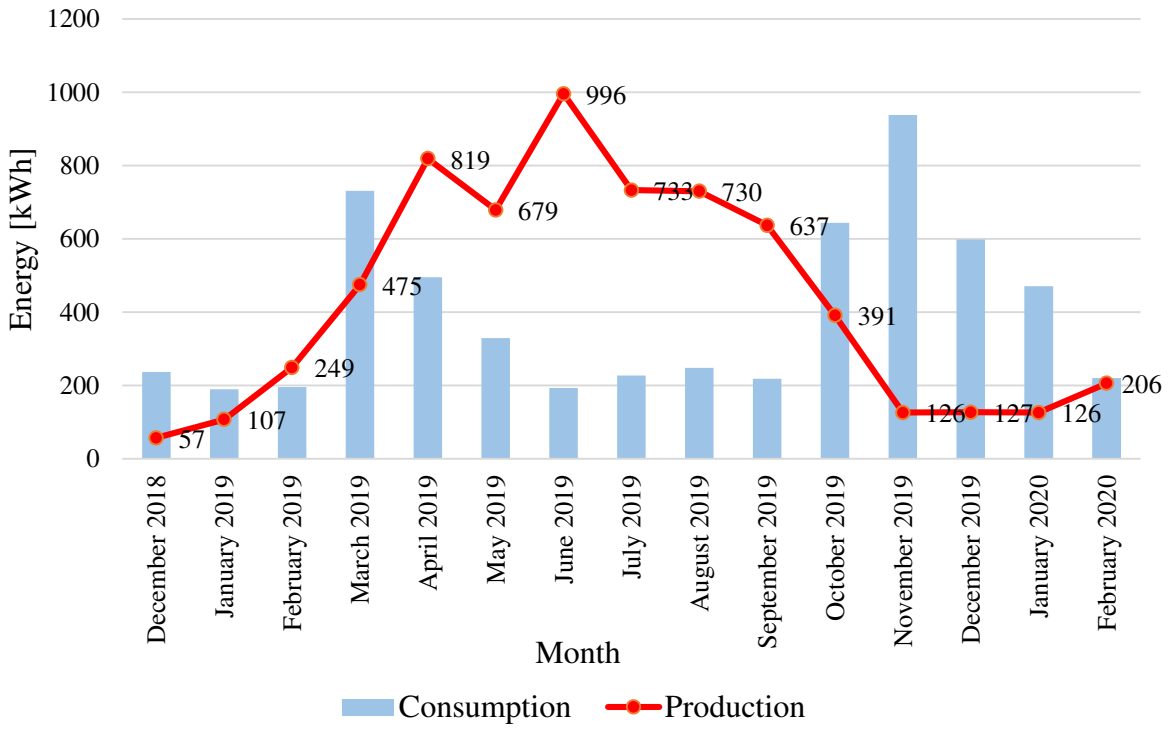

Figure 4. Relationship between energy production and consumption.

Source: Own study.

2.6. Savings resulting from the photovoltaic installation

The annual energy consumption for 2019 was 5,007 kWh, while the photovoltaic installation operating in this period produced 6,069 kWh. It can therefore be concluded that the installation covered 100% of the energy demand for the building.

$$6{,}069 \text{ kWh}/5{,}007 \text{ kWh} = 1.21 = 121\%$$

The surplus energy that was produced by the PV system was distributed in such a way that it covered the demand for energy in a different period of time. This is also evidenced by electricity bills (PLN 77 for the period from January to June and PLN 81 for the period from July to December). Therefore, the owner of the installation paid only fixed fees. The household uses the G11 tariff (basic tariff for individual customers).

The savings resulting from the installed photovoltaics can therefore be calculated by subtracting the electricity bills in a given year.

$$5{,}007 \text{ kWh} * \text{PLN } 0.60/\text{kWh} = \text{PLN } 3{,}004/\text{year}$$

The calculations assume the rate of PLN 0.60 per 1 kWh of energy used. For the sake of transparency of the settlements, it was assumed that the installation is not degraded in the considered period. Service costs are therefore PLN 0. Energy prices are stable. The total installation cost of the analyzed installation is PLN 32,200. The owner of the building benefited from funding from the "Clean Air" Program, under which natural persons can obtain co-financing of the investment from 40 to 100% of the cost, depending on their income.

3. Summary and discussion

The subject of the analysis was the operational evaluation of the photovoltaic installation on the example of a selected single-family building located in a rural area of Mazowieckie Province.

The selected photovoltaic installation consisted of: 15 multicrystalline photovoltaic panels with the power of 400 W each (total power of 6,000 W), a transformerless inverter with the rated power of 5 kW, wiring and security devices inside the building. The criterion for the choice of these photovoltaic panels was the projected yields for a specific latitude and the roof area which limited the number of pieces. Exactly such a solution was used in the building in question.

The installation was commissioned in 2018. The fitted installation covered 100% of the household electricity consumption, and the costs incurred were only certain fixed fees imposed by the network operator. Thanks to this, the owner of the household is able to save over PLN 3,000 on electricity bills per year.

The efficiency assessment was made on the basis of the adopted assumptions, both those resulting from weather conditions, as well as the basic parameters of the functioning installation. In the analysis, own calculations were made and a simulation program of the production of energy from photovoltaic panels was used. With data on the balance of energy supplied to and collected from the grid, the annual production from PV, energy consumption, and the calculated value of photovoltaic savings, it was possible to carry out a detailed analysis of the operation in a specific building.

After doing so, it can be concluded that the working photovoltaic installation has been selected with due accuracy. All its calculation parameters comply with the required values and are within the ranges provided by the manufacturer of the panels and the inverter. In addition, the size of the installation is ideally suited to the electricity consumption profile of the residents, and the surplus production is used at a later time.

The results of the analysis:

- Annual electricity consumption: 5,007 kWh;
- Theoretical yield from photovoltaic panels: 5,431 kWh;
- Actual energy production from photovoltaic panels: 6,069 kWh;
- Difference between projections and actual yields: 638 kWh;
- Coverage of energy demand by photovoltaics: 100%;
- Energy collected from the grid: 3,577.5 kWh;
- Energy transferred to the grid: 4,639.7 kWh;

Final conclusions:

1. Thanks to the operational analysis conducted, it can be concluded that that the production of energy from photovoltaic panels is higher by 638 kWh per year than the estimated production from the program, which is as much as 10.5%.
2. The economic analysis conducted proves that the savings resulting from the installation of photovoltaic panels on a given building generate savings of around PLN 3,000 within a calendar year.
3. Before purchasing selected photovoltaic panels, an operational analysis should be carried out in order to determine which variant will work best for a given facility, electricity consumption and at a specific latitude.
4. Multicrystalline panels are the most favourable for the weather conditions of Poland due to the very good ratio of yields to the purchase price.
5. The fitted installation is certainly able to produce more electricity if it faced directly southward (currently it is south-west).

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CAREER INTEREST PREFERENCES, RANDOMNESS OF STUDY PROGRAM CHOICE, AND COMPETENCIES VS. ACADEMIC MAJOR RESELECTION

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Purpose: The paper aims to present a review of literature on key competencies related to the significance of education and skills in selecting studies. It also explores the factors considered in study major selection, including career preferences, choice randomness, and competencies possessed. The research aims to understand how study majors were selected and the satisfaction levels associated with those choices.
Design/methodology/approach: The research objective implementation was divided into two stages. The first stage involved an analysis of secondary sources, including a review of literature on the subject. The second stage entailed conducting a survey using an online questionnaire tool, which consisted of 133 questions about career interest preferences, 21 questions regarding competencies, 11 questions about the studies pursued, and a 4-question metric.
Findings: The research concluded that study majors were selected in accordance with the preferences and interests of the decision-making persons. It also found that those who made the decision independently or randomly were often dissatisfied, while those who made the choice with their preferences and with the influence of third parties were satisfied and would not change their decision.
Practical implications: Understanding the factors that lead to satisfaction or dissatisfaction in study major selection may help educators and counselors guide students more effectively.
Originality/value: Insight into the factors affecting the choice of the field of study and the relationship between decision-making processes and the level of satisfaction can provide valuable information for educators, career advisors, students and employers making decisions about their educational path.

Keywords: competence; professional preferences; professional interests; sustainable education.

Category of the paper: Research paper.

1. Introduction

This article focuses on selected factors taken into account during academic major decision making. The study entailed an attempted to determine the consistency of the major-selecting persons' interests and preferences, including identification of possible differences in an instance of academic major reselection, taking the preferred career interests, the choice randomness of the major currently pursued, and the competencies possessed into account. To implement the study, four research questions had been posed:

1. Is the selection of academic major made taking the major-selecting person's preferences and interests into account?
2. Are there differences in possible academic major reselection, assuming a possibility of decision remaking taking the major-selecting person's interests into account? Would the academic major selection be then the same or different?
3. Are there differences with respect to academic major reselection, assuming a possibility of decision remaking taking the manner in which the first selection was made into account?
4. Are there differences with respect to academic major reselection, assuming a possibility of decision remaking taking the major-selecting person's competencies into account?

Based on these questions, three research hypotheses were posed:

H1. The inclination to switch to another academic major is lower when the respondent's career preferences are compatible with the profession for the performance of which the major selected is intended, than the case of the respondent's career preferences' incompatibility with the profession for which the study major selected is intended.

H2. In an instance of academic major selection that was not preceded by analysis, the respondents are more inclined to correct their choice of the major, than in an instance of a major selection preceded by such analysis.

H3. The selection of an academic major does not depend on the selecting person's competencies.

This article focuses on selected factors taken into account in the academic major decision making, including determination of possible differences, in an instance of a potential major reselection, taking the preferred career interests, the choice randomness of the major currently pursued, and the competencies possessed into account.

2. Literature review

2.1. Sustainable education

Sustainable development is interconnected with the far-reaching technological progress and globalization. The subject literature pinpoints that the objectives of sustainable development are intended to counter the consequences of the globalization processes, which, so far, have not been much conducive to the harmonious development of civilization (Ferreira, 2017; Nowak, 2017).

The concept of sustainable development was first mentioned in 1980 in the World Conservation Strategy. One of the key events considered to constitute the onset of the idea of sustainable development, was the speech given by U Thant, the Secretary General of the United Nations, in 1968. A year later, the "Problems of the human environment" (also known as the U Thant Report) report was published. In addition to the aforementioned report, it is worth mentioning the Club of Rome's 1972 publication "The Limits to Growth", which attempted to determine human impact on the environment (Meadows et al., 1972; Lemkowska, 2020)

The very definition of sustainable development incorporates three aspects: the environment, economy and society. According to the report, sustainable development entails such manner and form of development which allows the needs of the present generation to be met without limiting the future generations' ability to meet their needs (Turner, 1988; Draghici, 2019).

One of the most important documents, considered an official interpretation of the society's further development, is the Action Program – Agenda 21, developed during the 1992 United Nations conference on the Environment and Development held in Rio de Janeiro. Education has been given special significance in this document (Rydz-Żbikowska, 2012; Douša, 2021). As Nowak M. (Nowak, 2017) notes in his study, education entails one of the conditions underlying and enabling sustainable development. Access to education has been one of the Sustainable Development Goals adopted on September 25, 2015.

The importance of education, which affects the level of competency, is also visible in the labor market. The changes brought about by the Industrial Revolution 4.0 have contributed to the fact that many companies are facing organizational challenges, including, first and foremost, changes in the functioning of teams within an organization. These changes encompass changes in employee competencies. The reasons for the changes in employee competencies can be sought in the progressive technological development (e.g., emergence of new professions) (Steinerowska-Streb, Głód, 2020; Kryk, 2021; Matwiejczuk, 2021).

Due to the development of the economy, employers require university graduates to possess the ability to operate in complex work environments. Employees very often face misdiagnosed problems, incomplete and divergent information, or dynamically evolving integrated processes in such work environments. This is why properly diagnosed competencies, which involve the ability to deal with specific situations, play such an important role (Westera, 2001).

Competencies are formed through the reciprocity (Figure 1) that occurs between attitudes, knowledge and skills, while the contribution of each element largely depends on a person's interests and his/her ability to develop those. The direction in which interests are developed is determined by the educational, followed by the professional, path.

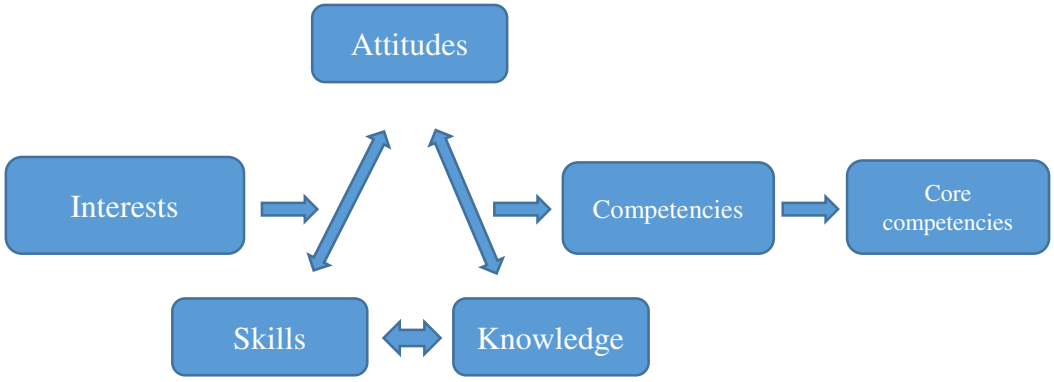

Figure 1. Competence formation. Source: own elaboration.

Source: own elaboration.

In European countries, an increase in the number of higher education students has been evident over the past few years. The increase in the number of the individuals raising their education levels indicates a general strong desire to enrich one's education, which is inherently linked with improvement of one's qualifications, level of knowledge or further development of interests (Lieberman, Remedios, 2007; Jarecki, 2008).

The manner in which the decision on whether to undertake higher education studies at all and what to major in is made affects the commitment to knowledge acquisition. According to various studies conducted by many research teams, the desire to satisfy family needs/expectations constitutes a very common motive underlying the decisions about applying to college/university (Richardson, Watt, 2005; Mudhovozi, Maree, 2012; Jarecki, 2015; Costaños, Moneva, Malbas, 2020). Another such motive pertains to financial security. Young people choose academic majors which will provide them with better job opportunities and thus with financial independence and a financially secure future(Lieberman, Remedios, 2007; Russkikh, 2019; Herz, ElAyouti, 2022). Women who plan to start a family in the future show significant differences in terms of the motives underlying their college/university application decisions. The subject literature mentions the so-called 'caregiving roles and responsibilities', which are the main factors determining young women's field-of-study decisions (Mudhovozi, Maree, 2012). One common motive fundamental in the pursuit of higher education is primarily the desire to develop one's own interests and deepen one's knowledge (Jarecki, 2015; Kember, 2016; Hudig et al., 2021).

2.2. Core competencies – definition and breakdown

Both the Polish and world literature present various attempts to expound the concept of competency, nevertheless, the term is not easy to define. Various definitions of competency have emerged in the subject literature, which often lead to inconsistent understanding of the term. The definition of competency constitutes a very important element in the terminology linking many scientific disciplines dealing with management, human resources, sociology, psychology and economics. A problem arises in the interchangeable use of the term. In the literature, the term is often linked with the concept of 'core competencies' (Prahalad, Hamel, 1990; Spanos, Prastacos, 2004; Matwiejczuk, 2021).

Currently, the concept of competency should be considered through two currents: the British and American. In the British view, competency refers to areas of work, professions or activities in which a person should be complete. This understanding of competency was developed in Scotland, during the formulation of the National Occupational Classification standards. The second view is based on the American current, initiated by McClelland and further developed by many scientists (R. Boyatzis, L. Spencer, S. Spencer). According to the American current, competencies are the human qualities enabling effective performance of professional tasks (McClelland, 1973; Boyatzis, 1982; Spencer Jr, Spencer, 1993; Bolden, Gosling, 2004; Stratton et al., 2011).

Competencies can also be viewed from two different perspectives. The first entails the individual perspective, also known as the personal perspective, involving an approach that relies on the personal skills in the performance of specific processes and tasks. The second entails a collective perspective, also known as the managerial perspective, which is pertains to the coordination of company resources and capabilities (Le Deist, Winterton, 2005; Matwiejczuk, 2022).

Various authors have made important contributions to clarifying what competencies are. An overview of the definitions of the term 'competency' is presented in Table 1.

Table 1.
Overview of the term 'competency' definitions

Author/s	Definition
Weinert F.E.	The cognitive abilities and skills available to or learnable by individuals in order to solve specific problems, including the associated motivational, volitional and social readiness, as well as the ability to use problem solutions effectively and responsibly in a variety of situations.
Borkowska S.	The behaviors determined by the knowledge, skills, motivation and attitudes differentiating employees in specific work situations.
Lehtonen T.J.	The enduring capabilities which, taking the current and future competitive conditions into account, are or can be of strategic importance in a company's pursuit of success.
Markus L.H., Cooper-Thomas H.D., Allpress K.N.	The general set of knowledge, motives, traits, self-images and (fulfilled) social roles, as well as the skills existing in a causal relationship to the extraordinary or effective performance of a specific job.

Cont. table 1.

Eriksen B., Foss N.	The unique corporate knowledge involved in the processes of effective development as well as production and marketing of appropriately defined products and services, concerning the organization and management of these processes in particular.
Kioupi, W., Voulvoulis N.	Competencies represent the integrated set of knowledge, skills, attitudes and values brought into play in different contexts (society, education, work and family) in order to deal with situations involving complex challenges.

Source: own elaboration based on: (Eriksen, Mikkelsen, 1996; Borkowska, 2001; Weinert, 2001; Lehtonen, 2005; Markus, Cooper-Thomas, Allpress, 2005; Plawgo, Ertman, 2021; Kioupi, Voulvoulis, 2022; Pacher et al., 2022).

The above-presented definitions of competency show a rather pronounced lack of consistency in individual authors' views, resulting in the aforementioned difficulty in unambiguous definition of the term. Some authors note that competencies are the character traits enabling individuals to perform certain tasks or activities. Other authors equate competencies with the resources used by companies to achieve financial or market objectives. It is also worth noting that most of the definitions of competency presented refer to the work environment and the manner in which professional objectives are achieved.

Researchers (Goddard, 1997; Savanevičienė, Stukaitė, Šilingienė, 2008; Coşgun Ögeyik, 2016) have been searching for links between the combination of competencies and the relevance thereof to (work, learning) performance (Hecht et al., 2003; Cath, 2019; Scheel, Vladova, Ullrich, 2022) since the 1960s. The literature on the subject does not unify the division typology of competencies and the factors shaping them, while the multiplicity of the criteria results from the changeability of the world (Winterton, Delamare-Le Deist, Stringfellow, 2006; Lumme-Tuomala, 2017; Cath, 2019). The generally accepted breakdown indicates the existence of the so-called soft and hard competencies. Soft competencies are those which people are born with and which they subsequently strive to perfect, whereas hard competencies are those they learn and are taught over the course of their lives (Tewari, Sharma, 2010; Lumme-Tuomala, 2017; Doyle, 2021).

Competencies entail a subject matter important enough to be highlighted in the Official Journal of the European Union, the key premises for which are listed in Table 2. They not only are universal-general, but also intersect (European Parliament and of the Council, 2006).

Table 2.
Core competencies – improvement opportunities in the learning process

Core competency	Knowledge and skills required	Attitudes
Ability to communicate in own language (native, official, etc.) as well as in foreign language	Cognitive abilities; contextualization; information searching, gathering and processing	understanding, expression, interpretation
Technical and mathematical	logical and spatial thinking, presentation of thoughts	ability to discover and infer based on premises (evidence), ability to evaluate arguments, ability to exploit technical and technological capabilities

Cont. table 2.

Computer competency	information searching, gathering and critical processing	use of interactive tools
Learning skills	motivation and a sense of self-confidence building	use of life experience, problem-solving attitude, self-management managing in time
Social and civic	the behaviors needed for active participation in social life, knowledge and application of rules of social coexistence	assurance of physical and mental health, tolerance, equality, assertiveness, commitment, respect for human rights
Initiative and entrepreneurship	Translation of intentions into action, based on creative solutions, taking risks into account	Knowledge of ethical conduct, independence, orientation towards social responsibility (collectivism, respect for phenomena of free market economy)
Awareness	respect for national heritage	cultural expression, sense of identity, openness, creativity

Each competency is used to varying degree, and there is no formula for optimization thereof. The typology of competencies is not unified, nor any uniform criteria for division have been established. F.D. Le Deist and J. Winterton (Le Deist, Winterton, 2005) classify competencies within four dimensions, i.e., cognitive, social, meta-competence, functional. M. Tyranska (Tyrańska, 2016), in turn, makes a division into general competencies (substantive professional skills, ethical approach, use of IT tools), leadership (teamwork, subordinate motivation, communication skills, negotiation skills), business competencies (analytical and strategic thinking, implementation of changes, project management, innovation). Competencies aimed at communicating through well-learned languages (native and foreign), on the other hand, facilitate the understanding of reality and reduce communication barriers in multilingual economies. Language competencies allow communities to actively participate in the life of many countries, which translates into teamwork and creative thinking. The use of languages demonstrates professionalism as well as proper team management ability (Lehmann, 2007; Hermanto, 2008).

Development of mathematical and technical competencies is essential in every area of life - from product/service creation to consumption process, from the level of a child to old age. The ability to use numbers, manifests itself in planning, constructing, accounting, etc. Technology supports the learning opportunities in the areas of humanities and/or sciences (Myburgh, Tammaro, 2013; Lee, 2016). Possession of these competencies determines innovation (creative creation), through logical thinking and analytical abilities, for these are used to learn about the relationships and phenomena occurring in the world (European Commission, 2018).

IT competencies, especially manner in which they are used for work or studying (the level of the usefulness thereof was made evident during the pandemic and lockdown), primarily entail the knowledge of computer applications (MS World, Excel, PowerPoint), Internet applications, knowledge of the information collection, storage and management regulations as well as the use of appropriate safeguards to ensure the safety thereof (Cath, 2019; Tumbas et al., 2019). Such competencies are particularly useful when teamwork, analytical thinking, goal

achievement, self-management in time and adherence to ethical standards are required (European Commission, 2018).

Learning competency is some of the most important abilities, as it is present in everyone's life from the moment of birth until the moment of death. It is this competency which we owe the ability to expand our mental horizons, build societies, but also to skillfully manage ourselves in time or solve problems to. This competency allows the formation of the other competencies (POPA and BUCUR, 2017; European Commission, 2018; Cath, 2019).

The socio-civic competencies are developed through the study of democracy, human rights, the history of tradition, world history, but also through human evolution. Owing to this process, critical thinking, decision-making abilities, teamwork, communication, persuasive valences, responsibility for oneself and others, and resistance to stress are developed (Haste, Bermudez, Carretero, 2017).

The initiative and entrepreneurship competencies are undoubtedly rooted in and developed through education at every level (Mets et al., 2022). Entrepreneurial competency is essential for free-market economy development and is in great part associated with the desire to develop/educate the society. Its significance lies in the fact that the 'level' of entrepreneurship and the actions taken by individuals determine the societies' development as well as enable the nations' enrichment. Such formation of competencies is to a large extent linked with awareness, and self-awareness more precisely, which allows development at different levels of society (Morin, 2011; Pāvels, 2014). Awareness is formed through attitudes of openness, creativity, but also through the shaping and promotion of the culture, region or country (European Commission, 2018).

2.3. Occupational preferences – the key element in the career path

Occupational preferences, including the attempts to define such predilections, currently constitute a popular subject of interest in both Polish and world literature. This is consequent to the rapidly developing economy and the socio-cultural changes, which have had a significant impact on the labor market. The young people's decisions to undertake higher education studies is often associated with the satisfaction of their high aspirations. As a result, insufficient growth in highly skilled jobs is observed. Ultimately, the young graduates often face problems with finding a suitable, but also developmental or satisfactory, jobs guaranteeing decent pay and further professional development (Jończy, Rokita-Poskart, 2014; Ochnik, Stala, Rosmus, 2018).

Every pupil, student or employee possesses certain abilities, skills or developmental potential. Each of these traits will be favorable to various specific occupational groups. It is therefore important to identify the potential dormant in young people at an early stage of their development and guide them appropriately, so those skills, abilities or the future professional potential develop accordingly. The preferences, abilities and vocational interests constitute an important component of human personality. The preferences are basic in nature

and determinant of one's professional orientation. Identification of given preferences is individual character. Due to the use of individual abilities in the functioning on the labor market, however, this individual nature of preferences is also of economic significance. The compatibility of work with preferences therefore constitutes an important element of functioning on the labor market. It primarily increases employee motivation as well as facilitates the overcoming of the difficulties emergent during the performance of a particular job. The fact that work accordant with one's preferences is more effective and results in greater satisfaction is an important aspect to be kept in mind (Bajcar et al., 2006; Mitrovic Veljkovic et al., 2019; Arbab et al., 2022; Lecy, Osteen, 2022).

Occupational preferences are currently one of the key elements influencing career path and professional development choices. Veljkovic (Mitrovic Veljkovic et al., 2019) et al. and Yan et al. (Yan et al., 2018) pinpoint that young people's decisions are subject to the influence of their parents and the people the closest to them acting as role models. The concept presented by A. Roe also emphasizes family relations as one of the determinants of both personality development and career path choices (Peplińska, Połomski, Pogorzelska, 2014).

Young people's career path choices should be fitted on the basis of personality type, taking internal and external factors into account. This choice should stem from such factors as the young person's knowledge, skills or career preferences. Nowadays, as Kalyani et al (Kalyani, Chathuranga, 2021) indicate, young people's choices are influenced not only by the above indicated parent-student relationship but by siblings, peers, mentors or teachers as well.

3. The method used

The process of research objective implementation was divided into two stages. The first involved an analysis of secondary sources, including a review of domestic and foreign literature on the subject. The second entailed a survey developed using a free-of-charge online questionnaire tool, which included:

1. 133 questions regarding career interest preferences.
2. 21 questions regarding competencies.
3. 11 questions regarding the studies pursued - the academic major as well as the manner of major and profession selection.
4. A metric consisting of 4 questions.

The research sample selection was divided into steps. First, the research population was defined. The subjects of the research were full-time and part-time students of first- and second-degree programs. The channels by which the questionnaire was to be made available were defined as well.

The next step was to determine the spatial scope of the survey and the time frame of its implementation. The survey was conducted between February and April 2022. Prior to completing the survey, the participants were informed about taking part in a research the results of which would be presented in an article. All the survey participants agreed to the taking part in the study and to the publishing of the results obtained. The survey ensured full anonymity, meaning that neither the researchers, the subjects, nor the recipients of the survey are able to link the answers provided to specific respondents taking part in the study (Babbie, 2009). Participation in the study was voluntary.

The survey covered a group of 389 full-time and part-time students. The academic majors represented by less than 10 respondents were eliminated, which ultimately yielded 371 survey questionnaires subject to the analysis. The exact number of the survey respondents is given in Table 3.

The age of the participants ranged from 19 to 52 y/o, with 84.37% of the study sample falling within the range of 19-24 years of age (Table 3).

Table 3.
Number of survey participants in distribution by age range

Age range	Number of survey participants by age range	Total %
19-24	313	84.37
25-30	28	7.55
31-35	11	2.96
36-40	7	1.89
41-45	5	1.35
46-52	7	1.89
Total	371	100.00

Source: Own elaboration based on the data collected in an authorial study.

The study sample covered 254 females (68.46%), 116 males (31.27%) and 1 person of non-binary gender (0.27%).

Table 4.
Number of survey participants in distribution by the academic major pursued

Study major	Number of survey participants	Total %
Management	74	19.95
Management and production engineering	23	6.20
Finance and Accounting	155	41.78
Business Design	38	10.24
Economics/Managerial economics	40	10.78
Information Technology in Business	23	6.20
Tourism	18	4.85
Total	371	100.00

Source: Own elaboration based on the data collected in an authorial study.

The most numerous survey participant group, i.e., 41.78% of the total number of the respondents, were students of Finance and Accounting, whereas the least numerous group were the students of Tourism - 4.85% of the total number of the respondents (Table 4).

The career interest preferences were examined using the Multidimensional Preference Questionnaire (MPQ) developed by Matczak et al. The questionnaire enables diagnosis of the interest preferences regarding the types of job activities and work conditions. It allows generation of a list of preferred and advised-against professions. The questionnaire consists of 133 questions addressing nine groups of interests and types of activities performed: Linguistic Interests; Mathematical and Logical Interests; Practical-Technical Interests; Practical-Aesthetic Interests; Care and Service Interests; Managerial-Organizational Interests; and Biology Interests; as well as the respondent's preferred working conditions: planning and improvising, strong/weak stimulation (Matczak et al., 2015).

With regard to preferences, the respondents were asked to provide answers on a 5-point Likert scale containing the following options:

- strongly disagree,
- disagree,
- difficult to say,
- rather agree,
- strongly agree.

The questions regarding competencies involved answers on a 5-degree Likert scale containing the following options:

- very low,
- low,
- average,
- high,
- very high.

4. Results, discussion and conclusion

4.1. Results and discussion

Seeking an answer to the first research question, i.e., “is the selection of academic major made taking the major-selecting person’s preferences and interests into account?”, an analysis of the differences with respect to academic major selection was carried out taking the results on the interest scale into account. The results are presented in Table 4. As indicated by Arbab A.H. et al. (Arbab et al., 2022), academic major selection in accordance with one’s preferences and interests raises young people's awareness with regard to the future career planning, can facilitate effective achievement of their goals, and influences their career decisions, which are crucial to their propensity to excel in the areas of their interest and will be utilized in their future professional lives.

Table 5.
Differences in academinc major selection, taking the interest scale scores (df = 12; N = 371) into account

Scale	Pearson's chi-squared		chi-square test	
	Chi-2	p value	Chi-2	p value
linguistic interests	13.21	0.3541	13.86	0.3098
mathematical and logical interests	36.13	0.0003	34.09	0.0007
practical-technical interests	22.76	0.0298	22.00	0.0376
practical-aesthetic interests	29.16	0.0037	31.25	0.0018
caregiving and service interests	30.12	0.0027	30.90	0.0020
managerial-organizational interests	20.02	0.0668	22.19	0.0355
Biology interests	24.03	0.0201	25.30	0.0135
Planning and improvising interests	14.41	0.2754	15.96	0.1930
Strong/weak stimulation	18.31	0.1065	21.77	0.0402

Source: Own elaboration based on the data collected in an authorial study.

Statistically significant differences in academic major selection, taking the level of interest into account, were noted for the following scales (Table 5):

- mathematical and logical interests,
- practical-technical interests,
- practical-aesthetic interests,
- caregiving and service interests,
- biology interests.

Table 6.
Academic major selection, taking the level of interest (N = 371) into account

Academic major selected	Low		Average		High		Total in # of persons
	in # of persons	in %	in # of persons	in %	in # of persons	in %	
Mathematical and logical interest scale							
Management	24	32.43	26	35.14	24	32.43	74
Management and Production Engineering	2	8.70	13	56.52	8	34.78	23
Finance and Accounting	14	9.03	51	32.90	90	58.06	155
Business Design	7	18.42	19	50.0	12	31.58	38
Economics/ Managerial economics	4	10.00	17	42.50	19	47.50	40
Information Technology in Business	4	17.39	11	47.83	8	34.78	23
Tourism	4	22.22	7	38.89	7	38.89	18
Practical-technical interest scale							
Management	22	29.73	36	48.65	16	21.62	74
Management and Production Engineering	4	17.3	9	39.13	10	43.48	23
Finance and Accounting	38	24.52	84	54.19	33	21.29	155
Business Design	10	26.32	17	44.74	11	28.95	38
Economics/ Managerial economics	13	32.50	22	55.00	5	12.50	40
Information Technology in Business	2	8.70	9	39.13	12	52.1	23
Tourism	7	38.89	6	33.33	5	27.7	18

Cont. table 6.

Practical-aesthetic interest scale							
Management	27	36.49	24	32.43	23	31.08	74
Management and Production Engineering	12	52.17	5	21.74	6	26.09	23
Finance and Accounting	45	29.03	65	41.94	45	29.03	155
Business Design	5	13.16	14	36.84	19	50.00	38
Economics/ Managerial economics	10	25.00	17	42.50	13	32.50	40
Information Technology in Business	14	60.8	8	34.7	1	4.35	23
Tourism	8	44.44	5	27.78	5	27.78	18
Caregiving and service interest scale							
Management	24	32.43	43	58.11	7	9.46	74
Management and Production Engineering	6	26.09	12	52.17	5	21.74	23
Finance and Accounting	43	27.74	77	49.68	35	22.58	155
Business Design	21	55.26	12	31.58	5	13.16	38
Economics/ Managerial economics	6	15.00	24	60.00	10	25.00	40
Information Technology in Business	13	56.52	9	39.13	1	4.3	23
Tourism	7	38.89	9	50.00	2	11.11	18
Biology interest scale							
Management	19	25.68	32	43.24	23	31.08	74
Management and Production Engineering	1	4.35	14	60.87	8	34.78	23
Finance and Accounting	55	35.48	70	45.16	30	19.35	155
Business Design	8	21.05	24	63.16	6	15.79	38
Economics/ Managerial economics	8	20.00	20	50.00	12	30.00	40
Information Technology in Business	7	30.43	13	56.52	3	13.04	23
Tourism	5	27.78	9	50.00	4	22.22	18

Source: Own elaboration based on the data collected in an authorial study.

High levels of mathematical and logical interests were exhibited by students of Economics and Managerial Economics as well as Finance and Accounting. Among the students of Economics, 47.50% indicated a high and 42.50% an average level of such interests. Among the Finance and Accounting students, a high level was indicated by 58.06% and an average level by 32.90%. In the case of the remaining majors, high levels were indicated by between 31.57% and 38.89% of the students majoring in a field of interest (Table 6).

Among the respondents distinguished by practical-technical interests, the highest percentage, taking the academic major into account, was recorded for the Information Technology in Business major, where 52.17% of the respondents majoring in this field and 43.48% of the Management and Production Engineering students indicated a high level of the respective interests. The surveyed students of other majors mostly indicated an average level of practical-technical interests (Table 6).

With regard to practical-aesthetic interests, the highest percentage of high-level indications was noted among the students of Business Design. It accounted for 50% of the total number of the students majoring in this field. A low level of such interests was indicated by 5 students,

which accounted for 13.16%. The Information Technology in Business as well as Management and Production Engineering students most commonly indicated a low level of practical-aesthetic interests. In the case of the Information Technology in Business students, 60.87% of the total number of these students indicated a low level of such interest (Table 6).

With regard to care and service interests, none of the majors surveyed showed high levels as the highest percentage. In the case of the Tourism, Economics and Managerial Economics, Finance and Accounting, and Management majors, the highest percentage of students, in the total numerosity of the students majoring in each respective field, was characterized by an average level of care service interests (Table 6).

The managerial-organizational interests were most commonly indicated at an average level by the survey respondents pursuing the academic majors analyzed. With regard to biology interests, a low level was most often indicated by the students of such majors as Information Technology in Business, Finance and Accounting, Management and Production Engineering. Students of the remaining majors mostly indicated an average level of such interests (Table 6). As Peplinska A. et al. (Peplińska, Połomski, Pogorzelska, 2014) pointed out in their study, interests include not only the interest in social influence on other people as well as in supervision and support, but also cover the interests in work on data, design, and work organization, without taking interpersonal contact into account. This has application in managerial and organizational activity as well as in various areas of managerial competency. Subsequent to that, the incidence of differences in academic major reselection was analyzed taking the results on the scale of the surveyed respondents' interests into account.

Table 7.
Differences in academic major reselection, taking the respondents' interest scale results (df = 2; N = 371) into account

Scale	Pearson's chi-squared		chi-square test	
	Chi-2	p value	Chi-2	p value
linguistic interests	0.23	0.8896	0.23	0.8892
mathematical and logical interests	8.52	0.0141	7.64	0.0220
practical-technical interests	0.49	0.7815	0.50	0.7787
practical-aesthetic interests	0.50	0.7790	0.49	0.7809
caregiving and service interests	2.13	0.3446	2.36	0.3078
managerial-organizational interests	1.35	0.5086	1.32	0.5168
biology interests	0.84	0.6567	0.85	0.6534
planning and improvising interests	2.18	0.3368	2.09	0.3523
strong/weak stimulation	3.64	0.1619	4.06	0.1312

Source: Own elaboration based on the data collected in an authorial study.

The results obtained show statistically significant differences with regard to academic major reselection, taking the scale of mathematics and logic interests into account. Statistically significant differences were not shown for the remaining interest scales (Table 7).

Table 8.
Academic major reselection, taking the interest scale results (N = 371) into account

Scale	Study major reselection	Low		Average		High	
		in # of persons	in %	in # of persons	in %	in # of persons	Total in # of persons
linguistic interests	the same	97	85.84	169	84.08	49	85.96
	other	16	14.16	32	15.92	8	14.04
linguistic interests	the same	43	72.88	128	88.89	144	85.71
	other	16	27.12	16	11.11	24	14.29
practical-technical interests	the same	80	83.33	155	84.70	80	86.96
	other	16	16.67	28	15.30	12	13.04
practical-aesthetic interests	the same	103	85.12	119	86.23	93	83.04
	other	18	14.88	19	13.77	19	16.96
caregiving and service interests	the same	100	83.33	156	83.87	59	90.77
	other	20	16.67	30	16.13	6	9.23
managerial-organizational interests	the same	84	81.55	158	85.71	75	87.21
	other	19	18.45	26	14.29	11	12.79
Biology interests	the same	133	86.93	130	83.33	52	83.87
	other	20	13.07	26	16.67	10	16.13
planning and improvising interests	the same	73	80.22	141	87.04	101	85.59
	other	18	19.78	21	12.96	17	14.41
strong/weak stimulation	the same	111	81.62	154	85.08	50	92.59
	other	25	18.38	27	14.92	4	7.41

Source: Own elaboration based on the data collected in an authorial study.

With regard to the mathematical and logical interest scale, 72.88% of the respondents in the group showing low levels of these interests would opt for the same major upon a possible academic major reselection, while 27.12% would select a different major. Considering the remaining scales including low, average and high levels, more than 80% of the respondents would opt for academic major reselection (Table 8).

Table 9.
Differences in the manner of academic major decision making vs. academic major reselection (df = 3; N = 371)

	Chi-2	Diff.	p value
Pearson's Chi-squared test	20.07	df = 3	0.0002
Maximum Likelihood Chi-square test	17.59	df = 3	0.0005

The results of the Maximum Likelihood Chi-square ($p = 0.00053$) and the Pearson's Chi-squared ($p = 0.00016$) tests, at the adopted level of significance ($\alpha = 0.05$), indicate rejection of the null hypothesis under verification. This means that, taking the manner of study major decision making into account, statistically significant differences in the academic major choices declared occur in the case of possible academic major reselection.

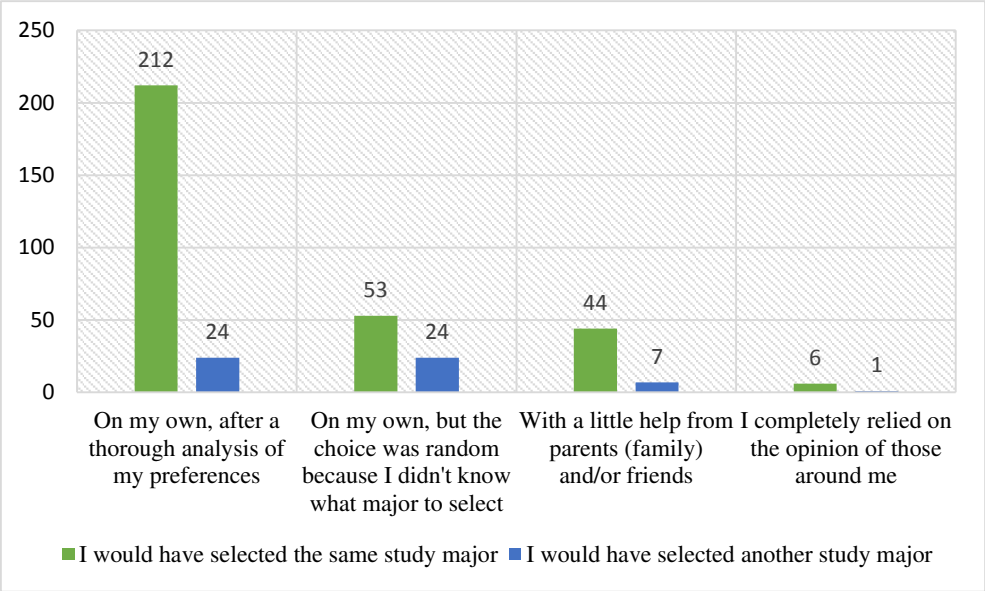

Figure 2. The manner of academic major selection, taking major reselection into account (N = 371).

Source: Own elaboration based on the data collected in an authorial study.

Taking the manner of academic major selection into account, the same major would be selected again by:

- 89.83% of those who had decided independently, after careful analysis of one's preferences,
- 68.83% of those who had made the choice on their own, but the selection was random,
- 86.27 % of those who had made the choice with a marginal help from parents and/or friends,
- 85.71% of those who had fully relied on the opinion of those around them.

Table 10.

Differences in assessment of one's competencies vs. academic major reselection (df = 4; N = 371)

Competency	Pearson's Chi-squared	p value	Max. Lik. Chi-square test	p value
Result orientation	6.31	0.1774	8.12	0.0872
Success orientation	1.43	0.8383	1.89	0.7564
Ability to implement innovations	1.31	0.8594	1.13	0.8896
Autonomy	4.35	0.3616	4.53	0.3385
Initiative	12.4	0.0146	8.78	0.0669
Analytical skills	6.36	0.1741	4.5	0.342
Self-management in time	13.97	0.0074	11.08	0.0257
Logical thinking	1.82	0.7685	2.37	0.6672
Resistance to stress	4.10	0.3930	3.94	0.4148
Ability to communicate	3.39	0.4946	3.08	0.5451
Communicative skills	6.36	0.1736	5.75	0.2186
Cooperative attitude	3.44	0.4864	2.86	0.5823
Ethics	4.49	0.3435	3.53	0.4739
Conflict resolution	4.04	0.4006	3.33	0.5046
Persuasive skills	5.02	0.2854	4.46	0.3472

Cont. table 10.

Team leading ability	5.80	0.2148	5.96	0.2025
Leadership	3.28	0.5127	3.4	0.4937
Strategic thinking	1.07	0.8988	1.24	0.8719
Shaping one's own development path	7.97	0.0925	5.85	0.2106
Planning skills	0.82	0.9353	0.95	0.9169
Motivating	2.32	0.6763	2.82	0.5883

Source: Own elaboration based on the data collected in an authorial study.

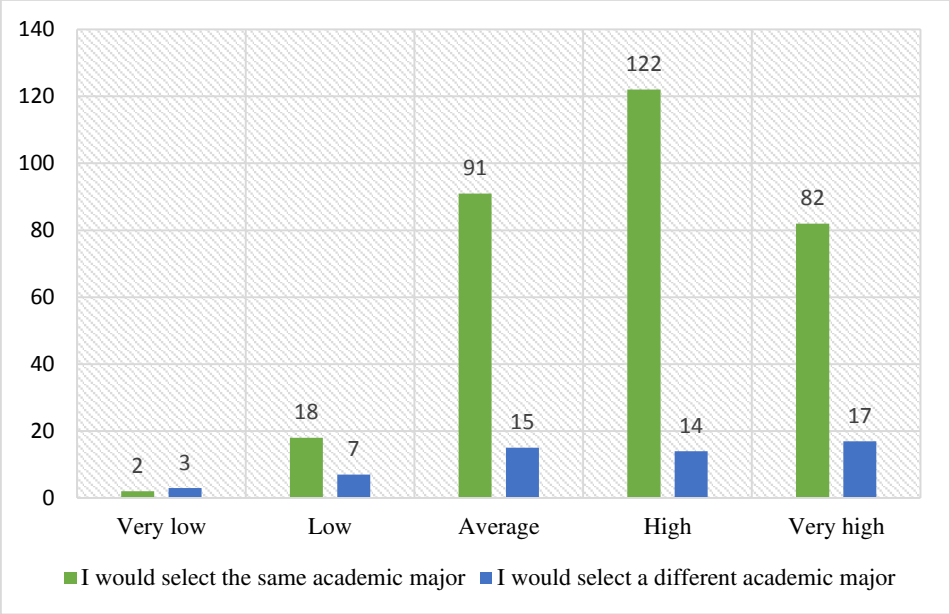

Figure 3. Academic major reselection vs. assessment of own 'self-management in time' competency (N = 371).

Source: Own elaboration based on the data collected in an authorial study.

Among those who rated self-management in time at low and very low levels, 66.67% would select the same major if given an opportunity to choose the study major again, while 33.33% would make a different choice. Among those who rated their self-management in time competency at an average level, 85.85% would not change their major if given an opportunity to select the study major again. Similarly, those who rated this competency at a high or very high level 86.70% would choose to keep the same study path (Figure 3).

4.2. Conclusions

Analyzing the results obtained, it can be concluded that academic major selection is made with consideration of the selecting person's preferences and interests. Statistically significant differences in major selection were noted with regard to the level of interest for the following scales:

- mathematical and logical interests,
- practical-technical interests,
- practical-aesthetic interests,
- care and service interests,
- biology interests.

High scale levels for at least 40% of the students pursuing individual academic majors were also shown for the following:

- the scale of mathematical and logical interest for the Finance and Accounting as well as Economics/Managerial Economics majors,
- the scale of practical-technical interests for the Management and Production Engineering as well as Information Technology in Business majors,
- the scale of practical-aesthetic interests for the Business Design major.

Table 11 shows a list of the academic majors for which at least 40% of the students declared interests in a given particular field, with indication of selected professions which are recommended for those with interests in those areas, as per the Multidimensional Preference Questionnaire (Matczak et al., 2015).

Table 11.
List of the profession consistent with academic major pursued and the interests displayed

Scale	**Academic major rated highly by over 40% of the students surveyed**	**Exemplary professions included in the Multidimensional Preference Questionnaire**
Mathematical and logical interests	Finance and Accounting Economics/Managerial Economics	Insurance agent Financial analyst Market analyst Auditor Banker Economist Tax advisor Accountant Cashier Clerk
Practical-technical interests	Management and Production Engineering Information Technology in Business	Network administrator Automator Computer graphic designer Process Engineer Industrial and Manufacturing engineer Environmental engineer Test and measurement equipment controller Draughtsman/Detailer Polygraphy technician Interior designer
Aesthetic-practical interests	Business Design	Industrial designer

Source: Own elaboration based on the data collected in an authorial study and the MPQ (Matczak et al., 2015).

The professions recommended in the Multidimensional Preference Questionnaire correspond with the professions for the performance of which the academic major pursued is intended. This possibly indicates conscious selection of a field of study enabling development of preferred interests.

The path for one's career development can be delineated autonomously or with the help of third parties. The results obtained in the study allow a conclusion that the least satisfactory academic major choices are made by those who decide independently, nevertheless, this choice is random. With regard to those who make such decisions autonomously, after a thorough

analysis of their preferences, or with consideration of the opinion expressed by those around them, including parents, more than 85% would maintain the same path of development if given a chance to select the academic major again. This suggests that interest preferences are not taken into account in random major selection only, which can result from either the lack of prior analysis of preferences or from broad interests or, quite the contrary, the lack of interests (Bielas, Czerw, 2022).

The results regarding the 'self-management in time' competency show that the higher the surveyed person's rating, in terms of the possession of this competence, the lower the probability of different academic major selection if given a chance to make the decision again. With regard to the remaining competencies under examination, statistically significant differences were not found.

One of the important elements in young people's education is career counseling. It is the appropriate diagnoses of individual mental and cognitive abilities, preferences or interests which one's further career development depends on. This is what career counseling is, inter alia, intended to serve (Arthur, McMahon, 2005). As Robert C. Chope (Chope, 2011) pinpoints in his study, career counseling primarily motivates individuals to find the right job and the right path in life. This goal is achieved by helping people understand their own abilities and preferences more comprehensively, as well as by assisting them in gaining a deeper insight on themselves, their future adaptation to the work environment and to their choice of the right profession or career path (Lo, 2019; Ulrich, Helker, Losekamm, 2021).

Research on the differences characterizing the future career choices, including investigation of the factors influencing those choices, is a topic which still needs to be developed. As Chi-Hung Lo (Lo, 2019) pointed out in his study, such research should involve an optimal approach to the counselling and guidance of young people in the right career decision making.

The relationship between career preferences, choice of study, and sustainable development is complex and multifaceted. Both career preferences and choice of study can have an impact on sustainable development. This is related to the importance of achieving long-term economic, social, and environmental balance. As previously mentioned, sustainable development is the practice of meeting present needs without compromising the ability to meet the needs of future generations. In the context of career preferences and competencies, sustainable development refers to the ability to consider environmental, social, and economic aspects in work to achieve positive outcomes for both people and the planet.

To achieve the goals of sustainable development, it is important for individuals in all fields and professions to acquire the necessary competencies to perform their assigned tasks effectively. Preferences are also significant here. The more aligned they are with the tasks performed, the higher the development of competencies. For example, a finance specialist may consider sustainable development issues in investment decisions, while an engineer may design sustainable infrastructure. Similarly, a healthcare worker can promote a healthy and sustainable lifestyle, and a teacher can educate students about the principles of sustainable development.

While preferences for career interests and the randomness of choosing a field of study are important factors in career development, approaches to competency development vary. Choosing multiple specializations may be appropriate for individuals with diverse interests, but it can delay the development of competencies related to a specific career. Sustainable education focuses on acquiring transferable competencies that contribute to sustainable development across multiple fields, emphasizing the importance of lifelong learning and continuous development.

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ARCHITECTURE OF THE PLATFORM FOR SELF-ADAPTATION OF E-COMMERCE INTERFACES

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Purpose: Personalising the e-shop content is one of the marketing methods used in e-commerce. However, it has been limited to product recommendations, advertisements, and prices. Meanwhile, layout personalisation also offers great, but underestimated, opportunities.
Design: The analysis of existing solutions, the research and development work allowed for the design, implementation and practical verification of a platform that enables serving multiple interface variants to e-shop customers.
Findings: One of the results achieved is a solution architecture that can be successfully used for customer segmentation and allows for dedicated interface variants to be served.
Research limitations/implications: The research conducted was aimed at practical verification of the effectiveness of the proposed architecture and was therefore limited in scope. Further work should include more in-depth research, including elements of self-adaptation of the user interface.
Practical implications: The proposed architecture can be applied to e-commerce solutions that combine the ability to analyse customer behaviour using machine learning methods with a personalised approach to the user interface. Such approach has already found its practical implementation in the e-shop of a major sportswear brand.
Social implications: Personalisation of the e-commerce interface also has social impact. Recipients of a dedicated interface, served on the basis of the described architecture, can also be customer groups requiring non-standard solutions, such as the elderly or people with disabilities.
Originality/value: Serving customers with dedicated interfaces, resulting from analysis of their behaviour and preferences, is not yet a common practice. The proposed solution presents a proposal for an innovative, but already field-verified, solution architecture that can provide a significant competitive advantage in a very demanding e-commerce market.

Keywords: e-commerce, user interface, recommendation, clusterization.

Category of the paper: Research paper, Case study.

1. Introduction

E-commerce has become an important part of the modern economy due to its convenience, cost-efficiency, increased reach, data-driven insights, improved customer experience, and flexibility. As technology continues to advance, e-commerce is likely to become even more important in the years to come. Such solutions can provide a more personalised and streamlined customer experience. With features such as product recommendations, personalised offers, and easy checkout processes, e-commerce platforms can improve customer satisfaction and loyalty. One of the critical aspects of e-commerce that can significantly impact customer satisfaction and retention is user interface (UI) and user experience (UX). By creating a positive user experience, businesses can increase user engagement, build trust with customers, increase loyalty, reduce bounce rates, and generate more revenue.

In order to provide an appropriate and personalised interface to an e-commerce customer, a series of activities must be carried out to gather information about user behaviour and preferences, analyse the data, group customers, prepare a dedicated interface, serve it, and verify the results, so that the solution can then be optimised in a feedback loop. This is important for commonly used approaches such as product recommendations, as well as for more advanced solutions that could deliver a personalised layout.

Preparing an end-to-end solution capable of supporting different models for delivering a multi-variant e-commerce user interface is not a trivial matter. The complexity of the challenge and the services required to solve it makes it crucial to have the right solution architecture to achieve the business goal while meeting the non-functional requirements. This problem was tackled in the design, implementation and refinement of the AIM^2 - the platform for self-adaptation of e-commerce interfaces. This solution - an intelligent system that allows e-commerce platforms to optimise their user interfaces automatically – is described in the paper. This is a unique approach that has only been signalled in a few publications, but without any practical verification of the concept. The architecture of the platform consists of several components that work together to provide a seamless user experience:

- User model - a representation of the user's behaviour and preferences.
- Designer module - that let to generate different versions of the UI, which are tested against the user model to determine which version performs best.
- Adaptation engine - provides UI variants and uses artificial intelligence (AI) algorithms to group customers based on actions, events, purchases, and other factors.
- Monitoring - provides feedback on performance of various UI versions, which is used for improving the effectiveness of the adaptation engine and UI variants.

An important element of the evaluation of the proposed architecture was putting it into practice and verifying its effectiveness by analysing the impact of dedicated interfaces on e-commerce KPIs. The pilot implementation has confirmed that the AIM^2 platform can improve the e-commerce user experience and has a positive impact on the conversion rate.

2. Literature review

Studies on the effect of UI design on the user experience in e-commerce can be found in the literature. The design of a user interface (UI) in e-commerce can have a significant impact on the user experience (UX) of a website or an application. The UI design can influence how users perceive the usability, efficiency, and satisfaction from the e-commerce platform (Gunawan, 2021). Guidance and examples in designing web interfaces of e-commerce applications that are good and easy to use are presented by a number of authors (Heriyandi, 2021; Polewski, 2022; Syafrizal, 2022).

At the beginning, user interface recommendation services for e-commerce systems did not use artificial intelligence methods (Baraglia, 2007; Kopel, 2013). Today, solutions that make extensive use of various AI algorithms, e.g. collaborative filtering (Laksana, 2023) and different methods of clusterization, such as K-means (Zhao, 2022), DBSCAN (Yang, 2015), BIRCH (Jabade, 2023), etc. are applied in practice.

Automatic optimization of e-commerce user interface (UI) can be achieved using various techniques based on traditional approaches or on artificial intelligence (AI) and machine learning (ML) algorithms. It may be the implementation of a computational method that supports the design, revision, and amendment of web e-commerce GUI, streamlining the overall process and minimising the need for HCI experts (Fasciani, 2018). Three interaction approaches in e-commerce UX optimisation are possible: adaptable, semi-adaptable and fully adaptable (Alotaibi, 2013). The first involves manual adaptation by the user or an expert, the second manual adaptation supported by system recommendations, and the third fully automatic adaptation.

The involvement of users and the analysis of their behaviour when using the information system are of great importance in order to achieve the desired result of an effective UI (Evers, 2014). It has been taken into account in a three-phase approach for modelling and developing dynamically adaptive systems based on the combination of the runtime models technique and the AOSD (Aspect Oriented Software Development) paradigm (Loukil, 2017).

The analysis of the architecture of selected digital platforms in e-commerce allowed to propose a tailored four-layers platform architecture for the e-commerce context (Wulfert, 2022). Solutions based on the SOA (Service Oriented Architecture) paradigm can also be used to implement e-commerce platforms (Li, 2019). The next-generation e-commerce platform with

the personalised portal, instead of the traditional trading platform, can make better use of the opportunities offered by modern technology (Huang, 2019).

The architecture of a recommendation system in e-commerce typically involves multiple components working together to provide personalised product recommendations to users (Ricci, 2022). At the highest level of generality, the individual elements are responsible for: the acquisition of source data, processing of this data, generation of recommendations and their delivery to the final recipient and can be found in various applications of recommendation systems, such as purchasing recommendations (Oldridge 2022), educational hypermedia targeting (Kristofic, 2005), image recommendation (Melo, 2018), media recommendation (Amatriain, 2013), but also for recommending website personalization (Baraglia, 2007).

The analysis of existing solutions has made it possible to propose an initial architecture to collect customer behaviour data, analyse it using selected machine learning methods and serve a dedicated interface to specific customer groups. Practical verification of the implemented solution enabled the evaluation of the proposed architecture and its iterative improvement.

3. Proposed architecture

The AIM^2 platform architecture has four general components, that are typical for AI-based recommendation system (Figure 1).

Monitoring	User behavior analysis UI variants efficiency measurement
Adaptation engine	AI based clustering UI variants providing mechanism
UI Designer	Possible changes to the interface Variants of UI
User model	User actions and activities Tokenization User behavior patterns

Figure 1. Components of the recommendation system for e-commerce multi-variant UI.
Source: own study.

The detailed architecture refers to the main components, but allows it to be divided into functional modules, identify relationships and define a rough process to achieve the platform's goals (Figure 2).

It contains all the elements necessary to deliver a dedicated user interface in different business models:

- personalised UI for customer groups defined by rule-based methods (e.g. different interfaces for new users, VIPs, loyalty-club members, etc.), with manually designed layout,
- personalised UI for customer groups generated by AI-based algorithms (clusterization), with manually designed layout,
- self-adaptive user interface, a solution that can operate autonomously, without the supervision of a UX specialist, with automatically designed layout.

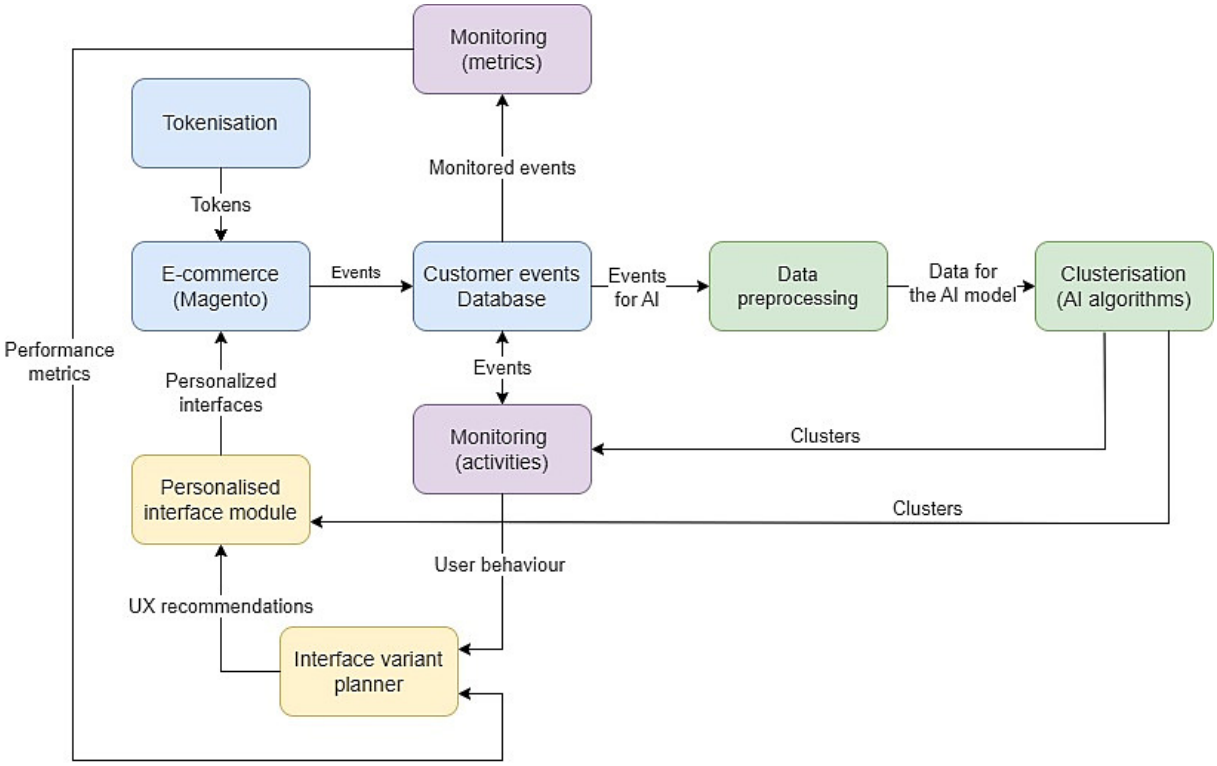

Figure 2. Detailed architecture of the platform for e-commerce multi-variant UI.
Source: own study.

3.1. User model

The collection of reliable data on e-commerce user behaviour is crucial to the functioning of the platform. It is important that the data collected reflects the actual actions taken by the e-shop customers, but with a high level of anonymity guaranteed. This component includes 3 modules:

- Tokenisation.
- User profiling.
- Data collection.

The first of them is responsible for ensuring privacy and compliance with the legal conditions for the protection of personal data (GDPR). Before the user activities observed in the e-shop are stored, a process of deletion or anonymization of personal data takes place and

the observations are assigned to unique tokens associated with e-shop customers. Tokens can be generated using existing standards, e.g. UUID (ISO-9834, 2014).

The CattyFingerStrike module, developed within AIM^2 platform, is responsible for ensuring the anonymity of the data collected. It generates UUID token which is stored as *cookie* file on the customer's device.

The original solution involved the use of three tokens:

- *deviceToken* - based on the relevant parameters when a device is used the first time,
- *customerToken* - generated for the logged-in user only,
- *lastToken* - the token generated after entering a valid e-mail address in the observed fields.

Such approach proved to be impractical and insufficient, so it was replaced by a single unique token.

Tokens are sent to the e-shop and stored in the database together with events resulting from customer activity and allow to create user profile. Such profiles include pairs: user ID and theme ID (identifier of the interface variant to be served to the client) and are used to show the correct interface variant in the customer's browser**.**

Data collection is achieved through a combination of two solutions - Tag Management System (TMS) and a Web Analytics System (WAS). TMS is software that can be used to manage tracking tags. A *tag* is a snippet of JavaScript code put into website's source code to gather data about visitors' activity on the website. Such systems can simplify the deployment and maintenance of tags, used in online content to interface with applications such as web analytics, personalisation, and advertising. Top TMS vendors include Google Tag Manager, Tealium iQ Tag Management, Adobe Experience Platform Launch, Qubit and Signal Customer Intelligence Platform (TTC, 2019). WAS is used to track and analyse user behaviour on the website using cookies, log files or hybrid solutions. The most popular system in this class is Google Analytics (GA), with a market share of more than 50%. Other popular tools are: Facebook Pixel, WordPress Jetpack, Yandex.Metrica, Hotjar, MonsterInsights and Matomo (W3TECHS, 2023). The collected information on user behaviour is used to group customers and to analyse the differences between generated clusters.

3.2. UI Designer

The UI Designer component includes two modules: *Interface variant planner* and *Personalised interface module*. The first is responsible for management of layout areas that can be modified within the user interface.

Examples of the website design modifications may include, (but are not limited to:

- Menu - changes in the order of categories, changes in the location of tabs, placing the menu in the mobile version.
- Listing - buttons with levels of sales or changes in product categories.

- Product card - larger images, tabs at the bottom, change in content, collapse descriptions, larger price.
- Page footer - collapse/expansion.
- Pop up in the login and registration.
- Search - magnifying the search icon.
- Shopping cart - repositioning of the bar with information about free delivery.
- Filters - changes in order of: category, price, size, colour and other, collapse/expansion of attributes, horizontal filters, category as dropdown, categories in sidebar, filters on top.

Examples of the different search engine design options are shown in Figure 3.

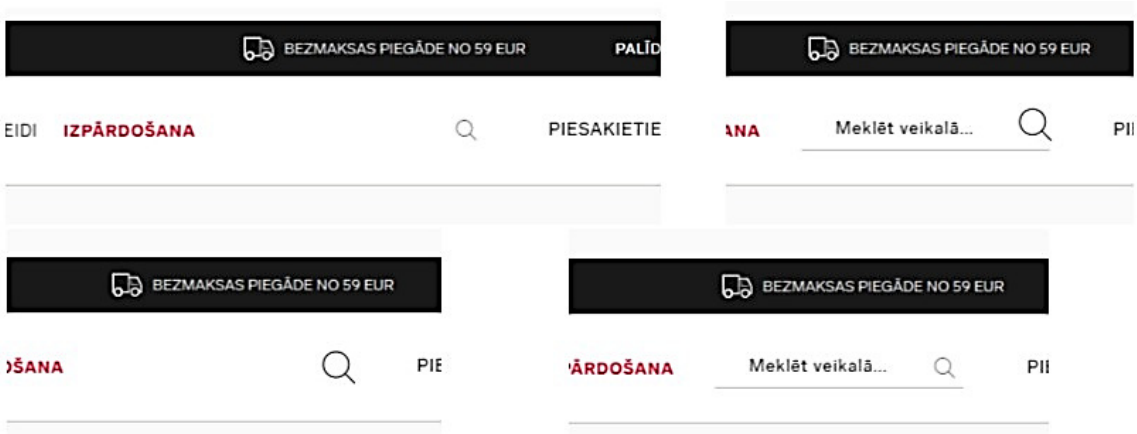

Figure 3. Different variants of the search engine in e-shop.

Source: own study.

The second module allows an interface variant to be configured as a collection of changes in individual areas. The choice of modification depends on the characteristics of each customer cluster. A dedicated interface variant can be prepared, and then served, for all or only selected customer groups.

3.3. Adaptation engine

The first part of data analysis is preprocessing. For the purposes of clustering, data is aggregated by customer identifiers, with a particular focus on those with registered accounts. As characteristics of each visitor, the dates of the first and last visit and the purchase amount are included, among others. The most important activities should be predefined. All types of stored activities are then counted. In addition, key statistics on the most frequently viewed products, sizes and categories, are taken into account.

The resulting matrix is subjected to a PCA (Principal Component Analysis) transformation for data dimension reduction and information extraction. This involves constructing a linear space basis in which successive dimensions explain the data variance in the best possible way. The algorithm successively maximises the variance after the first coordinate, the second, and so on. The transformation of the data obtained in this way is easier for further analysis.

The second part of the data analysis is grouping of the e-shop customers. One of the possible options is to use machine learning approach - clusterization (also clustering or cluster analysis). It is an unsupervised learning technique that groups a set of objects (e.g. customers) in such a way that objects in the same group (cluster) are more similar (in defined sense) to each other than objects in other groups (clusters). The aim is to identify groups of users with similar behaviour in order to provide them with dedicated user interface variants (Everitt, 2011).

It is difficult to explicitly categorise clustering algorithms because the categories may overlap, so that a method may have features from several categories. One popular approach to classifying clustering algorithms includes (Han, 2011):

- Partitioning methods.
- Hierarchical methods.
- Density-based methods.
- Grid-based methods.
- Model-based methods.
- Spectral methods.
- Model evaluation-based methods.

The choice of clustering method and its parameters depends on the specific requirements of the e-commerce in which the self-adaptation mechanism is implemented. For this reason, it is important that a platform for serving dedicated interfaces has several different clustering algorithms implemented. The preparation of a set of clusters of users to whom dedicated interface variants will be served should be preceded by an analysis of the effects of clustering by various available methods.

A preliminary analysis of the efficiency of different clustering methods showed that two methods - K-means (Li, 2022) and hierarchical (agglomerative) clustering (Ah-Pine, 2018) - exhibited the most promising results. Therefore, both of these methods have been firstly implemented within the described platform and could be selected to generate customer clusters. In the next stages of development, six more clustering methods were added, which could potentially be used to group e-commerce customers.

3.4. Monitoring

Monitoring within the platform involves two modules - analysing the behaviour of users assigned by AI to clusters and verifying the performance indicators of the served dedicated interfaces.

The aim of user behaviour analysis is to identify user patterns that can be used to make changes to dedicated interfaces. The basis for this analysis is an overview of actions and action sequences (predecessor - action - successor) and their occurrence frequency. An additional element of this study is the analysis of the values of indicators describing cluster differentiation (Figure 4).

	label 0, mean/mode	label 1, mean/mode	label 2, mean/mode	label 3, mean/mode	label 4, mean/mode
action	13.9553	123.5409	85.5175	44.3444	17.5494
event	3.9731	33.5366	28.9879	11.0461	3.3089
firstTimestamp	2023-05-31 01:22:11	2023-05-24 02:54:48	2023-06-04 06:47:30	2023-05-31 21:12:59	2023-06-02 22:17:12
lastTimestamp	2023-06-01 07:17:28	2023-06-06 07:28:55	2023-06-15 21:24:42	2023-06-07 03:46:33	2023-06-06 22:23:01
revenue	0.413	13.0102	9.8347	4.1907	0.0771

Figure 4. Sample clustering summary.

Source: own study.

The efficiency of the dedicated interfaces is verified by calculating the values of selected indicators - partial conversion rate (PCR), conversion rate (CR) and average order value basket (AOV) of orders placed.

The first assesses the consistency of expected customer journey within e-shop with preferred actions (e.g. homepage - listing - product card - add to cart).

The PCR can be calculated according to the formula:

$$PCR_c = \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{s} EPP_{ij} \tag{1}$$

where:

n is the number of sessions related to a customer from the cluster c.

s is the number of activities within the session n,

PCR_c is the calculated PCR metric value for the cluster c,

EPP_{ij} is the score of an activity j during a session i.

For the purposes of the solution evaluation, it was assumed that points are added if the activity was compliant with the expected customer journey, such as going from the homepage to the listing weighted 10 points, adding to the shopping cart weighted 20 points, and moving between product pages weighted 5 points.

CR and AOV are typical and the most important KPIs that help organizations measure and track their business performance (Saleh, 2010). CR is defined as the number of orders a website captures to the number of visitors:

$$CR_c = \frac{O}{n} \tag{2}$$

where O is the number of orders placed by customers from the cluster c.

AOV represents the average amount a customer spends when placing an order:

$$AOV_c = \frac{\sum_{i=1}^{O} V_i}{O} \tag{3}$$

where V_i is the value of i-th order placed by customers from the cluster c.

It is worth noting here that the PCR metric can be calculated for all customer sessions, while the other metrics require the customer to complete the visit with placing an order.

This difference is important because only a few percent of visits result in an order, meaning that a much longer study period is needed to obtain statistically significant results when it comes to CR and AOV indicators.

4. Evaluation of the architecture

4.1. Research methodology

The research was conducted using the AIM^2 platform, developed by Fast White Cat. S.A. The platform includes modules that address collecting information about customer behaviour in an e-shop, grouping customers using different clustering algorithms, designing different user interface variants, serving these variants to selected groups of customers and monitoring of effectiveness of these interface variants.

The evaluation consisted of the following stages:

- gathering information about customer behaviour of the e-shop,
- dividing customers into groups based on the selected clustering method,
- analysing characteristics differentiating the customer behaviour in the groups,
- designing a variant of the interface on the basis of the behaviour of users from the selected group,
- serving of a dedicated interface variant to half of the customers in each group, while the other half of the customers was provided with a default interface,
- collecting information about the purchasing behaviour of the customers when studying the impact of the delivered interface and analysing the results obtained.

The analysis was carried out twice to increase the reliability of the results obtained.

In the first iteration information was collected for 73 days, in the second for 96 days. Actions taken by the customer were recorded for each session, in particular those related to navigating the e-shop, selecting options and filters, adding products, using the search engine. The above constituted learning datasets that allowed customers to be divided into groups.

The learning dataset was processed using the agglomerative clustering algorithm. The clustering method was selected based on the results of previous studies, as its use allowed for clusters with the least variation in abundance. In addition, it was assumed that the size of a single group should not be less than 10% of the total number of clustered customers.

An analysis of customer behaviour in each of the designated clusters was then carried out during which the values of the indicators describing each group, such as number of actions and events, completed purchases, use of the search engine and the most frequently executed action sequences describing how customers navigate the e-shop, were compared. This analysis formed on the basis for the design of a dedicated user interface variant.

The designed interface variant included 13 modifications to the default interface. Changes were made in the following components of the e-shop: the homepage, category page, product page and search engine. These were chosen to match as closely as possible the customer behaviour of the cluster containing the most active users. In both iterations, the dedicated interface was the same and was provided to the cluster of users with the highest activity.

Each customer group was split in half and for the next 21 days (during both iterations separately) one half was served a dedicated interface variant and the other half the default interface. Customers from each cluster were served the same dedicated interface variant. Customers who visited the e-shop for the first time during the study, which means they did not belong to any cluster, were served the default interface.

The efficiency of the dedicated interface was verified based on three indicators: CR, AOV, and PCR. At the time of the study, the expected customer journey (necessary to calculate the PCR value) was defined as the sequence of homepage - listing - product card - add to cart. Any activity that conformed with the expected journey was scored to allow verification of the impact of the dedicated interface on customer behaviour.

4.2. Results of the evaluation

In the first iteration the learning dataset included 261,774 customer sessions, and 333,637 customer sessions in the second iteration. The number of sessions was influenced by the fact that during the second iteration of the research, there was a large promotion in the e-shop, which significantly affected the number of sessions and the number of orders.

In both cases, agglomerative clustering was carried out, with the number of clusters set at 4. It allowed to achieve clusters with the size exceeding 10% of the total population. The size of clusters in the first and second iterations is shown in Table 1.

Table 1.
The size of customer clusters

cluster		**1**	**2**	**3**	**4**
Iteration 1	size	14870	**18080**	9966	5873
	percentage	30.4782%	**37.0575%**	20.4267%	12.0375%
Iteration 2	size	22190	**23644**	13909	10830
	percentage	31.4426%	**33.5029%**	19.7087%	15.3458%

Source: Own study.

Scatter plot of the 2nd iteration clustering along the dimensions of low-dimensional representation produced by the UMAP algorithm (McInnes, 2018) is shown in Figure 5.

It was decided to prepare a dedicated interface variant based on the behaviour of customers from **cluster 2**. The results indicate that this is the group of users who make the most use of the e-shop which means the highest number of actions and events and buy the most often, meaning the highest revenue value. Therefore, it can be assumed that providing them with a dedicated interface, could bring the greatest benefit to the e-shop owner.

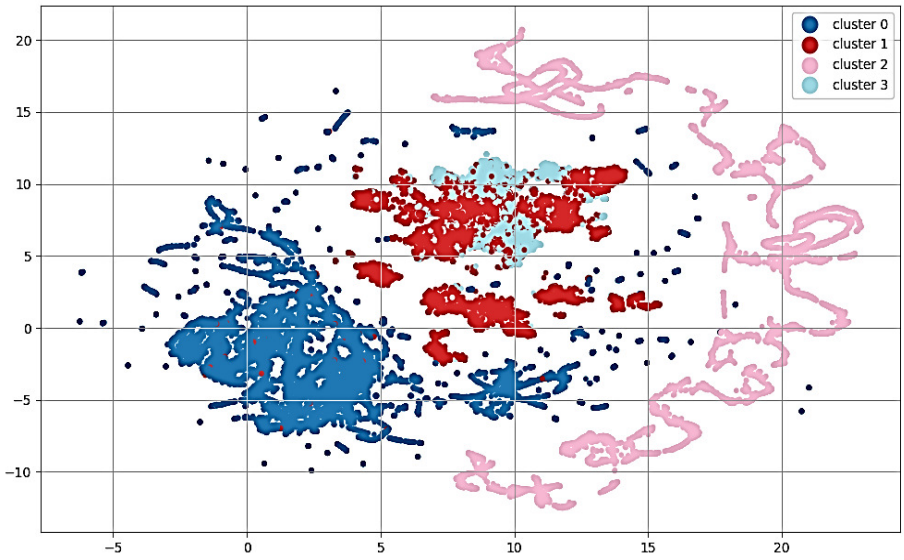

Figure 5. Scatter plot of the clustering.

Source: own study.

The PCR, CR and AOV values obtained in the first iteration of the study are shown in Table 2, while those from the second iteration of the study are shown in Table 3.

Table 2.
Comparison of metric values (iteration 1)

cluster	interface	sessions	orders	PCR	CR	AOV
1	default	970	18	30.49	1.86%	26.49
	dedicated	1077	10	30.79	0.93%	42.60
2	**default**	**2440**	**71**	**46.71**	**2.91%**	**43.38**
	dedicated	**2582**	**110**	**45.77**	**4.26%**	**48.41**
3	default	270	5	35.07	1.85%	42.62
	dedicated	282	9	28.21	3.19%	33.77
4	default	778	29	38,76	3.73%	27.95
	dedicated	799	26	44.10	3.25%	38.63

Source: Own study.

Table 3.
Comparison of metric values (iteration 2)

cluster	interface	sessions	orders	PCR	CR	AOV
1	default	1548	33	33.64	2.13%	44.60
	dedicated	1604	30	31.01	1.87%	44.97
2	**default**	**2799**	**86**	**44.47**	**3.07%**	**41.25**
	dedicated	**2930**	**129**	**46.28**	**4.40%**	**36.18**
3	default	385	21	41.38	4.91%	45.69
	dedicated	428	23	46.66	5.97%	38.92
4	default	1926	83	56.14	4.31%	41.52
	dedicated	2015	75	52.77	3.72%	40.36

Source: Own study.

It is worth noting that the clusters in both iterations of the study may have contained different customer groups, but the characteristics of the clusters (number of actions, events, revenue, etc.) were similar so the results obtained can be considered comparable.

5. Discussion

The research carried out allowed verification of the correctness of the developed platform architecture for serving a multi-variant e-commerce user interface. The selection of the solution components as well as their interrelationships made it possible to prepare the study by collecting and preliminary analysing data, grouping (clustering) customers and designing a dedicated interface variant for one of the clusters. It was also possible to collect data on the behaviour of users who were served a dedicated interface and compare them with customers from the same cluster who were served the default interface.

The results also verified the effectiveness of the dedicated interfaces and their business value. The interface variant designed for a selected group of customers confirmed its superiority over the default interface, above all in terms of conversion rate, but showed no significant impact of the dedicated interface on the other performance indicators. In both iterations of the study, customers from the selected cluster who had a dedicated interface served achieved a higher CR - by 46% and 43% respectively. From an e-commerce efficiency perspective, this is a significant difference that can be converted into tangible financial benefits. Analogous benefits of a dedicated interface did not occur for the other clusters, supporting the hypothesis that it is worth serving different interface variants for different customer groups. For the other performance indicators tested (PCR and AOV), no clear results could be observed. While the AOV for the dedicated interface was significantly higher in the first iteration, it was lower in the second iteration than for the customers in cluster 2 who were served the default interface. The PCR value was similar for the client subgroups in cluster 2 in both iterations, so it was not possible to conclude on the impact of the dedicated interface on this indicator.

The study also identified some limitations in the application of the proposed approach. Firstly, the short period of learning data collection meant that only about 20% of the customers visiting the shop during the research period were returning customers, i.e. recognised and allocated to any of the clusters. This means that in order to collect information on as many customers as possible, the learning data collection time should be extended, and the clusters should be regularly updated with new customers. In addition, treating new (unclustered) customers as a separate supercluster, which can also be served a dedicated interface, tailored to customers who have not visited the e-store in a long time.

The second limitation is the relatively long time required to gather feedback to assess the effectiveness of the interface variant in terms of CR and AOV indicators. This means that in the case of interfaces served to less active customers, one has to expect long waiting times for orders to assess the quality of modifications.

The third limitation is related to the preparation of interface variants for customer clusters. In the proposed solution, this is the task of a UX specialist, who proposes a set of modifications to the interface variant on the basis of knowledge and collected characteristics of the clusters.

Such a solution can be inefficient, as the specialist works by trial and error. Therefore, it is necessary to consider expanding the proposed architecture with modules that will automate the process of tuning interface variants, thus eliminating the need for human labour.

The research carried out made it possible to confirm the correctness of the proposed solution architecture, to prove the economic efficiency of dedicated interface variants in e-commerce, and to confirm the theoretical considerations on the subject. As no analogous experiments have been conducted before, the results obtained during the study represent an important step towards the commercialisation of multi-variant UIs, providing evidence of the tangible benefits of their implementation.

Taking into account the findings of the research, further work should focus on optimising dedicated interfaces and on preparing a solution that extends the use of dedicated UIs to new users whose behaviour is unknown and therefore cannot be clustered.

6. Conclusion

The primary objective of the research described in the publication was to propose and verify the correctness of a platform architecture that allows serving multiple variants of the e-commerce user interface. The correct implementation of all the steps foreseen in the process of providing a dedicated interface allows to conclude that the proposed architecture is suitable and can be used in the design of analogous solutions. Based on the analysis of publications and existing applications on the market, the results of the research carried out provide a unique validation of the sense and the way in which dedicated UIs should be served to e-commerce customers.

In addition, the hypothesis that designing a dedicated interface variant for a selected group of customers may increase the conversion rate (by more than 40% in both studies) has been confirmed. This is a key achievement that confirms the business value of the implemented platform and provides the basis for further practical implementations. The implementation of new solutions requires an analysis of their effectiveness (e.g. ROI), and the results of the studies provide a measurable assessment of the benefits of the proposed approach.

The research carried out provides a basis for further work, particularly related to the need to minimise identified limitations and weaknesses, such as the possibility of serving dedicated interfaces only to returning customers and the need to prepare interface variants by trial and error. It also allows to identify directions for further development of the solution architecture - the problem of a large group of new users should be addressed, and consideration should be given to expanding the platform with modules that allow self-adaptation of interface variants.

In conclusion, it can be said that layout personalization in e-commerce has great potential and can be an important part of gaining competitive advantage in e-commerce. The development of technology allows for the effective collection and processing of a large amount of data, including on user behaviour, and thus for far-reaching personalization, of which the described platform is an example.

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Credit authorship contribution statement:

- Adam Wasilewski: Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original Draft.
- Elżbieta Pawelek-Lubera: Project administration, Writing - Review & Editing.

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WORK-LIFE BALANCE – POLAND IN COMPARISON WITH SELECTED EUROPEAN COUNTRIES

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Purpose: The purpose of this article is to assess the possibility of balancing work and non-work life in Poland against selected European countries.
Design/methodology/approach: The article employs the Z. Hellwig development pattern method. Using 11 diagnostic characteristics, a composite measure of work-life balance was derived. A ranking of 30 European countries was then compiled, based on their ability to balance work and non-work life.
Findings: Given the characteristics selected for this study, the capacity for work-life balance in Poland is relatively low, particularly when compared to countries like the Netherlands, Norway, Denmark, and Finland. Conversely, Cyprus and Greece are notable for their especially low ability to maintain a balance between these two spheres of life.
Research limitations/implications: The research presented here can contribute to a more profound analysis of the factors influencing work-life balance in economic, social, and psychological terms. An intriguing avenue for future research might be to identify the potential shifts in the broadly understood work culture, especially considering the growing aspirations of younger generations to maintain a balance between work and other life activities.
Originality/value: The article provides a critical review of concepts related to maintaining a balance between work and non-work life, considering changes in the labor market. Based on the diagnostic characteristics chosen by the author, a composite indicator was constructed to evaluate European countries in terms of their ability to balance work and non-work life. Leaders in this area were identified, and the gap between Poland and these leading nations was assessed. The results of the research are intended for public authorities and business entities within the surveyed European countries. For the former, they may guide the creation and development of legal and economic solutions that foster a balance between work and non-work life, especially family life. This is becoming increasingly significant given the aging population and demographic crisis in European countries. For the latter, the results can offer employers insights for creating a work-life balance-oriented approach to human resource management.

Keywords: work-life balance, flexible forms of employment, working time reduction, Z. Hellwig method.

Category of the paper: Research paper.

1. Introduction

The issue of work-life balance, despite being part of economic, psychological, and management science discourses for over fifty years, remains pertinent. However, its conceptualizations are evolving, largely in response to socio-economic shifts. Intensified competition due to globalization, advancements in information and communication technologies, the need to enhance labor efficiency, increasing customer demands, and fluctuating demand all contribute to the transformation of the labor market. Employees are compelled to continually improve and develop their professional skills, not only to advance in their chosen career paths but also to secure and retain employment, reducing the risk of unemployment. This leads to a de-standardization of the work life trajectory (Kotowska, 2004), increasing the amount of time devoted not just to work, but also to job acquisition and retention. This often comes at the expense of non-work activities such as family life, hobbies, and personal development.

The impact of remote work is also a point of contention. This working mode, propelled by the digitalization of the economy, the fourth industrial revolution, and more recently, the Covid-19 pandemic, has complicated work-life balance. On one hand, remote work offers time-saving benefits related to preparation and commuting, along with the flexibility to tailor work hours to individual preferences. On the other hand, it blurs the line between personal and professional life, leading to a sense of "constant work" (Sidor-Rządkowska, 2021).

Remote work, by merging the workplace with the home, increasingly intertwines these two domains of human life (Sadowska-Snarska, 2014)**.**

In highly developed European countries, efforts have been made for years to promote measures that balance work and non-work life. Countries are enacting relevant regulations, exemplified by the Directive of the European Parliament and Council (EU) 2019/1158 of June 20, 2019, on work-life balance for parents and caregivers. This directive has now been implemented in Poland.

The purpose of this article is to assess the possibility of balancing work and non-work life in Poland against selected European countries.

Our research employs the Z. Hellwig development pattern method. Based on 11 diagnostic characteristics, a composite measure was developed. This measure then served as the foundation for constructing a ranking of countries based on their ability to balance work and non-work life. The study encompassed 30 European countries.

The first part of the article offers a critical review of the work-life balance concept, while the second part presents the findings of the research. When examining the consequences of an imbalance between work and non-work life, references were made to international research and studies conducted in this field.

2. Work-Life Balance (WLB) – a critical review of the concept

The WLB concept originated in the United States in the 1970s. Its roots lie in the crisis of the traditional family model, where women focused their efforts on family responsibilities, and men focused on professional work. Women's emancipation, coupled with their increasing educational and professional aspirations leading to their massive entrance into the labor market, necessitated the creation of solutions to reconcile work and family life.

WLB is defined as an individual's equal involvement in work and family roles, characterized by an equal amount of time devoted to work and family commitments, and equal satisfaction derived from both roles (Greenhaus, Collins, & Show, 2003). The concept, as proposed by H. Greenhaus, K.M. Collins, and J.D. Shaw, raises several objections. Firstly, it presumes a clear boundary between work and life outside of it and even suggests competition between these two spheres of human activity, whereas they are inseparable and interpenetrate each other. Secondly, the balance between involvement in work and non-work life varies over time (depending on life cycle phase), and an imbalance does not necessarily result in lower satisfaction levels in either sphere. In this context, it is accurate to state that "when we talk about work-life balance, we mean that the individual has sufficient influence (autonomy) over when, where, and how much time they spend on tasks in both the work and non-work domains" (Machol-Zajda, 2008a). Additionally, "the idea of WLB is to help individuals find fulfillment in each of these areas, not only bringing them satisfaction, but also enhancing their capabilities and potential" (Sadowska-Snarska, 2014). Additionally, S. Friedman highlights that life is not just about the interaction between work and home, but also involves community and self (Friedman, 2014). The quality of a person's life depends on the relationships among all these domains.

Often, the relationship between work and non-work life is perceived as conflicting, stemming from the differing expectations of these two life spheres (Greenhaus & Beutell, 1985). Another definition follows this line of thought, positing that work-life balance is a state where an individual effectively navigates potential conflicts in managing their time and energy, thereby achieving well-being and a sense of fulfillment (Clutterbucka, 2005).

This conflicting view of the relationship between work and non-work life overlooks the fact that these domains can positively interact with each other, mutually "enriching" work and non-work experiences. Here, "enrichment" refers to "the degree to which experiences in one role improve the quality of life in the other role" (Greenhaus & Powell, 2006). D. Mroczkowska and M. Kubacka offered a critique of the work-life balance concept, proposing the more contemporary concept of work boundaries as a better fit for modern socio-economic conditions (Mroczkowska & Kubacka, 2020). According to these authors, work-life balance "is a kind of utopia, representing a state that is impossible to achieve under modern conditions" (Mroczkowska & Kubacka, 2020). Boundary areas, in contrast, signify the overlap of different

spheres of human functioning and the various roles individuals perform in life, which shape their experiences (Mroczkowska & Kubacka, 2020). Boundary areas are a consequence of individuals actively transitioning between work and non-work domains where "blurring" of roles is commonplace (Allen, Cho, & Meier, 2014).

3. Methodology of own research

The purpose of this article is to assess the possibility of balancing work and non-work life in Poland against selected European countries.

A critical review of work-life balance concepts in the literature served as the basis for developing an operational definition of this concept. For the purpose of our research, work-life balance was defined as a state in which the spheres of work and life outside of work coexist and intersect without causing disruption to an individual's function in either, allowing for personal satisfaction. It was assumed "that balance is not achieved by sacrificing certain areas of life, but rather by integrating them in such a way that all interests, needs, and responsibilities merge into one harmonious whole" (Wilson, 2012). This interpretation of balance rules out any discord between the two spheres of human life.

To evaluate the ability to balance work and non-work life, 11 diagnostic characteristics were utilized (Table 1), which formed the basis for calculating the synthetic Z. Hellwig index. The selection of diagnostic characteristics was informed by a range of criteria – substantive, formal, statistical, data availability, and the researcher's discretionary decisions.

These diagnostic characteristics were derived from a diagnostic survey conducted as part of the 2021 European Working Conditions Survey by the European Foundation for the Improvement of Living and Working Conditions (Eurofound, 2021). The selection of respondents in this study was random, with sample sizes ranging from 1,000 to 4,200 people per country. As Eurofound indicates, this allows for highly robust estimates at the European level that can aid in analyzing thematic modules and developing detailed secondary analyses. It also enables the collection of data and analysis on the quality of work at the national level (Eurofound, 2021). Diagnostic traits for assessing the ability to balance work and non-work life in selected countries pertain to two aspects of the phenomenon under investigation, namely, the time allocated to work and the capacity to adapt it to the respondents' needs (traits: x_1, x_2, x_3, x_4, x_8) and the psychophysical burden of work and family responsibilities (traits: $x_5, x_6, x_7, x_9, x_{10}, x_{10}, x_{11}$). The study includes statistics for 2021.

Original research started with the creation of a statistical database and the conversion of de-stimulants into stimulants.

The diagnostic characteristics were then standardized using the so-called zero-one formula, taking into account the arithmetic mean and standard deviation of the set of values of the standardized characteristic (see formula (1)).

$$Z_{ik} = \frac{x_{ik} - \bar{x}_k}{s_k} \tag{1}$$

where:

z_{ik} – the standardized value of trait k in unit i,

x_{ik} – the absolute value of feature k in unit i,

$\bar{x}_k$ – arithmetic mean of feature k,

s_k – standard deviation of feature k.

The development pattern was then defined as the object with the highest values for the stimulants.

The distance between the individual countries and the P_0 object (pattern), marked as c_{io}, was calculated using the formula:

$$c_{i0} = \sqrt{\sum_{k=1}^{K} (z_{ik} - z_{0k})^2} \tag{2}$$

(i = 1, 2, 3, ..., N).

The created c_{i0} variable, according to formula (2), is not normalized. In order to meet this requirement, a so-called relative taxonomic development meter is constructed, which is calculated according to the formula:

$$d_i = 1 - \frac{c_{i0}}{c_0} \tag{3}$$

(i = 1, 2, 3, ..., N),

where:

$$c_o = \bar{c}_o + 3 \cdot s_o \tag{4}$$

$\bar{c}_o$, s_o – respectively the arithmetic mean and the standard deviation of the $c_{i\,0}$ sequence (i = 1, 2, 3, ..., N);

d_i – synthetic indicator;

whereas:

$$\bar{c}_o = \frac{1}{N} \cdot \sum_{i=1}^{N} c_{i0} \tag{5}$$

and

$$s_o = \sqrt{\frac{1}{N} \cdot \sum_{i=1}^{N} (c_{io} - \bar{c}_o)^2} \tag{6}$$

Synthetic measure of development d_i (3) takes values from 0 to 1. The closer the value of the d_i measure is to one, the less distant an object, in this case a country, is from the benchmark and the higher is the level of the work-life balance index.

Z. Hellwig's synthetic measure was used for identifying four groups of European countries with different levels of the work-life balance index. These are accordingly:

1) group I – countries with the highest level of the work-life balance index, where $d_i \geq \overline{d}_\iota + S_{di}$,
2) group II – countries with an average level of the work-life balance index, where $\overline{d}_\iota \leq d_i < \overline{d}_\iota + S_{di}$
3) group III – countries with a low level of the work-life balance index, where $\overline{d}_\iota - S_{di} \leq d_i < \overline{d}_\iota$
4) group IV – countries with the lowest level of the work-life balance index, where $d_i < \overline{d}_\iota - S_{di}$,

where:

d_i – value of the synthetic indicator,

$\overline{di}$ – average value of the synthetic indicator d_i,

S_{di} – standard deviation of the indicator d_i.

Table 1.
Diagnostic features adopted in the study

Feature no.	Name of the diagnostic feature
x_1	Individuals stating the need to report to work several times a week promptly when summoned by the employer.
x_2	The combined number of hours worked by respondents at their primary and secondary jobs per week.
x_3	Individuals stating the need to work (several times a week) during their leisure time to fulfill job requirements.
x_4	Individuals expressing a significant challenge in taking 1 or 2 hours off during work time to address personal or family matters.
x_5	Individuals stating that work-related fatigue prevented them from completing essential household chores over the past 12 months.
x_6	Individuals stating their inability to concentrate on work due to family responsibilities.
x_7	Individuals stating that they were worried about work-related matters during their leisure time in the past 12 months.
x_8	Individuals stating very poor or poor ability to adjust working hours to family and social commitments.
x_9	Individuals reporting emotional exhaustion from work.
x_{10}	Individuals reporting physical exhaustion from work.
x_{11}	Individuals reporting feelings of health and safety risks due to work.

Source: Original Research.

4. Research findings – work-life balance in European countries

Own study showed a moderate degree of variation in diagnostic characteristics. The coefficient of variation ranged from 5.6% to 39.3%. European countries are notably characterized by a similar total of hours dedicated to work at primary and secondary workplaces per week. For this diagnostic characteristic, the coefficient of variation reached the lowest value. Greeks reported the highest number of working hours, i.e., 44.3 hours, while the Dutch reported the lowest, at 33 hours. The feature that most differentiated countries was the need to report promptly to an employer's call outside working hours even several times a week. This was reported primarily by residents of Romania (10% of respondents). In contrast, Lithuania had the lowest percentage of such reports (1.5%).

Considering the diagnostic features used in the study, the greatest ability to balance work and non-work life was found in six countries: the Netherlands, Norway, Denmark, Finland, Switzerland, and Lithuania (Table 2).

Another group of seven countries (Estonia, Ireland, Slovenia, Austria, Latvia, Germany, Sweden) had an average index level, indicating fewer work-life balance opportunities (Table 2).

Table 2.
Ranking of European countries in terms of work-life balance in 2021

No.	Country	The value of the synthetic Z. Hellwig index (di)
Countries with the highest index		
1.	Netherlands	0.787
2.	Norway	0.693
3.	Denmark	0.643
4.	Finland	0.627
5.	Switzerland	0.613
6.	Lithuania	0.612
Countries with an average index		
7.	Estonia	0.595
8.	Ireland	0.550
9.	Slovenia	0.547
10.	Austria	0.519
11.	Latvia	0.506
12.	Germany	0.497
13.	Sweden	0.492
Countries with a low index		
14.	Croatia	0.455
15.	Portugal	0.451
16.	Romania	0.445
17.	Belgium	0.442
18.	Hungary	0.431
19.	Great Britain	0.421
20.	Italy	0.396
21.	Slovakia	0.393
22.	Poland	0.386

Cont. table 2.

23.	Bulgaria	0.383
24.	Spain	0.355
25.	Luxembourg	0.348
26.	Czech Republic	0.325
27.	Malta	0.324
28.	France	0.319
Countries with the lowest index		
29.	Cyprus	0.134
30.	Greece	0.063

Source: Original Research.

The largest group of countries, which also includes Poland, are those with low levels of this indicator (Table 2). Poland ranks 22nd. Z. Hellwig's index characterizing Poland was more than twice lower than that of the top-ranked country, the Netherlands. The ability to balance work and non-work life in Poland is similar to that in Slovakia and Bulgaria.

Workers in Cyprus and Greece have the lowest ability to balance work and non-work life (Table 2). It's worth noting that within this group, Greeks struggle much more to maintain a work-life balance. In their case, Hellwig's synthetic index is more than twice lower than for Cyprus.

Greece and Cyprus, whose economies are largely based on tourism services, present specific challenges. Both working time and workload are unevenly distributed in these countries, and private life and work are particularly strongly intertwined. The demands of the tourism market often require work on Saturdays, Sundays, and holidays, coinciding with the leisure time of other family members, especially children. This scenario hinders the family's ability to fulfill care, socialization, or integration functions. Under these conditions, achieving a sense of balance between work and life outside of work can be difficult.

4.1. Work-life balance in Poland in the light of own study

In the following part of the article, the focus shifts to a detailed analysis of the situation of Polish workers in terms of the diagnostic features adopted in the survey. These features pertain to two aspects of the phenomenon under study: the time allocated to work and the possibility of adapting it to the needs of respondents, as well as the psychophysical strain of work and family responsibilities.

Working time is subject to numerous legal regulations both at national and sector-specific levels and in collective agreements, as well as in the international legislation of the European Union and conventions of the International Labor Organization. The aim of these regulations is to protect the health and safety of workers by setting minimum standards for working hours. In European Union member states, this issue is primarily regulated by Directive 2003/88/EC of the European Parliament and of the Council of November 4, 2003 concerning certain aspects of the organization of working time. According to this directive, the maximum weekly working hours, including overtime, should not exceed 48 hours.

Despite a trend toward shorter formal working hours in European Union countries, they are often, in reality, extended. Several reasons contribute to the extension of working hours. On one hand, individuals fear wage reduction or job loss, particularly in environments of high unemployment. On the other hand, the desire to advance one's career also prompts longer working hours. The increasing demand for highly skilled and proficient workers, professionals in their professional fields, accompanied by high wages, keeps them working longer. For these workers, reducing their work not only implies higher unused opportunity costs, but also the necessity to curb career aspirations and a strong orientation towards career development. Consequently, highly educated individuals are more likely to experience conflict between work and personal life, finding it particularly challenging to balance both spheres (Michoń, 2015).

According to Eurostat, the average weekly working time in the European Union in 2021 was 36.4 hours. However, research by Eurofund indicates that Polish workers were working significantly longer. The total hours worked in their primary and secondary jobs were among the highest in Europe, averaging 41.5 hours. Only Greeks (44.3 hours), Cypriots (42.2 hours), and Czechs (41.3 hours) reported a higher number of working hours in contrast, Dutch workers reported the fewest working hours, with 33 hours per week, which is more than 8 hours less than in Poland. The relatively lower number of working hours in the Netherlands can be attributed to a higher proportion of part-time workers.

Regrettably, work often "invades" employees' leisure time. The research shows that the necessity to work during free time, even several times a week, is a common feature across all countries. Formal working hours often fall short for the tasks and responsibilities that employees are assigned. This phenomenon is most pronounced in Greece, with over 25% of Greeks reporting having to surrender their leisure time for work multiple times during the week. In Poland, 15% of employees reported similar situations.

Availability is now a standard requirement for employment. Unfortunately, it can disrupt the balance between work and non-work life, particularly when employers excessively impose it. This is evident in survey results indicating that a substantial percentage of respondents in many countries are obliged to report to work swiftly multiple times a week upon their employer's request. Workers in Romania (10.5%) and Greece (9.7%) were most likely to face this situation, while Lithuanians (1.5%) were least likely. In Poland, such workers accounted for just over 5%.

In this context, it's worth citing the conclusions of international studies advocating for reducing working hours. These studies affirm that shorter working hours generally increase productivity (Bosch & Lehndorff, 2001),(Golden, 2012).

J.H. Pencavel differentiated between nominal and effective working hours and suggested that reducing nominal working hours can increase so-called effective working hours, leading to enhanced labor productivity (Pencavel, 2018). Studies also confirm the positive impact of shorter working hours on health and life satisfaction, which in turn reduces absenteeism at

work(Albertsen, 2008). Long working hours increase the risk of developing depression, with those working more than 11 hours a day facing risks 2.5 times higher than those working 7-8 hours (Virtanen, Stansfeld, Fuhrer, Ferrie, & Kivimak, 2012).

Flexibility in forms of employment and working hours is considered a factor in maintaining a balance between work and non-work life. However, it's crucial to note that this is only applicable to so-called positive flexibility, that is, when the employee chooses the form of employment and working hours to suit their own preferences. Situations where an employer enforces flexible solutions of their own preference, motivated solely by their own interests, can hardly be viewed as promoting a balance between work and non-work life. These instances are a manifestation of negative flexibility, which often means working on short-term contracts or reduced hours (in the absence of alternative choices), during inconvenient or extended hours, with no opportunity for the employee to object (Machol-Zajda, 2008). It can also entail frequent overtime work, whether compensated financially or through time off, and unpredictable alterations in work schedules (Machol-Zajda, 2008).

The study also addressed the issue of the so-called positive flexibility of working hours. Countries like Poland, Greece, Cyprus, and Bulgaria have a relatively high percentage of workers who report a limited ability to adjust their working hours to accommodate family and social obligations. Over 27% of Poles made such a declaration. The highest percentage of such workers were in Greece (30.4%), Cyprus (28.9%), and Bulgaria (27.6%). Conversely, the Netherlands (9.4%) and Denmark (11.1%) had the fewest, suggesting that these countries have the highest levels of positive working time flexibility. A relatively high percentage of Poles, 24.8%, also reported problems with taking 1 or 2 hours off during work to take care of personal or family matters. By comparison, the Netherlands had the fewest individuals with this problem, at 10.2%.

The disruption of the balance between work and non-work time adversely affects an individual's functionality across all activities. It hinders the fulfillment of family and social responsibilities, leisure time, and the development of passions and interests. Often, an intense commitment to work, coupled with high professional ambitions and perfectionism, leads to a compulsion to ponder work-related tasks, even after work hours. This risk is particularly high among white-collar workers engaged in non-standard, conceptual work. In such situations, balancing work and broader non-work life becomes difficult, increasing the likelihood of professional burnout.

Survey results clearly indicate a relatively high percentage of respondents who reported concern over work-related issues in their free time. Luxembourgers (44%), Croats (40.5%), and Cypriots (38.3%) reported the highest numbers. On the other hand, Austrians (15%) and the Dutch (15.4%) reported the lowest numbers. In Poland, the figure stood at 27.4%.

Working under time pressure is a characteristic of current economic processes. This is evident in the labelling of modern organizations as always "in a hurry"(Pluta, 2015). The push for maintaining a competitive edge places organizations in a perpetual race against

time. These "hurried organizations" need to meet their commitments faster, collecting information on the development of new products, services, and processes, executing ambitious projects, innovating, and responding to specific customer demands subject to ever-changing trends as quickly as possible (Pluta, 2015).

Even though there is a progressive shortening of formal working hours to harmonize work and personal life, the pace of professional work simultaneously intensifies. This intensification is marked by work overload, multitasking, constant shifts in the nature of work and responsibilities, and the requirement of constant availability. How can one meet this challenge during ever-shrinking working hours? Paradoxically, the collision of these two processes – the reduction of working hours and the intensification of work's pace – incites frustration, emotional tension, and stress, leading to mental and physical exhaustion. As a result, the actual working time becomes noticeably longer than the formal one set by the current legal rules. Under these conditions, a harmonious and rewarding balance between work and non-work life is challenging to attain.

The survey results clearly indicate disruptions in the balanced functioning of employees in their work and personal life spheres According to respondents, work responsibilities interfere with their family life. In Poland, 24% of workers reported that work fatigue had hindered them from performing necessary housework in the past 12 months, a rate more than 10 percentage points higher than in Slovenia and the Netherlands. Workers in Cyprus and Greece most frequently reported an inability to complete household chores due to work fatigue, with 41.9% of Cypriots and 36.3% of Greeks making such declarations. In all surveyed countries, the percentage of people reporting a negative impact of family life on fulfilling their work duties was significantly lower. The inability to concentrate on work due to family obligations was highest among Greeks (15%) and Cypriots (13.4%), and lowest among Danes (3.4%) and Finns (4.8%). In Poland, 9.4% of respondents made such declarations.

It's concerning that a relatively high number of workers feel that their work poses a threat to their health and safety. In Poland, over 37% of employees expressed such worries, while the highest number of such declarations was made by Spaniards (49.4% of employees). The Netherlands and Denmark had the lowest percentages of this concern, in both cases around 20%. It's therefore crucial to deepen research to identify the factors that cause employees to feel such threats.

Workers report both physical and mental exhaustion due to work. In Poland, nearly 20% of workers reported physical exhaustion, while 6% reported emotional exhaustion. Italy had the highest percentage of people reporting physical exhaustion, which was more than 11 percentage points higher than in Poland. Emotional exhaustion was most frequently reported by Cypriots (10% of respondents), and least frequently by the Dutch (1.8%).

5. Conclusion

Poland is characterized by a relatively low level of opportunities for maintaining a balance between work and personal life. This imbalance is exacerbated by a high number of working hours and limited opportunities for flexibly adjusting work schedules to accommodate employees' non-work responsibilities. This prevents the completion of necessary household tasks and creates a perception of health and safety risks.

In contrast, the Netherlands and Scandinavian countries, namely Norway, Denmark, and Finland, distinctly excel in implementing solutions that help maintain a balance between work and other facets of employees' lives. The success of these countries lies in a work culture rooted in social trust, marked by a high degree of development and utilization of flexible forms of employment and working hours. An individualized approach to employees, focusing not only on their professional development but also on supporting their personal life, fosters an atmosphere of cooperation, kindness, and support, which in turn generates a sense of security and well-being.

It's also worth noting that achieving a balance between work and personal life significantly depends on the values and choices of individual workers. Some prioritize family and personal life, treating work as a means to an end, while for others, work itself is an end in itself, and all other life activities are subordinated to it. Although maintaining equilibrium among all facets of human activity is most conducive to harmonious social, mental, and physical development, individuals often make choices that disrupt this balance. They misallocate their intellectual, emotional, and physical resources, subjecting themselves to stress and frustration, either due to work overload or frustration stemming from unmet career aspirations.

The pursuit of a balanced work-life becomes more pertinent in wealthier societies with relatively high levels of material needs satisfaction. This shift is evident in the attitudes of young Europeans entering the job market today. They are notably critical of the values held by their grandparents and parents, for whom work and career advancement were seen as paths to high material status and social advancement. Today's young workers are less willing to significantly subordinate their personal lives to work. The 2022 Randstad international survey reveals that nearly 60% of workers aged 18-24 are willing to quit their jobs if it hinders their enjoyment of life (Randstad, 2023). At the same time, as many as 38% of Generation Z employees have quit their jobs because they did not align with their personal lives (Randstad, 2023). These attitudes among young people necessitate a shift in employers' approaches to human capital management, which is crucial for gaining a competitive edge. Flexible hiring and reduced working hours are just the first steps in this transition. Another critical shift involves building partnerships based on mutual respect for the interests and needs of both employers and employees, participatory management, and the establishment of an organizational culture centered on humanistic values—respect, trust, and a sense of community.

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HYDROGEN ENERGY AS A CATALYST FOR SUSTAINABLE DEVELOPMENT: A COMPARATIVE ANALYSIS OF POLICIES, STRATEGIES, AND IMPLEMENTATION IN POLAND AND GERMANY

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Purpose: The study aims to investigate the role of hydrogen technology in sustainable energy in Poland and Germany. It seeks to offer a comparative analysis to fill gaps in existing literature and provide insights for stakeholders in achieving Sustainable Development Goals.
Design/methodology/approach: A multifaceted approach is employed, integrating a literature review, tabular analysis, and surveys. Scientific publications, government reports, and research papers are analyzed. Tabular comparisons elucidate differences and similarities in strategies and regulations between the two countries. Surveys among social and professional groups capture public perception and attitudes.
Findings: Hydrogen technology has gained significant attention as a sustainable energy source. Germany emerges as a leader with a comprehensive strategy, while Poland aligns with EU objectives but faces infrastructure challenges. Both nations have introduced regulations to promote hydrogen technology investment, although challenges such as high production costs persist. Public support is robust in both countries, with higher awareness in Germany.
Research limitations/implications: The study's scope could be expanded for a more comprehensive understanding. Future research could focus on addressing these limitations and offering more granular insights.
Practical implications: The study serves as a roadmap for stakeholders, offering insights that can guide policy formulation and investment decisions. It has implications for climate change mitigation efforts and could inform public engagement campaigns.
Social implications: The study underscores hydrogen technology's potential in reducing greenhouse gas emissions and fostering economic growth, thereby impacting various societal aspects including environmental protection and economic development.
Originality/value: The study's uniqueness lies in its comparative analysis of hydrogen technology in Poland and Germany, contributing to the global discourse on sustainable development by offering practical insights for policymakers and industry leaders.

Keywords: Hydrogen energy, sustainable development, Poland, Germany, energy strategies, government policies, renewable energy, decarbonisation.

Category of the paper: research paper.

1. Introduction

Amidst the accelerating global shift toward sustainable energy, hydrogen technologies have garnered substantial attention as potential catalysts for achieving Sustainable Development Goals (SDGs). The original contribution of this study lies in its attempt to bridge an epistemological gap; while existing literature broadly investigates the technological facets of hydrogen as an energy carrier, scant attention has been paid to its multi-dimensional implications across economic, social, political, and environmental spheres. Consequently, this study aims to answer the question: How do hydrogen technologies align with, and potentially advance, the objectives of sustainable development in varying national contexts, specifically Poland and Germany? The principal objective of this article is to conduct a comparative analysis of hydrogen policies and their implications for sustainable development in Poland and Germany. To achieve this, the analysis will also elucidate key frameworks and theories that govern the adoption of hydrogen technologies, thereby providing a multi-dimensional perspective. It is hypothesized that the strategic adoption of hydrogen technologies will vary between Poland and Germany due to their respective economic, political, and cultural landscapes. To substantiate these objectives and hypotheses, a mixed-methods approach will be employed, encompassing both qualitative and quantitative data analysis.

In recent years, the hydrogen technology boom has gained importance as a key element in the global energy transformation, leading to increased interest in this element as a potential source of energy. The movement is part of a broader trend where new and sustainable technologies are becoming a key pillar in the pursuit of sustainable development around the world. The hydrogen tech boom is not random or isolated; it is related to the global understanding and recognition that conventional energy sources such as oil and coal are becoming less and less sustainable from both an economic and ecological point of view. The development of hydrogen technologies is part of the global movement towards ecology and sustainable development, which assumes that the future of the energy sector must be built on the principles of sustainable resource management. A comprehensive approach to analyzing the role of hydrogen in the pursuit of sustainable development is key. This means that hydrogen cannot be seen solely as a technological energy carrier; instead, it must be considered in political, economic, social and environmental contexts, as these aspects are interrelated and influence how hydrogen can be used to achieve the Sustainable Development Goals. It is important to combine theoretical and practical analysis of hydrogen energy in two different national contexts: Poland and Germany. While economically, politically and culturally different, these two countries are interesting cases to study as both are actively seeking to understand and exploit the potential of hydrogen as a key element of their energy strategies. It is essential to understand the broader context of hydrogen energy, exploring key concepts, theories and frameworks that can help explain why hydrogen has become such an important element in today's energy strategies.

Therefore, the theoretical analysis is not just limited to the technical and engineering aspects of hydrogen, but goes deeper, trying to understand how hydrogen fits into the larger sustainability narrative, what are its potential benefits and challenges, and how it can be put into practice in different national and international contexts, including Poland and Germany.

2. Development of Hydrogen Energy in Poland

The beginnings of hydrogen energy in Poland date back to the 1970s, when research on the use of hydrogen as an energy carrier began. Leading scientific institutes conducted experiments on the storage and transport of hydrogen and its use in fuel cells. In the 1990s, the first investments in hydrogen technology appeared (Spandagos, Reanos, Lynch, 2022).

The introduction of research and development initiatives enabled the implementation of several key projects related to the production of hydrogen from renewable energy sources. These early projects contributed to the development of expertise in the field of hydrogen technologies in Poland. Over the last two decades, hydrogen has started to play a more important role in the Polish energy mix. Hydrogen technologies are increasingly being considered as a key tool in the country's energy transformation, helping to decarbonise the energy sector. Hydrogen is used not only as an energy carrier but also in industry and transport (Jałowiec et al., 2022; Kochanek, 2022, pp. 72-73).

Currently, Poland is witnessing dynamic growth in the field of hydrogen energy. There are initiatives at both government and private sector levels to promote and develop hydrogen technologies. Projects related to the integration of hydrogen with renewable energy sources and the development of hydrogen refueling stations are an undoubted success (Pawłowski, 2022, p. 29). In the context of global efforts to reduce CO2 emissions and local efforts to diversify energy sources, Poland is turning to hydrogen technologies as a key element of its future energy mix (Gawlik, Mokrzycki, 2021, pp. 63-67).

The government plan for hydrogen energy presents ambitious goals aimed at making Poland one of the leaders in this field in Europe.

The development of hydrogen energy in Poland is the result of decades of research, investment and innovation. From early experiments to current applications and initiatives, Poland shows that hydrogen energy is an important and growing element of the national energy strategy. Key projects and technological achievements testify to the country's production capacity and its aspirations to be a leader in the field of hydrogen energy in the region. In the face of challenges related to decarbonisation and the need to diversify energy sources, hydrogen will play a key role in Poland's energy future (Murray, Seymour, Rogut, Zechowska, 2008, pp. 20-27).

The Polish government recognized the potential of hydrogen as a key element of a sustainable energy future and initiated many strategies related to hydrogen energy. This includes the development of a national hydrogen energy strategy that outlines targets for hydrogen production, storage and use by 2030 and beyond (Navaid, Emadi, Watson, 2023).

As a member of the European Union, Poland is obliged to implement EU regulations on hydrogen energy. This includes both commitments to reduce greenhouse gas emissions and the promotion of renewable energy sources, including hydrogen. Poland also participates in international initiatives promoting hydrogen technologies.

The government has introduced various legal acts to support the development of hydrogen energy. These include acts on taxes and reliefs, permits for the construction and operation of hydrogen installations, as well as regulations on research and development. In addition to legislation, there are also various programs and initiatives to support hydrogen energy. These include grants, loans and guarantees for companies and researchers working on hydrogen technologies. These initiatives are aimed at accelerating innovation and commercialization of hydrogen technologies in Poland. Despite positive support from the government, there are some legal barriers that may hinder the development of hydrogen energy. These include complex authorization procedures, lack of harmonized technical standards and possible conflicts with other legislation, such as environmental legislation.

Government policy and regulations in Poland in the field of hydrogen energy are a complex combination of national strategies, EU and international commitments, key legal acts, support initiatives and legal barriers. The government actively supports the development of this technology through a variety of measures, such as tax breaks, subsidies and regulation to promote innovation (Igliński et al., 2022).

However, some legal barriers still exist and require further analysis and intervention to ensure the harmonious development of hydrogen energy. The long-term success of the sector will depend on the skillful balancing of the promotion of hydrogen technologies with compliance with other public policy objectives, such as environmental protection and energy security.

This section shows that hydrogen energy is an important part of Poland's national energy strategy, and the government is taking significant steps to promote and regulate this sector. At the same time, it highlights the challenges and opportunities faced by the sector in terms of regulation and underlines the need for further work to optimize the regulatory environment (Bednarczyk, Brzozowska-Rup, Luściński, 2022).

3. Development of Hydrogen Energy in Germany

The development of hydrogen energy in Germany has a long and rich history. Starting with pioneering research and experimentation in the 1970s (Wali et al., 2023).

Germany has become a world leader in hydrogen technology. For decades, the government has supported research and development, leading to the commercialization of hydrogen technologies in various sectors.

Currently, hydrogen energy is an integral part of the German energy. The country is home to numerous hydrogen projects, including power plants, refueling stations and industrial initiatives. Germany is also a leader in the export of hydrogen technologies.

In Germany, hydrogen energy has found application in various sectors, such as transport, industry and energy. The government also supports initiatives such as public-private partnerships to accelerate technology development.

With strong government support and a dynamic private sector, Germany is well positioned for further development and innovation in the field of hydrogen energy. This is a key element in the country's quest for carbon neutrality and sustainable energy development.

The German government has developed a comprehensive national hydrogen energy strategy that includes goals and guidelines for the development of this sector This strategy is in line with the objectives of the European Union and emphasizes the role of hydrogen in achieving carbon neutrality.

The Poland, Germany is obliged to implement EU regulations on hydrogen energy. Additionally, Germany is an active participant in international hydrogen initiatives and agreements.

In Germany, there are many legal acts and initiatives supporting hydrogen energy, from tax breaks and subsidies to regulations supporting research and innovation (Trencher, Edianto, 2021). These measures aim to create an attractive environment for investment and development.

Despite significant progress, there are some challenges and legal barriers that may affect the further development of hydrogen energy in Germany. These include issues related to safety regulations, technical standards and integration with the existing energy infrastructure.

The development of hydrogen energy in Germany is the result of a long-term commitment to research, innovation and supportive policy. As a result, Germany has created a strong and dynamic hydrogen energy sector, which is a key element of the country's energy strategy. Government policies and regulations create a favorable environment for further development and innovation, but they also require further attention in terms of regulatory challenges and barriers.

4. Analysis of policies and strategies. Comparison of Poland and Germany

Comparing the hydrogen energy policies and strategies of Poland and Germany is a key element in understanding how both countries approach this modern technology. This analysis helps to understand the similarities and differences in the approach, goals, regulations and initiatives of the two countries.

Sustainable development of the energy sector is becoming a key priority for countries around the world, and hydrogen can play a significant role in achieving this goal. Poland and Germany, although at different stages of implementing hydrogen technologies, have taken significant steps towards integrating this energy carrier with their national energy strategies. Comparing government policies, goals, regulations, support initiatives, challenges and implementation strategies in the two countries can provide valuable insights for both practitioners and policy makers.

Table 2. Comparison of Governmental Policies, Goals, Regulations, Support, Challenges and Strategies for the Implementation of Hydrogen Technologies in Poland and Germany presents a detailed analysis broken down by Poland and Germany, taking into account various aspects related to the implementation of hydrogen technologies. This comprehensive table can serve as a reference for further research and analysis in this field. A detailed analysis broken down by Poland and Germany is presented in Table 1 below.

Table 1.
Comparison of Governmental Policies, Goals, Regulations, Support, Challenges and Strategies for the Implementation of Hydrogen Technologies in Poland and Germany

Government Policy and Objectives	
Poland	Poland is actively investing in the development of hydrogen energy, with particular emphasis on research and innovation. National authorities have taken support initiatives within the framework of national plans and strategies, in line with the objectives of the European Union.
Germany	Germany is a leader in hydrogen energy, with a well-defined and comprehensive national strategy. They are also an active participant in international hydrogen initiatives and agreements.
Regulations and Support Initiatives	
Poland	Poland has introduced various regulations and supporting initiatives, such as tax breaks, subsidies and public-private partnerships, to create a favorable environment for investments in hydrogen energy.
Germany	Germany has a more extensive support system, including significant research and development funding, and regulations that promote the commercialization of hydrogen technologies.
Challenges and Barriers	
Poland	Poland faces challenges related to infrastructure, technology availability and integration into the current energy mix.
Germany	Germany, despite its advanced development, also experiences challenges such as safety regulations and technical standards that may affect further development.
Comparison of Strategy and Implementation	
Similarities	Both Poland and Germany consider hydrogen energy to be a key element of their energy strategies. Both countries strive to comply with the objectives of the European Union and actively support the development of hydrogen technologies.
Differences	Germany is much more advanced in the field of hydrogen energy, with a longer history of research and commercialization. Poland, although actively investing in development, is at an earlier stage and focuses more on research and innovation.

Source: Based on (Murray, Seymour, Rogut, Zechowska, 2008, pp. 20-27; Włodarczyk, Kaleja, 2023; Wali et al., 2023; Kochanek, 2022, p. 7235; Lebrouhi et al., 2022; Zhao et al., 2022).

5. Impact of Hydrogen on Sustainable Development

Hydrogen, as a clean and renewable energy source, has the potential to have a major impact on sustainable development. This impact can be understood in the context of various aspects of sustainable development, such as environmental performance, economy and society.

In the era of the global climate crisis, measures to reduce greenhouse gas emissions and promote sustainable development are becoming increasingly important. Hydrogen, as a clean and renewable energy source, has the potential to become a key element in this global transformation.

Table 2. Impact of Hydrogen on Ecology, Economy and Society: Analysis of Emissions, Fossil Fuel Substitution, Cost Efficiency, Economic Impact, Energy Availability, Public Health and Support to Other Renewable Energy Sources and the UN Sustainable Development Goals provides a comprehensive overview of various aspects that can be affected by hydrogen. This includes both environmental benefits such as emission reduction and fossil fuel substitution, as well as economic and social impacts such as cost efficiency, economic stimulus, energy availability and public health.

This table shows the complexity of hydrogen's impact on various areas of sustainability, offering readers an understanding of how hydrogen can be used to achieve wide-ranging environmental, economic and social goals.

Table 2.
Impact of Hydrogen on Ecology, Economy and Society: Analysis of Emissions, Fossil Fuel Substitution, Cost Efficiency, Economic Impact, Energy Availability, Public Health and Support to Other Renewable Energy Sources and the UN Sustainable Development Goals

Ecological Impact	
Reducing Emissions	Hydrogen can be used as a fuel that does not emit carbon dioxide. Therefore, it is of key importance in the pursuit of reducing greenhouse gas emissions and limiting climate change,
Substitution of Fossil Fuels	As an alternative to fossil fuels, hydrogen can play a key role in the decarbonisation of various sectors such as transport, industry and energy.
Economic Impact	
Cost Efficiency	In the long term, hydrogen has the potential to be cost-competitive with traditional fuels. Investments in technology and infrastructure can further reduce,
Stimulating the Economy	The development of hydrogen technologies can lead to the creation of new jobs, increased innovation and economic growth,
Social Influence	
Energy Availability	Hydrogen can help to increase access to energy in remote and deprived regions through local energy production and storage.
Public Health	Reducing fossil fuel-related air pollution through the use of hydrogen can lead to improved public health.

Cont. table 2.

Impact on Other Sustainable Development Goals	
Support for Other Renewable Energy Sources	Hydrogen can be used as a means of storing renewable energy, supporting the integration of other renewable energy sources such as wind and solar power.
Compliance with the UN Sustainable Development Goals (SDGs)	Hydrogen energy is compliant with many of the UN Sustainable Development Goals, such as access to clean energy, climate action and responsible consumption.

Source: Based on (Mneimneh et al., 2023, p. 1368; Kandidayeni, Trovão, Soleymani, Boulon, 2022; Wali et al., 2023; Scheller et al., 2023; Sadik-Zada, 2021; Włodarczyk, Kaleja, 2023; Bridgeland et al., 2022; Spandagos, Reanos, Lynch, 2022; Zhao et al., 2022).

Hydrogen is not only a promising source of energy from a technological and economic point of view, but also plays a key role in the context of sustainable development. Its potential to reduce emissions, support economic growth, improve public health and support other renewable energy technologies has made it a central component of global sustainability strategies. However, the future development of hydrogen energy requires taking into account challenges such as production costs, technology availability, lack of infrastructure and security risks in order to fully realize its potential for sustainable development.

6. Impact of Hydrogen on Sustainable Development in Poland and Germany

Impact of Hydrogen on Sustainable Development in Poland and Germany Hydrogen as an energy source plays a key role in sustainable development, and Poland and Germany are two countries that are actively working to integrate hydrogen into their energy strategies. Table 3 below presents the impact of hydrogen on sustainable development manifested in Poland and Germany.

Hydrogen, being a clean and renewable energy carrier, is becoming a key element of sustainable development strategies around the world. Poland and Germany, two different economies in Europe, are interested in exploring and implementing hydrogen technologies from different perspectives.

Table 3. Impact of Hydrogen on Ecology, Economy and Society in Poland and Germany: Analysis of Emissions, Economic Impact, Social Impact and Support for Other Sustainable Development Goals shows the different approaches of these two countries to hydrogen.

In terms of ecological impact, Poland sees hydrogen as an opportunity to diversify energy sources and reduce CO2 emissions, while Germany is investing in hydrogen technology as a means to further decarbonise the economy. In terms of economic impact, both countries see the opportunity to create new jobs and stimulate innovation, but with varying degrees of commitment and expectations. In terms of social impact, both Poland and Germany see benefits

related to improved air quality and public health, but with different priorities and delivery methods.

This table 3 shows the analysis of differences and similarities between Poland and Germany in the context of hydrogen use, which may provide important lessons for other countries seeking to integrate hydrogen into their sustainable development strategies.

Table 3.
Impact of Hydrogen on Ecology, Economy and Society in Poland and Germany: Analysis of Emissions, Economic Impact, Social Impact and Support for Other Sustainable Development Goals

Ecological Impact	
Poland	Poland, which is largely dependent on coal, sees hydrogen as an opportunity to diversify energy sources and reduce CO2 emissions. The introduction of hydrogen can help meet the country's climate goals.
Germany	Germany, as a leader in the field of renewable energy sources, is investing heavily in hydrogen technology. Hydrogen can help further decarbonise the economy, especially in sectors that are difficult to electrify.
Economic Impact	
Poland	Investments in hydrogen technology can open up new economic opportunities, creating jobs and stimulating innovation.
Germany	Germany is at the forefront of innovation in hydrogen technology and has the potential to be a global leader in this sector, which could contribute to further economic growth.
Social Influence	
Poland	Hydrogen can contribute to improving air quality, especially in urban areas, which can lead to improved public health.
Germany	The integration of hydrogen into the public and private transport system can lead to sustainable mobility and reduction of air pollution.
Impact on Other Sustainable Development Goals	
Poland	The use of hydrogen to store renewable energy can support the development of other renewable technologies, such as wind and solar energy.
Germany	Germany is committed to international hydrogen cooperation, promoting global sustainability and increasing access to clean energy.

Source: Based on (Bałamut, 2022; Kochanek, 2022; Zhao et al., 2022; Stevens, Tang, Hittinger, 2023; Kumar et al., 2022; Stevens, Tang, Hittinger, 2023, pp. 431-441).

In Poland and Germany, hydrogen plays an increasingly important role in the context of sustainable development. Both countries are actively exploring hydrogen opportunities to address the environmental, economic and social challenges they face. Germany, being at the forefront of innovation, is a model for other countries, while Poland is considering the possibilities of hydrogen as part of its energy transition strategy. Cooperation and knowledge exchange between the two countries can contribute to the further development of hydrogen technology internationally, with benefits for both the environment and the economy.

7. Impact of Hydrogen on Sustainable Development in Poland and Germany

The importance of hydrogen as an energy source is attributed to the potential to play a key role in sustainable development, especially in countries such as Poland and Germany, which are actively looking for alternative and green energy sources. The implementation and effective use of hydrogen, while promising, has many potential benefits, but also challenges.

Table 4. Impact of Hydrogen on Sustainable Development in Poland and Germany. Analysis of Potential Benefits and Challenges Related to the Introduction and Efficient Use of Hydrogen as an Energy Source provides a detailed analysis of these aspects.

On the one hand, hydrogen can contribute to the reduction of harmful gas emissions, support renewable energy sources and stimulate economic growth. On the other hand, there are challenges such as the need for significant investments in infrastructure, security standards and technological barriers to entry.

This table 4 shows the complexity of the process of implementing hydrogen as a key element of a sustainable energy strategy, offering a full picture of the opportunities and limitations that Poland and Germany may encounter on this path. This insight can be a valuable tool for policy makers, investors and scientists interested in exploring hydrogen as a key tool in the transition to a cleaner and more sustainable energy future.

Table 4.
Impact of Hydrogen on Sustainable Development in Poland and Germany. Analysis of Potential Benefits and Challenges Related to the Introduction and Efficient Use of Hydrogen as an Energy Source

Potential Benefits	
Reducing Emissions	Hydrogen can make a significant contribution to reducing greenhouse gas emissions, especially in industrial sectors and transport.
Support for Renewable Energy Sources	As an energy store, hydrogen can offset the volatility of some renewable sources such as wind and solar.
New Jobs	Investments in hydrogen technology can create new jobs and stimulate the economy.
Improving Air Quality	Hydrogen in transport and heating can help improve air quality in urban areas.
Increasing Energy Reliability	Hydrogen can increase the reliability of energy supply, especially when combined with renewable sources.
Challenges	
Production costs	Currently, hydrogen production, especially from renewable sources, is relatively expensive, which is a barrier to widespread deployment.
Availability of Technology	Advanced hydrogen technologies are not always available or adapted to local conditions.
Lack of Infrastructure	There is a lack of adequate infrastructure, such as refueling stations, to support a hydrogen-based economy.
Safety Risks	Hydrogen requires special safety precautions during production, transportation and storage, which can be challenging.
Regulations and Policy	Inconsistencies in regulations and government support can inhibit the development of hydrogen energy.

Source: Based on (Kumar et al., 2022; Bridgeland et al., 2022; Evans, Wilson, 2021; Johnston, Mayo, Khare, 2005, pp. 569-585; Kandidayeni, Trovão, Soleymani, Boulon, 2022; Kirchem, Schill, 2023).

Hydrogen has great potential to contribute to sustainable development in Poland and Germany, but its effective implementation requires solving a number of challenges. Both countries need to work to create a favorable environment for investment in hydrogen technology, taking into account both benefits and potential obstacles. Long-term vision, strategic planning, international cooperation and local adaptation will be key to realizing the full potential of hydrogen in the context of sustainable development.

8. Impact of Hydrogen on Sustainable Development in Poland and Germany

Faced with the growing global demand for energy and the need to reduce greenhouse gas emissions, the world is turning to new, sustainable energy sources. Hydrogen, as one of the most promising energy carriers, is gaining importance as part of the green transformation, especially in countries such as Poland and Germany.

In Poland, a country with a rich tradition of coal mining, the hydrogen industry is part of the clean energy transition strategy and can play a key role in minimizing dependence on fossil fuels. Germany, as one of the leading countries in the field of innovation and technology, is also investing in the development of hydrogen technologies, striving to create efficient and sustainable energy systems (Table 5).

Table 5.
Benefits and challenges related to the use of hydrogen technology in Poland

POLAND	
Potential Benefits	
Reducing Emissions	Poland, where coal is the main source of energy, can gain significant benefits from hydrogen in reducing CO2 emissions.
Support for Renewable Energy	Hydrogen can help integrate renewable energy sources such as wind power .
Job creation	The development of hydrogen technology can support the local economy and create new jobs.
Increased Reliability	Improved diversification of energy sources by incorporating hydrogen.
Challenges	
Costs and Availability of Technology	Higher production costs and limited availability of technology in Poland.
Lack of Infrastructure	Need to expand hydrogen infrastructure.
Regulations and Policy	The need for clear and consistent regulations supporting the development of hydrogen energy.
GERMANY	
Potential Benefits	
Green Energy Source	In Germany, with a strong focus on ecology, hydrogen could be a key element of the green transition.
Innovation and Leadership	Germany can leverage its position as a leader in innovation and hydrogen technology.
Support for Renewable Energy	Hydrogen can support Germany's renewable energy targets, especially in the automotive sector.

Cont. table 5.

Challenges	
Integration with Existing Infrastructure	Using hydrogen in existing energy infrastructure can be challenging.
Costs and Competition from Other Sources	Balancing the costs of hydrogen and other competing energy sources.
Security Threats	The need to manage specific security risks associated with hydrogen production and storage.

Source: Based on (Borowski, Karlikowska, 2023; Spandagos, Reanos, Lynch, 2022; Budzianowski, 2012; Kochanek, 2022; Kirchem, Schill, 2023; Egeland-Eriksen, Hajizadeh, Sartori, 2021; Salvi, Subramanian, 2015).

Hydrogen can play different roles in Poland and Germany, with different benefits and challenges. Poland can focus on using hydrogen as a tool to reduce dependence on coal, while Germany can use its position as an innovation leader to promote hydrogen as a green energy source. However, both countries will have to overcome specific challenges to fully realize the potential of hydrogen in the context of sustainable development.

9. Impact of Hydrogen on Sustainable Development in Poland. Case Study: Hydrogen Projects

In Poland, hydrogen energy is gaining in importance as a key element of the sustainable development strategy. In Germany, being one of the leaders of hydrogen technology in Europe, the development of hydrogen energy is a key element of the national energy strategy. Below are some notable hydrogen projects that demonstrate Germany's commitment to this groundbreaking technology. Table 6 below presents some significant hydrogen projects that reflect the diversity and potential of this technology in the Polish and Germany context.

Table 6.
Impact of Hydrogen on Sustainable Development in Poland. Case Study: Hydrogen Projects

Impact of Hydrogen on Sustainable Development in Poland	
"Hydrogen Valley" project in Lower Silesia	It is one of the most ambitious hydrogen projects in Poland, which aims to create an entire ecosystem around hydrogen, combining production, distribution and consumption. This includes the creation of a hydrogen refueling station, a fleet of hydrogen vehicles, and integration with renewable energy sources.
Hydrogen Buses in Warsaw	The capital of Poland has taken the initiative to introduce hydrogen-powered buses to public transport. This project aims to reduce exhaust emissions and show the possibilities of hydrogen transport technology.
Cooperation with Zakłady Chemiczne "Police"	This initiative, carried out in cooperation with a large chemical producer, aims to develop hydrogen production technology from chemical processes. This could lead to more efficient use of hydrogen in various industrial applications.
"Green Hydrogen" project in Pomerania	This project aims to integrate hydrogen production with wind energy in a coastal region. This includes using surplus wind power to electrolyze water and produce green hydrogen.
Education and Research Initiatives	Various universities and research institutes in Poland are conducting projects related to hydrogen, including research into new technologies for the production, storage and use of hydrogen.

Cont. table 6.

Impact of Hydrogen on Sustainable Development in Germany	
H2mobil project	This pioneering project aims to create a national network of hydrogen refueling stations, thus facilitating the transition to hydrogen vehicles. This is part of a wider strategy to promote sustainable transport in Germany.
Hydrogen Lab Bayern (HLB)	This research and development center focuses on developing innovative technologies for the production, distribution and use of hydrogen. It works with industry, government and academia to accelerate the commercialization of hydrogen technology.
Hydrogen Power Plant in Hamburg	This state-of-the-art power plant uses hydrogen to produce electricity, demonstrating hydrogen's potential as a large-scale sustainable energy source. This is part of the city of Hamburg's strategy to become CO2-neutral.
HyFleetCUTE Design	This international project, based in Germany, will investigate the use of hydrogen in commercial vehicle fleets. The knowledge gained will be used to promote hydrogen as an alternative fuel for various types of transport.
Cooperation with Siemens AG in Industrial Projects	Large corporations such as Siemens are investing in hydrogen-related projects, including hydrogen power and manufacturing technologies, demonstrating the growing interest of the private sector in hydrogen technology.
Educational and Academic Initiatives	Various German universities are conducting advanced research on hydrogen technology, creating a platform for innovation and supporting the future development of this field.

Source: Based on (Bałamut, 2022; Bednarczyk, Brzozowska-Rup, Luściński, 2022; Bednarczyk et al., 2022; Reijalt, 2010; Igliński et al., 2022; Panchenko et al., 2023; Kirchem, Schill, 2023; Salvi, Subramanian, 2015; Egeland-Eriksen, Hajizadeh, Sartori, 2021).

Hydrogen projects in Poland are diverse and reflect the wide range of possibilities of this technology. From urban transport to integration with renewable energy sources, hydrogen has the potential to contribute to the sustainable development of Poland on various levels. However, the implementation of these projects requires an integrated strategy, investments and cooperation between various sectors to fully realize the potential of hydrogen in Poland.

Germany plays a key role in the development of hydrogen technology, investing in a wide range of projects from transport to energy. The commitment to innovation, cross-sector collaboration and an integrated approach to the hydrogen strategy makes Germany one of the most advanced countries in this field. These projects not only highlight the potential of hydrogen as a tool for sustainable development, but also point to Germany as a model for other countries seeking to exploit this versatile technology.

10. Impact of Hydrogen on Sustainable Development in Poland and Germany. Future prospects

In Poland, hydrogen energy is a relatively new area, but the potential and interest in the technology is growing. Below we present the prospects for the future of hydrogen energy in Poland, both in terms of sustainable development and in the economic, social and environmental context. In Germany, as one of the leaders in renewable energy and sustainability, hydrogen has great potential to play a key role in the country's future energy mix. Here are the prospects for the future of hydrogen energy in Germany (Table 7).

Table 7.
Impact of Hydrogen on Sustainable Development in Poland and Germany. Future prospects

POLAND	
Integration with Renewable Energy Sources	In Poland, there is a noticeable trend towards increased production of energy from renewable energy sources (RES). Hydrogen can become a key element in RES integration, enabling the storage of excess energy and stabilization of the power grid.
Development of Transport Infrastructure	Planning and implementing infrastructure for hydrogen transport, such as refueling stations, can drive the development of the hydrogen vehicle sector, in line with the global trend to decarbonize transport.
Investments in Research and Development	Increasing investment in hydrogen research and development, both at the government and private level, can accelerate innovation and reduce the cost of hydrogen technology.
Regulatory and Policy Support	Active government support, including incentives and regulation, can drive the growth and commercialization of hydrogen technology in Poland, supporting both the country's environmental and economic objectives.
International cooperation	Participation in international initiatives and cooperation with neighboring countries can enable the exchange of knowledge and technology, as well as increase the scale and efficiency of hydrogen implementations.
Education and Social Awareness	Raising social awareness and education about hydrogen as a sustainable energy source can contribute to social acceptance and further development of the market.
GERMANY	
Leader in Hydrogen Technology	Germany is already considered a leader in hydrogen technology in Europe. Further investment and support for research and development can strengthen this position in the international arena, creating opportunities to export technology and knowledge.
Integration with the Energy Grid	Hydrogen can play a key role in storing renewable energy and ensuring grid flexibility, supporting Germany's transformation towards a low-carbon economy.
Sustainable Transport and Industry	The use of hydrogen in the transport sector and industry can contribute to a significant reduction in greenhouse gas emissions. The development of hydrogen infrastructure in these sectors is key to meeting Germany's climate goals.
International Cooperation	Germany can increase its partnerships and cooperation with other European and global countries in the field of hydrogen technology by promoting standards and best practices around the world.
Hydrogen Policy and Regulations	The adoption of an integrated hydrogen policy and regulation, in line with the EU's sustainable development goals, can provide long-term certainty and stability for investors and businesses.
Society and Education	Building public awareness and understanding about the benefits and applications of hydrogen as a sustainable energy source can contribute to social acceptance and promote hydrogen technologies in everyday life.

Source: Based on (Bhandari et al., 2021; Hassan et al., 2023; Panchenko et al., 2023; Salvi, Subramanian, 2015; Kirchem, Schill, 2023; Egeland-Eriksen, Hajizadeh, Sartori, 2021).

Poland faces an exciting opportunity to become a key player in the field of hydrogen energy in Europe. Long-term success will require an integrated approach combining policy, investment, innovation and education. Using its rich energy resources and innovative spirit, Poland can play an important role in the global energy transformation, using hydrogen as a sustainable development tool for the future.

In Germany, the prospects for hydrogen energy are promising and in line with the country's long-term vision for a sustainable economy. With the right political support, investment, innovation and education, hydrogen can play a key role in Germany's energy transition. Given the growing global focus on decarbonisation and sustainable development, Germany has the potential to become a global leader in hydrogen energy, setting the stage for other countries and contributing to the global Sustainable Development Goals.

11.Analysis of the survey on Hydrogen Energy in Poland and Germany

The survey was designed to explore the understanding of the public and various stakeholders in the field of hydrogen energy. This is often a new and unfamiliar field for many people, so understanding how people view hydrogen as an energy source, what benefits and challenges they see can provide important clues for policy makers, scientists and entrepreneurs.

Hydrogen energy is becoming an increasingly important area in the global energy transformation. However, public opinion and attitudes towards hydrogen may vary depending on national context, education, experiences and values. Poland and Germany, although they are neighbors and part of the same European Union, have different energy traditions, strategies and goals. These differences may affect how hydrogen energy is perceived in both countries. In the survey on hydrogen energy in Poland and Germany, proper sample selection and representativeness are key to obtaining reliable and generally applicable results. Here is how these aspects were applied and why they are relevant in the context of this study: Poland (898 respondents): The sample was selected in such a way as to reflect the demographic diversity of Poland, taking into account factors such as age, gender, education, place of residence and interest and experience in the field of energy.

Germany (924 respondents): As in Poland, the German sample was structured to reflect the diversity of the country. It covered various social groups, regions and levels of understanding and involvement in hydrogen energy.

Representativeness in a survey study refers to the extent to which the research sample reflects the general population from which it was drawn. This is a key aspect that determines whether survey results can be generalized to the entire population. In the context of the hydrogen energy study in Poland (898 respondents) and Germany (924 respondents), representativeness can be understood by applying the following formulas and concepts.

Sample size (n): This is the number of units in the sample, i.e. 898 for Poland and 924 for Germany.

Population Size (N): This is the total number of units in the population from which the sample was drawn. It could be the total number of adult citizens in both countries, for example.

- Margin of Error (e): The margin of error expresses how far the results of a sample may differ from the actual results of the population as a whole. The standard margin of error is often 5% or 3%.
- Confidence Level (Z): This is the Z-score corresponding to the desired confidence level, often 95% or 99%.
- Standard Deviation (σ): This is a measure of the dispersion of results in the sample.
- Sample Size Calculation Formula:

sample size - Z-score value - standard deviation - population size - margin of error

$$n = \frac{Z^2 \cdot \sigma^2 \cdot (N - n)}{e^2 \cdot (N - 1) + Z^2 \cdot \sigma^2}$$

where:

n - sample size,

Z - Z-score value,

σ - standard deviation,

N - population size,

e - margin of error.

For this particular study, the appropriate values for: N, e, Z and σ should be selected based on the purpose of the study and the characteristics of the population to achieve adequate representativeness. The selection of 898 and 924 respondents for Poland and Germany must comply with these parameters to ensure that the results are reliable and can be generalized to the wider population in both countries. In both countries, the sample was structured to include a variety of social groups, including industry experts, policy makers, academia, entrepreneurs, and the general public. Efforts were made to make the sample demographically balanced, in line with national statistics, so that the results could be generalized to a wider population.

Although the number of respondents in Poland and Germany was slightly different, this difference is not significant and does not affect the ability to compare results between the two countries. The diversity of perspectives across different age groups is essential for a comprehensive understanding of attitudes towards hydrogen energy in Poland and Germany. The distribution of respondents across various age brackets is illustrated in Figure 1. This age analysis ensures a wide-ranging insight into the opinions and perceptions across generations, enriching the study's conclusions about hydrogen's role in sustainable development.

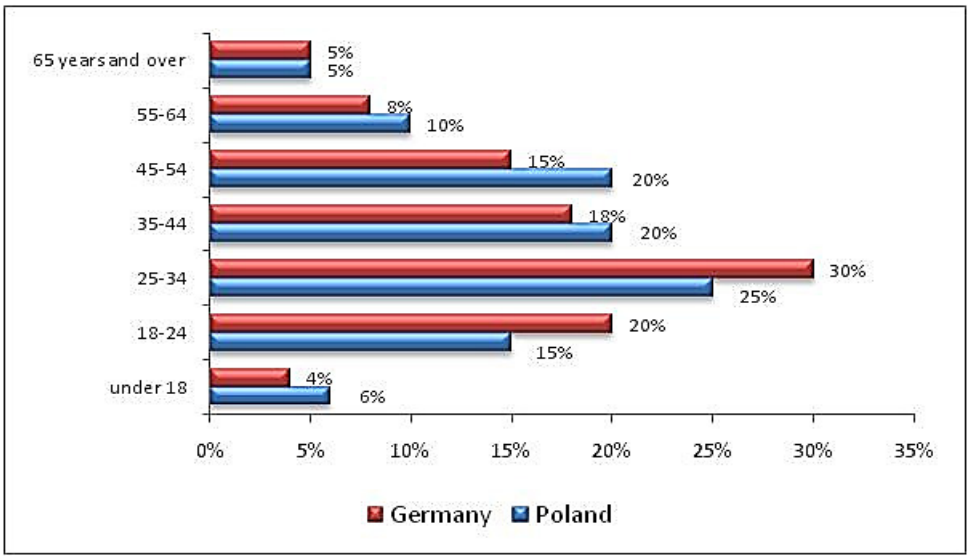

Figure 1. Analysis of respondents in Poland and Germany in terms of age.

Source: Research led by the Author.

Interpreting the age results in Poland and Germany, it can be seen that both countries have similar proportions in age groups, but there are some differences. In the 18-24 age group, Germans have a higher percentage (20%) compared to Poland (15%), which may indicate a larger young adult population. This difference also persists in the 25-34 age group, where Germany has 30% and Poland 25%. In the 35-44 and 45-54 age groups, Poland has slightly higher percentages than Germany, which may suggest that Poland has more middle-aged people. In terms of people aged 55 and over, both countries have relatively similar percentages, with a slight advantage for Poland in the 55-64 age group.

These results may reflect differences in the demographic structure between Poland and Germany, with a higher percentage of younger people in Germany and a slightly higher percentage of middle-aged people in Poland. These differences can have implications for various aspects of society, such as the labor market, education or social policy.

The variation in opinions on hydrogen energy can often be influenced by educational background. Figure 2 illustrates the level of education of respondents in Poland and Germany, providing insights into how educational attainment might shape perspectives and understanding of hydrogen technologies in both countries.

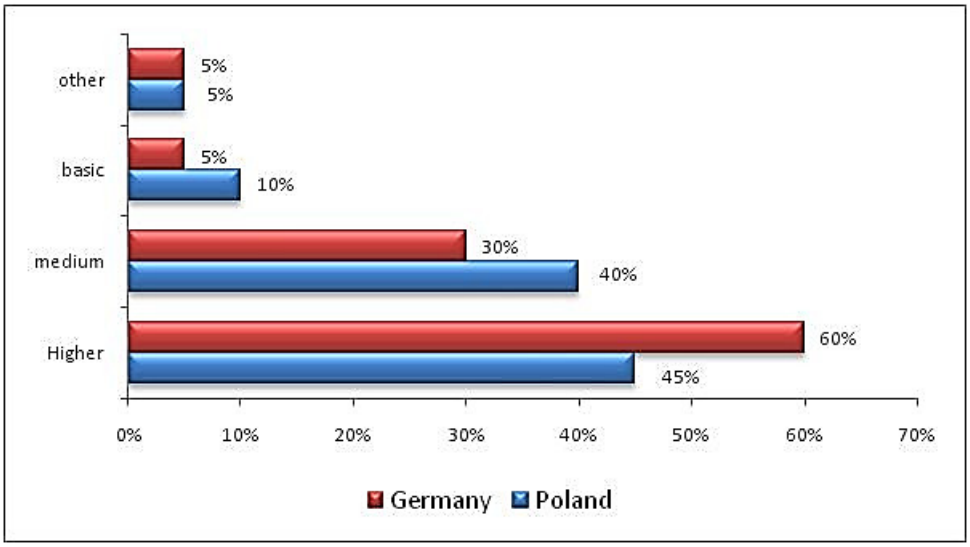

Figure 2. Level of education of respondents in Poland and Germany.

Source: Research led by the Author.

When interpreting the results concerning education in Poland and Germany, significant differences can be noticed in the structure of education of citizens of both countries. In Poland, a higher percentage of respondents report secondary education (40%) compared to Germany (30%). Meanwhile, Germany has a significantly higher percentage of people with higher education (60%) compared to Poland (45%). In the category of primary education, Poland has a double percentage (10%) compared to Germany (5%), which may indicate differences in education systems and access to further education. Also, the percentages in the category "Other" are identical for both countries at 5%, which may reflect non-standard educational paths or specific qualifications.

These results may suggest that in Germany there is a greater tendency to obtain higher education, while in Poland secondary education may be more common. These differences can affect various socio-economic aspects, such as job mobility, earnings and investment in education.

Understanding the public's knowledge of hydrogen as a source of energy is essential in assessing its potential adoption and support. Figure 3 provides an analysis of the knowledge on hydrogen energy in Poland and Germany, shedding light on the current awareness and comprehension of this emerging technology in both nations.

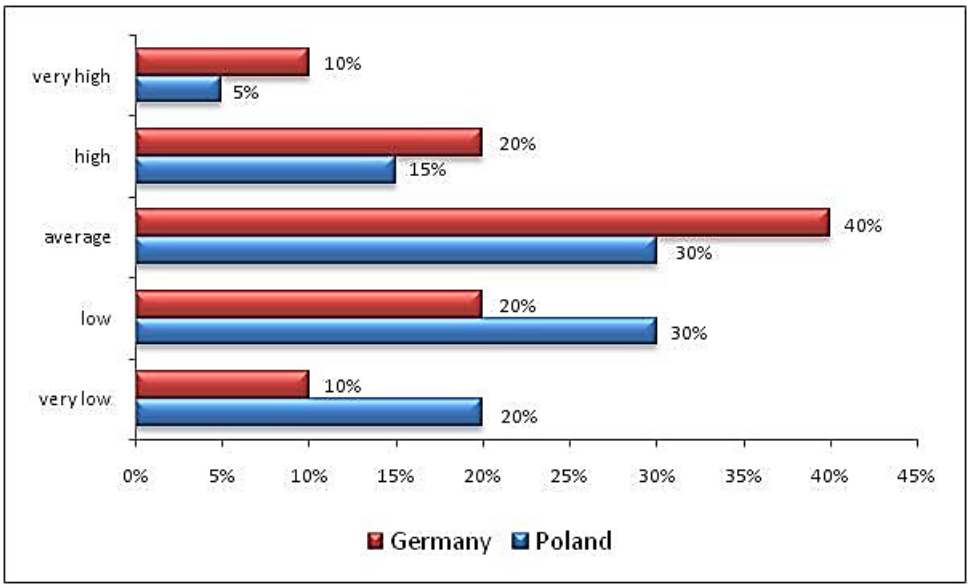

Figure 3. Analysis of knowledge on Hydrogen as a Source of Energy in Poland and Germany.
Source: Research led by the Author.

Analyzing the results regarding the assessment of knowledge about hydrogen as an energy source in Poland and Germany, some differences between the citizens of both countries can be observed. In Poland, the percentage of people who consider their knowledge to be "very low" or "low" is much higher (50% in total) compared to Germany (30% in total). This may indicate less exposure to topics related to hydrogen energy in Poland or differences in education and promotion of this topic. In Germany, a greater proportion of respondents (70% in total) rate their knowledge of hydrogen as an energy source as "medium", "high" or "very high", compared to Poland (50% in total). This may indicate greater awareness and education on hydrogen energy in Germany.

Overall, these results may suggest that there is a better understanding and perhaps a greater commitment to hydrogen energy topics in Germany. These differences may be the result of differences in education policy, investment in research and development, as well as in the methods of communication and promotion of hydrogen technologies in both countries. Identifying where people obtain information about hydrogen energy is critical in understanding public perception and beliefs about this technology.

Figure 4 illustrates the sources of information on hydrogen energy in Poland and Germany, offering insights into the channels that influence opinions and knowledge in these countries.

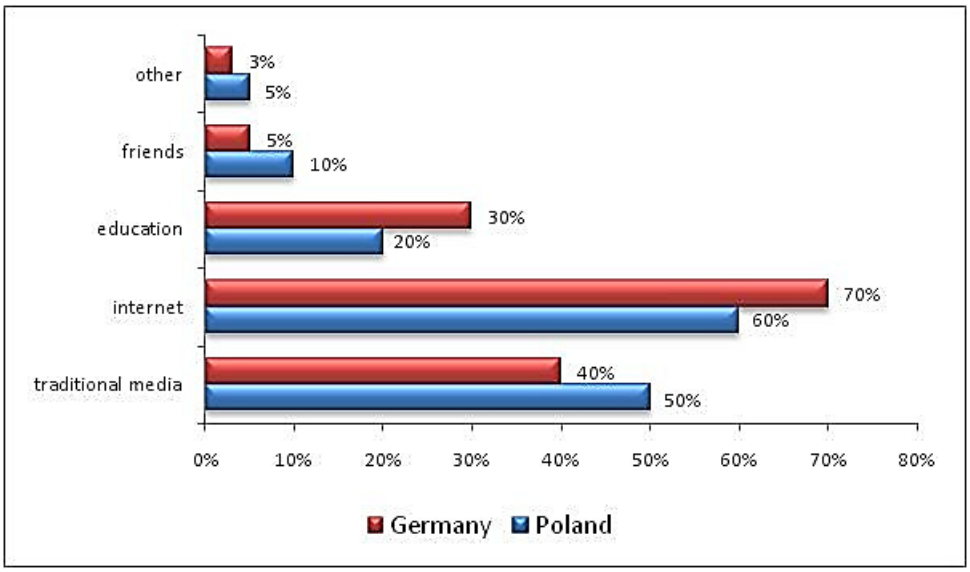

Figure 4. Sources of information on hydrogen energy in Poland and Germany.
Source: Research led by the Author.

Upon analyzing the sources of information on hydrogen energy in Poland and Germany, one can observe notable differences and similarities. In Poland, a higher proportion of individuals (50%) rely on traditional media for information compared to Germany (40%). This suggests that traditional media exert a more significant influence on shaping public opinion about hydrogen energy in Poland. In both nations, the internet and social media serve as the predominant sources of information on hydrogen energy. However, the percentage is marginally higher in Germany (70%) than in Poland (60%), potentially indicating a more engaged and integrated online community in Germany.

Germany also has a higher proportion of individuals (30%) who acquire information from the educational system compared to Poland (20%). This discrepancy may reflect divergent educational priorities and emphasis on renewable energy topics, including hydrogen, in the educational systems of the two countries.

Poland exhibits greater reliance on information obtained from friends and family (10%) compared to Germany (5%), possibly highlighting cultural variances in communication styles and trust in different information sources. In both countries, "Other" sources of information are relatively insignificant, although Poland has a slight edge (5%) over Germany (3%).

Collectively, these disparities may be indicative of cultural, educational, and media differences between Poland and Germany. Germany appears to be more integrated with the internet and educational systems as primary sources of knowledge about hydrogen energy, whereas in Poland, traditional media and social relationships play a more significant role.

Understanding public sentiment toward the utilization of hydrogen as an energy source is crucial for shaping policy and outreach strategies. Figure 5 offers an overview of the general stance on hydrogen use in Poland and Germany, reflecting public attitudes and acceptance of this emerging energy solution.

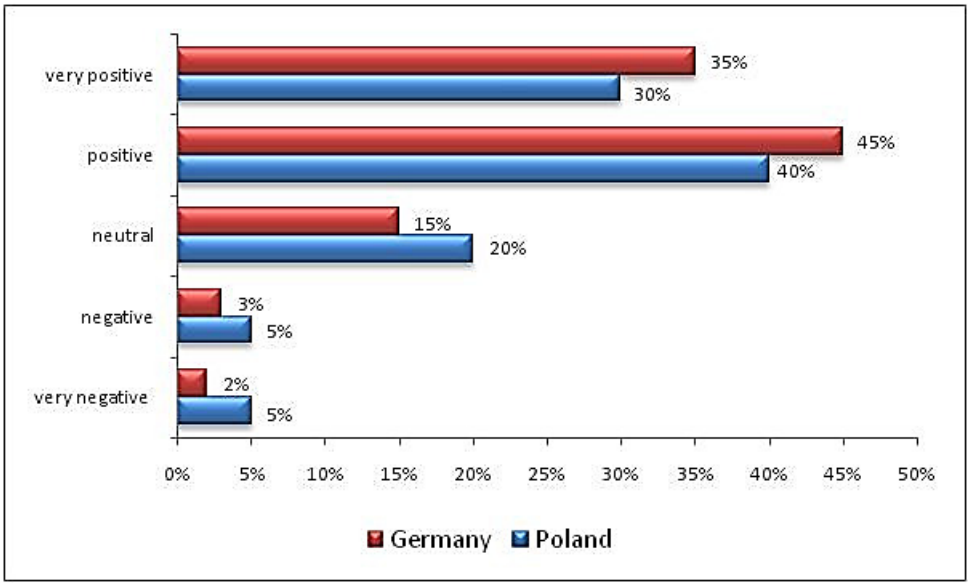

Figure 5. General position on the use of hydrogen as an energy source in Poland and Germany.
Source: Research led by the Author.

The answers to the question about the general position on the use of hydrogen as an energy source in Poland and Germany show a generally positive attitude in both countries. In Germany, the overall position is slightly more positive compared to Poland, with a higher proportion of respondents expressing positive and very positive views.

Positive feelings also dominate in Poland, but there is also a larger percentage of people expressing a neutral position. Negative and very negative opinions are relatively rare in both countries, suggesting a generally positive perception of hydrogen as an energy source in both Poland and Germany.

Government investment plays a critical role in advancing hydrogen technology and facilitating its integration into the energy system. Figure 6 offers a comparison of opinions on government investments in hydrogen technology in Poland and Germany, shedding light on public support or criticism of these strategic initiatives.

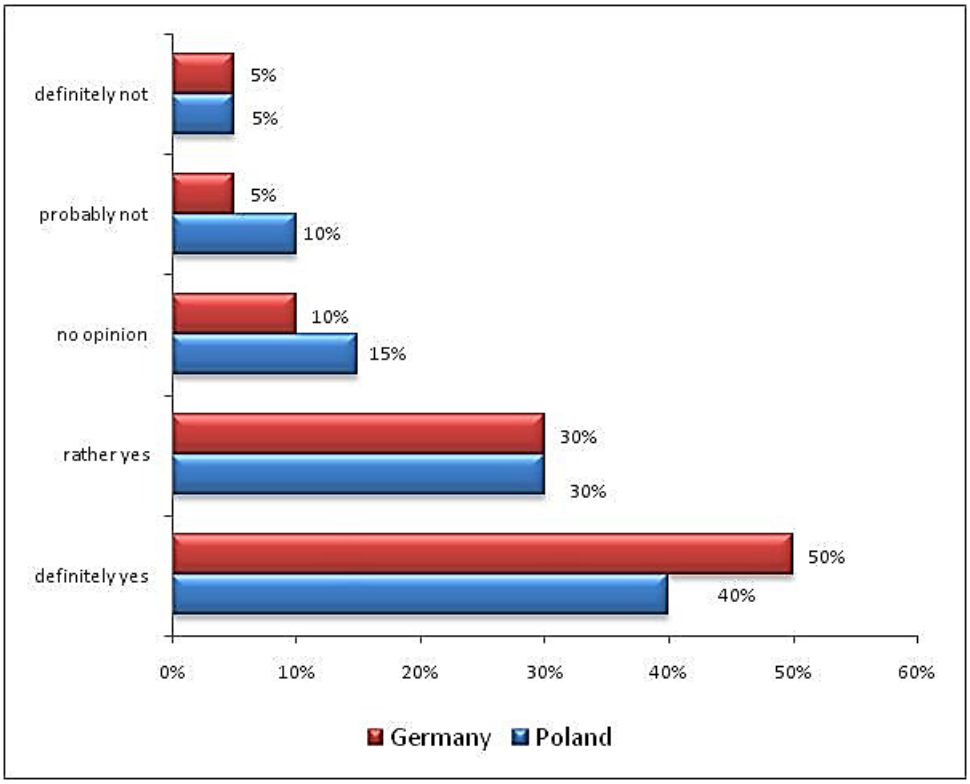

Figure 6. Comparison of Opinions on Government Investments in Hydrogen Technology in Poland and Germany.

Source: Research led by the Author.

The answer to the question about readiness to personally support the development of hydrogen energy in Poland and Germany shows the diversity of opinions. 30% of respondents in Poland and 40% in Germany strongly support the development of hydrogen energy. This indicates the existence of a strong supporter base in both countries, particularly in Germany, who may be interested in actively participating in this field. An additional 30% in both Poland and Germany express moderate support, increasing the total number of supporters in both countries. 20% of Poles and 15% of Germans have no opinion on this issue, which may reflect a lack of information, understanding or commitment to the issue. 15% of respondents in Poland and 10% in Germany are unlikely to support this idea, and 5% in both countries are strongly against it. These figures indicate that there is some opposition, but it is not dominant.

The higher level of strong support in Germany may reflect more advanced hydrogen technology development and better education on hydrogen as an energy source in the country. There is also significant support in Poland, suggesting that there may be potential to increase support through education and public involvement. The neutrality of a significant proportion of respondents may indicate the need for further education and awareness in this area to enable more informed decisions.

Overall, many more people seem to support hydrogen energy than oppose it, suggesting an overall positive trend towards the technology in both countries.

These results indicate that there is an understanding and interest in hydrogen energy in both countries, but also underline the importance of education, communication and social involvement in the further development and adoption of this technology.

Understanding the perceived advantages of hydrogen as an energy source is vital for shaping policies and public engagement strategies. Figure 7 illustrates the advantages of hydrogen as an energy source according to respondents from Poland and Germany, providing insights into what features are considered most valuable in these two countries.

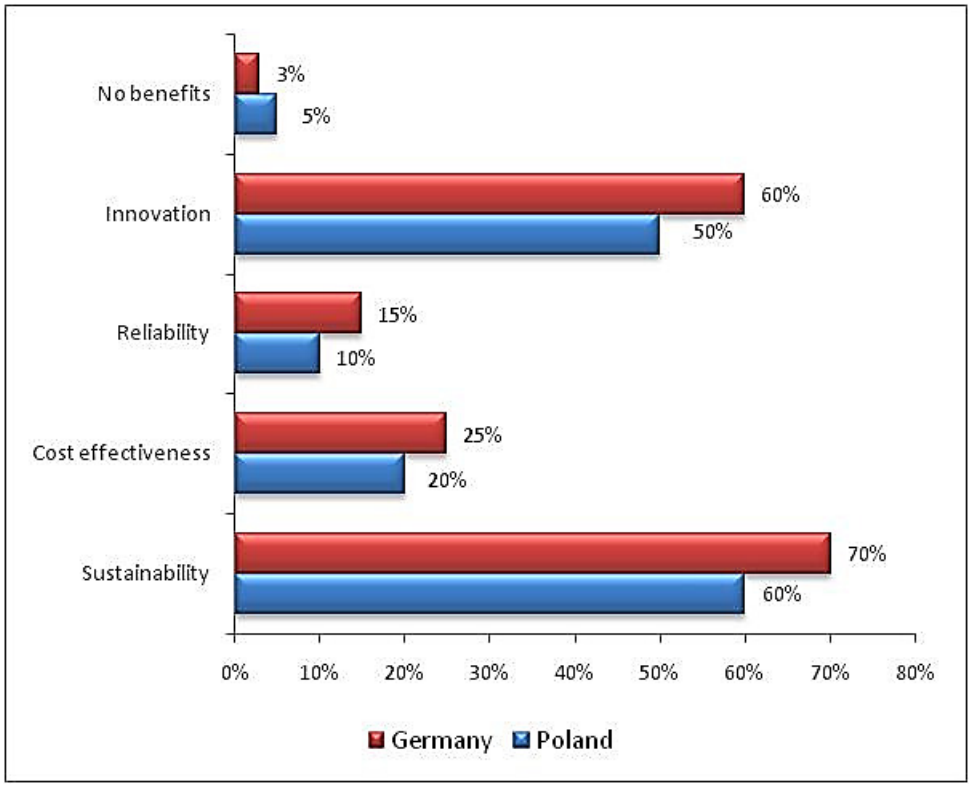

Figure 7. Advantages of hydrogen as an energy source in the opinion of respondents from Poland and Germany.

Source: Research led by the Author.

In analyzing the main benefits of hydrogen as an energy source, both Polish and German respondents point to several key aspects: Most Poles (60%) and Germans (70%) consider environmental friendliness to be the main benefit of hydrogen. This reflects the global trend and emphasis on sustainable and clean energy sources. For 50% of Poles and 60% of Germans, innovation is an important asset of hydrogen energy. This may indicate the perception of hydrogen as a technology of the future, related to scientific and technological progress. Fewer respondents, but still a significant proportion, see cost-efficiency as a benefit, respectively 20% in Poland and 25% in Germany. This may indicate the growing recognition of hydrogen as a potentially competitive energy source.

Germans (15%) are slightly more likely than Poles (10%) to point to reliability as their main benefit, which may reflect different experiences and expectations in these countries.

A small percentage in both countries (5% in Poland and 3% in Germany) do not see any benefits from hydrogen as an energy source, which may suggest some communication challenges or a lack of understanding of the technology. Sustainability and innovation are clearly common values in both countries, highlighting the importance of sustainable development and innovation in public perception. Differences in perceptions of reliability and cost-effectiveness may reflect the unique economic and energy contexts of the two countries.

The small percentage of people who do not see the benefits may indicate the need for better communication and education regarding hydrogen, its possibilities and role in the future energy mix.

Overall, these results seem to emphasize that the societies of both Poland and Germany see significant potential in hydrogen energy, especially in the context of ecology and innovation, but also in other aspects that may differ between these countries. Assessing the challenges related to hydrogen as an energy source is essential for overcoming barriers and facilitating its adoption. Figure 8 presents an analysis of the main challenges associated with hydrogen energy in Poland and Germany, based on our own research, shedding light on the obstacles perceived in both nations.

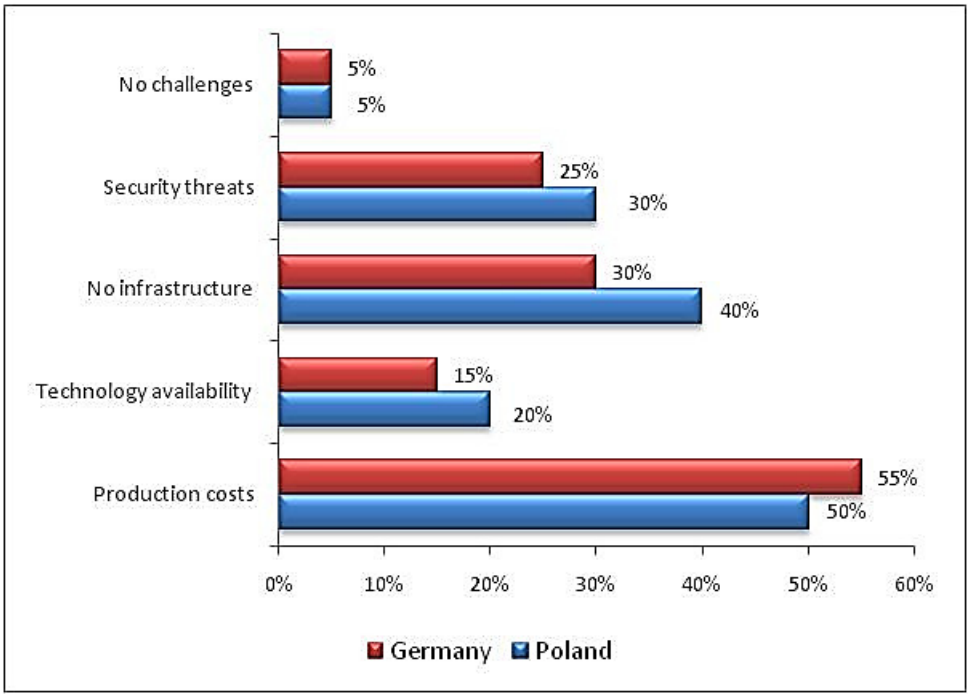

Figure 8. Analysis of the main challenges related to hydrogen as an energy source in Poland and Germany.

Source: Research led by the Author.

In an analysis concerning the primary challenges associated with hydrogen as an energy source, respondents from Poland and Germany identified several key areas. Production costs were highlighted by 50% of the Polish respondents and 55% of the German respondents, indicating a pervasive perception that costs could be a barrier to the social acceptance of hydrogen technologies. A lack of infrastructure was cited by 40% of respondents in Poland and

30% in Germany, suggesting an awareness of the substantial infrastructure investments required for hydrogen energy technologies. Security concerns were noted by 30% of Polish respondents and 25% of German respondents, potentially reflecting apprehensions about the introduction of new technologies and the necessity for adequate risk management. Additionally, 20% of respondents in Poland and 15% in Germany identified the availability of technology as a challenge, possibly indicating perceived technological barriers in the development of hydrogen energy.

Interestingly, a minor percentage of respondents in both countries (5%) did not identify any challenges, which could signify variations in perception and awareness. Production costs were commonly cited in both nations, potentially reflecting broader concerns about the economic viability of hydrogen as an emerging energy source.

Divergences in the perception of other challenges, such as infrastructure and security, could be attributed to cultural differences, energy policies, and market experiences in these countries. These findings may also underscore the necessity for enhanced education and communication regarding hydrogen technologies to manage perceptions of risks and challenges appropriately.

In summary, the data reveal that both Polish and German populations are cognizant of the challenges associated with hydrogen as an energy source. However, the weighting and perception of these challenges may vary depending on the national context. The role of government investments in shaping the future of hydrogen energy is also significant. An analysis of opinions on governmental investments in hydrogen technology, based on the research conducted, highlights the perspectives and expectations of respondents in these two countries.

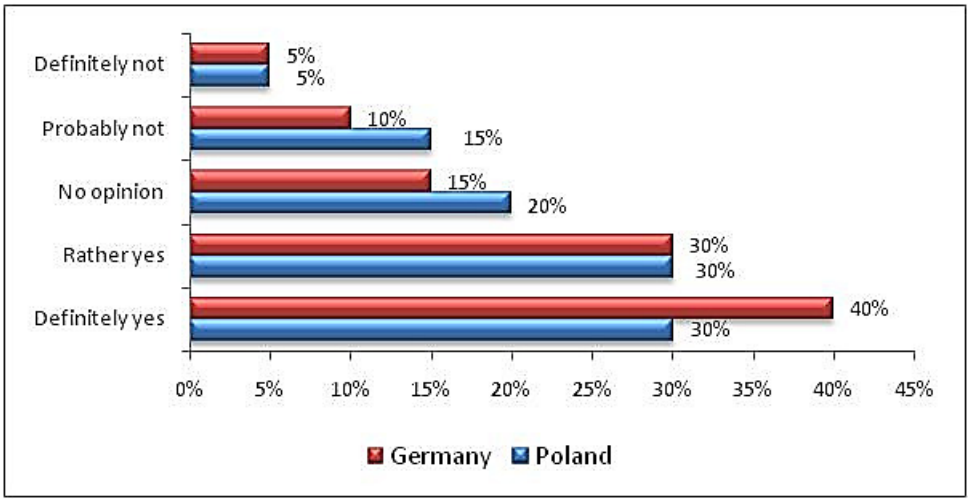

Figure 9. Analysis of opinions on government investments in Poland and Germany.
Source: Research led by the Author.

In Poland, the vast majority of respondents express support for increasing government investment in the development of hydrogen technologies, with 40% definitely yes and 30% rather yes. Germany shows even more support, with 50% definitely yes and 30% rather yes. A neutral position is expressed by 15% of Poles and 10% of Germans. Opinion against

increasing investment is relatively low in both countries, with 10% rather not and 5% definitely not in Poland, and 5% rather not and 5% definitely not in Germany.

These data indicate that there is strong public support for increased government investment in hydrogen technologies in both countries, which may reflect the growing understanding and acceptance of hydrogen as a key energy source in the future. The higher level of strong support in Germany may indicate a greater willingness of the public to introduce more ambitious measures in the area of hydrogen energy. A small number of respondents in both countries express opposition to increased investment, which may suggest that there are no significant social or political barriers against this direction. These data can provide important clues to policy makers in both countries as to the potential direction and intensity of hydrogen policies.

Overall, these results seem to suggest that both Poland and Germany are on track to increase investment in hydrogen technologies, with strong public support for such an initiative. In Germany, this support is slightly stronger, which may reflect differences in perceptions and experiences with hydrogen technology.

12.Discussion

Hydrogen Technology Trend: There has been a significant global trend in recent years towards the development and adoption of hydrogen technologies as a new and sustainable energy source.

Part of Global Sustainability Movement: This boom in hydrogen technology is not an isolated phenomenon but is linked to a broader global movement towards sustainability. This recognizes the decreasing sustainability of traditional energy sources like oil and coal. Complex Analysis Required: The role of hydrogen in sustainable development cannot be understood solely through a technological lens. It must be analyzed from political, economic, social, and environmental contexts as these are interrelated and influence how hydrogen is utilized. Two Case Studies - Poland and Germany: The text emphasizes the importance of comparing and contrasting the role of hydrogen energy within two specific national contexts: Poland and Germany. These countries, although different in many respects, present an interesting study due to their active pursuit of hydrogen technology within the shared framework of the European Union's CO2 reduction goals.

Broader Context Understanding: It emphasizes the importance of understanding hydrogen beyond just an energy source, exploring the theoretical frameworks that explain its importance in the modern energy landscape, potentially redefining our approach to energy and sustainability.

Not Just Technical: The study of hydrogen technology should not be limited to its technical and engineering aspects. It should delve deeper into understanding how hydrogen fits into the larger sustainability narrative, exploring potential benefits and challenges, and how it can be applied in different national and international contexts.

Unified Interest but Diverse Approaches: Despite a unified interest across different regions, including European countries like Poland and Germany, there are varying approaches to achieving sustainability goals through hydrogen, reflecting the unique economic, political, and cultural conditions of individual nations and regions.

In summary, the text portrays hydrogen technology as a multifaceted and critical element in the global shift towards sustainable energy. It emphasizes the importance of a comprehensive and contextual analysis to understand its role, potential, and challenges in different national scenarios.

Hydrogen energy research and development in Poland began in the 1970s, focusing on storage, transport, and usage. Investments and key projects in the 1990s have contributed to the country's expertise in this field (Kowalski, 2002; Szczepanski, 1995; Lewandowski, 2000). In the past two decades, hydrogen has gained prominence in Poland's energy landscape, being seen as vital for decarbonization and playing roles in industry and transport.

Poland is experiencing rapid growth in hydrogen energy, with successful initiatives at both governmental and private levels, such as integration with renewable sources and the establishment of refueling stations. The Polish government has recognized hydrogen's potential, setting ambitious goals to become a leader in Europe and outlining targets for hydrogen usage up until 2030 and beyond. The government has implemented various legal acts to support the development of hydrogen energy, including tax breaks, permits, and research regulations. Alongside this, there are support initiatives such as grants and loans to accelerate innovation. Despite the positive support, legal barriers exist that may hinder development, including complex authorization procedures and potential conflicts with environmental legislation. As an EU member, Poland must comply with EU regulations regarding hydrogen energy, including commitments to reduce emissions and promote renewables, and it actively participates in international initiatives.

The success of hydrogen energy in Poland will require a delicate balance between promotion and compliance with other public policy objectives, recognizing that some legal barriers still need to be addressed.

The text illustrates how hydrogen is a significant part of Poland's national energy strategy, reflecting decades of research, investment, policy support, and innovation. The country's ambition to be a regional leader in hydrogen energy is clear, backed by governmental plans and support mechanisms, though challenges remain that require further analysis and strategic planning. In essence, Poland's journey with hydrogen energy is marked by progressive growth, robust governmental support, alignment with international commitments, and the recognition of both the opportunities and challenges that lie ahead in shaping a sustainable energy future.

Germany has been at the forefront of hydrogen technology since the 1970s, demonstrating a long-standing commitment to pioneering research, experimentation, and commercialization. Hydrogen energy is an essential part of the German energy strategy. The country's focus on hydrogen reflects its position as both a domestic priority and an export opportunity. Germany's hydrogen technologies have found applications in various sectors, including transport, industry, and energy. This reflects a multifaceted approach to integrating hydrogen into the national energy framework. Germany's government has been actively supporting hydrogen energy through research, development, public-private partnerships, and a comprehensive national hydrogen strategy aligned with the EU's objectives.

Numerous legal acts and initiatives, such as tax breaks and subsidies, have been introduced to support hydrogen energy. However, challenges related to safety regulations, technical standards, and energy infrastructure integration must be addressed. Germany aligns with and actively contributes to EU regulations on hydrogen energy. Its participation in international agreements emphasizes its leadership role in the global hydrogen energy landscape.

Hydrogen energy is considered a vital element in Germany's pursuit of carbon neutrality and sustainable development. This aligns hydrogen technology with broader environmental and societal goals. Germany's hydrogen energy development showcases a dynamic balance between innovation and supportive policy. While the sector's success is evident, there is recognition that regulatory challenges and barriers must be addressed to maintain growth and leadership in the field.

With both government and private sector engagement, Germany is well-positioned for further innovation in hydrogen energy. The collaborative approach indicates a holistic understanding of the role of hydrogen in the country's future energy needs. In summary, Germany's development of hydrogen energy is marked by historical leadership, strategic integration into national energy goals, multifaceted applications, strong government support, alignment with international objectives, and a clear path towards future sustainability and innovation. Despite existing challenges and legal barriers, the commitment to research, investment, and policy support signifies Germany's role as a global leader in hydrogen energy and its importance in the nation's pursuit of sustainable energy development.

Poland is focusing on the development of hydrogen energy through research and innovation, aligning with EU objectives. Germany is leading in this field with a comprehensive national strategy and active international participation. Poland has introduced various regulations and initiatives to promote hydrogen investment, while Germany offers more extensive support, including significant research funding. Both Poland and Germany face challenges in developing hydrogen energy, with Poland struggling with infrastructure and technology, and Germany with safety regulations and standards. Both countries consider hydrogen energy crucial to their energy strategies and comply with EU objectives, but Germany is more advanced with a history of research and commercialization, while Poland is in earlier stages. Hydrogen energy has the potential for significant impact on sustainable development, including reducing emissions,

economic stimulation, enhancing public health, and alignment with UN Sustainable Development Goals. However, realizing its full potential requires overcoming challenges such as production costs, technology availability, and security risks.

In Poland and Germany, hydrogen is emerging as a vital component in achieving sustainable development goals. Poland views hydrogen as a means to diversify energy sources, reduce emissions, and stimulate economic opportunities. Germany, a leader in renewable energy, sees hydrogen as a tool for further decarbonization and global leadership in economic growth. Both countries also acknowledge the potential social benefits of hydrogen, such as improved air quality and sustainable mobility. The commitment to international cooperation and the development of renewable technologies demonstrates a shared vision for a sustainable future.

Hydrogen energy presents a promising opportunity for sustainable development in both Poland and Germany, with the potential for reducing emissions, supporting renewable energy, creating jobs, improving air quality, and increasing energy reliability. However, the realization of these benefits is contingent on overcoming several challenges, including high production costs, limited technology availability, lack of infrastructure, safety risks, and regulatory inconsistencies. Strategic planning, investment, cooperation, and careful consideration of local conditions will be vital in harnessing hydrogen's full potential for sustainable development in these countries.

In Poland, hydrogen offers promising benefits, such as reducing emissions in a coal-dependent country, supporting renewable energy integration, creating jobs, and increasing energy reliability. However, realizing these benefits requires overcoming challenges such as high production costs, limited technology availability, a lack of infrastructure, and the need for clear regulations to support hydrogen energy development.

For Germany, hydrogen could be a key element in its green transition, offering a green energy source, reinforcing its leadership in innovation, and supporting renewable energy targets, especially in the automotive sector. Challenges include the integration of hydrogen with existing infrastructure, cost balancing with other energy sources, and managing specific security risks associated with hydrogen production and storage. Both countries will need targeted strategies and collaboration to overcome these obstacles and harness the full potential of hydrogen energy.

Poland is showing growing interest in hydrogen energy, with opportunities in integrating renewable energy sources, developing transport infrastructure, and investing in research and development. Government support, international cooperation, and public education will be key to driving the growth and commercialization of hydrogen technology. With the right strategy, Poland could become a significant player in the European hydrogen landscape.

Germany, already a leader in hydrogen technology, has great potential to further integrate hydrogen into its energy grid, transport sector, and industry. Continued investment, international cooperation, clear policies, and public awareness will strengthen its leading position. Hydrogen can play a vital role in Germany's transition towards a sustainable economy

and enhance its global leadership in the field. Both countries, though at different stages of development, have the potential to reap significant benefits from hydrogen energy. Collaborative efforts and strategic planning will be essential in realizing this potential in alignment with sustainability goals. There's an overall positive perception of hydrogen energy in both Poland and Germany. However, awareness and understanding are higher in Germany, reflecting possible differences in education and promotion. Similar age demographics exist in both countries, with a younger population in Germany and a more middle-aged population in Poland. Education structures differ significantly, with Germany having more people with higher education.

Traditional media has greater influence in Poland, while Germany leans more towards the internet and educational systems for information on hydrogen energy. This suggests cultural and educational differences between the two countries. Both countries show a strong support base for hydrogen energy development, particularly in Germany. A significant proportion of neutrality indicates the need for further education and awareness.

Respondents in both nations consider environmental friendliness and innovation as primary benefits of hydrogen energy. There's recognition of hydrogen as a potential competitive energy source, although perceptions of reliability and cost-effectiveness vary between the two nations. Both societies are aware of challenges related to hydrogen, including production costs and lack of infrastructure. Perceptions of these challenges may differ based on culture, energy policy, and market experience. There's strong public support for increased government investment in hydrogen technologies in both Poland and Germany. The higher level of support in Germany may indicate a greater willingness to introduce ambitious measures in hydrogen energy.

These conclusions collectively emphasize a shared positive perspective on hydrogen energy between Poland and Germany, with notable differences in awareness, education, information sources, and perceptions of challenges and advantages. The results highlight opportunities for policy alignment, educational initiatives, and strategic investments in both countries to foster the development and adoption of hydrogen energy.

The present study, while comprehensive in its comparative analysis of hydrogen technologies in Poland and Germany, exhibits certain limitations. Primarily focused on policy-level aspects, the research may overlook grassroots challenges and localized barriers in the implementation of hydrogen technologies. Moreover, the multidimensional framework, although extensive, may not capture all relevant variables such as local governance or community engagement. Despite these limitations, the research offers novel insights into the role of hydrogen technologies in sustainable development. It highlights the need for frameworks that consider not just the technological but also the socio-economic and political facets of energy transformation. These findings hold significant implications for policy decisions and strategic planning in the broader field of energy and environmental studies. The information gathered can serve as a foundational element for future research and inform the development of more comprehensive sustainable energy models. These observations align closely with the

survey results presented, indicating a strong preference for sustainable technologies like hydrogen in energy strategies. The study thus holds both theoretical and practical implications, most notably the need for an integrated policy approach that acknowledges the interplay of technological, economic, and social factors.

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THE APPLICATIONS OF USAGE OF BUSINESS ANALYTICS IN INDUSTRY 4.0

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Purpose: The purpose of this publication is to present the applications of usage of business analytics in Industry 4.0.
Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.
Findings: Specifically, the paper discussed how business analytics is employed in predictive maintenance, supply chain optimization, and quality control. Predictive maintenance allows organizations to proactively address equipment failures, thereby reducing downtime and maintenance costs. Supply chain optimization optimizes resource allocation, minimizes costs, and improves customer service through data-driven decision-making. Quality control relies on data analytics to monitor, assess, and enhance product and service quality, ultimately leading to cost reduction and customer satisfaction. It is evident that business analytics is not merely a tool but a strategic imperative for organizations in the era of Industry 4.0. It empowers them to continuously improve their operations, mitigate risks, and stay ahead in a rapidly evolving business landscape. As technology and data analytics capabilities continue to advance, businesses that effectively leverage these tools will be better positioned to thrive in the dynamic and competitive world of Industry 4.0.
Originality/value: Detailed analysis of all subjects related to the problems connected with the usage of business analytics in Industry 4.0.

Keywords: business analytics, Industry 4.0, digitalization, artificial intelligence, real-time monitoring.

Category of the paper: literature review.

1. Introduction

Business analytics plays a pivotal role in Industry 4.0, revolutionizing the way organizations operate and make informed decisions. In this era of advanced technology and data-driven insights, businesses across various industries harness the power of analytics to optimize

processes, enhance efficiency, and drive growth (Wolniak, 2016; Czerwińska-Lubszczyk et al., 2022; Drozd, Wolniak, 2021; Gajdzik, Wolniak, 2021, 2022; Gębczyńska, Wolniak, 2018, 2023; Grabowska et al., 2019, 2020, 2021; Wolniak et al., 2023; Wolniak, Grebski, 2023; Wolniak, Skotnicka-Zasadzień, 2023; Jonek-Kowalska, Wolniak, 2023).

The purpose of this publication is to present the applications of usage of business analytics in Industry 4.0.

2. The juxtaposition of business analytics usage in business

The table 1 is summarizing examples of the usage of business analytics in Industry 4.0. These examples illustrate how business analytics is leveraged in Industry 4.0 to enhance efficiency, reduce costs, improve product quality, and provide a competitive edge by making data-driven decisions across various aspects of industrial and business operations making (Cam et al., 2021).

Industry 4.0 relies heavily on data, and business analytics facilitates the collection and integration of data from various sources (Jonek-Kowalska, Wolniak, 2021, 2022; Jonek-Kowalska et al., 2022; Kordel, Wolniak, 2021; Orzeł, Wolniak, 2021, 2022, 2023; Rosak-Szyrocka et al., 2023; Gajdzik et al., 2023; Ponomarenko et al., 2016; Stawiarska et al., 2020, 2021; Steculа, Wolniak, 2022; Olkiewicz et al., 2021). This includes sensors, IoT devices, production equipment, and even external data sources. By aggregating this data, businesses gain a comprehensive view of their operations.

Table 1.
Examples of the usage of business analytics in Industry 4.0

Application of Business Analytics in Industry 4.0	**Description**
Predictive Maintenance	Analyzing historical and real-time data to predict when machinery or equipment needs maintenance, reducing downtime and costs.
Supply Chain Optimization	Using data to optimize supply chain operations, including demand forecasting, inventory management, and logistics, for efficiency and cost savings.
Quality Control	Real-time monitoring of production processes to detect defects and anomalies, ensuring consistent product quality and reducing waste.
Inventory Management	Accurate demand forecasting and real-time inventory tracking to minimize carrying costs while meeting customer demand.
Personalized Customer Experiences	Analyzing customer data and behavior to offer personalized products, services, and marketing, enhancing customer satisfaction and loyalty.
Process Optimization	Identifying inefficiencies and areas for improvement in manufacturing and operations, leading to increased productivity.
Cost Reduction	Data-driven decisions to identify and reduce operational costs, improving profitability and competitiveness.
Energy Management	Monitoring and optimizing energy consumption in manufacturing processes to reduce costs and promote sustainability.
Global Supply Chain Coordination	Coordinating global supply chains using data analytics to reduce disruptions and improve responsiveness.

Cont. table 1.

Environmental Sustainability	Using data analysis to identify areas for improvement in resource usage, waste reduction, and environmental impact.
Customization and Personalization	Tailoring products and services to individual customer preferences based on data insights.
Risk Mitigation	Identifying and mitigating risks through data analysis, enhancing overall operational resilience.
Maintenance Resource Allocation	Optimizing the allocation of maintenance resources based on equipment performance data.
Worker Safety and Health	Analyzing data from wearable devices and sensors to ensure worker safety and well-being in industrial settings.
Predictive Maintenance	Analyzing historical and real-time data to predict when machinery or equipment needs maintenance, reducing downtime and costs.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam, et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020, Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz at al., 2015; Nourani, 2021; Peter et al., 2023).

3. The usage of business analytic in predictive maintenance

Business analytics employs predictive models to monitor equipment and machinery in real-time. By analyzing historical data and current performance metrics, organizations can predict when equipment is likely to fail, enabling proactive maintenance and reducing downtime (Scappini, 2016).

Predictive analytics plays a crucial role in predictive maintenance, a proactive approach to maintenance that aims to predict when equipment or machinery is likely to fail so that maintenance can be performed just in time to prevent costly breakdowns. The first step in predictive maintenance is collecting data from various sensors and monitoring devices installed on the equipment. These sensors capture real-time information such as temperature, pressure, vibration, and other relevant parameters. Predictive analytics relies on this continuous data feed.

Raw sensor data can be noisy and contain anomalies. Predictive analytics involves data preprocessing steps, such as cleaning, filtering, and normalization, to ensure that the data used for analysis is accurate and consistent (Greasley, 2019).

Predictive maintenance leverages historical data to build predictive models. These models analyze past equipment performance, failures, and maintenance records to identify patterns and trends. Machine learning algorithms are often used to extract meaningful insights from this historical data. Engineers and data scientists identify relevant features or variables from the data that are indicative of equipment health and potential failure. Feature engineering involves selecting, transforming, and creating new variables to improve the predictive accuracy of models (Charles et al., 2023).

Predictive analytics models are developed based on historical data and feature engineering. Commonly used models include regression analysis, time-series forecasting, machine learning algorithms (such as decision trees, random forests, or neural networks), and more advanced techniques like deep learning for complex data patterns. As new data streams in from sensors, the predictive maintenance system continuously analyzes this real-time data using the established models. The models compare the current equipment's performance metrics with the expected values to detect deviations or anomalies (Hurwitz et al., 2015).

Predictive analytics models establish thresholds or trigger points beyond which maintenance action is recommended. When sensor data breaches these thresholds or exhibits abnormal patterns, alerts are generated to notify maintenance teams or operators. Predictive maintenance systems provide actionable insights, including information about which components of the equipment are likely to fail and when. Maintenance teams can plan their schedules accordingly, ensuring that maintenance is performed only when necessary, reducing downtime, and minimizing maintenance costs (Peter et al., 2023).

By addressing maintenance needs precisely when they arise, organizations can significantly reduce unplanned downtime, avoid costly equipment failures, and extend the lifespan of their assets. This results in substantial cost savings and improved operational efficiency. Predictive maintenance is an ongoing process. Organizations continuously refine and improve their predictive analytics models as they gather more data and gain a deeper understanding of their equipment's behavior (Nourani, 2021).

Predictive analytics in predictive maintenance transforms equipment maintenance from a reactive, time-based approach to a proactive, data-driven strategy. It enhances equipment reliability, reduces operational costs, and maximizes the uptime and performance of critical assets in industries such as manufacturing, transportation, energy, and healthcare.

Table 2 is outlining examples of how business analytics is used in predictive maintenance. These examples showcase how business analytics is integrated into predictive maintenance to improve equipment reliability and reduce maintenance costs.

Table 2.
Examples of how business analytics is used in predictive maintenance

Use Case	Description
Data Collection	Gathering data from sensors, IoT devices, and equipment to monitor real-time performance and health.
Data Preprocessing	Cleaning, filtering, and normalizing raw sensor data to ensure accuracy and consistency for analysis.
Historical Data Analysis	Analyzing historical maintenance records and equipment performance data to identify patterns and failure trends.
Feature Engineering	Selecting and transforming relevant features from data to improve predictive model accuracy.
Predictive Model Development	Creating models using machine learning algorithms, regression analysis, or deep learning to predict equipment failures.

Cont. table 2.

Real-time Data Analysis	Continuously monitoring real-time sensor data and comparing it to predictive models to detect deviations or anomalies.
Threshold and Alert Generation	Establishing trigger points and generating alerts when sensor data breaches predetermined thresholds or exhibits abnormal patterns.
Condition-Based Maintenance Planning	Providing insights into which equipment components are likely to fail and when, enabling proactive maintenance planning.
Reduced Downtime and Cost Savings	Minimizing unplanned downtime, avoiding costly breakdowns, and extending equipment lifespan, resulting in significant cost savings.
Continuous Model Improvement	Continuously refining and enhancing predictive models as more data becomes available and the understanding of equipment behavior deepens.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam, et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020, Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz et al., 2015; Nourani, 2021; Peter et al., 2023).

4. The usage of business analytic in supply chain optimization

Analytics helps in optimizing the supply chain by providing insights into demand forecasting, inventory management, and logistics. This leads to more efficient resource allocation and cost savings.

Business analytics is a powerful tool used extensively in supply chain optimization to enhance efficiency, reduce costs, improve customer service, and make informed decisions. Business analytics leverages historical sales data, market trends, and other relevant factors to develop accurate demand forecasts. These forecasts help organizations align production, procurement, and inventory levels with expected demand, reducing the risk of overstocking or stockouts. Analytics assists in determining optimal inventory levels by analyzing factors such as demand variability, lead times, and carrying costs. By optimizing inventory, companies can free up capital, reduce storage costs, and minimize the risk of obsolescence (Adel, 2022).

Businesses use analytics to evaluate the performance of suppliers. Key metrics like on-time delivery, quality, and cost can be tracked and analyzed to make data-driven decisions regarding supplier relationships and contracts. For transportation and logistics, analytics helps in route optimization. It considers factors like traffic conditions, fuel costs, and vehicle capacity to determine the most efficient routes for deliveries, reducing transportation costs and delivery times. Analytics is used to optimize warehouse layout, picking routes, and storage allocation. This leads to reduced labor costs, improved order accuracy, and faster order fulfillment (Cillo et al., 2022).

By analyzing historical data, companies can gain insights into lead times for various suppliers and products. This information is vital for managing inventory levels effectively and meeting customer demand promptly. Business analytics can identify potential risks in the supply chain, such as disruptions due to natural disasters or geopolitical events. Companies can develop contingency plans and assess the impact of these risks on their operations. Analytics

fosters collaboration with suppliers by sharing data and insights. This collaborative approach helps in aligning supply chain activities and improving overall performance (Sułkowski, Wolniak, 2015, 2016, 2018; Wolniak, Skotnicka-Zasadzień, 2008, 2010, 2014, 2018, 2019, 2022; Wolniak, 2011, 2013, 2014, 2016, 2017, 2018, 2019, 2020, 2021, 2022; Gajdzik, Wolniak, 2023; Wolniak, 2013, 2016; Hys, Wolniak, 2018).

Businesses use analytics to segment customers based on purchasing behavior, preferences, and profitability. This information informs decisions about service levels, pricing strategies, and inventory allocation for different customer segments. Supply chain analytics provides real-time dashboards and reports that monitor key performance indicators (KPIs) such as inventory turnover, order fill rates, and transportation costs. This allows for quick identification of performance issues and opportunities for improvement (Di Marino et al., 2023).

Analytics is employed in production scheduling to balance demand and capacity. It helps in determining the most efficient production sequences, minimizing changeover times, and reducing production bottlenecks. Companies are increasingly using analytics to assess the environmental impact of their supply chain operations. This includes measuring carbon emissions, evaluating sustainable sourcing options, and identifying areas for eco-friendly improvements results (Wolniak, Sułkowski, 2015, 2016; Wolniak, Grebski, 2018; Wolniak et al., 2019, 2020; Wolniak, Habek, 2015, 2016; Wolniak, Skotnicka, 2011; Wolniak, Jonek-Kowalska, 2021; 2022).

Analytics enables organizations to perform "what-if" scenarios to assess the impact of different decisions or external events on the supply chain. This helps in risk mitigation and strategic planning.

Table 3.
Examples of how business analytics is used in supply chain optimization.

Use Case	Description
Demand Forecasting	Utilizing historical data and market trends to forecast future demand accurately, helping in inventory planning and production scheduling.
Inventory Management	Analyzing demand variability, lead times, and carrying costs to determine optimal inventory levels, reducing excess stock and minimizing stockouts.
Supplier Performance Analysis	Evaluating supplier metrics like on-time delivery, quality, and cost to make data-driven decisions about supplier relationships and contracts.
Route Optimization	Using analytics to optimize transportation routes by considering factors such as traffic, fuel costs, and vehicle capacity, reducing transportation costs and delivery times.
Warehouse Optimization	Optimizing warehouse layout, picking routes, and storage allocation to reduce labor costs, improve order accuracy, and enhance order fulfillment efficiency.
Lead Time Analysis	Analyzing historical lead time data for suppliers and products to manage inventory effectively and meet customer demand promptly.
Risk Management	Identifying and mitigating potential supply chain risks using analytics, such as disruptions due to natural disasters or geopolitical events.
Supplier Collaboration	Collaborating with suppliers by sharing data and insights to align supply chain activities and improve overall performance.
Customer Segmentation	Segmenting customers based on purchasing behavior, preferences, and profitability to inform service levels, pricing strategies, and inventory allocation.

Cont. table 3.

Performance Metrics Monitoring	Monitoring key performance indicators (KPIs) like inventory turnover, order fill rates, and transportation costs in real-time through dashboards and reports for quick issue identification and improvement opportunities.
Production Scheduling Optimization	Using analytics to balance production capacity with demand, optimizing production sequences, minimizing changeover times, and reducing production bottlenecks.
Sustainability and Environmental Impact Assessment	Assessing the environmental impact of supply chain operations, measuring carbon emissions, evaluating sustainable sourcing options, and identifying areas for eco-friendly improvements.
Scenario Analysis	Performing "what-if" scenarios to assess the impact of different decisions or external events on the supply chain, aiding in risk mitigation and strategic planning.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam, et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020, Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz et al., 2015; Nourani, 2021; Peter et al., 2023).

Business analytics in supply chain optimization empowers organizations to make data-driven decisions at every stage of the supply chain, from demand forecasting to logistics management. It leads to cost savings, improved customer satisfaction, reduced risks, and greater overall competitiveness in today's complex and dynamic business environment (Ghibakholl et al., 2022).

Table 3 is presenting examples of how business analytics is used in supply chain optimization. These examples demonstrate how business analytics is applied to various aspects of supply chain management to enhance efficiency, reduce costs, and improve overall performance.

5. The usage of business analytic in quality control

In manufacturing, analytics is used to ensure product quality. By analyzing data from sensors and cameras, companies can identify defects or anomalies in real-time, allowing for immediate corrective actions and reducing waste. Business analytics plays a critical role in quality control by providing organizations with data-driven insights and tools to monitor, assess, and improve the quality of products or services.

Business analytics in quality control begins with the collection and integration of data from various sources. This data includes information from production processes, customer feedback, supplier data, and quality inspection records. Integrating this data into a centralized system allows for comprehensive quality analysis. Analytics tools can continuously monitor production processes and quality parameters in real time. Sensors and IoT devices are often used to collect data on factors like temperature, pressure, and product dimensions. Any deviations from predetermined quality standards trigger alerts for immediate corrective action (Akundi et al, 2022).

Statistical techniques and control charts are employed to analyze process data and detect trends or variations that might indicate potential quality issues. SPC helps organizations maintain consistent quality and reduce defects by identifying when processes are out of control. When quality issues occur, analytics can assist in identifying the root causes behind defects or deviations. By analyzing historical data and process variables, organizations can pinpoint the factors contributing to quality problems and take corrective measures (Olsen, 2023).

Predictive analytics models use historical data to predict the likelihood of future quality issues. This allows for proactive quality control measures, such as adjusting production processes or identifying critical control points. Analytics helps assess the quality performance of suppliers by tracking key metrics like defect rates, on-time deliveries, and quality audits. This information guides decisions regarding supplier selection, improvement, or termination (Aslam et al., 2020).

Analytics tools can analyze customer feedback, including complaints and product reviews, to identify recurring quality issues or patterns. This information informs product improvement efforts and helps in addressing customer concerns. Analytics aids in the planning and execution of quality audits and inspections. It can prioritize inspection areas based on historical data and risk assessment, optimizing resource allocation (Bakir, Dahlan, 2022).

By analyzing quality data over time, organizations can identify long-term trends and patterns that impact quality. This information is crucial for making strategic decisions about process improvements and product development. Analytics can assess the financial impact of quality issues, including the cost of defects, rework, warranty claims, and customer returns. This data helps in cost reduction efforts and justifying investments in quality improvement initiatives (Javaid et al., 2020).

Business analytics supports the principles of continuous improvement by providing data-driven feedback loops. Organizations can set quality improvement goals, track progress, and adjust strategies based on analytical insights. In industries with stringent quality and safety regulations, analytics ensures compliance by monitoring processes and records to identify potential compliance risks (Javaid, Haleem, 2020).

Business analytics in quality control empowers organizations to proactively manage and enhance product and service quality. It enables them to reduce defects, minimize waste, lower costs, and maintain customer satisfaction by leveraging data-driven insights and process optimization techniques.

Table 4 provides examples of how business analytics can be used in quality control. These examples of how business analytics can be applied to quality control in various industries to enhance product quality, reduce costs, and improve overall operational efficiency.

Table 4.
Examples of how business analytics can be used in quality control

Use Case	Description
Defect Analysis	Analyzing production data to identify patterns and trends related to defects, helping organizations pinpoint root causes and reduce defects in products or processes.
Statistical Process Control (SPC)	Utilizing statistical techniques to monitor and control manufacturing processes, ensuring they remain within acceptable quality limits and identifying any variations or anomalies.
Predictive Maintenance	Using predictive analytics to anticipate equipment or machinery failures, enabling proactive maintenance to minimize downtime and ensure product quality.
Supplier Quality Management	Evaluating supplier performance through data analysis to ensure consistent quality of raw materials and components, reducing the risk of defects in the final product.
Six Sigma Analysis	Applying statistical analysis and data-driven methodologies like DMAIC (Define, Measure, Analyze, Improve, Control) to improve process efficiency and quality.
Root Cause Analysis	Investigating quality issues by analyzing data to identify the underlying causes, allowing for targeted corrective actions to be taken.
Customer Feedback Analysis	Analyzing customer feedback and complaints data to identify recurring issues, helping to improve product quality and customer satisfaction.
Process Optimization	Using data analytics to identify inefficiencies in manufacturing or service processes and making data-driven adjustments to enhance overall quality and efficiency.
Warranty and Returns Analysis	Analyzing warranty claims and product returns data to identify common problems and improve product design and manufacturing processes.
Data-driven Decision Making	Providing decision-makers with real-time quality data and insights, enabling them to make informed decisions that positively impact product quality and customer satisfaction.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam, et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020, Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz et al., 2015; Nourani, 2021; Peter et al., 2023).

6. Conclusion

In conclusion, this paper has highlighted the significant role of business analytics in quality control and its broader applications in Industry 4.0. The examples presented in Tables 1, 2, 3, and 4 demonstrate the diverse ways in which business analytics is leveraged to enhance efficiency, reduce costs, improve product quality, and gain a competitive edge across various industrial and business operations. In the context of Industry 4.0, business analytics acts as a central pillar by enabling organizations to harness the power of data from multiple sources, including sensors, IoT devices, production equipment, and external data sources. This data aggregation empowers businesses with a comprehensive view of their operations, facilitating informed decision-making at every level.

Specifically, the paper discussed how business analytics is employed in predictive maintenance, supply chain optimization, and quality control. Predictive maintenance allows organizations to proactively address equipment failures, thereby reducing downtime and maintenance costs. Supply chain optimization optimizes resource allocation, minimizes costs, and improves customer service through data-driven decision-making. Quality control relies on data analytics to monitor, assess, and enhance product and service quality, ultimately leading

to cost reduction and customer satisfaction. It is evident that business analytics is not merely a tool but a strategic imperative for organizations in the era of Industry 4.0. It empowers them to continuously improve their operations, mitigate risks, and stay ahead in a rapidly evolving business landscape. As technology and data analytics capabilities continue to advance, businesses that effectively leverage these tools will be better positioned to thrive in the dynamic and competitive world of Industry 4.0.

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THE USAGE OF SMARTPHONE APPLICATIONS IN SMART CITY DEVELOPMENT – URBAN MOBILITY AND TRAFFIC MANAGEMENT

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Purpose: The purpose of this publication is to present the usage of smartphone application in Smart Cities in urban mobility and traffic management.
Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.
Findings: Smartphone applications have undeniably transformed urban mobility and traffic management in smart cities. Their real-time data capabilities, optimization features, and user-friendly interfaces have created more efficient, sustainable, and enjoyable transportation systems. However, it is essential for smart cities to tackle the associated challenges effectively, ensuring that these applications contribute to equitable, safe, and efficient transportation systems within the urban landscape. The future of urban mobility is digital, and it's driven by the convenience and connectivity offered by our smartphones.
Originality/value: Detailed analysis of all subjects related to the problems connected with the usage of smartphone applications in urban mobility and traffic management in smart cities.

Keywords: Smart City, urban mobility, traffic management, smartphone applications, smart mobility.

Category of the paper: literature review.

1. Introduction

Smartphone applications are instrumental in the development of smart cities, revolutionizing urban living and improving city services in numerous ways. Smartphone applications are integral to the development of smart cities, enabling residents and authorities to optimize urban living, enhance services, and work toward a more sustainable and efficient future. Their real-time data capabilities and user-friendly interfaces are powerful tools for

creating smarter, more connected urban environments (Prajeesh, Pillai, 2022; Kuntska et al., 2023).

Smart cities are on the rise, reshaping urban landscapes to make them more sustainable, efficient, and livable. A significant aspect of this transformation involves reimagining urban mobility and transportation. In the digital age, smartphone applications have emerged as a driving force behind the creation of smart, interconnected transportation networks. In this article, we explore how smartphone applications are revolutionizing urban mobility in smart cities.

The purpose of this publication is to present the usage of smartphone application in Smart Cities.

2. The usage of smartphone applications in urban mobility

One of the most visible impacts of smartphone applications on urban mobility is the proliferation of navigation apps like Google Maps, Apple Maps, and Waze. These apps have become essential tools for city dwellers, offering real-time traffic updates, optimized routes, and turn-by-turn directions. Commuters can now avoid traffic jams and arrive at their destinations faster, reducing both travel time and stress levels.

Smart cities recognize the importance of public transportation in reducing traffic congestion and carbon emissions. Smartphone applications play a pivotal role in making public transit more accessible and user-friendly (Wolniak, Sułkowski, 2015, 2016; Wolniak, Grebski, 2018; Wolniak et al., 2019, 2020; Wolniak, Habek, 2015, 2016; Wolniak, Skotnicka, 2011; Wolniak, Jonek-Kowalska, 2021, 2022). Many cities have developed their own transit apps that provide information on bus and train schedules, routes, and real-time arrival predictions. Passengers can plan their journeys with ease and even purchase tickets electronically, eliminating the need for paper tickets and long queues (Rahman, Dura, 2022).

Ridesharing and carpooling apps like Uber and Lyft have disrupted traditional transportation models. These platforms encourage carpooling, reducing the number of single-occupancy vehicles on the road. They also offer a more convenient alternative to traditional taxis, with the added benefit of cashless payments and driver ratings for safety and accountability (Rachmawati et al., 2021; Dutta et al., 2021; Ivanyi, Biro-Szigeti, 2019).

Smart cities are embracing micromobility solutions, such as electric scooters and bikes, as a means of reducing congestion and promoting eco-friendly transportation. Smartphone apps are the primary means by which users locate and unlock these vehicles. Users can easily check the availability of scooters or bikes in their vicinity, rent them with a few taps on their smartphones, and enjoy convenient and cost-effective short-distance transportation (Herdiansayah, 2023; Rose et al., 2021).

Traffic management is a significant challenge in urban areas, but smartphone applications are making strides in addressing this issue. Cities are increasingly implementing smart traffic management systems that utilize data from mobile apps to monitor traffic flow. This data helps traffic authorities adjust signal timings, reroute traffic, and minimize congestion. Additionally, apps that offer real-time parking information help drivers find parking spaces efficiently, reducing the time spent circling the block in search of a spot (Boichuk, 2020).

Smartphone applications are also contributing to sustainable commuting habits. They enable users to track their carbon footprint by monitoring their transportation choices. Some apps offer incentives for using eco-friendly modes of transportation, such as walking, cycling, or using public transit. These efforts encourage residents to make greener choices and contribute to a reduction in greenhouse gas emissions (Benevolo et al., 2016; Kalasova et al., 2021).

Smartphone applications are at the forefront of revolutionizing urban mobility in smart cities. These apps empower residents with real-time information, convenient options, and sustainable alternatives for their transportation needs (Wolniak, 2016; Czerwińska-Lubszczyk et al., 2022; Drozd, Wolniak, 2021; Gajdzik, Wolniak, 2021, 2022; Gębczyńska, Wolniak, 2018, 2023; Grabowska et al., 2019, 2020, 2021). As smart cities continue to evolve and prioritize efficient, eco-friendly transportation, smartphone applications will remain indispensable tools for making urban mobility more accessible and enjoyable for all. The future of urban transportation is digital, and it's driven by the convenience and connectivity offered by our smartphones (Simonofski et al., 2023; Chmielarz et al., 2021).

Table 1 gives examples of smartphone application usage in urban mobility within smart cities. These applications cover a wide range of urban mobility needs, from finding the quickest route to managing transportation services efficiently and promoting sustainable transportation options. Smart cities leverage these tools to create more efficient, convenient, and eco-friendly transportation systems.

Table 1.
Smartphone application usage in urban mobility within smart cities

Usage category	Examples
Navigation and Maps	Google Maps, Apple Maps, Waze
Public Transportation	City-specific transit apps, Moovit, Transit App
Ridesharing and Carpooling	Uber, Lyft, BlaBlaCar, DiDi
Micromobility Solutions	Lime, Bird, JUMP, Spin
Traffic Management	Waze, INRIX, TomTom Traffic
Parking Assistance	ParkMobile, SpotHero, ParkWhiz
Sustainable Commuting	Eco-friendly commute tracking apps, bike-sharing apps
Emergency Transit Alerts	Local government transit alert apps

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Leal et al., 2023; Chowdhury et al., 2023; Sanchez et al., 2018; Aguilera, Boutueil, 2018).

Table 2 contains descriptions of how smartphone applications are used in urban mobility within smart cities. These smartphone applications enhance urban mobility in smart cities by providing convenient, data-driven solutions that make transportation more efficient, sustainable, and user-friendly

Table 2.
How smartphone applications are used in urban mobility within smart cities

Usage category	Description
Navigation and Maps	Smartphone apps like Google Maps, Apple Maps, and Waze provide real-time navigation, traffic updates, and optimized routes, making daily commutes more efficient and less stressful.
Public Transportation	City-specific transit apps and platforms like Moovit and Transit App offer schedules, routes, and real-time updates for public transportation, making it easier for residents and visitors to navigate the city using buses, trains, and trams.
Ridesharing and Carpooling	Apps like Uber, Lyft, BlaBlaCar, and DiDi enable ridesharing and carpooling, reducing the number of single-occupancy vehicles on the road, lowering congestion, and providing convenient, cashless transportation options.
Micromobility Solutions	Micromobility apps such as Lime, Bird, JUMP, and Spin offer access to electric scooters and bikes, allowing users to conveniently cover short distances while promoting sustainable transportation and reducing traffic.
Traffic Management	Traffic management apps like Waze, INRIX, and TomTom Traffic use real-time data to monitor traffic conditions and provide users with alternative routes, contributing to reduced congestion and smoother traffic flow.
Parking Assistance	Apps like ParkMobile, SpotHero, and ParkWhiz help users find available parking spaces, reserve spots in advance, and streamline the parking process, reducing the time and stress associated with parking in urban areas.
Sustainable Commuting	Eco-friendly commute tracking apps and bike-sharing apps encourage users to make environmentally conscious transportation choices, such as walking, cycling, or using public transit, while offering incentives for green commuting.
Emergency Transit Alerts	Local government transit alert apps notify residents of critical information during emergencies, such as changes to public transportation schedules or disruptions in service, ensuring public safety and timely communication.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Leal et al., 2023; Chowdhury et al., 2023; Sanchez et al., 2018; Aguilera, Boutueil, 2018).

Table 3 highlighting the advantages of using smartphone applications in urban mobility within smart cities. These advantages illustrate how smartphone applications play a pivotal role in shaping modern urban mobility in smart cities, ultimately leading to more efficient, sustainable, and livable urban environments.

Table 3.
Advantages of using smartphone applications in urban mobility within smart cities

Advantage	Description
Efficient Navigation	Smartphone apps offer real-time traffic data and optimized routes, reducing travel times and minimizing congestion for commuters.
Enhanced Public Transportation	Transit apps provide schedules, real-time updates, and mobile ticketing, making public transportation more accessible and user-friendly.
Reduced Traffic Congestion	Ridesharing and carpooling apps decrease the number of vehicles on the road, alleviating traffic congestion and improving air quality.

Cont. table 3.

Eco-Friendly Transportation	Micromobility apps promote sustainable commuting options, reducing carbon emissions and contributing to cleaner, greener cities.
Improved Traffic Management	Traffic apps help manage traffic flow, enabling authorities to adjust signals and routes for smoother traffic and fewer bottlenecks.
Convenient Parking Solutions	Parking apps simplify the process of finding and reserving parking spaces, reducing the time spent searching for parking in urban areas.
Promotion of Sustainable Commuting Habits	Eco-commute apps incentivize users to make environmentally conscious choices, leading to reduced environmental impact and healthier lifestyles.
Emergency Transit Alerts for Safety	Transit alert apps provide crucial information during emergencies, ensuring the safety and well-being of city residents and visitors.
Data-Driven Decision Making for Urban Planning	Mobility data collected by these apps aids city planners in making informed decisions to optimize transportation infrastructure.
Enhanced User Experience	Smartphone apps offer a user-friendly interface, making navigation and transportation services more accessible and enjoyable for residents and visitors alike.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Leal et al., 2023; Chowdhury et al., 2023; Sanchez et al., 2018; Aguilera, Boutueil, 2018).

Table 4 highlighting some of the common problems and challenges associated with the usage of smartphone applications in urban mobility within smart cities. These problems and challenges underline the need for careful consideration and effective solutions when implementing smartphone applications in urban mobility to ensure equitable, safe, and efficient transportation systems within smart cities.

Table 4.
Problems of using smartphone applications in urban mobility within smart cities

Problem	Description
Data Privacy Concerns	Users often share personal and location data with these apps, raising concerns about data security and privacy breaches.
Digital Divide	Not all residents may have access to smartphones or the internet, creating disparities in access to transportation information.
Dependency on Technology	Overreliance on navigation apps can lead to reduced map-reading and navigation skills among users.
Traffic Data Accuracy	Traffic data used by apps may not always be accurate, leading to frustration and inefficient route planning for users.
Sustainability Challenges	While micromobility apps promote sustainability, they also face challenges related to vehicle maintenance and environmental impact.
Ridesharing Congestion	Increased use of ridesharing services can lead to additional traffic congestion and may not always reduce the number of vehicles on the road.
Digital Distractions and Safety	Smartphone use while driving or walking can lead to accidents and safety hazards, particularly in densely populated areas.
Service Reliability	Apps can suffer from downtime or technical issues, leaving users stranded or unable to access essential transportation services.
Inadequate Internet Connectivity	In some areas, poor internet connectivity can hinder the functionality of these apps, making them less reliable for users.
User Discrimination	Concerns exist about potential biases in algorithms used by ride-hailing services, resulting in discriminatory practices.
Environmental Impact of Data Centers	The data centers supporting these apps can consume significant energy, contributing to the environmental footprint of urban mobility solutions.
Accessibility Issues	Apps may not be fully accessible to individuals with disabilities, limiting their use and mobility options for some users.

Cont. table 4.

Congestion from App-Enabled Services	The convenience of on-demand services like food delivery can lead to increased road congestion and air pollution in urban areas.
Lack of Standardization	Different cities may use a variety of apps and platforms, making it challenging for travelers to adapt to different systems when moving between cities.
Security Risks	Apps are susceptible to hacking and cyberattacks, which can compromise user data and the functioning of transportation services.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Leal et al., 2023; Chowdhury et al., 2023; Sanchez et al., 2018; Aguilera, Boutueil, 2018).

3. The usage of smartphone applications in traffic management

One of the most significant contributions of smartphone applications to traffic management is the collection and dissemination of real-time traffic data. Apps like Waze, Google Maps, and INRIX provide drivers with up-to-the-minute information on road conditions, accidents, and traffic jams. This data helps commuters make informed decisions about their routes, avoiding congested areas and reducing travel time (Kalasova et al., 2021).

Smartphone apps enable traffic management authorities to optimize traffic flow in real-time. By analyzing the data collected from these apps, city officials can adjust traffic signals, implement dynamic lane control, and reroute traffic as needed. This not only minimizes congestion but also reduces fuel consumption and greenhouse gas emissions. Crowdsourced traffic reporting is a game-changer in smart cities (Jonek-Kowalska, Wolniak, 2021, 2022, 2023; Rosak-Szyrocka et al., 2023; Gajdzik et al., 2023; Jonek-Kowalska et al., 2022; Kordel, Wolniak, 2021; Orzeł, Wolniak, 2021, 2022; Ponomarenko et al., 2016; Stawiarska et al., 2020; 2021; Stecuła, Wolniak, 2022; Olkiewicz et al., 2021). Smartphone apps allow users to report accidents, road closures, and other traffic incidents instantly. This crowdsourced data complements official traffic monitoring systems and helps authorities respond more swiftly to emergencies and incidents, improving overall safety (Rose et al., 2021).

Finding parking in a crowded city can be a daunting task, leading to traffic bottlenecks and frustration. Smartphone apps like ParkMobile and SpotHero help drivers locate available parking spaces and even reserve them in advance. This reduces circling for parking and eases traffic congestion near popular destinations. Smart cities aim to reduce the number of private vehicles on the road by promoting public transportation (Sułkowski, Wolniak, 2015, 2016, 2018; Wolniak, Skotnicka-Zasadzień, 2008, 2010, 2014, 2018, 2019, 2022; Wolniak, 2011, 2013, 2014, 2016, 2017, 2018, 2019, 2020, 2021, 2022; Gajdzik, Wolniak, 2023). Transit apps provide users with real-time information on bus and train schedules, routes, and delays. Users can plan their journeys efficiently, leading to increased use of public transit and reduced traffic congestion (Dutta et al., 2019).

Dynamic road pricing, or congestion pricing, is an effective tool for managing traffic in smart cities. Smartphone apps can calculate tolls or fees based on real-time traffic conditions, encouraging commuters to travel during off-peak hours or use alternative routes. This approach helps alleviate congestion during peak times and raises revenue for infrastructure improvements (Ivanyi, Biro-Szigeti, 2019).

Smart cities recognize the importance of offering multiple transportation options to reduce car dependency. Mobility apps integrate various modes of transportation, including public transit, ridesharing, bike-sharing, and walking, into a single platform. This encourages residents to choose the most suitable and sustainable mode for each journey (Chmielarz et al., 2021).

Smartphone apps can assist in traffic enforcement and safety efforts. Authorities can use traffic camera apps to monitor intersections and identify traffic violations. Additionally, some apps provide alerts about speed limits and dangerous road conditions, promoting safer driving practices.

Smartphone applications are invaluable tools in the quest to improve traffic management in smart cities. With real-time data, optimization capabilities, crowdsourced reporting, and integration of transportation modes, these apps contribute to more efficient, sustainable, and safe urban mobility. As smart cities continue to evolve, the role of smartphone applications in traffic management will only grow, creating smoother and more enjoyable commutes for residents and visitors alike.

Table 5 gives examples of smartphone application usage in traffic management within smart cities. These applications cover various aspects of traffic management, including real-time data collection, optimization, safety enforcement, and the promotion of sustainable transportation options, making them integral to the efficient functioning of smart cities.

Table 5.
Smartphone application usage in traffic management within smart cities

Usage category	Examples
Real-Time Traffic Data	Waze, Google Maps, INRIX, TomTom Traffic
Traffic Flow Optimization	City-specific traffic management apps, traffic signal control apps
Crowdsourced Traffic Reporting	Waze, Google Maps, HERE WeGo, community-based traffic apps
Parking Solutions	ParkMobile, SpotHero, ParkWhiz, PayByPhone
Promoting Public Transportation	Transit apps (e.g., Moovit, Transit App, City-specific transit apps)
Dynamic Road Pricing	Congestion pricing apps (e.g., Singapore's ERP system)
Integrating Multiple Modes	Mobility apps (e.g., Uber, Lyft, bike-sharing apps)
Traffic Enforcement and Safety	Traffic camera apps, speed limit alert apps

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Aljoufie, Tiwari, 2022; Sofat, Bansal, 2016; Campolo et al., 2012).

Table 6 covers descriptions of how smartphone applications are used in traffic management within smart cities. These smartphone applications play a crucial role in modern traffic management within smart cities, providing real-time data, optimizing traffic flow, enhancing safety, and encouraging sustainable transportation choices.

Table 6.
How smartphone applications are used in traffic management within smart cities

Usage category	Description
Real-Time Traffic Data	Smartphone apps like Waze, Google Maps, INRIX, and TomTom Traffic collect and provide real-time traffic data, including congestion, accidents, and alternative routes, aiding commuters in making informed travel decisions.
Traffic Flow Optimization	City-specific traffic management apps and traffic signal control apps leverage smartphone data and sensors to optimize traffic flow by adjusting signal timings, rerouting vehicles, and reducing congestion in real-time.
Crowdsourced Traffic Reporting	Apps like Waze and Google Maps allow users to report accidents, road closures, and traffic incidents, providing valuable crowdsourced data that complements official traffic monitoring systems, enhancing overall safety and incident response.
Parking Solutions	Smartphone apps such as ParkMobile, SpotHero, ParkWhiz, and PayByPhone help drivers locate available parking spaces, pay for parking, and even reserve spots in advance, reducing traffic congestion caused by parking searches.
Promoting Public Transportation	Transit apps like Moovit, Transit App, and city-specific transit apps provide real-time information on public transportation schedules, routes, and delays, encouraging the use of buses and trains to reduce traffic congestion.
Dynamic Road Pricing	Congestion pricing apps, as seen in cities like Singapore, calculate tolls or fees based on real-time traffic conditions, incentivizing commuters to travel during off-peak hours or use alternative routes, thereby reducing congestion.
Integrating Multiple Modes	Mobility apps like Uber, Lyft, and bike-sharing apps offer users a range of transportation options, integrating public transit, ridesharing, bike-sharing, and walking into a single platform, promoting multi-modal mobility.
Traffic Enforcement and Safety	Traffic camera apps assist authorities in monitoring intersections, identifying traffic violations, and enforcing traffic laws. Speed limit alert apps provide drivers with warnings about speed limits and hazardous road conditions, enhancing road safety.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Aljoufie, Tiwari, 2022; Sofat, Bansal, 2016; Campolo et al., 2012).

Table 7 highlighting the advantages of using smartphone applications in traffic management within smart cities. These advantages illustrate how smartphone applications are pivotal in improving traffic management within smart cities, leading to more efficient, sustainable, and enjoyable urban transportation systems.

Table 7.
Advantages of using smartphone applications in traffic management within smart cities

Advantage	Description
Real-Time Traffic Data	Smartphone apps provide real-time traffic information, enabling users to make informed route decisions, reducing travel time and congestion.
Traffic Flow Optimization	Traffic management apps optimize traffic flow through signal control and dynamic routing, leading to smoother traffic and reduced delays.
Crowdsourced Traffic Reporting	Crowdsourced data from apps enhances incident response, allowing authorities to react quickly to accidents, road closures, and other issues.
Parking Solutions	Parking apps ease the search for parking spaces, reducing traffic congestion, fuel consumption, and environmental impact near popular areas.
Promoting Public Transportation	Transit apps encourage the use of public transportation, reducing the number of private vehicles on the road and mitigating congestion.
Dynamic Road Pricing	Congestion pricing apps reduce traffic during peak hours, generating revenue for infrastructure improvements and discouraging congestion.
Integrating Multiple Modes	Mobility apps offer convenience and flexibility by integrating various modes of transportation, encouraging sustainable travel choices.
Traffic Enforcement and Safety	Traffic camera apps enhance safety by monitoring intersections and deterring traffic violations, contributing to safer roadways.

Cont. table 7.

Efficient Resource Allocation	Data from apps allows authorities to allocate resources effectively, responding to incidents and traffic conditions in a timely manner.
Reduced Environmental Impact	By optimizing traffic flow and promoting sustainable transportation, these apps contribute to reduced air pollution and greenhouse gas emissions.
Enhanced User Experience	Smartphone apps offer user-friendly interfaces, improving the overall experience of navigating traffic and using transportation services.
Data-Driven Decision Making for Planning	Traffic data collected through apps aids city planners in making informed decisions for optimizing transportation infrastructure.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Aljoufie, Tiwari, 2022; Sofat, Bansal, 2016; Campolo et al., 2012).

Table 8 put information about some of the common problems and challenges associated with the usage of smartphone applications in traffic management within smart cities. These problems and challenges underline the need for careful consideration and effective solutions when implementing smartphone applications in traffic management to ensure equitable, safe, and efficient transportation systems within smart cities.

Table 8.
Problems of using smartphone applications in traffic management within smart cities

Problem	Description
Data Privacy Concerns	Users often share personal and location data with these apps, raising concerns about data security and privacy breaches.
Digital Divide	Not all residents may have access to smartphones or the internet, creating disparities in access to real-time traffic information.
Over-Reliance on Technology	An over-dependence on navigation apps may lead to reduced map-reading and navigational skills among users, causing potential problems when technology fails.
Data Accuracy and Reliability	The accuracy of traffic data in apps can vary, leading to potential frustration and inefficiencies if users encounter inaccurate information.
Sustainability Challenges	While apps promote sustainable transportation, there can be sustainability challenges related to vehicle maintenance and environmental impact.
Traffic Congestion from Ridesharing Services	Increased use of ridesharing services can lead to additional traffic congestion, particularly in densely populated areas.
Digital Distractions and Safety Hazards	Smartphone use while driving or walking can lead to accidents and safety hazards, potentially contributing to road safety concerns.
Service Reliability and Downtime	Apps may suffer from downtime or technical issues, leaving users stranded or unable to access essential traffic and navigation information.
Inadequate Internet Connectivity	In areas with poor internet connectivity, the functionality of these apps may be compromised, impacting their reliability and usefulness.
User Discrimination and Bias in Algorithms	Concerns exist about potential biases in algorithms used by ridesharing and navigation services, resulting in discriminatory practices.
Environmental Impact of Data Centers and Servers	The data centers supporting these apps can consume significant energy, contributing to the environmental footprint of digital infrastructure.
Accessibility and Inclusivity	Not all apps are fully accessible to individuals with disabilities, limiting mobility options for some users and causing equity concerns.
Congestion from On-Demand Services and Deliveries	The convenience of on-demand services like food delivery can lead to increased road congestion and air pollution in urban areas.
Lack of Standardization Across Cities	Different cities may use a variety of apps and platforms, making it challenging for travelers to adapt to different systems when moving between cities.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Aljoufie, Tiwari, 2022; Sofat, Bansal, 2016; Campolo et al., 2012).

4. Conclusion

This paper has highlighted the profound impact of smartphone applications on the development of smart cities, particularly in the domains of urban mobility and traffic management. Smart cities, characterized by their pursuit of sustainability, efficiency, and enhanced quality of life, have harnessed the capabilities of smartphone applications to create more connected and livable urban environments.

The usage of smartphone applications in urban mobility has ushered in a new era of convenience and efficiency for city dwellers. Navigation apps like Google Maps, Apple Maps, and Waze have become indispensable tools, providing real-time traffic data and optimized routes that reduce travel times and alleviate congestion. These applications have not only improved the daily commute but have also contributed to a reduction in stress levels for urban residents. Furthermore, smartphone apps have played a pivotal role in making public transportation more accessible and user-friendly. City-specific transit apps, along with platforms like Moovit and Transit App, offer schedules, real-time updates, and mobile ticketing options, making it easier for residents and visitors to navigate cities using public transportation.

Ridesharing and carpooling apps like Uber, Lyft, BlaBlaCar, and DiDi have disrupted traditional transportation models, encouraging carpooling and reducing single-occupancy vehicles on the road. These apps offer convenience, cashless payments, and safety measures, transforming the urban transportation landscape. Micromobility solutions, such as electric scooters and bikes, have gained popularity in smart cities. Smartphone apps are the primary means by which users locate and unlock these vehicles, providing convenient and eco-friendly options for short-distance transportation.

Traffic management in urban areas has always been a challenge, but smartphone applications have made significant strides in addressing this issue. These apps provide real-time traffic data that is crucial for smart traffic management systems. Cities can adjust signal timings, reroute traffic, and minimize congestion, all while reducing fuel consumption and greenhouse gas emissions. Moreover, parking apps have simplified the parking process, helping drivers find available spaces efficiently and reducing traffic caused by parking searches. These apps have made urban life more convenient and less frustrating.

In terms of sustainability, smartphone applications have promoted eco-friendly commuting habits. Some apps encourage users to track their carbon footprint and offer incentives for choosing environmentally conscious modes of transportation, such as walking, cycling, or public transit. Traffic enforcement and safety have also benefited from smartphone apps. Traffic camera apps monitor intersections and help identify violations, enhancing road safety. Speed limit alert apps provide drivers with warnings about speed limits and hazardous conditions, further contributing to safer roadways.

However, it's essential to acknowledge the challenges associated with the widespread usage of smartphone applications in smart cities. These include data privacy concerns, the digital divide, over-reliance on technology, data accuracy and reliability issues, sustainability challenges, and the potential for increased traffic congestion from ridesharing services. Furthermore, digital distractions, service reliability and downtime, inadequate internet connectivity in certain areas, user discrimination, and environmental impacts related to data centers and servers are challenges that must be addressed as smart cities continue to evolve.

Smartphone applications have undeniably transformed urban mobility and traffic management in smart cities. Their real-time data capabilities, optimization features, and user-friendly interfaces have created more efficient, sustainable, and enjoyable transportation systems. However, it is essential for smart cities to tackle the associated challenges effectively, ensuring that these applications contribute to equitable, safe, and efficient transportation systems within the urban landscape. The future of urban mobility is digital, and it's driven by the convenience and connectivity offered by our smartphones.

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THE USAGE OF BUSINESS ANALYTICS IN INDUSTRY 4.0 – ADVANTAGES AND PROBLEMS

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Purpose: The purpose of this publication is to present the potential usage of business analytics in Industry 4.0.
Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.
Findings: Business Analytics and Industry 4.0 represent a dynamic synergy that has the potential to revolutionize industries, drive sustainability, and elevate businesses to new heights. To fully realize these possibilities, organizations must invest in data strategies, talent development, and an organizational culture that embraces data-driven decision-making. The journey ahead is both challenging and promising, and those who navigate it adeptly will shape the future of industry and business in profound ways.
Originality/value: Detailed analysis of all subjects related to the problems connected with the usage of business analytics in Industry 4.0.

Keywords: business analytics, Industry 4.0, digitalization, artificial intelligence, real-time monitoring.

Category of the paper: literature review.

1. Introduction

Industry 4.0, often referred to as the fourth industrial revolution, has ushered in a new era of manufacturing and business operations. It is characterized by the integration of digital technologies, the Internet of Things (IoT), artificial intelligence (AI), and automation into various industries. One of the key enablers of Industry 4.0 is business analytics, which plays a pivotal role in transforming data into actionable insights (Wolniak, 2016; Czerwińska-Lubszczyk et al., 2022; Drozd, Wolniak, 2021; Gajdzik, Wolniak, 2021, 2022; Gębczyńska, Wolniak, 2018, 2023; Grabowska et al., 2019, 2020, 2021; Wolniak et al., 2023; Wolniak,

Grebski, 2023; Wolniak, Skotnicka-Zasadzień, 2023; Jonek-Kowalska, Wolniak, 2023). This article explores the significant usage of business analytics in Industry 4.0 and its impact on modern businesses.

The purpose of this publication is to present how business analytics concepts can be used in Industry 4.0.

2. Business analytics

Business Analytics is the process of using data analysis and statistical methods to make informed, data-driven decisions within a business or organization. It involves the collection, processing, interpretation, and visualization of data to gain valuable insights that can be applied to improve various aspects of an organization's operations, strategy, and decision-making (Cam et al., 2021).

Business analytics starts with the collection of data from various sources, including internal databases, external data providers, customer interactions, social media, sensors, and more. This data can be structured (e.g., databases, spreadsheets) or unstructured (e.g., text, images, videos). Raw data often contains errors, inconsistencies, and missing values. Data cleaning and preparation involve the process of cleaning, transforming, and structuring the data into a usable format for analysis. This step is critical for ensuring the accuracy and reliability of insights (Jonek-Kowalska, Wolniak, 2021, 2022; Jonek-Kowalska et al., 2022; Kordel, Wolniak, 2021, Orzeł, Wolniak, 2021, 2022, 2023; Rosak-Szyrocka et al., 2023; Gajdzik et al., 2023; Ponomarenko et al., 2016; Stawiarska et al., 2020, 2021; Steculа, Wolniak, 2022; Olkiewicz et al., 2021).

Once the data is cleaned and prepared, it undergoes various forms of analysis. This may include descriptive analysis to summarize and explore the data, predictive analysis to make forecasts or predictions, and prescriptive analysis to recommend actions based on the data (Scappini, 2016). Business analytics often employs a wide range of statistical techniques and tools to uncover patterns, trends, and correlations in the data. Common statistical methods include regression analysis, hypothesis testing, clustering, and classification (Charles et al., 2023).

In addition to traditional statistical methods, business analytics also makes use of machine learning algorithms and artificial intelligence (AI) to analyze data. These techniques can handle large datasets, identify complex patterns, and make real-time predictions. Data visualization is a crucial component of business analytics. It involves presenting data in graphical or visual formats such as charts, graphs, and dashboards. Visualization helps in conveying complex information in a comprehensible manner, aiding decision-makers in understanding data insights (Greasley, 2019).

Business analytics provides decision support by offering actionable insights and recommendations based on data analysis. These insights assist organizations in making informed decisions related to marketing strategies, product development, customer service, supply chain management, and more. Analytics is not a one-time process; it involves continuous monitoring and measurement of key performance indicators (KPIs). This allows organizations to assess the impact of decisions, track progress toward goals, and adapt strategies accordingly (Hurwitz et al., 2015).

Business analytics is closely related to business intelligence, which involves the use of data and analytics tools to generate reports, dashboards, and visualizations for business users. BI tools enable non-technical personnel to access and understand data easily (Nourani, 2021). Business analytics plays a pivotal role in strategic planning. Organizations use data-driven insights to formulate long-term strategies, identify market opportunities, mitigate risks, and allocate resources effectively. Effective business analytics can provide a competitive advantage by enabling organizations to respond quickly to market changes, optimize operations, improve customer satisfaction, and innovate based on data-driven insights (Peter et al., 2023).

3. Industry 4.0

Industry 4.0 is a transformative concept that represents the fourth industrial revolution in manufacturing and business. It's a paradigm shift characterized by the integration of digital technologies, automation, data analytics, the Internet of Things (IoT), artificial intelligence (AI), and other advanced technologies into industrial processes and operations (Adel, 2022).

Industry 4.0 relies heavily on the digitalization of physical assets and processes. Machines, sensors, and devices are interconnected through the IoT, creating a seamless flow of data. This connectivity enables real-time monitoring, control, and communication between various components of a manufacturing system (Cillo et al., 2022). Data is at the heart of Industry 4.0. Enormous volumes of data are generated from sensors, machines, and operations. This data is collected, processed, and analyzed to extract valuable insights. Businesses use this data to make informed decisions, optimize processes, and gain a competitive edge (Sułkowski, Wolniak, 2015, 2016, 2018; Wolniak, Skotnicka-Zasadzień, 2008, 2010, 2014, 2018, 2019, 2022; Wolniak, 2011, 2013, 2014, 2016, 2017, 2018, 2019, 2020, 2021, 2022; Gajdzik, Wolniak, 2023; Hys, Wolniak, 2018).

Industry 4.0 introduces the concept of smart manufacturing, where machines and systems are not just automated but also intelligent. These smart systems can self-optimize, self-diagnose issues, and adapt to changing conditions (Di Marino et al., 2023). This results in increased efficiency, reduced downtime, and improved productivity. Industry 4.0 emphasizes the

collaboration between humans and machines. While automation plays a significant role, human workers are still essential for complex decision-making, creativity, and tasks that require emotional intelligence. Humans and machines work together synergistically to achieve better results (Wolniak, Sułkowski, 2015, 2016; Wolniak, Grebski, 2018; Wolniak et al., 2019, 2020; Wolniak, Habek, 2015, 2016; Wolniak, Skotnicka, 2011; Wolniak, Jonek-Kowalska, 2021; 2022).

Industry 4.0 enables mass customization, allowing products to be tailored to individual customer needs without sacrificing efficiency or cost-effectiveness. Production processes become more flexible and responsive to changing market demands (Ghibakholl et al., 2022). Traditional hierarchical decision-making structures are replaced by decentralized decision-making in Industry 4.0. Intelligent systems at various levels of the production process can make autonomous decisions based on real-time data, reducing response times and increasing agility (Akundi et al., 2022).

With increased connectivity, there's a growing emphasis on cybersecurity and data privacy. Protecting sensitive data and systems from cyber threats becomes paramount to maintain the integrity and security of operations. Industry 4.0 also promotes sustainability by optimizing resource usage and reducing waste. Data analytics can help identify areas for improvement in energy consumption, materials usage, and overall environmental impact (Olsen, 2023).

Industry 4.0 has a global reach, with interconnected supply chains that can adapt to changing market dynamics. It allows for better coordination and efficiency across the entire supply chain network. Industry 4.0 is a dynamic and evolving concept. It encourages organizations to embrace a culture of continuous innovation, as new technologies and approaches are constantly emerging (Aslam et al., 2020).

Industry 4.0 represents a fundamental shift in the way businesses and industries operate. It offers the promise of increased efficiency, competitiveness, and sustainability through the intelligent use of technology and data. As it continues to evolve, it will reshape various sectors, from manufacturing and logistics to healthcare and beyond, impacting the global economy and the way we live and work (Bakir, Dahlan, 2022).

4. The usage of Business Analytics in Industry 4.0

In Industry 4.0, data is generated at an unprecedented rate and from various sources, including sensors, machines, production lines, and customer interactions. Business analytics facilitates the collection and integration of this data, allowing organizations to gain a holistic view of their operations. Data can be gathered in real-time, providing decision-makers with up-to-the-minute information to make informed choices.

One of the standout applications of business analytics in Industry 4.0 is predictive maintenance. Through the analysis of historical data and the real-time monitoring of machinery and equipment, analytics models can predict when maintenance is required, thus preventing costly downtime and ensuring continuous production. This proactive approach enhances efficiency and reduces maintenance costs.

Business analytics plays a vital role in optimizing supply chains in Industry 4.0. By analyzing data related to demand forecasts, inventory levels, transportation, and supplier performance, organizations can make data-driven decisions to streamline their supply chain operations. This results in reduced lead times, lower carrying costs, and improved customer satisfaction (Javaid et al., 2020).

Maintaining high-quality standards is essential in modern manufacturing. Business analytics can be employed to monitor the production process, detect defects or anomalies in real-time, and make immediate adjustments to maintain product quality. This level of precision ensures that defective products are minimized, reducing waste and rework.

Inventory management is a critical aspect of Industry 4.0, where just-in-time production and reduced stock levels are key objectives. Business analytics helps organizations optimize their inventory by forecasting demand accurately and aligning procurement and production processes accordingly. This not only saves costs but also ensures that products are readily available when needed.

Table 1.
Table summarizing the key relationships between business analytics and Industry 4.0

Aspect of Industry 4.0	Role of Business Analytics
Data Collection and Integration	Facilitates data collection and integration from various sources, enabling real-time data access and analysis.
Predictive Maintenance	Utilizes historical and real-time data to predict maintenance needs, minimizing downtime and increasing operational efficiency.
Supply Chain Optimization	Analyzes demand forecasts, inventory levels, and supplier data to optimize supply chain operations for cost savings and efficiency.
Quality Control	Monitors production processes in real-time, detecting defects and anomalies to ensure consistent product quality.
Inventory Management	Improves inventory management by accurately forecasting demand, aligning procurement and production processes, and reducing carrying costs.
Personalized Customer Experiences	Utilizes customer data and behavior analysis to offer personalized products and services, enhancing customer satisfaction and loyalty.
Process Optimization	Identifies inefficiencies and areas for improvement in operations, allowing for continuous process optimization.
Cost Reduction and Profitability	Enables data-driven decisions to identify cost-saving opportunities, allocate resources efficiently, and respond to market changes, ultimately improving profitability.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020, Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz et al., 2015; Nourani, 2021; Peter et al., 2023).

In Industry 4.0, businesses can harness the power of analytics to offer personalized customer experiences. By analyzing customer data and behavior, companies can tailor their products and services to individual preferences. This level of customization enhances customer satisfaction and loyalty (Javaid, Haleem, 2020).

Table 2.
Benefits of using business analytics in Industry 4.0.

Benefits of Business Analytics in Industry 4.0	Description
Data-Driven Decision-Making	Enables informed decisions based on real-time data insights.
Operational Efficiency	Optimizes processes, reduces waste, and improves productivity.
Predictive Maintenance	Prevents unplanned downtime, extends equipment life, and lowers maintenance costs.
Supply Chain Optimization	Enhances supply chain visibility, reduces lead times, and minimizes carrying costs.
Quality Control	Ensures consistent product quality, reducing defects and rework.
Customization and Personalization	Allows for mass customization and personalized customer experiences.
Inventory Management	Reduces excess inventory, minimizing storage costs while meeting demand.
Cost Reduction	Identifies cost-saving opportunities and reduces operational expenses.
Improved Customer Satisfaction	Enhances customer service, responsiveness, and overall satisfaction.
Competitive Advantage	Provides a competitive edge through better decision-making and efficiency.
Sustainability	Supports sustainability efforts by optimizing resource usage.
Global Supply Chain Coordination	Enables better coordination in global supply chains, reducing disruptions.
Continuous Innovation	Fosters a culture of innovation and adaptation to changing market conditions.
Risk Mitigation	Helps identify and mitigate risks through data analysis.
Data Security and Compliance	Ensures data security and compliance with data protection regulations.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020, Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz et al., 2015; Nourani, 2021; Peter et al., 2023).

Business analytics enables continuous process optimization in Industry 4.0. Through the analysis of operational data, organizations can identify bottlenecks, inefficiencies, and areas for improvement. This data-driven approach empowers organizations to make changes that enhance productivity and reduce waste.

In table 1 there is an analysis of relations between business analytics and Industry 4.0. These relationships showcase how business analytics is integral to Industry 4.0, driving data-driven decision-making and optimizing various aspects of modern business operations.

A table 2 summarizing the key benefits of using business analytics in Industry 4.0. These benefits demonstrate how business analytics in Industry 4.0 can drive improvements across various aspects of business operations, from efficiency and cost reduction to customer satisfaction and innovation.

The table 3 summarizing some of the common problems and challenges associated with the usage of business analytics in Industry 4.0. These challenges highlight the complexity and multifaceted nature of implementing business analytics in the context of Industry 4.0.

Overcoming these issues requires careful planning, investment, and a commitment to data-driven decision-making.

Table 3.
Common problems and challenges associated with the usage of business analytics in Industry 4.0.

Challenges in Using Business Analytics in Industry 4.0	Description
Data Quality Issues	Poor data quality, including inaccuracies, inconsistencies, and missing data, can lead to unreliable insights.
Data Privacy and Security	Concerns about data privacy, cyber threats, and compliance with data protection regulations can be significant.
Complexity of Data Sources	Managing and integrating data from diverse sources, including IoT devices, can be complex and challenging.
Skill Shortages	A shortage of skilled data analysts, data scientists, and IT professionals with analytics expertise can hinder progress.
Data Silos	Data may be fragmented and stored in isolated systems, making it difficult to access and analyze holistically.
Cost of Implementation	Implementing analytics solutions and infrastructure can be costly, particularly for small and medium-sized enterprises (SMEs).
Resistance to Change	Organizational resistance to adopting data-driven decision-making culture can impede progress.
Lack of Clear Objectives	Without well-defined objectives and goals, businesses may struggle to derive meaningful insights from analytics.
Interoperability Issues	Compatibility and integration challenges between different systems and technologies can arise.
Data Overload	The sheer volume of data generated in Industry 4.0 can lead to information overload, making it hard to extract meaningful insights.
Ethical Concerns	Ethical considerations related to the use of data, AI, and automation, such as bias in algorithms, may arise.
Maintaining Analytics Models	Models and algorithms require continuous maintenance and updates to remain effective.
Limited Understanding of Analytics	Decision-makers and employees may have limited understanding of how to interpret and use analytics insights.
Vendor Lock-In	Depending heavily on specific analytics vendors may result in vendor lock-in and limited flexibility.
Scalability Challenges	Scaling analytics solutions to meet growing data demands and business needs can be complex.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020, Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz et al., 2015; Nourani, 2021; Peter et al., 2023).

5. Conclusion

This paper has explored two pivotal concepts that are reshaping the landscape of modern business and industry: Business Analytics and Industry 4.0. Business Analytics, as discussed in Section 2, is the process of harnessing the power of data analysis and statistical methods to drive informed, data-driven decisions within organizations. It encompasses various stages,

from data collection and cleaning to analysis and visualization, and is a cornerstone for achieving efficiency, competitiveness, and innovation.

On the other hand, Industry 4.0, as detailed in Section 3, represents the fourth industrial revolution characterized by the integration of cutting-edge technologies, such as IoT, AI, and automation, into industrial processes. It introduces the concept of smart manufacturing, emphasizes human-machine collaboration, and champions sustainability, driving businesses toward a more connected, efficient, and adaptable future. The next section underscores the synergy between Business Analytics and Industry 4.0, highlighting how data-driven decision-making powered by analytics plays a vital role in the success of Industry 4.0. Whether it's predictive maintenance to minimize downtime, supply chain optimization for cost savings, or quality control for consistent product excellence, Business Analytics is the catalyst that enables organizations to harness the full potential of Industry 4.0.

Furthermore, we have outlined the significant benefits of this symbiotic relationship, including data-driven decision-making, improved efficiency, enhanced customer experiences, and competitive advantage. However, it is crucial to acknowledge the challenges posed by data quality, security, and skill shortages, as presented in Section 5.

As organizations navigate the complex terrain of Industry 4.0 and continue to leverage Business Analytics, they must tread carefully, addressing these challenges while embracing the transformative opportunities. In this era of digitalization and data-driven insights, the ability to adapt, innovate, and make informed decisions will be the defining factors that separate successful organizations from the rest.

Summing up Business Analytics and Industry 4.0 represent a dynamic synergy that has the potential to revolutionize industries, drive sustainability, and elevate businesses to new heights. To fully realize these possibilities, organizations must invest in data strategies, talent development, and an organizational culture that embraces data-driven decision-making. The journey ahead is both challenging and promising, and those who navigate it adeptly will shape the future of industry and business in profound ways.

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THE ORGANIC FOOD MARKET IN SELECTED EU COUNTRIES 2012-2021

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Purpose: Organic farming is a farming concept whose development is justified by pro-environmental measures. In recent years, there has been a steadily increasing market demand for goods supplied by organic farms. An important objective of organic farming, which is emphasised in EU regulations, is to respond to consumer demands, which is related both to changes in the structure of consumption and to environmentally friendly consumer attitudes. As a result, there is an increasing demand for organic food. The aim of the article is to present the differentiation of EU countries in terms of the development of organic agriculture, based on selected indicators presenting the supply and demand side of the organic food market.
Methodology: The assessment of development of the organic food market in EU countries was carried out on the basis of annual data from 2012 to 2021. Dynamic measures and development trend models were used to characterise the time series. In a second step, the EU countries were classified by development of the organic market using a synthetic variable.
Findings: Demand for organic food is increasing, both in economically more developed countries and in developing countries. Nevertheless, sales of organic food in overall food sales are still low, as they do not on average exceed 3,7%, while there are countries like Denmark where they even reach 13%. In addition to the presentation of the diversity of EU countries in terms of the level of the organic food market, the dynamics of change in the selected indicators in 2021 in comparison with 2012 are also shown. The most dynamic changes in the food market in terms of the number of producers and the area of crops are observed in the new Member States, i.e. Croatia, Bulgaria and Latvia.
Originality: The article presents the organic food market leaders in terms of organic food producers, area occupied and volume of sales worth. It then identifies the countries with the most dynamic changes taking place in this market in 2021 in comparison with 2012.

Keywords: organic area, organic market, organic producers, organic retail sales.

Category of the paper: research paper.

1. Introduction

The organic food market is playing an increasingly important role in the food sector. The difference between organic and non-organic (conventional) food has to do with how food is produced. For example, organic foods like vegetables, fruit, eggs, milk and meat are produced without: pesticides, herbicides and fertilisers. Organic food production is perceived as being beneficial not only for the environment, but also for humans - such foods have more nutritive value and better pro-health properties than conventionally grown foods. Organic food is defined as foodstuff with the lowest possible level of contamination, produced on farms using ecological methods of plant cultivation and animal husbandry (Mróz, 2013). These products are frequently referred to as health food or natural products. The term organic food describes products certified under certain legal provisions.

The global organic food market is expected to grow from $227,19 billion in 2021 to $259,06 billion in 2022 at a compound annual growth rate (CAGR) of 14,0%. The Russia-Ukraine war disrupted the chances of global economic recovery from the COVID-19 pandemic, at least in the short term. The war between these two countries has led to economic sanctions on multiple countries, a surge in commodity prices, and supply chain disruptions, causing inflation across goods and services effecting many markets across the globe. The organic food market is expected to grow to $437,36 billion in 2026 at a CAGR of 14,0%. (Organic Food Global Market Report 2023, 2023).

One of the primary factors driving market expansion is growing awareness about the health benefits associated with the consumption of organic products. Sales of organic food and beverages are projected to rise as a result of the change in the purchasing behavior of the consumer. Additionally, the rising popularity of non-GMO products amongst consumers is driving the growth of the market (Organic Food…, 2023). The organic food and beverage market in Europe is rated second only after North America in terms of size. According to the most recent data provided by the Research Institute for Agricultural Ecology (FiBL), European consumers spent around €54,5 billion on organic food in 2021 (Willer, Kilcher, 2023). Analysts predict that demand for organic food and beverages in Europe could grow at a rate of around 7% per year (Dovleac, 2016).

The European market for organic products is highly diversified and characterised by high sales volumes. The most dynamically developing markets for organic food are at present the German market and the markets of the Scandinavian countries, where the share of organic food in total food sales has exceeded 5%. In these countries, the trade in organic food is growing dynamically and, at the same time, new forms and ways of communication of the benefits of organic food to consumers are being sought in order to build a competitive advantage. It should be emphasised that in addition to the Western European and Scandinavian countries, where organic food sales and consumption are highest, the countries of Central Europe are also becoming increasingly important.

However, despite the observed trends in the development of the organic food market, the share of organic products in overall food sales in Europe is still low, the reasons for which can be found both on the supply side and the demand side for organic food (Żakowska-Biemans, 2011). The most important factors influencing the development of the organic market are the concern for human health and environmental sustainability in the context of food safety, the agricultural practices used, pesticide-free cultivation and attention to animal welfare (Cavaliere, Peri, Banterle, 2016). The increasing number of certified organic producers and a wider range of organic product categories are influencing the provision of higher food safety and quality (Hamzaoui-Essoussi, Zahaf, 2012).

The main barrier against buying such products is related to the problem of lack of trust in producers, as consumers are unable to verify whether a product is indeed produced according to the organic system or not (Krystallis, Chryssohoidis, 2005). Baecke points out that the main constraints to the development of the sector are the lack of information combined with the high price of products and the high production costs (Baecke, Rogiers, De Cock, Van Huylenbroeck, 2002).

Organic food is offered both in direct sales channels, including directly from the producer, at markets and occasional fairs, as well as in shops specialising in organic food and in large supermarkets (on separate stands or shelves) (Żakowska-Biemans, 2008). The most varied assortment of organic food is offered by specialised shops, which are one of the preferred places for many consumers to buy organic food. Sales of organic food in large supermarkets are slower to grow due to a little varied assortment and a failure to adapt the organic food offer to consumer expectations. Johns predicted that organic food sales would move from niche shops, such as small specialist health food shops, to large supermarkets (Jones, Clarke-Hill, Shears, Hillier, 2001). A growing number of distribution channels are shifting towards the use of supermarkets and grocery networks, which offer and expand their range of organic foods at more competitive prices. Borgerson emphasises that retailers have the advantage of being very close to organic consumers which makes it easier for them to tailor their offerings to the preferences of the end consumers (Borgerson, 2007). The level of competition in this market will intensify due to an increase in the number of retailers introducing their own brands of organic products.

A large number of own brands are emerging on the market, which will further intensify the level of competition between retailers, which will certainly have an impact on organic food prices.

The development of the organic food market is also influenced by EU policy. Łuczka emphasises that in the case of the organic food market, EU policy needs to be refocused through:

- Promotion of food quality and safety including stimulation of organic farming.
- Focusing on the long term, reaching a "win-win" situation (i.e. both sides win, e.g. agriculture and environment, producer and consumer).
- Coordinate agricultural policy towards increasing its coherence with other sectoral policies (Łuczka, 2016).

The implemented legal conditions for the functioning of the organic food market should be fundamentally influenced by the principles of organic production, which were extensively discussed by Zegar (2012) and Zyznarska (1997).

Among the most significant occurring in organic production, they mention the following:

- treating agricultural production processes in relation to the natural environment so as to preserve the sustainability of the agro-ecosystem,
- closing the substance cycle within the farm, which requires a balance of crop and animal production, i.e. feed and fertiliser self-sufficiency,
- reducing all polluting species, using local raw materials and production resources,
- cultivation and nutrition of soil organisms through soil aeration and the application of organic fertilisers,
- using organic materials such as manure, organic waste, rock powder,
- use of a variety of agro-technical measures,
- selection of plant and animal species and varieties for specific site conditions,
- protection of natural enemies of pests, use of biotechnical pest control,
- pursuing soil protection and energy saving techniques,
- aiming to protect the health, longevity and productivity of animals,
- adaptation of animal density to the area of Utilised Agricultural Area (UAA),
- maintaining and creating a varied and attractive countryside with high leisure values,
- ensuring workplaces are adapted to human needs,
- farm organisation connected with a small market and low expenditure on the purchase of production resources,
- prohibiting the use of mineral chemical fertilisers and plant protection products, hormones, growth substances.

From an environmental point of view, organic food production is a very demanding system, which manifests itself by the complete elimination of the use of resources of industrial origin; these include pesticides and artificial fertilisers. It implies the maintenance of a closed nutrient cycle. This system eliminates the possibility of supplying the farm with fodder of conventional origin from the market.

Despite the higher price of organic food recently, it has been observed that the demand for organic food products in Europe is rising rapidly. Much of this growing organic market share and demand can be attributed to the populace's growing preference for a healthy lifestyle and the rising awareness about the health benefits of organic food products. This paradigm shift in the consumer's preferences will spur the demand for organic food products and beverages during the forecast period (Technavio, 2016). The growth in demand for organic food is influenced by an increase in the area under.

2. Materials and Methods

The assessment of the development of the organic food market in EU countries was based on annual data from 2012 to 2021 (t = 1, 2, ..., 10). Not covered in the analysis are: Luxembourg, Malta, Cyprus, Portugal, Slovakia due to the lack of complete data. The selection of indicators was preceded by a literature review (i.a.: Gulbicka, 2007; Komorowska, 2014; Brągiel, Ślusarczyk, 2017), data availability and statistical analysis (Table 1). All indicators in the studied group of objects meet the basic criterion for the selection of variables to describe a complex phenomenon, they are not quasi-constant variables (Kukuła, 2000).

In the first stage, the analysis of the dynamics of changes in selected indicators of the organic food market in EU countries over a decade was carried out. Dynamic measures and development trend models were used to describe the time series. Correlation analysis was carried out using Pearson's correlation coefficient.

Table1.
Organic food market indicators

Variable	Full name
X_1	Organic producers [thousand]
X_2	Organic area (farmland) [million ha]
X_3	Organic area share of total farmland [%]
X_4	Organic retail sales [million €]
X_5	Organic retail sales share [%]
X_6	Organic per capita consumption [€/person]

Source: Own study based on [Research Institute of Organic Agriculture FiBL. Available online: https://www.fibl.org (accessed on 1 February 2023); Eurostat. Available online: https://ec.europa.eu/eurostat (accessed on 15 January 2023)].

In a second stage, the EU countries were ranked by the development of the market for organic products using a synthetic variable, which has the character of a latent variable because its realisations are not directly observed. In the literature we can find many proposed methods for the construction of the synthetic variable and discussions on the criteria for their selection (i.a.: Panek, 2009; Walesiak, 2014; Nermed, 2017). Thus, the realisations of the synthetic variable using the proposal of the authors Kukuła, Luty (2015) were determined according to the formula:

$$DI_i = \frac{1}{m}\sum_{j=1}^{m}\frac{w_{ij} - \min\limits_i\{w_{ij}\}}{\max\limits_i\{w_{ij}\} - \min\limits_i\{w_{ij}\}} \tag{1}$$

where: DI_i - development indicator of object *i*, and:

$$w_{ij} = \frac{x_{ij,\ t=10}}{x_{ij,\ t=1}} \tag{2}$$

where: $x_{ij,\ t}$ - actual value of the characteristic X_j for object *i* per time unit *t*.

3. Results

From 2012 to 2021, variables X_1-X_4 showed an increasing trend. Of which the fastest growth can be observed in the case of variable X_4 (retail sales of organic products), where the value grew year by year with 11% (Fig. 1). Slightly smaller changes in the analysed period took place in the case of the area under organic cultivation and the share of organic cultivation in the total agricultural land, it was a year-to-year increase of 6%.

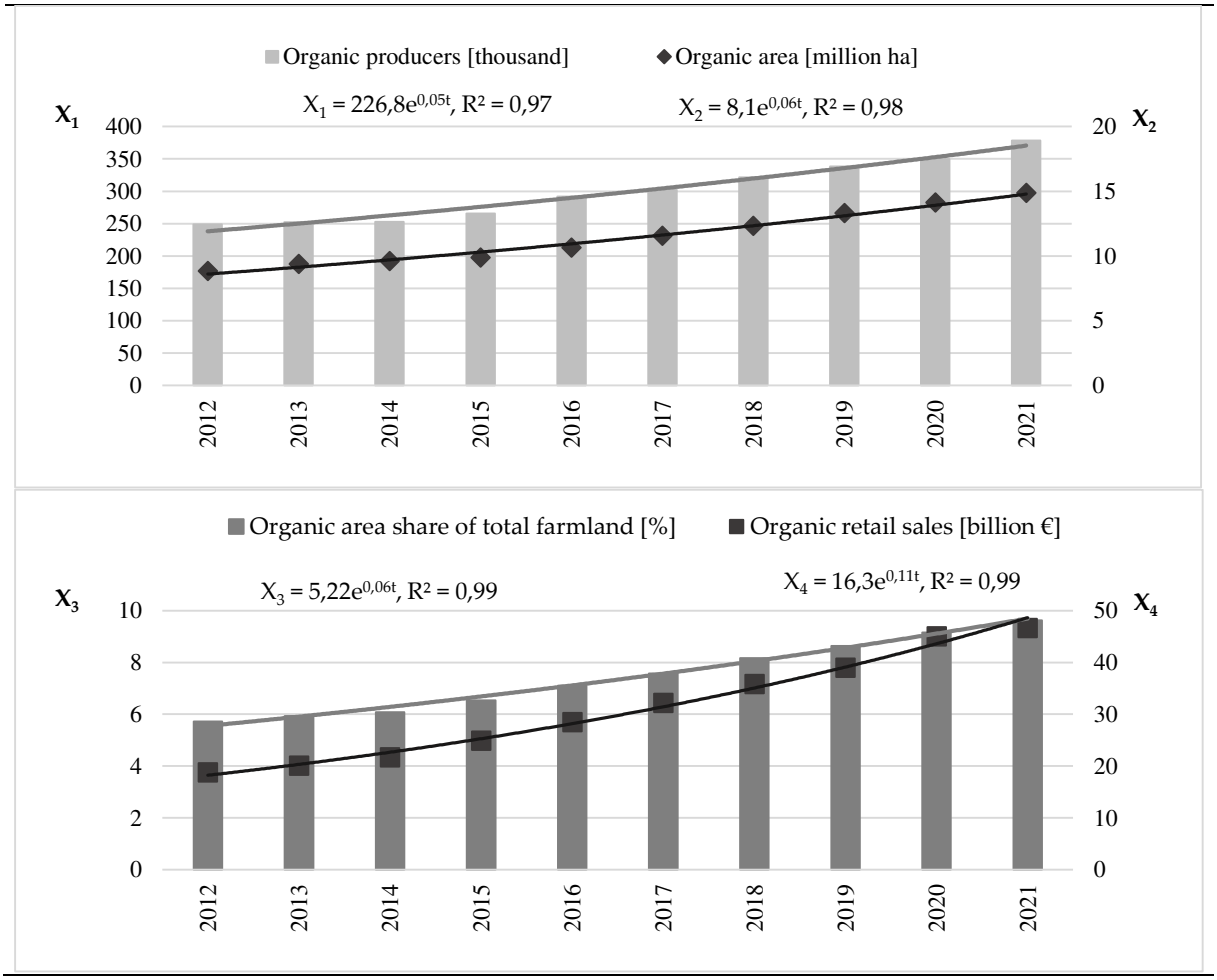


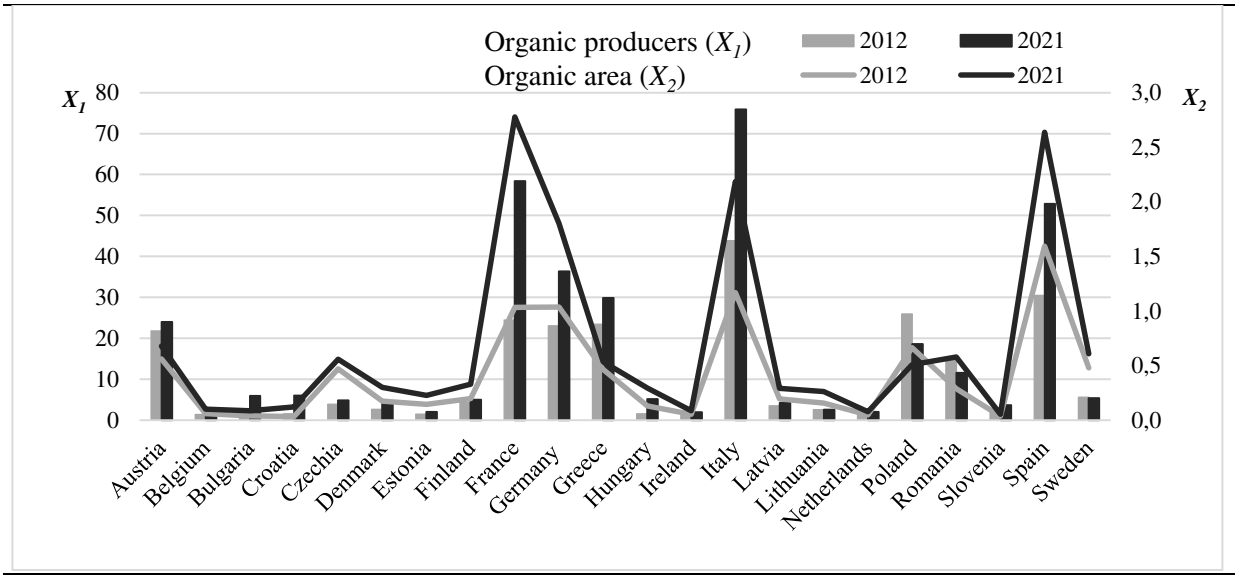
Figure 1. Values of selected indicators of the organic food market in the EU from 2012 to 2021 *(t = 1, 2, ..., 10)* with trend lines given.

Source: Own study based on designations as in Table 1.

The legal conditions for organic production and labelling of organic products introduced in the EU (Council Regulation (EC) No. 834/200, 2007) resulted in a systematic increase in the number of organic food producers in most Member States. Countries such as Italy, France, Spain, Germany and Greece were the leaders in this market during the analysed period. Poland was also in the lead in 2012, with more than 25,000 producers, but by 2021, the number of enterprises operating in this sector dropped significantly, by as much as 28%. An equally unfavourable trend was seen in Romania, where there was a 25% decrease in the number of producers in 2021 compared to 2012. In the remaining countries, the number of producers

increased, with Croatia up by almost 300% and Hungary by 229%. Favourable developments also occurred in France (up 139%) and Bulgaria (up 116%).

As the idea of healthy food is becoming more and more popular in the countries of the European Union, organic producers have increased the area under organic cultivation during the analysed period, as shown by the increase in the basic characteristics describing this phenomenon (Fig. 2). A particularly significant change took place in France, where organic area increased by 1,78 million ha in 2021 compared to 2012 (Fig. 2). Countries with large areas under organic cultivation also include Spain and Italy, where there was an increase of more than 1 million hectares of organic area compared to 2012. Organic crops also occupied a significant area in Germany and Austria. Countries that joined the EU after 2004 are increasing the area under organic production, with leaders including Croatia, which increased its area under organic production by more than 280% in 2021 compared to 2012, and Bulgaria, Hungary and Romania, where the growth exceeded 100%. In the group of analysed countries, the opposite trend can only be observed in Poland, where the area under organic farming decreased by 23%.



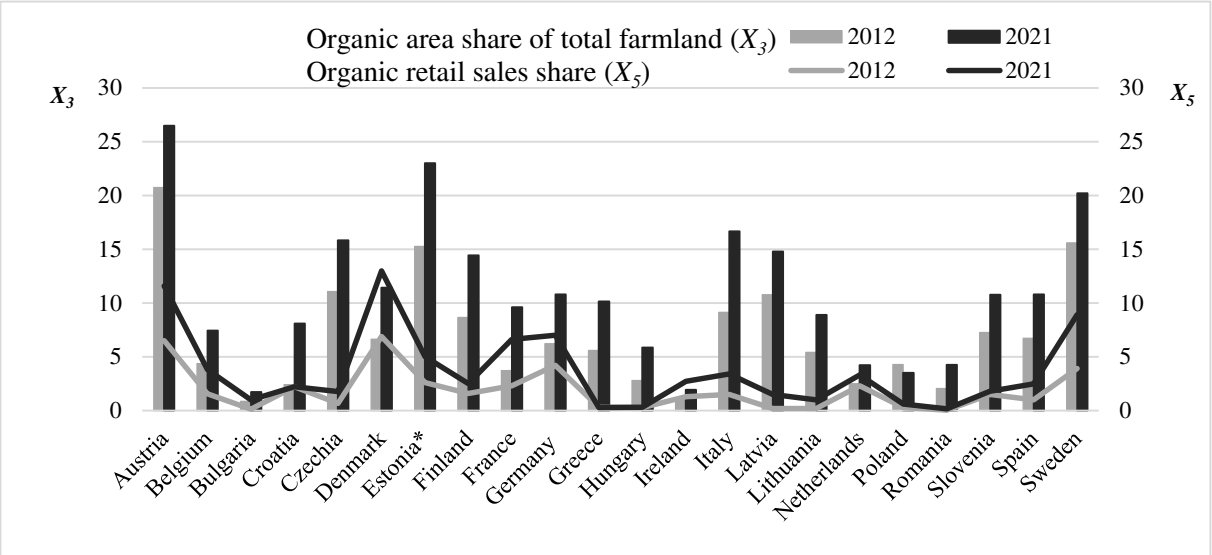
Specification	X_1		X_2	
	2012	2021	2012	2021
Min	1,26	1,91	0,03	0,05
Max	43,85	75,87	1,59	2,78
Median	3,70	5,24	0,20	0,31
Mean	11,14	16,49	0,41	0,69
Standard deviation	12,24	20,77	0,43	0,82
Coefficient of variation	1,10	1,26	1,04	1,20

Figure 2. Organic producers [thousand] and organic area [million ha] in selected EU countries and quantitative characteristics in 2012 and 2021.

Source: Own study based on designations as in Table 1.

As the area occupied by organic farms increases, their share of the total cultivated area increases. On average in the EU countries, organic farm area occupied 10,95% of the total area in 2021 (Fig. 3). The largest share of the area of farms producing healthy food in 2021 was in

Austria at 26,48% and also in Estonia (22,99%) and Sweden (20,19%). Estonia recorded the largest increase in the share of organic area in total crops in 2021 compared to 2012 and this was an increase of 7,74 p.p. In Italy, the increase in the share of cultivated area was 7,54 p.p.. Significant changes also took place in Austria (share increase of 5,73 p.p.), France (share increase of 5,90 p.p.) and Finland (share increase of 5,79 p.p.).



Specification	X_3		X_5	
	2012	2021	2012	2021
Min	0,87	1,71	0,04	0,15
Max	20,75	26,48	6,90	13,00
Median	5,90	10,46	1,50	2,49
Mean	6,96	10,95	1,88	3,68
Standard deviation	5,03	6,47	1,90	3,54
Coefficient of variation	0,72	0,59	1,01	0,96

*for Estonia X_5 lack of data for 2012, the data for 2017 was adopted.

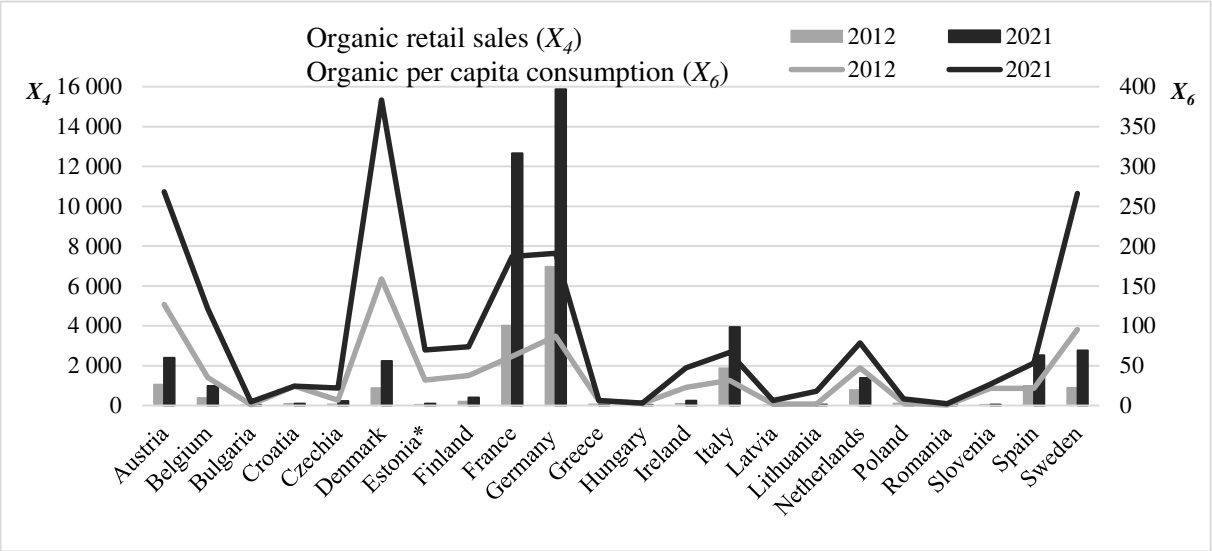
Figure 3. Organic area share of total farmland [%] and organic retail sales share [%] in selected EU countries and quantitative characteristics in 2012 and 2021.

Source: Own study based on designations as in Table 1.

The increase in cultivated area is a response to the growing demand for healthy food reported by consumers. The growing interest in healthy food is also confirmed by the increasing share of healthy food sales in total food purchases, in 2021 compared to 2012 in 20 of the 22 countries analysed. The share of organic food sales in EU countries increased on average from 1,68% to 3,68% in 2021 compared to 2012. In Denmark, which is the leader in terms of the share of healthy food sales in the food market this increase was at 6,1pp. (from 6,9% in 2012 to 13% in 2021) (Fig.3). Healthy food is also popular in Sweden with a share of 8,9%, Germany with a market share of 7% and France (6,63%).

In terms of sales value, consumers in the EU countries analysed have significantly increased their consumption of healthy food in 2021 compared to 2012. Germany is the clear market leader in organic food. The value of products sold on the German market increased from € 6970 million in 2012 to € 15870 million in 2021, an increase of 128% (Fig. 4). The average value for

this variable in EU countries increased by 148%. The largest markets in terms of sales value in 2021 were France, Italy, Sweden and Spain. In contrast, during the period under review, the most dynamic healthy food markets were Latvia with an increase in sales of 1175%, Lithuania (up 742%) Bulgaria (up 371%), Romania (up 246%) and the Czech Republic (up 223%).



Specification	X_4		X_6	
	2012	2021	2012	2021
Min	4,00	30,00	0,58	2,06
Max	6970,00	15870,00	158,94	383,55
Median	112,00	274,56	23,50	50,37
Mean	850,92	2111,22	37,56	87,63
Standard deviation	1609,21	4031,90	42,49	103,47
Coefficient of variation	1,89	1,91	1,13	1,18

*For Estonia X_4, X_6 lack of data for 2012, the data for 2017 was adopted.

Figure 4. Organic retail sales [million €] and organic per capita consumption [€/person] in selected EU countries and quantitative characteristics in 2012 and 2021.

Source: Own study based on designations as in Table 1.

Considering healthy food consumption per capita, all countries except Croatia increased in value. Consumption of healthy food in 2021 in comparison to 2012 increased the most in Denmark, Sweden and Austria by €225/person, €171/person and €141/person respectively.

A statistically significant correlation was identified in the data between the number producers (X_1) and area under organic cultivation (X_2) and the sales value of organic products (X_3) (Tab. 2).

Table 2.
Correlation coefficients between organic food market variables

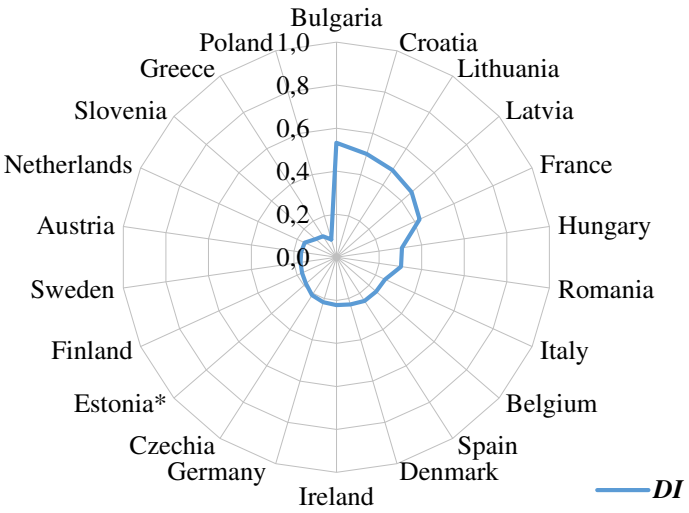
Specification	2012					2021				
	X_1	X_2	X_3	X_4	X_5	X_1	X_2	X_3	X_4	X_5
X_2	0,88***					0,92***				
X_3	0,12	0,18				0,16	0,16			
X_4	0,44*	0,57**	-0,05			0,57**	0,70***	0,04		
X_5	0,03	0,09	0,50*	0,35		0,11	0,19	0,55**	0,40	
X_6	-0,09	0,03	0,13	0,44*	0,72***	0,05	0,16	0,25	0,46*	0,84***

Statistically significant respectively: *: p value < 0,05; **: p value < 0,01; ***: p value < 0,001.

Source: Own study based on designations as in Table 1.

A statistically significant relationship was also found between the area occupied by organic crops (X_2) and the amount obtained from the sale of organic products (X_4). The increased interest in purchasing healthy food reported by consumers (X_6) increases the share of the healthy food market in total food sales (X_5), which is confirmed by the high value of the correlation coefficient between these variables.

Considering the aggregate indicator of organic food market development, the leading positions in the ranking were taken by the countries that joined the EU after 2004, Bulgaria, Croatia, Lithuania and Latvia. Poland was ranked lowest (Fig. 5).



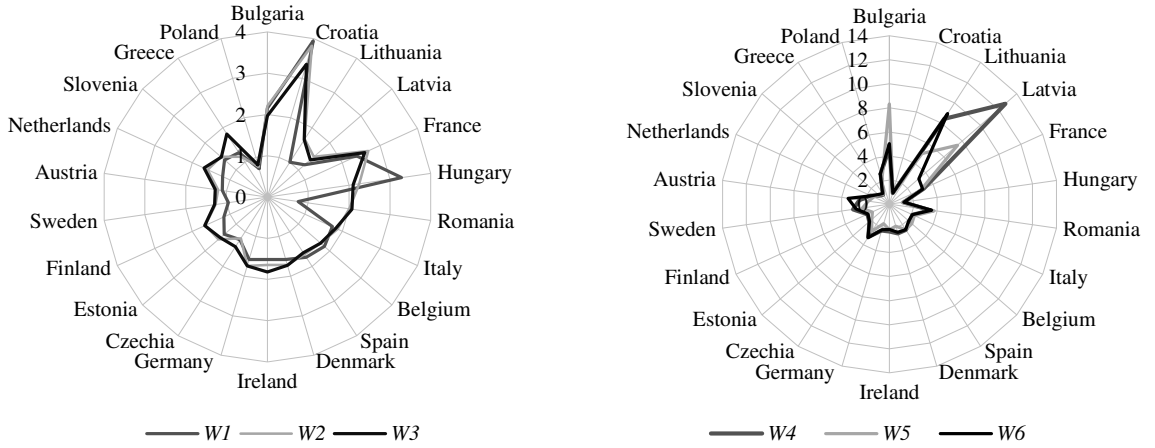
*for Estonia W_4, W_5, W_6 lack of data for 2012, the data for 2017 was adopted.

Figure 5. Ranking of EU countries on organic food market development indicator.

Source: Own study.

The largest increase in the W_1-W_3 indicators for the EU countries was observed in Croatia where the indicators describing the supply side of the market changed most dynamically. Croatia is described by the maximum values of the indicators (Fig. 6), which corresponds to a 294% increase in the number of organic producers, a 282% increase in the area under organic

cultivation and a 236% increase in the share of organic cultivation in the total crop. Significant changes took place in the Hungarian market where the number of organic producers increased by 230%.



Specification	W_1	W_2	W_3	W_4	W_5	W_6
Min	0,72	0,77	0,82	0,95	0,97	0,99
Max	3,94	3,82	3,36	12,75	8,33	8,94
Median	1,38	1,66	1,70	2,39	2,16	2,31
Coefficient of variation	0,48	0,35	0,28	0,84	0,71	0,61
Correlation coefficients						
W_2	0,85***					
W_3	0,82***	0,96***				
W_4	-0,27	-0,13	-0,22			
W_5	-0,14	0,01	-0,09	0,81***		
W_6	-0,31	-0,10	-0,17	0,64**	0,65***	

W_j defined according to the formula (2); for Estonia indicators W_4, W_5, W_6 determined in relation to the year 2017; Statistically significant respectively: *: p value < 0,05; **: p value < 0,01; ***: p value < 0,001.

Figure 6. Values of organic food market development indicators and their quantitative characteristics and correlation coefficients.

Source: Own study.

The lowest values for indicators W_1-W_3 were adopted for Poland with a decrease, the number of producers by 28%, the area of organic crops by 23% and the share of organic crops in the total area of crops decreased by 18%. Important from the point of view of the development of the organic food market is the information that, apart from Poland and, in the case of indicator W_1, Romania, the other countries recorded an increase in the indicators describing the supply side of the market.

Considering the demand side, the highest increase in the value of sales in 2021 compared to 2012 was in Latvia, with an increase of 1175%. This was followed by Lithuania and Bulgaria with increases of 742% and 371% respectively. A slight decrease in the value of organic goods sold was recorded in Croatia (by 5%) and Greece (by 4%).

The increase in the market share of healthy food in total sales was highest in Bulgaria, with a change of 733%, and in Latvia, with a change of 650%. For this indicator, only Greece saw a decrease in market share in 2021 compared to 2012.

4. Conclusion

Measures taken in EU countries to promote organic farming have been effective in increasing organic food production. As a result, there is an increase in the number of organic farms and organic areas, and the EU maintains its leading position in the global market for this type of production. The organic food market in Europe has been one of the most rapidly growing sectors of the food market since the 1990s. Increased organic awareness and the trend towards higher needs are also stimulating an increase in demand for healthy food. Such food is produced on organic farms, where no artificial fertilisers are used. The simultaneous increase in demand and supply creates favourable conditions for the development of a distribution system for organic products.

Demand for organic food is growing, both in countries with higher levels of economic development and in developing countries. Still, sales of organic food as a part of total food sales remain low. The highest share of organic food is found in Western European countries, including Denmark (13%), Austria (11,6%) and Sweden (8,9%), at the same time Denmark and Sweden had the highest per capita expenditure on organic food.

In addition to Western European and Scandinavian countries, where organic food sales and consumption are highest, Central European countries are also becoming more and more important. Considering the dynamics of market changes, the most significant changes took place in Croatia, which allowed it to take a leading position in terms of the dynamics of development of the supply side of the healthy food market, represented in the analyses by the number of organic producers and the area under organic cultivation. Considering the demand side of the market, the highest increase in organic retail sales (W_4) was recorded in Latvia, organic retail sales share (W_5) in Bulgaria and organic per capita consumption (W_6) in Lithuania.

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THE IMPACT OF THE USE OF REVENUE AND EXPENDITURE INSTRUMENTS BY THE MUNICIPALITY ON THE DEVELOPMENT OF ENTREPRENEURSHIP

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Purpose: The purpose of the article is to assess the range of use of revenue and expenditure instruments to support entrepreneurship by the municipality and to assess their impact on the development of entrepreneurship.
Design/methodology/approach: For the purposes of achieving the aim set in the article, a survey has been conducted among representatives of the scientific community. The invitation to participate in the survey was sent to the e-mail addresses of 36 representatives of the scientific community.
Findings: Within the range of its activities, the municipality should be significantly involved in supporting entrepreneurship using budgetary instruments, i.e. revenue and expenditure instruments. Owing to the impact on the development of entrepreneurship, the municipality should primarily apply reliefs and exemptions in local taxes and charges (without statutory reliefs and exemptions) as part of revenue instruments. However, in terms of expenditure instruments, the municipality should mainly use expenditure on technical infrastructure.
Research limitations/implications: The selection of the research sample was purposeful. Thus, the obtained results and the formulated conclusions apply to the analysed group, however, according to the author, they have undoubted cognitive values, and as a consequence, they are of significant importance in the analysed issues. Owing to the changes that have taken place in the activities of the municipality government caused by the COVID-19 pandemic and the energy crisis, it is reasonable to repeat the survey among experts in order to verify the conclusions drawn.
Practical implications: First of all, owing to the municipality's pursuit of the rational acquisition and expenditure of funds, and owing as well to the importance of entrepreneurship, the results of the study are addressed to people managing the municipality's government.
Social implications: The use of appropriate revenue and expenditure instruments by the municipality may have an impact on the development of entrepreneurship, and thus may contribute to e.g. a decrease in unemployment.
Originality/value: The originality of the work consists in the conducting of the survey among representatives of the scientific community and the required assessment of the impact of the use of both revenue and expenditure instruments by the municipality on the development of entrepreneurship.

Keywords: budgetary instruments, revenue instruments, expenditure instruments, the supporting of entrepreneurship, municipality.

Category of the paper: Research paper.

1. Introduction

Entrepreneurship, whose institutional dimension is the creation and development of enterprises, plays a very important role and also performs many vital functions in the country's economy (Późniak, 2013; Żołądkiewicz, 2016). Glinka and Gudkova (2011) include among others the following functions performed by entrepreneurship in the economic sphere:

- impact on the shape and functioning of the labour market,
- creating opportunities for the optimal use of existing resources and impact on the efficiency of markets,
- striving for an appropriate combination of the factors of production,
- impact on the local environment, both social and economic,
- ensuring benefits for investors,
- enabling quick identification of new opportunities and skilful organization of resources in order to use them.

Taking into account the role of entrepreneurship in the country's economy, it becomes important to support it, which is understood as by the planned and organized operation of institutions (Gancarczyk, 2010), aimed at creating conditions enabling the entrepreneur (Chmieliński, 2006) to establish, run, and develop an enterprise, as well as preventing its bankruptcy.

Among the institutions that undertake to support entrepreneurship, particular attention should be paid to local government units, including, above all, municipalities (Walczak, Żołądkiewicz, 2015). For example, Bania and Dahlke (2014), Dębniewska and Skorwider (2007), Rapacz and Jaremen (2014), Richter-Kaźmierska (2010) and Żołądkiewicz-Kuzioła (2019) are of the opinion that the supporting of entrepreneurship should be one of the most important tasks of municipality authorities. The municipality is believed to be the closest institutional ally of entrepreneurship. As emphasized by Banasiak (2013), the municipality government performs e.g. the role of a service entrepreneur, owner of public property, investor, planner, employer, and legislator. Rolewicz (1999) also attributes to the municipality the title of the host who is best able to identify and meet the needs of the community in a given area. According to Lutrzykowski (2017), it is the municipality government that meets the most important and current needs of urban and rural residents by implementing the assigned tasks. For example, it strives to provide jobs for the local community, and thus provide revenues at a level that they feel is satisfactory. The municipality government also aims to create

appropriate conditions for financial existence and spiritual development, as well as to guarantee a sense of security (Wołowiec, Reśko, 2012). It should also be noted that, to a large extent, the revenues of a municipality depend on the number and condition of taxpayers living and, above all, conducting business activities in its area (Sołtysiak, Zając, 2023). As emphasized by Wyszkowska (2012), both the situation of the municipality and its inhabitants depends on, among others, the number, structure and economic condition of enterprises.

Municipality authorities have at their disposal numerous instruments to support entrepreneurship, although, as the literature on the subject indicates, in practice they rely mainly on budgetary instruments (Denek, Rolewicz, 1998; Krajewski, Śliwa, 2004; Słomińska, 2007; Kogut-Jaworska, 2008; Lisowska, 2010) which include revenue and expenditure instruments. Instruments which have financial effects on the side of municipality budget revenues in the form of a decrease in their value are revenue instruments (Kogut-Jaworska, 2008). As emphasized by Hajdys (2010), the municipality government, by making decisions on the use of revenue instruments, contributes to the reduction in the costs of running a business, i.e. it makes it possible to leave a larger pool of funds in the enterprise, which can be used, among other purposes, for its development. On the other hand, the instruments with the use of which financial effects are associated on the side of the municipality's budget expenditure in the form of an increase in their value are expenditure instruments (Kogut-Jaworska, 2007).

Both revenue and expenditure instruments for supporting entrepreneurship by the municipality are subject to further classification. Revenue instruments include activities in the field of fiscal sovereignty, property management, and municipal management, while expenditure instruments include incurring expenses for technical and social infrastructure, for information and promotion purposes, for institutions supporting entrepreneurship, for training facilitating running a business, and for training aimed at improving the qualifications of the local population.

The use of revenue and expenditure instruments by the municipality is related to its financial management. By law, a municipality independently manages its finances. Such management is based on a budget resolution consisting of the budget of a given unit and appendices (Ustawa z dnia 27 sierpnia 2009 r. o finansach publicznych). The municipality government, when conducting financial management, should strive primarily for rational acquisition and expenditure of funds. A proper financial situation enables the municipality to carry out the public tasks assigned to it at an appropriate level, and as a consequence may lead to the development of a given unit.

The specificity of revenue and expenditure instruments, as well as the municipality's pursuit of the rational acquisition and expenditure of funds means that the municipality government in the field of supporting entrepreneurship should focus its activities on those budgetary instruments that bring the greatest possible benefits. The use of appropriate revenue and expenditure instruments by the municipality may have an impact on the development of entrepreneurship, and thus may contribute to e.g. a decrease in unemployment, an increase in

revenues to the municipality's budget, to the development of new areas of the economy, and a decrease in outlays related to social assistance.

The issue of revenue and expenditure instruments for supporting entrepreneurship by the municipality was the subject of research carried out, among others, by Dziemianowicz, Mackiewicz, Malinowska, Misiąg and Tomalak (2000), Kogut-Jaworska (2008), Kamiński (2009), Skica (2008), and also Dropek (2014). The considerations undertaken in the indicated research are limited primarily to the analysis of the range of application of selected revenue and expenditure instruments by the municipality. For example, Dropek (2014), in a study conducted in 2010 as part of revenue instruments, only analysed only the use by municipalities of local tax rates lower than the maximum, as well as reliefs and exemptions in local taxes.

The purpose of this article is to assess the range of use of revenue and expenditure instruments to support entrepreneurship by the municipality and to assess their impact on the development of entrepreneurship. In addition, two research hypotheses have been formulated in this paper:

Hypothesis 1: Among the revenue instruments, reliefs and exemptions in local taxes and charges (without statutory reliefs and exemptions) have the greatest impact on the development of entrepreneurship.

Hypothesis 2: Among the expenditure instruments, expenditure on technical infrastructure has the greatest impact on the development of entrepreneurship.

2. Metodology

For the purposes of achieving the aim set in the article, a survey has been conducted among representatives of the scientific community. The survey using the CAWI technique was carried out in the period from March 9 to May 21, 2020. The invitation to participate in the survey, along with a link to the electronic questionnaire available in the LimeSurvey electronic survey system, was sent to the e-mail addresses of 36 representatives of the scientific community. Owing to the specific nature of the respondents, the selection of the research sample was of a purposeful nature. Thus, the results obtained and the conclusions drawn will apply only to the analysed group, which means that they cannot be generalized to the entire community. In the author's opinion, however, they have undoubted cognitive values, and as a consequence, they are of significant importance in the analysed issues.

The group of those invited to participate in the study included 36 representatives of the scientific community who were also experts in the field of finance of local government units and entrepreneurship. 31 experts responded positively to the invitation to participate in the study. Thus the return rate was 86.1%. Respondents who took part in the survey were representatives of, among others, leading academic units such as SGH Warsaw School of

Economics, Wroclaw University of Economics and Business, Poznań University of Economics and Business, and Krakow University of Economics. Detailed characteristics of the respondents due to their connection with their academic unit are presented in Table 1.

Table 1.
Characteristics of the respondents due to their connections with the academic unit

Name of the academic unit	Number of respondents
The John Paul II Catholic University of Lublin	1
Lodz University of Technology	3
SGH Warsaw School of Economics	1
Krakow University of Economics	3
Poznań University of Economics and Business	1
Wroclaw University of Economics and Business	4
University of Gdańsk	2
University of Maria Curie-Skłodowska	2
Nicolaus Copernicus University in Toruń	1
University of Rzeszów	1
University of Szczecin	6
University of Warmia and Mazury in Olsztyn	2
University of Zielona Góra	1
WSB Merito University in Poznań	2
WSEI University	1

Source: own study based on the research results.

As part of the revenue instruments, the following were analysed:

- rates of local taxes and charges lower than the maximum,
- reliefs and exemptions in local taxes and charges (without statutory reliefs and exemptions),
- redemption of arrears in local taxes and charges,
- payment in instalments, deferral of payment in local taxes and charges,
- price reductions for municipal services,
- reliefs in rent payments for municipal commercial premises.

In turn, referring to expenditure instruments, the considerations covered:

- expenditure on technical infrastructure,
- expenditure on social infrastructure,
- expenditure on information and promotion purposes,
- expenditure on entrepreneurship support institutions,
- state aid expenditure,
- expenditure on training facilitating the running of a business,
- expenditure on training to improve the qualifications of the local population.

3. Research results

Before evaluating the range of application of revenue and expenditure instruments by the municipality and assessing their impact on the development of entrepreneurship, it is important to get to know expert opinions on the role of the municipality in supporting entrepreneurship. According to representatives of the scientific community, the municipality government, compared to the voivodeship and poviat governments, should be most involved in supporting entrepreneurship (figure 1). In the opinion of 45.2% of experts, the municipality government should play a very important role in this respect. It is worth adding that also according to 45.2% of the surveyed population, the role of the municipality government in supporting entrepreneurship should be important. In the context of supporting entrepreneurship, the municipality government was also rated better by experts than international institutions supporting entrepreneurship.

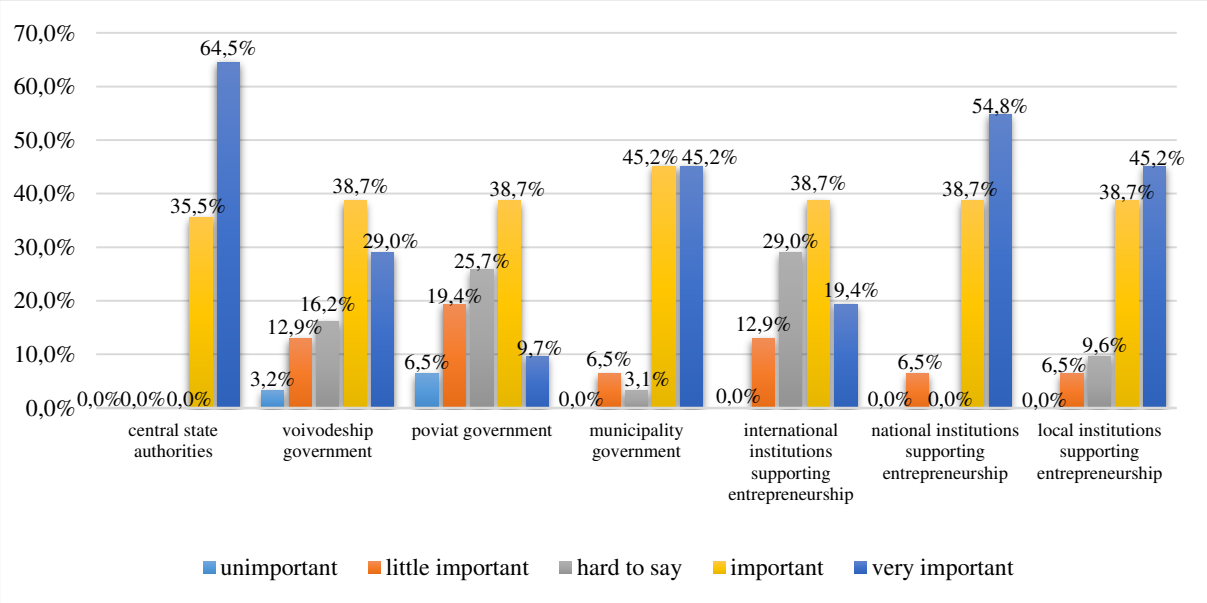

Figure 1. Distribution of answers to the question: "How important, in your opinion, should be the role of these entities in supporting entrepreneurship?" (in %).

Source: own study based on the research results.

Referring to the first type of budgetary instruments to support entrepreneurship, i.e. revenue instruments, according to most experts, a municipality, in supporting entrepreneurship, should primarily use instalment payments, deferral of payment in local taxes and charges, reliefs and exemptions in local taxes and charges (without statutory reliefs and exemptions), rates of local taxes and charges lower than the maximum, as well as reliefs in rent payments in the field of municipal commercial premises (figure 2). Most experts, as much as 93.5%, were in favour of using instalment payments and deferring payment deadlines in local taxes and charges. The second in order in the context of application by the municipality are reliefs and exemptions

in local taxes and charges (without statutory reliefs and exemptions). According to 83.9% of experts, the given instruments should be used by the municipality to support entrepreneurship. In the opinion of 12.9% of respondents, reliefs and exemptions in local taxes and charges (without statutory reliefs and exemptions) are revenue instruments characterized by a very large impact on the development of entrepreneurship (figure 3). These are also the instruments which were the most indicated by the respondents (38.7%), who defined their impact on the development of entrepreneurship as large.

The survey shows that, in the opinion of 61.3% and 51.6% of respondents, respectively, the municipality in supporting entrepreneurship should not apply price reductions for municipal services and redemption arrears in local taxes and charges. According to 12.9% of experts, the use of price reductions for municipal services has no impact on the development of entrepreneurship. On the other hand, according to 19.4% of respondents, the use of redemption of arrears in local taxes and charges by the municipality has no impact on the development of entrepreneurship. In the opinion of experts, the use of price reductions for municipal services could lead to unequal treatment of enterprises in comparison with other entities. On the other hand, the use of redemption of arrears in local taxes and charges by the municipality in the field of supporting entrepreneurship, according to the respondents, e.g. may lead to discretion and corruption, and may also have an impact on reducing the motivation of entrepreneurs to settle their liabilities.

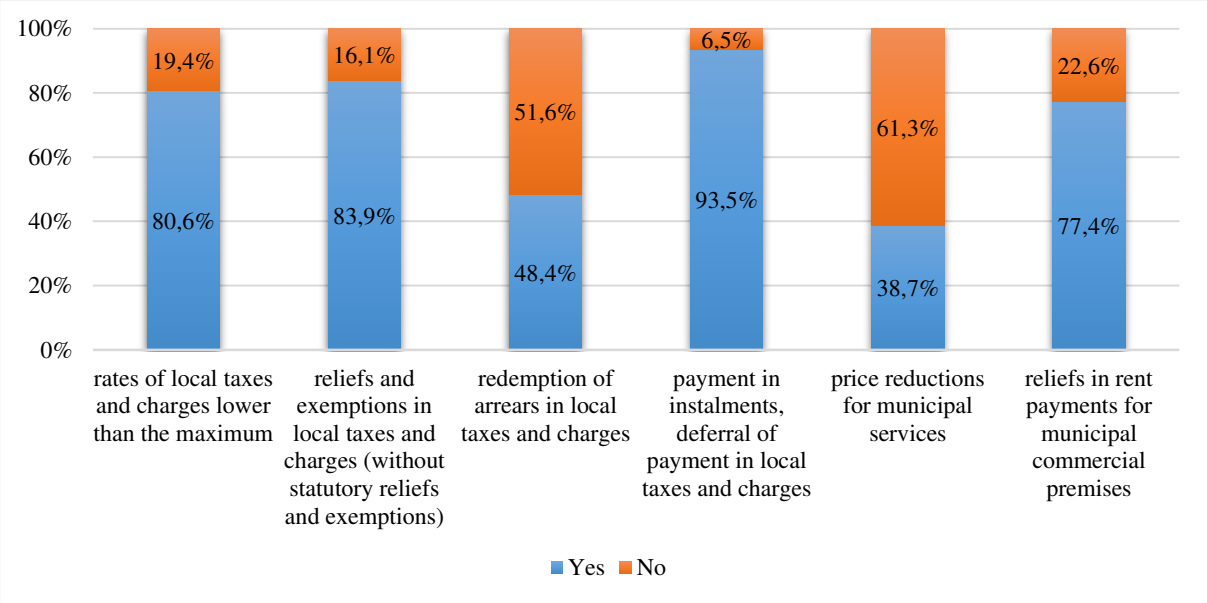

Figure 2. Distribution of answers to the question: "In your opinion, should the municipality use the following revenue instruments to support entrepreneurship?" (in %).

Source: own study based on the research results.

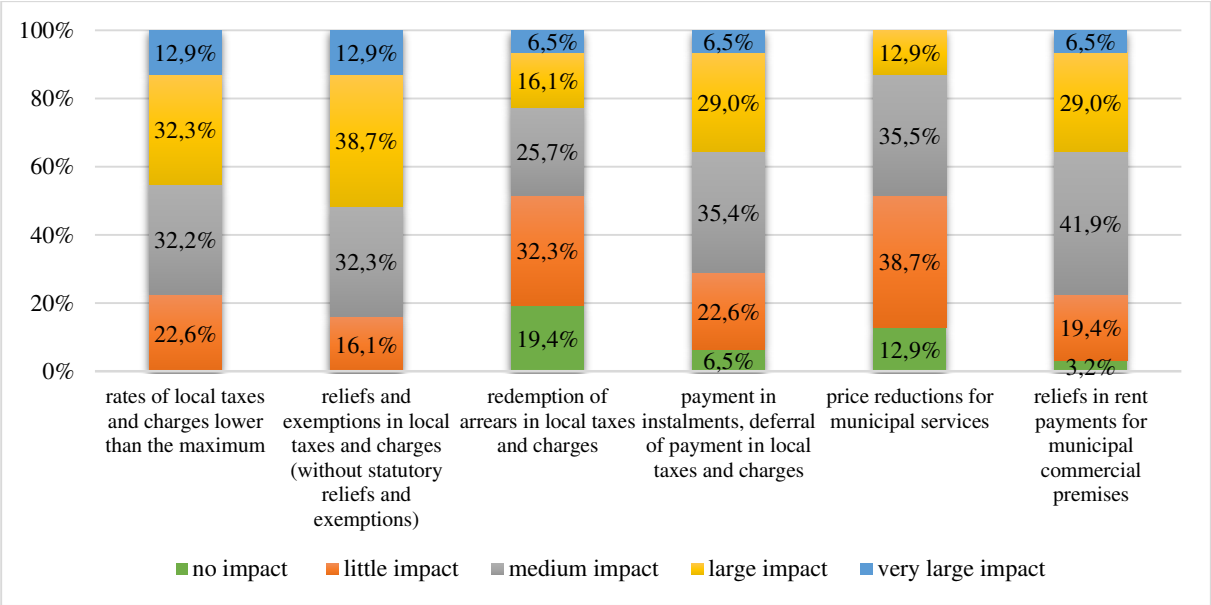

Figure 3. Distribution of answers to the question: "To what extent, in your opinion, can these revenue instruments supporting entrepreneurship affect the development of entrepreneurship in the municipality?" (in %).

Source: own study based on the research results.

Referring to the expenditure instruments, the majority of respondents were in favour of their use by the municipality in supporting entrepreneurship (figure 4). Most affirmative answers were given by the respondents in relation to expenditure on technical infrastructure (96.8%) and social infrastructure (87.1%) as well as expenditure on information and promotion purposes (83.9%). According to the largest percentage of representatives of the scientific community, expenditure on technical infrastructure is an instrument with both a very large and a large impact on the development of entrepreneurship (figure 5). This opinion was expressed by a total of 87.1% of the respondents. The second most important instrument indicated by a total of 58.1% of respondents is expenditure on social infrastructure.

Expenditure instruments which, in the opinion of 41.9% of respondents, should not be used by municipalities as expenditure instruments to support entrepreneurship are expenditure on training aimed at facilitating the running of a business and expenditure in the field of state aid. In the opinion of 41.9% of experts, public aid expenditure has little impact on the development of entrepreneurship, while in the opinion of 19.4% of the surveyed population, expenditure on training aimed at facilitating the running of a business has no impact on the development of entrepreneurship.

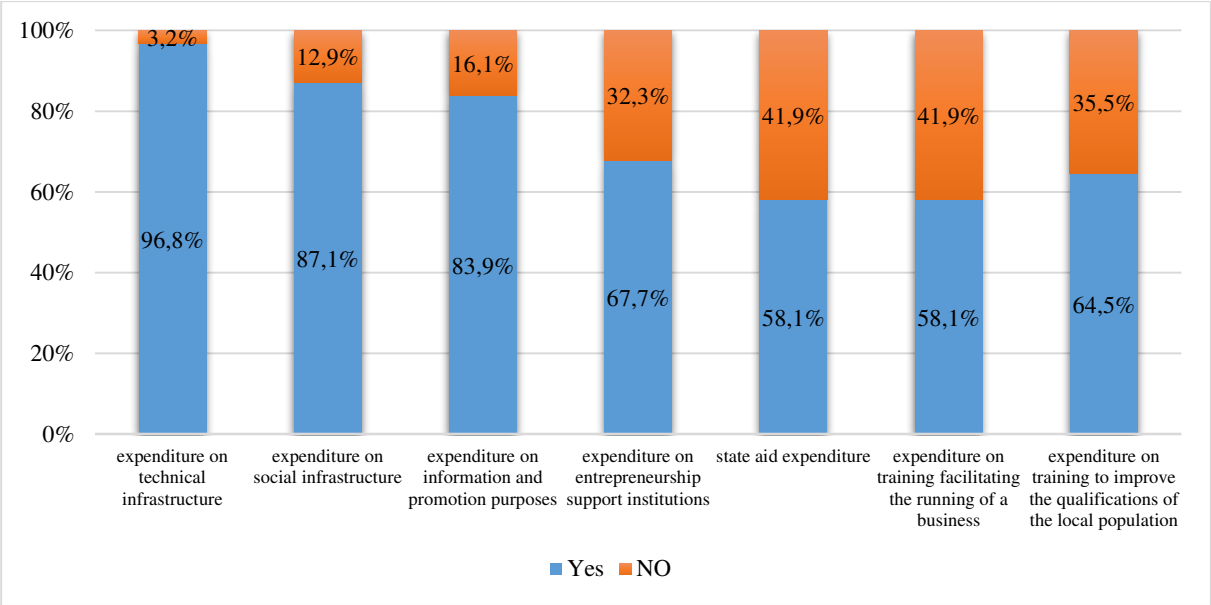

Figure 4. Distribution of answers to the question: "In your opinion, should the municipality use the following expenditure instruments to support entrepreneurship?" (in %).

Source: own study based on the research results.

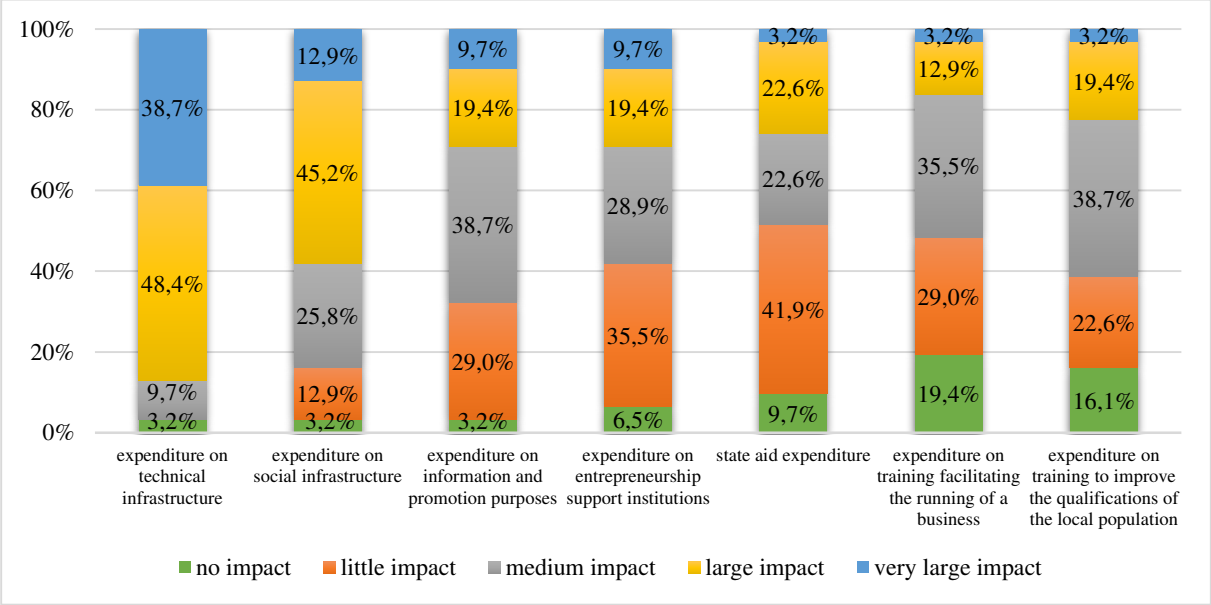

Figure 5. Distribution of answers to the question: "To what extent, in your opinion, can these expenditure instruments supporting entrepreneurship affect the development of entrepreneurship in the municipality?" (in %).

Source: own study based on the research results.

4. Conclusion

On the basis of the research carried out among representatives of the academic centre, it can be concluded that within the range of its activities, the municipality government should be significantly involved in supporting entrepreneurship using budgetary instruments, i.e. revenue and expenditure instruments. Although the use of these instruments is initially associated with a decrease in revenues and an increase in expenditure in the municipality budget, they play a special role in supporting entrepreneurship.

Owing to the specificity of revenue and expenditure instruments, as well as the municipality's pursuit of rational acquisition and expenditure of funds, in the field of supporting entrepreneurship the municipality government should focus its activities on budgetary instruments that bring the greatest possible benefits.

Taking into account the impact of the budgetary instruments used for the development of entrepreneurship, the municipality, should primarily apply reliefs and exemptions in local taxes and charges (without statutory reliefs and exemptions) as part of revenue instruments. However, in terms of expenditure instruments, the municipality should mainly use expenditure on technical infrastructure.

The presented results of the survey conducted among representatives of the scientific community make it possible to confirm the two research hypotheses put forward in the paper:

Hypothesis 1: Among the revenue instruments, reliefs and exemptions in local taxes and charges (without statutory reliefs and exemptions) have the greatest impact on the development of entrepreneurship.

Hypothesis 2: Among the expenditure instruments, expenditure on technical infrastructure has the greatest impact on the development of entrepreneurship.

The considerations presented in this article, primarily owing to the small sample in the experts' survey, do not fully exhaust the subject of budgetary instruments to support entrepreneurship by the municipality. In addition, owing to the changes that have taken place in the activities of the municipality government caused by, among others, the COVID-19 pandemic (Bąk, Dawidowicz, 2023) and the energy crisis, it is reasonable to repeat the survey among experts in order to verify the conclusions drawn.

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