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The impact of social capital on the economic performance of Polish family businesses

Beata Żukowska

ABSTRACT

Objective: This article aims to examine how various dimensions of family social capital (FSC) impact the economic performance of small and medium-sized family firms in Poland.

Research Design & Methods: This study employs a quantitative research design. I collected data from a sample of 196 family businesses. Structural modelling methods served to analyse the relationships between structural, cognitive, and relational dimensions of FSC and economic performance.

Findings: The main empirical results indicate that cognitive dimension of FSC which includes shared identity, shared vision, and shared goals have a significant positive impact on the economic performance of family firms.

Implications & Recommendations: It is crucial for family business managers to actively create opportunities for shared experiences among family business members and build a common cognitive foundation. It is also recommended to establish effective communication channels to ensure the development and maintenance of shared meanings and interpretations and development and acceptance of common goals. Advisory services and policymakers should highlight the benefits derived from strong social capital and recommend strategies to strengthen the cognitive dimension of FSC.

Contribution & Value Added: The novelty of this article lies in the applying multidimensional FSC framework in the context of Polish family businesses. Since the research about family business social capital is treated as one of its unique resources, there is a scarce of studies how this resource works in the context of transitional economies such as Poland, and they are mainly theoretical (Popczyk, 2017) or qualitative (*i.e.* Marjański *et al.*, 2019). This context is especially significant as many of these businesses are undergoing generational transfers for the first time now, leading to distinctive internal dynamics. Adopting the analytical method outlined by Carr (2011), this research implements a quantitative framework to analyse the FSC effects on the performance of family firm.

Article type: research article

Keywords: family businesses; social capital; performances; PLS-SEM; transitional economy

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INTRODUCTION

Social capital is an interdisciplinary concept widely used in both academic discourse and public debate. Strengthening social capital can be a goal pursued on a macro scale (potential directions for shaping the social and economic policy of the state), meso scale (an element of the development strategy of economic entities) and even micro scale (realization of the ambitions of individuals). The four great theorists of the issue, *i.e.* Bourdieu, Putnam, Coleman and Fukuyama, described the mechanisms of social capital and its benefits. The last of them, paid special attention to the family as the original, very important source of social capital in the world. Therefore, we assume that in organizations where there are family relationships between owners or management staff, social capital will take a different shape than in other entities, and as a result, uniquely affect their economic performance. Moreover, the dimensions

that build it can affect a variety of business outcomes, including non-economic ones (*e.g.*, successful succession), which, from the perspective of a family business, are among the key goals of its operation.

The research objective of the article is to analyse the impact of the various dimensions of social capital (structural, cognitive, and relational) on the economic performance of small and medium family businesses. This study contributes significantly to family business research by investigating family business capital within the context of a transitional economy, specifically Poland. The study employs an analytical approach developed by Carr *et al.* (2011), a framework widely used in examining FSC within family businesses in developed economies such as the United States (Rosecka & Machek, 2023), Spain (Herrero, 2018; Sanchez-Famoso *et al.*, 2015), and Chile (Llanos-Contreras *et al.*, 2022), as well as in developing countries like Tunisia (Mani & Lakhal, 2015) or Turkey (Tasavori *et al.*, 2018). However, this framework has yet to be applied in the context of a transitional economy with a relatively short history of a free market system, such as Poland's, which has only 35 years of market liberalization.

The topic of FSC in Polish firms has been part of the scientific discourse, but previous studies have been predominantly theoretical (Popczyk, 2017) or qualitative in nature (Marjański *et al.*, 2019). Notably, the uniqueness of the transitional economy context is particularly significant, as the majority of first-generation business successions began only around 2009 (Surdej & Wach, 2012). This offers a rare opportunity to observe how FSC influences performance in businesses where control remains largely in the hands of the first generation or has only recently shifted to subsequent generations.

Achieving the goal and verifying the stated hypotheses required a review of the domestic and foreign literature and empirical research. I collected primary data using the diagnostic survey method. Due to the multifaceted nature of the phenomena studied, I treated them as latent variables for the purposes of statistical analysis. Thus, I chose structural modelling as an appropriate method to explain the relationship between such variables.

In the first section, I will present a literature review and hypotheses development. The next section will discuss the research methodology, including data collection, variables description, and model specification. The results and discussion section will cover in detail the evaluation of the measurement and structural model. Finally, the conclusions section will present the main ideas and study limitations.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Social capital was introduced into economic discourse in the 1980s and quickly became one of the most popular concepts in the social sciences (Woolcock & Narayan, 2000). Its explicative value was appreciated not only in the macroeconomic field (as a predictor of material well-being or economic growth (Whiteley, 2000)) but also in the micro sphere (as a factor influencing competitiveness, innovation and, consequently, the financial performance of enterprises (Amara *et al.*, 2002; Wu, 2008)). However, before social capital found its way into models describing various economic relationships, researchers made attempts to theoretically organize this construct. It is widely accepted that the systematic foundation of the concept of 'social capital' was built by four authors, namely Bourdieu, Putnam, Coleman and Fukuyama.

The authors seem to agree that social capital is formed at least between two individuals who share a variety of relationships. Moreover, all four theorists recognize the value of social capital to achieve both individual and collective benefits.

The potential benefits, the development of which can support social capital, have become interesting not only from the perspective of theorists, but also business practitioners. Particularly interesting has become the microeconomic view of social capital (which boils down to the characteristics of a given organization that favour the emergence of benefits arising from internal cooperation and with the environment. Nowadays, there is a lot of research that precisely indicate how social capital resource can be supportive for innovativeness (Meyer, 2024; Eiteneyer *et al.*, 2019) and digital transformation (Daskalopoulos & Machek, 2024; Lang, 2023).

Making a distinction between internal cooperation and cooperation with the environment, it is necessary at this point to cite Putnam's proposed division of social capital into bonding and bridging capital. Bonding capital binds people together within a particular group, strengthens a sense of identity

and solidarity, and promotes homogeneity. On the other hand, bridging capital creates ties between groups and networks that integrate different actors and promotes cooperation between diverse entities (Claridge, 2018; Czapinski, 2008). Transferring this typology to the organizational setting, it can be said that bonding capital creates opportunities to ensure long-term, sustainable relationships between internal stakeholders (*e.g.,* employees) while social bridging capital enables the development of stable relationships with external stakeholders (*e.g.*, customers, contractors).

Each type of social capital is associated with different types of support or opportunities that can benefit the business entity. Table 1 summarizes selected potential benefits for the enterprise.

Table 1. Selected potential benefits of a company having a certain type of social capital

Type of social capital	Potential benefits
Bonding	- fosters an environment of collaboration, - shapes the motivation and commitment of employees, - enhances the dedication of the workforce, - promotes the sharing of information among the organization's members, - facilitates mutual learning among employees, - allows access to resources at the disposal of various employees, - enables a common understanding of terms and their use, - shapes the development of new products.
Bridging	- leads to enhanced trustworthiness, - fosters a network of partnerships with contractors/customers, - facilitates the exchange of resources with other entities, - builds customer loyalty, - supports entry into new markets, - favorable contract terms improve the company's performance, - reduces transaction costs, - increases the stability of the company's operations.

Source: own study based on Cofré-Bravo *et al.*, 2019.

The above-presented catalogue of potential opportunities brought by the possession and creation of social capital is not closed. Noteworthy, some of the listed benefits may, in the long term, translate into other benefits, *e.g.* the presence of loyal employees may positively affect the stability of the enterprise, access to knowledge about available forms of support may translate into an increase in the scope of business, etc.

However, social capital is also associated with certain phenomena that are much less desirable in the economic space. In the area of bonding and bridging social capital, abuses such as nepotism, corruption and price collusion are possible (Claridge, 2018). On the other hand, bonding capital can create a climate that excludes members of other groups ('cliquishness'). Moreover, excessive 'closure' of a group can stifle proactive behaviour and openness to innovation and the flow of new knowledge.

Fukuyama believed that 'the family is the first and very important source of social capital around the world.' In making this conclusion, he also recognized the risks that such a situation entails. Sometimes, trust within and outside the family remains in an inverse relationship: when one element is strong, the other usually weakens (Fukuyama, 2003, p. 174). According to Fukuyama, strong family ties can contribute to the realization of a closed attitude toward other social groups. Fukuyama illustrates his considerations by citing businesses in Latin America as an example. Most of the businesses established in the area are family businesses, since the strongest and most secure ties of trust are between family members or relatively small circles of close friends. Social capital is located primarily in kinship networks, which are consequently an important social resource. At the same time, the author notes that family ties in such enterprises can be a burden, resulting from a lack of trust in strangers. A manifestation of such a limitation may be the problems experienced by family businesses in the process of transforming themselves into large, professionally managed corporations with dispersed public ownership (Fukuyama, 2002).

The dual nature of social capital within family businesses, illustrated by the above considerations, provided the foundation for the concept of FSC developed by the team of Arregle (2007). The researchers recognized that family ties provide a foundation for moral behaviour, upon which cooperation guidelines and principles of reciprocity and exchange are then developed. Increased reciprocity and exchange enhance the creation and use of social capital, derived from dynamic factors specific to the family: stability, interdependence, interaction, and hermeticity. The uniqueness of these factors results in building unique resources, which Habbershon and Williams (1999) define as 'familiness.' According to Pearson *et al.* (2008), the concept of familiness plays a crucial role in the social capital found within family-owned enterprises. Numerous scholars acknowledge its vital role in securing competitive advantages (Sanchez-Famoso *et al.*, 2013; Sorenson *et al.*, 2009). As articulated by Sirmon and Hitt (2003), FSC serves as a fundamental element that fosters the unique 'familiness' within a business context. They point out how effectively FSC could contribute to the enhancement of human capital as represented by the upcoming generation.

Moreover, the cultivation of FSC is also significant within the framework of socioemotional wealth theory (SEW). According to SEW, family involvement in business brings non-economic resources, such as emotional attachment, that are unique to family firms (Gómez-Mejía *et al.*, 2007). These resources are inimitable, and scholars have explored their influence on business performance (e.g., Davila *et al.*, 2023; Razzak & Jassem, 2019). The benefits derived from SEW align with the structuralist perspective of social capital, which emphasizes the advantages that arise from close-knit groups within closed networks (Cruz *et al.*, 2012). Moreover, the emotional values emphasized by SEW play a crucial role in fostering and developing FSC. Families often prioritize long-term goals such as maintaining their reputation, preserving the business, and sustaining family identity. These motivations contribute to a heightened focus on cultivating trust, transparency, and cohesion within the family, which ultimately strengthens the FSC. Moreover, valuing their reputation positions family businesses might serve as a model of ethical leadership, which in turn also enhances internal social capital (Sanchez-Famoso *et al.*, 2021).

To better understand the construct of social capital in a family business, it is worth drawing on the analytical tool proposed by Nahapiet and Goshal (1998), which proposes distinguishing three of its dimensions: structural, cognitive, and relational. The structural dimension reflects the arrangement and strength of ties within the members of a group. It includes the resources that facilitate interaction and information transfer, as well as the extent to which the structural features of the organization create a network that facilitates joint action. The cognitive dimension consists of elements that ensure the existence of shared systems of meanings, interpretations or perceptions. It reflects the common purpose and meaning created by enduring relationships within an organization or group. On the other hand, the relational dimension represents trust, responsibilities, and obligations arising from personal relationships created through the structural and cognitive dimensions (Carr *et al.*, 2011).

In a family business, the structural dimension is formed by relationships developed within the family, which are then transferred to the business being run. Relationships developed over many years are well-known to family members and provide a strong foundation for taking initiatives together. On the other hand, the uniqueness of the cognitive dimension is due to its deep roots not only in the history of the business, but also in the history of the family. The family has shared systems of meanings, interpretations or perceptions, which can in turn serve to build a common vision and goals for the enterprise. In the relational dimension, the peculiarities of a family business are manifested primarily through attitudes and behaviours such as cooperation, communication and above average commitment. These are made possible by so-called 'resilient' trust – based on shared values and beliefs and a strong sense of identity (Żukowska, 2021).

Moreover, in the transition countries, FSC might also have its peculiarities. In transitional contexts, such as those found in post-communist countries like Poland, the general levels of social capital are relatively low (Czapiński, 2008). The trust towards formal institution (extended trust) is also lower than in developed countries (Raiser *et al.*, 2002). As a result, family businesses, especially small and medium ones may rely more heavily on their internal social capital to navigate uncertainties, compensate for weak external institutions, or fill gaps in formal support systems.

However, we should not treat even small and medium family businesses as homogeneous entities. They can differ in terms of non-family involvement in governance, goals or resources (Chua *et al.*, 2012). This heterogeneity is also visible in the form of involving FSC in family businesses. Sanchez-Ruiz *et al.* (2019) identified three types of firms: with instrumental, identifiable, and indistinguishable FSC. Family firms with instrumental social capital are most 'saturated' with its components, *i.e.* structural, cognitive, and relational capital. Firms that possess identifiable FSC have a recognizable manifestation of FSC. However, these resources are slightly below average. Enterprises with indistinguishable FSC represent the lowest levels of FSC. The researchers indicated that various types of family enterprises are uniquely affected by the interplay of different aspects of social capital, which is evident in both their financial and non-financial results.

The main issue related to the uniqueness of FSC in a family business is its impact on competitive advantage and, as a result, economic performance. Table 2 presents a review of previous studies on FSC and performance.

Table 2. Previous studies on family social capital (FSC) and performance in family firms

Reference	Outcomes
Sorenson *et al.* (2009)	FSC has a positive effect on firm performance.
Sanchez-Famoso *et al.* (2015)	FSC has a positive effect on firm performance. Non-FSC (social capital based on non-family relationships) also has a positive effect. The effect of non-FSC is stronger than the FSC effect.
Herrero (2018)	Higher levels of FSC have a positive effect on return on equity (ROE). Bonding capital earned by non-family employees, was an insignificant predictor of performance.
Tasavori *et al.* (2018)	FSC improves international firm performance (sales volume, market share, profitability, market access, return on investment, customer satisfaction and development of image in international markets).
Herrero & Hughes (2019)	Greater importance than the level of FSC has its form. The relational dimension has a positive impact on the financial performance of a family business. A curvilinear (inverted U-shaped) relationship was identified between the structural dimension of FSC and financial performance.
Sanchez-Ruiz *et al.* (2019)	FSC has a positive company impact on optimism about the company's prospects, the willingness of the older generation to hand over control of the company to future generations, and the degree to which successors accumulate experience outside their own family business.
Rosecká & Machek (2023)	There is a positive relationship between FSC and family firm performance. Relational conflict deteriorates firm performance indirectly through the destructive impact on FSC.
Stasa Ouzký & Machek (2024)	Bonding social capita, has negative or no effect on performance.

Source: own study.

The research shows that the family can indeed be a stable, strong source of social capital for a family business (Carr *et al.*, 2011; Barros-Contreras *et al.*, 2023). Nevertheless, research indicates that while social capital is known to provide advantages in both economies and organizations, having a surplus of it within a family business does not necessarily lead to improved financial outcomes. For example, studies indicate that over-saturation of FSC, especially on a structural level, can negatively affect a company's profitability or sales growth. According to Herrero and Hughes (2019), there is a certain level of 'entanglement' of family members in family relationships that makes it difficult for other external relationships and ideas to enter the family pool of knowledge. Moreover, examining the structural aspect, which pertains to the robustness and configuration of familial connections, suggests that an overabundance of these ties may lead to issues associated with nepotism or paternalism (Firfiray *et al.*, 2018). Conversely, there is research showing that nepotistic behaviours can contribute positively to organizational success (Schmid & Sender, 2021), whereas other findings suggest they have little to no effect on financial or

market outcomes (Urassa, 2016). In the realm of small family-run businesses in Poland, the practice of nepotism is regarded as a source of employee disillusionment (Sułkowski, 2012) and can result in a significant decline in ethical integrity (Dobrowolski *et al.*, 2022). The onset of such challenges may lead to a downturn in the company's financial performance. Hence, I hypothesised:

H1: The structural dimension of social capital has a negative impact on the economic performance of a family business.

According to Herrero and Hughes (2019) the relational dimension, which includes trust and commitment, positively impacts the financial performance of a family business and does not harm performance at relatively high levels. Numerous studies have confirmed the beneficial role of trust in reducing transaction costs (Puffer *et al.*, 2010) and fostering entrepreneurial outcomes (Shi *et al.*, 2015). Cruz *et al.* (2010) highlight that small to medium-sized family businesses are particularly well-positioned to capitalize on the advantages of trust. Moreover, family commitment, often characterized by a deep emotional attachment and long-term dedication to the firm, has been shown to correlate positively with business performance (Razzak *et al.*, 2021). This commitment enhances the unity of the organization, maintains strategic consistency, and strengthens the firm's capability to adeptly confront market challenges. These prior empirical results allowed us to assume the following research hypothesis:

H2: The relational dimension of social capital has a positive impact on the economic performance of a family business.

The cognitive dimension of FSC, which encompasses shared identity, vision, and goals, has been identified as particularly supportive in enhancing access to knowledge and capabilities (Parra-Requena *et al.*, 2010; Terry Kim *et al.*, 2013) and fostering product innovations (Zirena-Bejarano, 2024). Moreover, Sanchez-Ruiz *et al.* (2019) found that in family businesses where the cognitive dimension of FSC is most pronounced, the transgenerational intentions are enhanced, and the successors demonstrate greater preparedness and experience. This suggests that shared values and visions not only improve the internal coherence of family businesses but also strengthen their long-term viability. These positive influences can be supportive of the hypothesis:

H3: The cognitive dimension of social capital has a positive impact on the economic performance of a family business.

RESEARCH METHODOLOGY

Method of Data Collection and Description of the Sample

I applied quantitative research approach. I collected the data via a survey questionnaire between April 2021 and June 2021. The questionnaire was e-mailed to 7142 owners and managers of small and medium family businesses located in Poland. To classify the businesses according to their size, I applied the OECD definition (Madani, 2018). Since there is no official dataset of family businesses in Poland, I compiled the mailing by searching the media, family business foundations, and national registers. To qualify a company as a family business, I adopted the substantial family influence (SFI) criterion developed by Klein (2000). According to it, a family business should be considered such a business entity that is significantly influenced by one or more families (the family is the sole owner, or if not, the lack of influence on ownership is offset by involvement in the board of directors or management). A business should be considered family-owned when the SFI is greater than or equal to 1. To fulfil the requirements for SME classification, the number of employees should not exceed 250 people.

I collected a total of 326 responses. The final sample size was reduced to 196 observations due to missing information and the exclusion of companies that did not meet the SFI criterion or declare that their business employ more than 250 employees.

I addressed the concern of non-response bias by comparing the responses of early and late respondents (Kanuk & Berenson, 1975). I divided the sample into two subsets based on response time. The conducted t-tests did not reveal any statistically significant differences between the responses of these two groups.

To verify if the common method bias was an issue in the presented research, I conducted Harman's one-factor test. The total variance extracted by a single factor was 49.23%, which is below the commonly accepted threshold of 50% (Riley *et al.*, 2018).

The characteristics of the study sample (age, sectors, generations involved) are similar to those used in other studies conducted on family businesses in Poland (Pernsteiner & Węcławski, 2016; Żukowska *et al.*, 2021 – Table 3). Hence, we can conclude that the sample did not suffer from the sample bias. However, a significant problem in the context of the possibility of comparability of results is the lack of a universal definition of a family business used in Poland and around the world.

Table 3. Representativeness across samples

Variables	Current study	Pernsteiner & Węcławski, (2016)	Żukowska, Martyniuk & Zajkowski (2021)
Employment	48.93	114.00	43.74
Age	22.76	21.00	23.64
Sector			
Production (without building industry)	0.37	0.43	0.44
Retail	0.43	n/a	0.28
Other	0.67	n/a	0.58
Generation of owners			
Founder-owned	0.46	0.68	0.48
Second	0.51	0.31	0.47
Third or next	0.03	0.01	0.05
Generation of management			
Founder	0.50	n/a	0.40
Second	0.45	n/a	0.54
Third or next	0.05	n/a	0.06

Source: own study.

On average, the surveyed family business employed 36.4 people. Most businesses (79.6%) employed less than 50 employees (small enterprises). This finding aligns with Surdej and Wach's observations (2012), who noted that the predominance of small family businesses is an inherent characteristic of transition economies. On average, examined family businesses operated in the market for 22.76 years. Most of the companies operated in the service sector (67.3% of companies), less frequently in trade (42.9%) and production (including construction and agriculture) (36.7%), only 1.02% indicated 'other' sector. More than half of the companies had a representative of the second or next generation among their owners. Exactly 49.5% of the companies were managed only by the first generation. Thus, we can assume that at least partial succession (transfer of power or ownership to the next generation) had already taken place in about half of the family businesses surveyed.

Variables Used in the Model

I used a tool developed by Carr and his team (2011) to measure internal social capital. Questions from the questionnaire were independently translated into Polish and discussed with experts.

The structural, relational and cognitive dimensions of social capital presented in Table 4 were treated in further analyses as latent variables expressed by their corresponding indicators (SC_STR1, SC_STR2, SC_STR3, SC_STR4, SC_REL1, SC_REL2, SC_REL3,SC_REL4, SC_COG1, SC_COG2, SC_COG3, SC_COG4). These indicators have values between 1 and 7, with 1 indicating that the respondent certainly disagrees with a given statement, while 7 indicated that he or she certainly agrees with it.

To operationalize the assessment of a company's economic performance, I assumed that their overall perception is influenced by four areas: perceptions of their return on assets, market share, customer satisfaction, and increasing competitive position. The use of quasi-perceptual measures in economic and management sciences is a relatively common phenomenon, which often results from lacking access to objective sources and respondents' reluctance to provide real data. In the process of

evaluating a phenomenon, quasi-perceptual measures are based on the perception of 'ready-made' objective indicators, *e.g.* profitability, market share or sales growth (Ketokivi & Schroeder, 2004). Studies have shown that measurements made using such measures are positively correlated with those made using objective measures and indicators (Santos & Brito, 2012). In the present analysis, I used such measures to assess a company's economic performance, which relates to both its financial, strategic and market situation. A similar approach was used, for example, by Randolph *et al.* (2019).

Table 4. Indicators for measuring the dimensions of internal social capital

ID	Content of the indicator
Structural dimension	
SC_STR1	Family members who work in the company communicate honestly with each other
SC_STR2	Family members who work for the company have no hidden agendas
SC_STR3	Family members who work for the company are eager to exchange information
SC_STR4	Family members working in the company use family relationships to share information
Relational dimension	
SC_REL1	Family members working in the company can count on each other
SC_REL2	Family members who work in the company are very honest with each other
SC_REL3	In general, family members working in the company trust each other
SC_REL4	Family members who work for the company tend to respect each other's feelings
Cognitive dimension	
SC_COG1	Family members working in the company are dedicated to the goals of the company
SC_COG2	Family members working in this company share a common goal
SC_COG3	Family members who work in the company see themselves as partners in setting the company's direction
SC_COG4	Family members who work in the company share the same vision for the future of the company

Source: own study based on Carr *et al.*, 2011.

I asked respondents to rate their own company against the industry (on average over the past 5 years) according to the indicators in Table 5. Respondents answered using a 5-point scale, where 1 meant well below average, and 5 meant well above average.

Table 5. Indicators for measuring the economic performance of a family business

ID	Content of the indicator
PER_ROA	Return on assets
PER_Market_share	Market share
PER_Customer_satisfaction	Customer satisfaction with services/products provided
PER_Growth_competitive_position	Increase in competitive position

Source: own study.

Next, I used the presented measures to describe the multivariate latent variable, which was the financial performance of the family business.

The first step in developing a model to explain the impact of different dimensions of social capital on the economic performance of family firms was the preliminary preparation and analysis of the acquired data. The final sample included 196 observations. Among the variables describing the perception of economic performance, there were missing data (2.6% of observations for the PER_ROA variable, 1.5% of observations for the PER_Market_share variable and 1.5% of observations for the PER_Growth_competitive_position variable). I decided to perform an imputation. I inserted the median values for the entire sample in place of the missing data.

Table 6 presents the analysis of the descriptive statistics of the studied variables.

The analysis of descriptive statistics indicated that the distributions of variables describing dimensions of social capital were strongly left-skewed and leptokurtic. This indicate of their strong deviation from a normal distribution.

Research Method

Analysis of the acquired data showed that the distributions of the observed variables deviated significantly from normal distributions, which can be a significant burden when using traditional structural modelling methods (CB-SEM). Moreover, according to some researchers, the sample size (200 observations) limits their use. Therefore, I decided to use an alternative method, namely PLS-SEM. I used R programming language and the R Studio environment to conduct the analyses. I conducted the modelling process using the SEMinR package (Ray *et al.*, 2022).

Model Specifications

Based on a literature search indicating potential relationships between social capital (its dimensions) and the economic performance of family businesses, I constructed a hypothetical model presented in Figure 2.

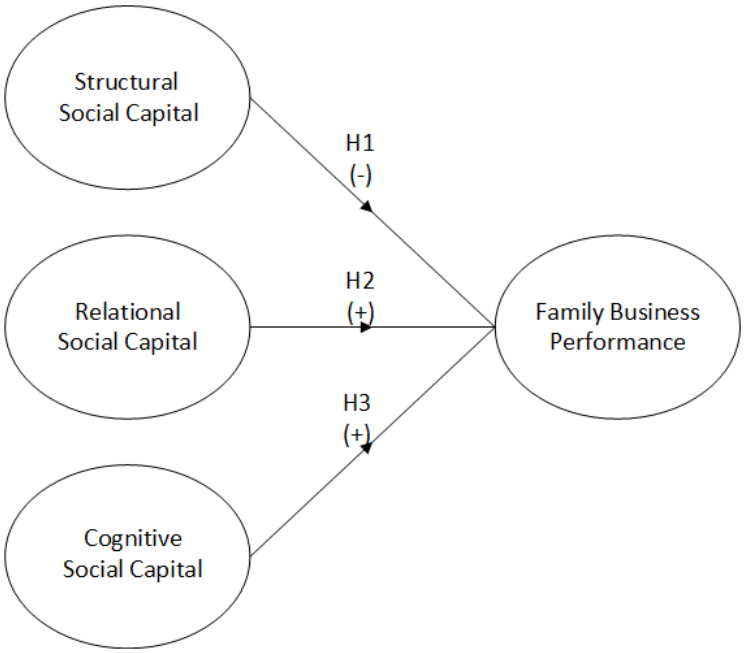

Figure 1. Hypothetical model of the impact of social capital dimensions on the economic performance of a family business
Source: own elaboration.

This structural model consists of latent variables described by the indicators presented in Tables 4 and 5. According to the literature, the FSC scale is conceptualized as a second-order reflective construct (Sanchez-Famoso *et al.*, 2015; Casanueva-Rocha *et al.*, 2010). Consequently, the dimensions that comprise it are also modelled reflectively. Previous studies also treated economic performance of family businesses as a reflective construct (Randolph *et al.*, 2019; Zellweger *et al.*, 2012). I evaluated PLS-SEM results according to the procedure for reflective constructs described by Sarstedt *et al.* (2014).

RESULTS AND DISCUSSION

Evaluation of the Measurement Model

Evaluation of the measurement model should begin with an assessment of the values of the external loadings of the indicators that make up the model. In the proposed measurement model, not all loadings reached a value above 0.70 (Table 7). However, the potential removal of indicators would not significantly increase the internal consistency reliability, Thus, I decided to leave them in the model. It is also acceptable to keep indicators with loadings above 0.5 (Cheung *et al.*, 2024).

The next step was to assess the internal consistency reliability of the measurement model. To perform it, I used Cronbach's alpha estimation (Table 8). The values exceeded or were close to exceeding

0.7, which, according to the rules of thumb, means the internal consistency of the tested constructs. Next, I assessed convergent validity, verifying the strength of correlation between the same characteristics measured by different indicators. Convergent validity was assessed using the average variance extracted (AVE – Table 8). A value higher than 0.5 was achieved for each latent variable, meaning that the constructs explain more than 50% of the variance in their indicators.

Table 7. Indicator loadings/weights

Measures	Structural dimension	Relational dimension	Cognitive dimension	Economic performance
SC_STR1	0.9022	–	–	–
SC_STR2	0.8466	–	–	–
SC_STR3	0.8920	–	–	–
SC_STR4	0.6288	–	–	–
SC_REL1	–	0.8478	–	–
SC_REL2	–	0.9349	–	–
SC_REL3	–	0.9472	–	–
SC_REL4	–	0.9085	–	–
SC_COG1	–	–	0.8526	–
SC_COG2	–	–	0.9099	–
SC_COG3	–	–	0.9096	–
SC_COG4	–	–	0.8788	–
PER_ROA	–	–	–	0.6223
PER_Market_share	–	–	–	0.6459
PER_Customer_satisfaction	–	–	–	0.8365
PER_Growth_competitive_position	–	–	–	0.7536

Source: own study.

Table 8. Assessment of internal compliance reliability

Measured construct	Cronbach's alpha	AVE
Structural dimension	0.837	0.6804
Relational dimension	0.931	0.8288
Cognitive dimension	0.910	0.7886
Economic performance	0.699	0.5180

Source: own study.

I examined discriminant validity, which determines the degree to which a construct differs empirically from other latent constructs used in the model, using the Fornell-Larcker criterion. The AVE square root values estimated for the structural dimension, relational dimension, cognitive dimension and economic performance were higher than their highest correlation with other constructs. Therefore, all analyzed constructs achieved discriminant validity (Table 9).

Table 9. Fornell-Larcker test of discriminant validity

	Structural	Relational	Cognitive	Economic performance
Structural dimension	0.8249	–	–	–
Relational dimension	0.7524	0.9104	–	–
Cognitive dimension	0.6923	0.7512	0.8880	–
Economic performance	0.1603	0.2573	0.3516	0.7197

Source: own study (AVE square roots are on the diagonal and construct correlations on the lower triangle).

Based on the above analyses, we can assume that the adopted measurement model was appropriate and met all the criteria related to the assessment of internal consistency reliability, convergent validity, and discriminant validity.

Evaluation of the Structural Model

The evaluation of the structural model should begin with the verification of potential collinearity between the predictors for the endogenous variable 'economic performance.' For this purpose, I estimated the VIF (variance inflation factor) measure for latent constructs describing each dimension of social capital (Table 10). Thus, I created three multiple regression models (for each variable 'structural dimension', 'relational dimension', 'cognitive dimension') using the remaining explanatory variables from the structural model as predictors. To calculate the VIF measure, it was necessary to estimate the R2 for each model. The VIF values below 3.3 indicated the absence of a collinearity problem in the indicators (Kock, 2015).

Table 10. Evaluation of collinearity in the structural model

Predictors	VIF
Structural dimension	2.520
Relational dimension	3.012
Cognitive dimension	2.510

Source: own study.

To begin the analysis of path parameters, allowing verification of the hypotheses, first, I had to perform a bootstrapping procedure. I assumed that the size of the bootstrap sample should be exactly the number of observations used for estimation in the model (196). In accordance with the recommendations, estimation was carried out on 5000 drawn samples (draw with return) (Hair *et al.*, 2013).

Figure 2 shows the standardized values of the path parameters. It turns out that the cognitive dimension of social capital had the strongest positive impact on the economic performance of family businesses. The relational dimension had a near-neutral impact (a small indicator value), while the structural dimension had a relatively small negative impact on economic performance.

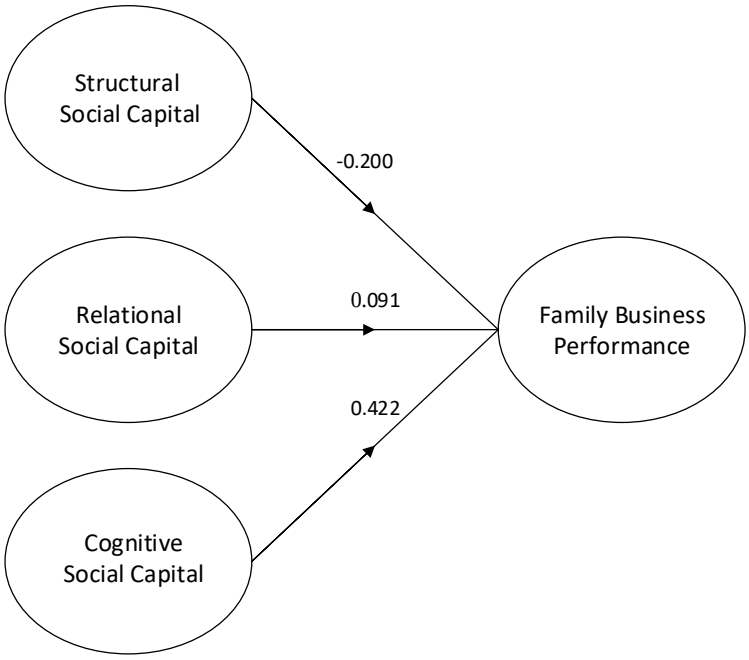

Figure 2. Impact of social capital dimensions on the economic performance of family businesses: Results of the path model

Source: own elaboration.

To verify the hypotheses, I assessed the statistical significance of the estimated parameters. I did it based on a 95% bootstrap confidence interval analysis. Only in the case of the path of the cognitive di-

mension economic performance, the interval contained a value of 0. This means that the parameter 'cognitive dimension' can be considered significant. The other dimensions did not have a statistically significant effect on the explanatory variable (Table 11). The Table also presents F2 effect sizes presenting how the exclusion of a specific predictor variable influences the R^2 value of an endogenous variable.

Table 11. Statistics of standardized path coefficients

Pathways	Value from output data	Average of 500 bootstrap trials	Standard error	95% bootstrap confidence interval		F2
				Lower limit	Upper limit	
Structural dimension → Economic performance	-0.200	-0.157	1.239	-0.361	0.090	0.017
Relational dimension →Economic performance	0.091	0.072	0.776	-0.147	0.315	0.003
Cognitive dimension →Economic performance	0.422	0.416	0.611	0.166	0.640	0.077

Source: own study.

The final step in evaluating a structural model is to check its explanatory power. The commonly used measure for this purpose is the coefficient of determination R2, which measures what proportion of the variance of an endogenous construct is explained by the model. The analyzed model was characterized by rather low coefficient of determination R2 = 14.05%. However, it should be kept in mind that low levels of these indicators are relatively common for models describing business phenomena, and, in this case, can be considered acceptable (Hair Jr. *et al.*, 2016, p. 199). The model's SRMR (calculated using SmartPLS software) is 0.074, which, according to Hu and Bentler (1998), indicates an acceptable model fit.

I employed Gaussian copula approach to check for potential endogeneity in the model. Since none of the copulas were statistically significant, it suggests that endogeneity was not a concern in this model.

CONCLUSIONS

Numerous studies have extensively examined the influence of social capital on SMEs, with a significant consensus among researchers that it positively affects businesses. This influence is evident in its ability to lower transaction costs, promote collaborative efforts, and foster learning opportunities (Dar & Mishra, 2020; Gamage *et al.*, 2020; Marjański *et al.*, 2019). In transitional economies, where the overall levels of social capital tend to be lower, leveraging this resource within SMEs becomes particularly critical. The challenges of weak institutional frameworks and limited access to external networks in such economies make the cultivation of internal social capital even more essential for business success. As Fukuyama (1995) emphasized, 'the family is the first and most important source of social capital worldwide,' making family businesses an ideal environment to harness and maximize this valuable resource.

The presented model was designed to explore the impact that FSC (its various dimensions) has on the economic performance of small and medium family businesses from transition countries. I based the concept of the measurement model on literature analysis. Estimation of the path model showed that there was a negative relationship between the structural dimension and economic effects. However, its significance was not confirmed statistically. The relational dimension of social capital turned out to be neutral in shaping the economic performance of family businesses. In contrast, the model showed that the cognitive dimension of social capital had a positive, statistically significant effect on economic performance. On this basis, we should assume that hypotheses 1 and 2 were verified negatively. However, the model confirmed hypothesis 3.

The model showed that the component of social capital that influences the economic performance of family businesses is its cognitive dimension. This dimension is formed by elements that build the existence of shared meanings, interpretations, goals and visions of the future. Noteworthy, the longer and deeper the relationship between individuals, the easier it is to find shared stories or experiences, which then translate into a similar 'perception' of situations that, in some sense, are similar to what they have

managed to experience together in such a relationship. This, in turn, may also be reflected in similar beliefs about further decision-making (because of shared experiences, it is easier to make similar choices or show a greater understanding of dissenting views). A strong cognitive dimension means that the goals of individual internal stakeholders are shared, as are their ideas about the future of the organization. The common cognitive underpinning of the owners or managers can be a strong asset for a family business, which, as the research presented here confirmed, also translates into the material dimension (economic performance). This finding aligns with the results obtained by Herrero and Hughes (2019), who demonstrated that the cognitive dimension of family social capital (FSC) positively influences the financial performance of family firms, specifically in terms of return on equity (ROE). Additionally, there is evidence suggesting that a high level of saturation in the cognitive dimension is critical for expanding market share through internationalization efforts (Tasavori *et al.*, 2018). This is also consistent with my results, as market share was one of the key measures used to assess economic performance.

The results indicate that the structural dimension of social capital has a negative, though statistically insignificant, impact on family business performance. While the direction of this finding is not surprising, the lack of statistical evidence limits the strength of this conclusion. High saturation of the structural dimension may lead to challenges for family businesses, particularly in terms of excessive closure within the family circle. Herrero and Hughes (2019) aptly describe this phenomenon as 'too much of a good thing,' where over-reliance on internal family ties can create inefficiencies. This can manifest in problems such as nepotism, where decisions are made based on familial relationships rather than merit, thereby negatively affecting the company's strategic direction and performance. Furthermore, it is important to emphasize that internal relations (bonding social capital) tend to be less impactful for family businesses than external relations, which contribute to bridging social capital. Stasa and Machek (2024) contend that bridging social capital – connections that go beyond familial ties – plays a vital role in enhancing firm performance while bonding capital tends to have neutral or even detrimental impacts on performance. This is particularly significant for smaller enterprises, where access to external resources is of greater importance (Stam *et al.*, 2012).

The lack of a statistically significant effect of the relational dimension on family business performance contradicts much of the existing literature, which emphasizes the positive impact of trust and commitment on the outcomes and advantages of family firms (Razzak *et al.*, 2021; Habbershon & Williams, 1999). This discrepancy may be attributed to cultural differences. Unlike their counterparts in economies with a longer history of market dynamics, Polish family entrepreneurs may not fully utilize the formal mechanisms that support trust, which is well-documented in international literature: family protocols (Rodriguez-Garcia & Menéndez-Requejo, 2020), family assemblies, family councils (Gnan *et al.*, 2015), and other governance mechanisms in fostering trust and commitment. These frameworks establish explicit mechanisms concerning the participation of family members, remuneration, and advancement opportunities within the organization, thereby minimizing uncertainty in roles and effectively aligning the expectations of both family stakeholders and employees (Sundaramurthy, 2008). Such measures are essential in building 'system trust' within the organization. However, research indicates that these family business governance mechanisms are rarely systematically applied in Polish family firms (Żukowska, 2021; Koładkiewicz, 2015). The absence of formal structures to guide family relationships in business may result in missed opportunities to capitalize on the potential benefits of trust and commitment. However, this assumption requires further studies.

Social capital, although it can be developed in any type of organization, in a family business is a unique resource, extremely difficult or even impossible to forge. This is due to the family ties present in such entities, which form the basis of moral behaviour, cooperation and reciprocity. Family relationships are usually characterized by greater stability, interdependence, increased scope of interaction and a kind of hermeticity. The conditions under which social capital is 'created' in a family business are, therefore, special, which consequently translates into the results that such an entity can achieve.

From a practical perspective, the results of this study suggest that organizational leaders should prioritize developing the cognitive dimension of social capital by fostering an environment that encourages shared narratives, experiences, and active discussions about the business's direction. Creating opportunities for team members to share stories and knowledge – through activities such as joint non-business

projects, regular family meetings, or retreats – can help build a shared understanding of the organization's goals and values. Moreover, facilitating discussions about the future of the company can address important topics like succession, which is critical for the long-term sustainability of family businesses.

These objectives can be further supported through formal mechanisms, such as family protocols, succession plans, and the establishment of governing bodies like family assemblies or family councils. These solutions are relatively low-cost and can be implemented even by small and medium-sized enterprises (SMEs).

Moreover, family business advisors should stress the importance of clear communication and transparency when setting business goals and emphasize the tangible benefits of these practices. Furthermore, policymakers could develop supportive frameworks that encourage social capital building, tailored specifically to the needs of family business SMEs. As some simple solutions are often not widely known or utilized by family business entrepreneurs, educational and awareness-raising initiatives could be beneficial in helping these firms adopt best practices.

The presented study has its limitations, the primary one being the small sample size, which precluded the use of traditional structural modelling methods. Secondly, due to the absence of an official register of family businesses in Poland, I could not verify whether the dataset of family businesses used in this study accurately reflects the entire population of Polish family businesses. This issue is common in family business research. To address this limitation and ensure the representativeness of the sample, I compared the characteristics of the final sample with findings from other studies on Polish family businesses. Thirdly, the study focused solely on the social capital based on family relations. It is worth exploring more on the non-FSC, which, according to previous studies, can be supportive of FSC development. Fourthly, gaining more detailed insights into the factors that impact performance could be highly valuable. Exploring the specific components that constitute each dimension of family social capital (FSC) can lead to more precise conclusions and recommendations for family business stakeholders.

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Appendix A: The survey questions

1. Please rate to what extent you agree with the following statements about social capital in relation to your company (1- strongly disagree, 7 – strongly agree).

Family members who work in the company communicate honestly with each other
Family members who work for the company have no hidden agendas
Family members who work for the company are eager to exchange information
Family members working in the company use family relationships to share information
Relational dimension
Family members working in the company can count on each other
Family members who work in the company are very honest with each other
In general, family members working in the company trust each other
Family members who work for the company tend to respect each other's feelings
Cognitive dimension
Family members working in the company are dedicated to the goals of the company
Family members working in this company share a common goal
Family members who work in the company see themselves as partners in setting the company's direction
Family members who work in the company share the same vision for the future of the company

2. How would you rate the company compared to the industry (on average over the last 5 years)? (1-significantly below average, 5-significantly above average) alternatively (5 – 20% best performance in the industry, 1 – 20% worst performance in the industry)

ROA
Market_share
Customer_satisfaction
Growth_competitive_position

3. Do you see your company as a family business? **Yes/No**
4. How much of the capital is owned directly or indirectly by the entrepreneur's family? (The total should be 100.)

Family members (in %)
Non-family members (%)

5. Which generation of the family owns shares in the company? (several answers can be ticked)

First generation (founder)
Second generation
Third generation
Fourth or further generation
The family does not own shares in the company

6. How many persons does the company's board of directors consist of? (if there is no board of directors, a management body)
   Total number of persons
   of which: number of persons who are family members
   of which: number of persons not in the family
   of which: number of women
7. Is the key decision maker in the company (CEO/principal decision maker) a family member?
   Yes/No/Refuse to answer
8. Which generation of family members is on the company's board/management? (several answers can be ticked)
   First generation (founder) ☐
   Second generation ☐
   Third generation ☐
   Fourth or further generation ☐
   There is no family representative on the board ☐
9. Does the company have an established (formal) supervisory body?
   Not ☐
   Yes, the supervisory board ☐
   Yes, another body ☐
10. How many people does the supervisory body in the company consist of?
    Total number of persons
    of which: number of persons who are family members
11. Please indicate the year in which the company was founded.
12. Please indicate the postal code of the company's headquarters.
13. Please specify the sector in which the company operates (several can be specified).

Trade
Services
Production
Other

14. Please indicate the number of employees in the last year (2020).
15. How many family members have worked for the company in the last year (2020)?

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Conflict of Interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Twitter/X activity and financial performance: Evidence from European listed companies

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ABSTRACT

Objective: The study aims to investigate the adoption level of Twitter/X for corporate communication in the European context, specifically aspects such as the creation of Twitter accounts, follower number, and tweet frequency. We expand the data analysis framework to provide a comprehensive description of the different types of businesses using Twitter. The article's ultimate goal is to provide insight into their financial characteristics, including profitability, growth options, and leverage.

Research Design & Methods: Using a large novel dataset (nearly 5.5 million tweets) from 41 European stock exchanges, we provide a comprehensive picture of the social media activity of 21 319 listed companies. We applied box plots, data visualisation, and exploratory data analysis to provide a concise visual summary of the data's distribution to compare multiple datasets or identify any potential outliers or skewness.

Findings: Our findings indicate that growth companies are more likely to use Twitter/X for corporate communications. However, the relationship between profitability and Twitter adoption is not clear. The level of Twitter/X adoption for corporate communication in companies listed in Europe is lower than in the Northern American ones.

Implications & Recommendations: Companies should consider adopting social media as part of their communication strategy to enhance their financial performance. Our study contributes to the understanding of social media's role in corporate communication and its potential impact on the financial performance of European listed firms.

Contribution & Value Added: The literature review reveals that the predominant focus of Twitter research has been on samples derived from the US market, whereas studies pertaining to Europe tend to concentrate on specific markets or sectors. To our knowledge, there is no comprehensive research on listed Twitter-using firms in the EU.

Article type: research article

Keywords: stock markets; Twitter; social media; corporate communication; financial performance

JEL codes: G14, G15, G41

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INTRODUCTION

The rise of real-time social networking platforms, exemplified by Twitter, has profoundly transformed the landscape of corporate communication, ushering in a new era of information dissemination (Kim *et al.*, 2022). We have witnessed a remarkable shift in the corporate sphere, with Twitter adoption surging from 15% in 2010 to an impressive 65% of firms in Corporate America by 2017. According to Al Guindy *et al.* (2024), by 2020, the majority of businesses listed in the three major US exchanges, namely 2 518 out of 3 882 firms (65%), were utilising the social media platform Twitter. This transition was catalysed by the Securities and Exchange Commission (SEC), which, recognising the evolving communication landscape, permitted in 2013 that corporations could use social media platforms for dis-

seminating corporate news. This pivotal change came with the stipulation that companies inform investors about the utilization of their social media accounts for such purposes, thus reinforcing the rationale for leveraging these platforms to engage stakeholders. However, social media adoption for corporate communication purposes varies across the world and is largely influenced by regulatory frameworks, linguistic diversity, and cultural landscapes. As far as China is concerned, where different social media platforms prevail, the government has implemented a policy that promotes internet usage while simultaneously exercising strict oversight (Ang *et al.*, 2021). While the USA has progressed towards incorporating social media channels into corporate disclosure frameworks, countries like Australia and Canada promote integrating social media communications with their pre-existing regulations (Hamade *et al.,* 2024). In contrast to the US, the European Union has enacted more stringent rules and procedures governing the dissemination of crucial corporate updates. These regulations are designed to ensure equitable access to precise information through national databases, known as Officially Appointed Mechanisms (OAMs), coupled with directives mandating the public availability of information on the company's website. While European firms are not precluded from sharing news on social media, it can only occur after making the information available via a regulatory information service. Due to differences in regulatory environments concerning disclosure channels in the US and Europe, we aim to analyse the extent of Twitter adoption for corporate communication purposes.

In response to evolving communication dynamics in global corporations, numerous empirical studies have scrutinized information dissemination and disclosure strategies (Blankespoor *et al.*, 2014; Jung *et al.*, 2018; Rakowski *et al.*, 2021). Though distinct, these mechanisms are inherently interlinked, encompassing disclosure (the supply of information) and dissemination (the consumption of information). While extant research predominantly delves into disclosure strategies, the exploration of strategic dissemination has been relatively limited, mainly due to the inherent complexities in isolating dissemination decisions from disclosure decisions (Jung *et al.*, 2018). Disclosure is typically measured by metrics like the number of tweets produced, the frequency of tweeting, and tweet word count, while dissemination is often proxied by metrics such as retweets, followers, and the Google search volume index (SVI). The realm of dissemination extends beyond mere disclosure and reveals how firms actively manage their information environment for effective communication with stakeholders, spanning employees, customers, shareholders, and the broader public. This encompasses a myriad of communication activities, including public relations, marketing, advertising, internal communications, and crisis management. We attempt to examine both disclosure (the supply of information) and dissemination (the consumption of information) in the European context.

Hamade *et al.* (2024) conducted a systematic review to thoroughly examine the literature on corporate communication in social media. They found that 48% of studies focus on the use of social media platforms for corporate communication in the USA, followed by 13% in China and 5% in the UK. To our knowledge, there is no comprehensive research on listed Twitter-using firms in the EU. Research concerning European public companies focuses solely on individual markets and even sectors, as well as marketing-related issues. This issue becomes especially significant for firms that do not receive widespread news coverage through traditional intermediaries like the press, as social media can effectively enhance their communication. This article, uniquely positioned at the intersection of corporate finance and digital communication, investigates Twitter usage by 21 319 companies listed on 41 European stock exchanges, which published nearly 5.5 million tweets between January 2018 and June 2020. Using a large dataset, we aimed to uncover the multifaceted dimensions of social media presence in the European corporate landscape. While the potential of social media for business communication in the United States has garnered substantial attention, the examination of its economic implications remains relatively understudied. The central question driving our research is whether Twitter presence correlates with increased profitability, growth potential and leverage thereby advancing theoretical insights within the domain of business valuation. Our findings affirm the potential of a social media presence in conferring a competitive edge to businesses. We uncovered a positive correlation between Twitter membership, tweet volume, follower count, and profitability. Moreover, our analysis highlights the prevalence of Twitter adoption within specific industries, with technology and consumer goods sectors exhibiting higher utilization rates. Moreover, larger firms tend to amass a larger following on Twitter,

boasting on average 16 times more followers, and even 21 times more followers at the median, compared to the smallest companies in the sample. In the case of EBIT, this relationship is not monotonic, as both companies generating the highest losses and those characterised by the highest operating income publish the most tweets and have the largest number of followers.

To provide a comprehensive understanding of our study, the subsequent sections will provide literature review and hypotheses development (Section 2), examine metrics describing Twitter activity, delineate our data collection process (Section 3), present corporate Twitter activity across different countries and industries, analyse the economic outcomes in the context of company social media presence (Section 4), and conclude with discussions and implications (final section).

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The rate of social media adoption may vary due to regulatory, language, and cultural differences between countries. However, these are not the only reasons for such differences. Financing systems dominated by banks tend to limit transparency and may deter investors from seeking out information (Bhattacharya & Chiesa, 1995), while market-based financing promotes greater disclosure of corporate information (Perotti & von Thadden, 2001). According to agency theory (Jensen & Meckling, 1976), lenders may avoid transparency to protect the value of their claims. We argue that since bank-dominated financing relationships are prevalent in Europe, the level of Twitter/X adoption in publicly traded companies in Europe and those registered in the EU is lower in comparison to those registered in North America.

H1: Among European-listed companies, the level of Twitter/X adoption for corporate communications in European companies is lower than in North American companies.

As this is an exploratory study, we formulated hypotheses to identify the factors associated with activity and stakeholder engagement on Twitter/X. Al Guindy (2021) and Feng and Johansson (2019) suggest that firms with weaker information environments are likely to benefit the most from adopting social media channels. In contrast, Ibrahim *et al.* (2022) highlight firm size as a key factor influencing disclosure, as larger firms face higher agency costs to reduce information asymmetry, prompting greater disclosure. Signalling theory further supports the importance of firm size in disclosure practices (Albarrak *et al.*, 2023). Moreover, Jung *et al.* (2018) show that firms with more analyst coverage are more likely to share earnings on social media. However, smaller firms may be less inclined to adopt social media, relying on conventional channels for information sharing. Based on that, we formulated the following hypothesis:

H2: Larger companies (in terms of capitalization and assets) are more likely to employ Twitter/X for corporate communication purposes.

According to Schiuma *et al.* (2024), the research identifies two principal channels via which corporate disclosure influences company value: one associated with enhanced profitability and the other connected to the capacity of corporate information to diminish the cost of equity capital. Previous research has hinted at a positive association between social media presence and financial performance (Akmese *et al.*, 2016; Al Guindy, 2021; Albarrak *et al.*, 2020; Paniagua & Sapena, 2014; Ravaonorohanta & Sayumwe, 2020). Al Guindy (2021) discovered that firms with higher book-to-market ratios particularly benefit from sharing financial information via Twitter. This aligns with Hasan and Cready's (2019) finding that expanding companies are more likely to share information on Facebook. However, Filip *et al.* (2021) found a negative correlation with growth. These insights are primarily confined to specific sectors or regional contexts. Our study seeks to broaden this perspective by scrutinizing the economic implications of social media presence at the corporate level, across diverse European listed companies. An important question driving our research is whether Twitter presence correlates with increased profitability, thereby advancing theoretical insights within the domain of business valuation. Therefore, we formulated the following hypotheses:

H3: More profitable companies (in terms of (EBIT, ROE and return on assets ratio) are more likely to employ Twitter/X for corporate communication purposes.

H4: Growth companies (in terms of P/BV and P/E ratio) are more likely to employ Twitter/X for corporate communication purposes.

Leverage is also examined as a determinant for using social media channels for corporate communication. Lee *et al*. (2013), Filip *et al.* (2021) and Feng and Johansson (2019) discovered a negative relationship between leverage and the use of Twitter. According to Al Guindy (2021), companies vulnerable to financial risk have stronger motives to use social media channels. Disclosure can affect the cost of capital by reducing monitoring costs for investors (Vitolla *et al.,* 2020). Therefore, we hypothesised:

H5: More indebted companies are more likely to employ Twitter/X for corporate communication purposes.

RESEARCH METHODOLOGY

The burgeoning use of social media platforms, most notably Twitter, has become a prevalent avenue for businesses to engage with their clientele, stakeholders, and the wider public. Twitter provides a real-time conduit through which businesses can disseminate information, express opinions, gather feedback, and gauge the sentiments of their followers. However, the full spectrum of Twitter's impact on business performance remains an ambiguous area. Existing studies have ventured into numerous facets of businesses' Twitter usage, encompassing metrics such as follower counts, tweet frequency and content, and the level of engagement through retweets.

Tweets' frequency and content are one of the most often used metrics to gauge a business's popularity and influence on Twitter. Tweets constitute brief messages posted on Twitter and can encompass a variety of media types, including text, images, videos, links, hashtags, and mentions. The frequency and content of tweets manifest the level of activity and strategic approach adopted by a business on Twitter. Several studies suggest that more frequent tweeting can augment a business's visibility, enhance awareness, generate increased traffic, and yield more leads (Xun & Guo, 2017; Lee *et al.*, 2015). However, a contrasting perspective posits that excessive tweeting can have adverse consequences, potentially vexing or distancing followers, diminishing tweet quality and relevance, and diluting the impact and value of each individual tweet (Pansari & Kumar, 2017). Moreover, the content of tweets can significantly shape follower perceptions and behaviours. Several investigations have probed the influence of various tweet types, including informational, promotional, emotional, or interactive tweets, on follower engagement and satisfaction (Chen & Shen, 2015; Kim *et al.*, 2022).

Another pivotal metric applied to assess the impact of Twitter on business performance is the follower count. Followers represent users who subscribe to receive updates from a specific account, effectively quantifying the scope and outreach of a business's Twitter audience. Nevertheless, it is imperative to acknowledge that follower quantity does not necessarily mirror audience's caliber or loyalty, nor does it encapsulate the interactions and feedback that transpire between a business and its followers. Consequently, some researchers contend that follower count may not be a dependable gauge of business performance on Twitter (Bank *et al.*, 2019; Cole *et al.*, 2015).

A third metric employed to assess the efficacy of Twitter for businesses pertains to the engagement level garnered through retweets. Retweets denote tweets that are re-posted by another user on their own timeline, thereby amplifying the reach and exposure of the original tweet. The engagement level through retweets offers insight into the degree to which a tweet resonates with and influences followers. Certain studies posit that retweets can bolster a business's reputation and credibility, fostering word-of-mouth marketing and referrals (Liu *et al.*, 2015; Zhang *et al.*, 2017). However, it is important to note that retweets do not inherently imply endorsement or agreement with the original tweet, and various motivations, such as humour, sarcasm, or criticism, may underpin retweeting behaviour (Wang *et al.*, 2019).

Table 1 provides an overview of the literature review focusing on metrics that describe Twitter activity.

The main aim of this study is to provide a comprehensive analysis of the social media practices of publicly traded companies in Europe. This area of research has received considerable empirical interest, albeit primarily in relation to North American stock markets, as demonstrated in Table 1. While an array of social media platforms is at the disposal of corporations, including Twitter, Facebook, YouTube, and LinkedIn, recent findings by Best and Caylor (2019) underscore Twitter's prominence as a channel for corporate communication, surpassing the reliance of shareholders to seek

press releases and instead favouring subscription to a company's Twitter feed. Additionally, recent research by Nuseir and Qasim (2021) underscores Twitter's paramount role in financial disclosure and the supplementary dissemination of corporate information. Given the extended timeframe of our study (January 2018 to June 2020), the multitude of local markets (41), and the comprehensive inclusion of more than 21 000 companies in our dataset, our focus narrows down to three principal proxies: Twitter membership (as a disclosure metric), the number of tweets posted by a firm (also as a disclosure metric), and the number of followers (as a dissemination metric). Although our utilization of these three metrics aligns with established practices, a review of prior research in this domain, as presented in Table 1, reveals a more extensive array of proxies. Nonetheless, it is imperative to underscore that our dataset stands as the most expansive in this domain to date.

Table 1. Metrics describing Twitter activity and research samples description

Researcher	Metrics	Country	Number of observations	Research period	Number of companies
Bank *et al.* (2019)	number of followers increase in number of followers number of tweets Twitter membership	BIST 50	128	01/11/2016 – 30/04/2017	28
Blankespoor *et al.* (2014)	number of followers number of tweets (since account inception) date of each firm's first tweet duration between a firm's first and last tweet per firm monthly average retweets percentage replies percentage links	Top IT firms from reputable rankings	4 516	04/03/2007 – 26/09/2009	85
Cole *et al.* (2015)	number of tweets months on twitter	S&P 500	38 275	01/12/2010 – 31/12/2011	215
Al Guindy (2021)	number of tweets number of tweeting days number of words contained in tweets number of retweets	NYSE, AMEX, NASDAQ	16 378	01/01/2006 – 31/12/2018	864
Liu *et al.* (2013, 2015)	official twitter account number of tweets number following	NYSE, NASDAQ	11 034	01/01/2008 – 31/12/2012	293
Prokofieva (2015)	number of tweets number of retweets	ASX 200	3 516	01/08/2013 – 01/01/2014	109
Rakowski *et al.* (2021)	number of tweets increase in number of followers increase in number of tweets	Russel 3000	2 215 535	01/01/2011 – 31/12/2015	1 976
Ranco *et al.* (2015)	financial tweets number of tweets (daily) number of tweets by sentiment type per day sentiment polarity	DJIA30	1 555 770	1/06/2013 – 18/09/2014	30
Zhang *et al.* (2011)	number of tweets per day number of followers per day number of retweets per day positive or negative mood on Twitter	DJIA, NASDAQ, and S&P 500	8 100-43 040/day	30/03/2009 – 07/09/2009	n/a

Source: own study.

The initial phase of our study involved the compilation of a roster of companies listed on European stock exchanges between 2018 and June 2020. To achieve this, we harnessed resources provided by the Federation of European Securities Exchanges, representing 35 exchanges. Subsequently, we expanded our dataset to encompass additional markets, adopting the categorization outlined by the United Nations Statistical Division, covering 44 European countries. The precise tally of stock exchanges across Europe hinges on nuanced definitions and geographical parameters, yet it can be estimated that over 40 stock exchanges operate across the continent. Notably, some countries, such as Germany and Switzerland, host multiple regulated markets, further augmenting the complexity of this landscape. Due to data unavailability within the EquityRT database, we excluded certain exchanges from our research sample, including the Belarusian Currency and Stock Exchange, Montenegro Stock Exchange, and Ukraine Stock Exchange. Consequently, we assembled a dataset encompassing companies listed on 41 stock exchanges.

To eliminate redundancies stemming from cross-listings, where a company's common shares are listed on multiple markets, we assigned companies to specific markets based on the primary code field. Within the EquityRT database, the market exhibiting the highest trading volume was designated as the primary market, a practice underpinned by financial instrument valuation principles applicable to all market participants. Following this phase, our sample encompassed 21 319 companies, which necessitated geographical attribution to the countries where they generated revenues, in adherence to IFRS 8 Operating Segments' requirement for companies to report revenue generation locations. This information was manually sourced from financial reports and populated the 'Business Country' field in the EquityRT database. Ultimately, our dataset comprised companies operating in 33 European countries, including 'other European countries' (encompassing European nations outside the Schengen area, except for Turkey, Bulgaria, Romania, Cyprus, and the UK), along with the USA & Canada, Americas, Australia and Oceania, Africa, and Asia, all listed on 41 stock exchanges.

Given the absence of a dedicated database housing Twitter account details for European-listed companies, we undertook the development of a program to scrape this data from company websites. Consequently, we developed a program for web scraping this data directly from the official websites of the companies. Subsequently, Twitter data was collected exclusively from the official Twitter accounts of the companies, using the Twitter Search API. This ensured that the data originated directly from Twitter's official source, maintaining accuracy and reliability. This method aligns with practices widely adopted in prior studies (*e.g.* Al Guindy, 2021; Ranco *et al.*, 2015; Debreceny *et al*., 2019). Leveraging the entirety of our compiled data, spanning tweets and financial characteristics, we curated an SQL database.

The limitation of our approach is that web scraping relies on the completeness and accuracy of the official websites from which we collected data. Companies that do not maintain their websites or that update their Twitter/X accounts infrequently might have been underrepresented in our dataset. Furthermore, the absence of a centralised European database for corporate social media accounts introduces the possibility that some firms using unofficial Twitter/X accounts or not publicly link them may have been missed. This could lead to selection bias, particularly in smaller firms or firms based in less technologically advanced countries. Moreover, U.S. companies are frequently identified through the use of cashtags, a system that has not been widely adopted in Europe by either investors or companies. Consequently, our efforts to identify European companies active on Twitter via cashtags yielded fewer results compared to data collected from official company websites. Table 2 provides a detailed summary of the sampling process used in this study, covering key aspects such as the number of companies, missing data, and a description of the variables analysed. Both the financial data and Twitter data used in this research correspond to the same period, ensuring consistency and alignment between the two datasets. Of the initial 21 319 observations, after balancing the sample, 7 107 observations remained for the final analysis. While this approach guarantees consistency between the financial and Twitter datasets, it may reduce the representativeness of the sample, particularly for firms in Eastern Europe. Therefore, the results should be interpreted with caution, particularly when generalizing beyond the companies included in the final sample.

Table 2. Number of companies, missing data and detailed description of the variables

Name [description]	Source	Number	% of all companies
All companies analysed	EquityRT	21 319	100.0
Companies active on Twitter			
- with account	Twitter API	7 885	37.0
- tweeting		7 107	33.3
- with followers		7 341	34.4
- all posted tweets		5 443	N/A
		502	
Companies with indicated country	EquityRT	21 319	100.0
Companies with indicated industry	EquityRT	21 098	99.0
Companies with identified financial indicators			
- Debt Ratio: total liabilities/total assets in EUR			
- Total Assets: total assets value of the company at the end of the research period in EUR		19 183	90.0
- Market Capitalization (Mcap): market capitalization of the company at the end of the research period in EUR		19 193	90.0
- Income TTM: income before extraordinary items of the company at the end of the research period in EUR		18 594	87.2
- Return of Assets (ROA): income before extraordinary items/book value of assets of the company at the end of the research period in EUR	EquityRT	18 059	84.7
- Return of Equity (ROE): income before extraordinary items/equity value of the company at the end of the research period in EUR		19 075	89.5
- Price to Book Value Ratio (P/BV): the current market value of a company/book value at the end of the research period in EUR		17 793	83.5
- Price Earnings Ratio (P/E): the relation between the market capitalization and earnings per share (EPS) in EUR		16 542	77.6
		17 142	80.4

Source: own study.

RESULTS AND DISCUSSION

Corporate Twitter Activity Descriptive Statistics

The database underpinning this study encompasses 5 443 502 tweets, posted by 7 107 companies listed on 41 European stock exchanges, deriving their revenue from 47 European countries,[1] as well as the US & Canada, Americas, Australia, Oceania, Africa, and Asia. When examining the composition of our dataset, British (7.58%), German (4.38%), French (4.10%), Polish (3.95%), and Swedish (3.94%) stock markets emerge as the most prominent players. Notably, these statistics exclude non-European countries of residence. Table A1 in the Appendix presents sample distribution and includes Twitter activity by country, focusing on both tweets frequency and the number of followers. A noteworthy trend in our dataset is the steady uptick in the number of tweets and the count of tweeting companies, a phenomenon commencing at the start of 2020 (Figure 1). We may attribute this surge to the global spread of the COVID-19 pandemic, leading to the widespread implementation of remote working solutions and the growing significance of online services. Furthermore, Figure 1 demonstrates that social media activity reached its zenith in the post-holiday season, particularly in October. This observation is not consistent with findings by Hirshleifer *et al.* (2009), who documented an escalation in investor attention on days featuring a flurry of earnings announcements.

[1] The political boundaries of Europe differ depending on the definition of Europe employed by various political organizations. For example, the Council of Europe and the European Court of Human Rights define Europe as 47 countries. The European Higher Education Area covers 48 countries, whereas the definitions of the European Cultural Convention and the European Olympic Committees encompass 50 countries.

On the other hand, companies involved in retail may intensify their marketing and promotional activities before the upcoming Black Friday, Christmas, and the New Year's sales events (Ibrahim & Wang, 2019), while companies in the sports and tourism industries increase their activity on social media to maintain fan engagement after the summer season (Watanabe *et al.*, 2015).

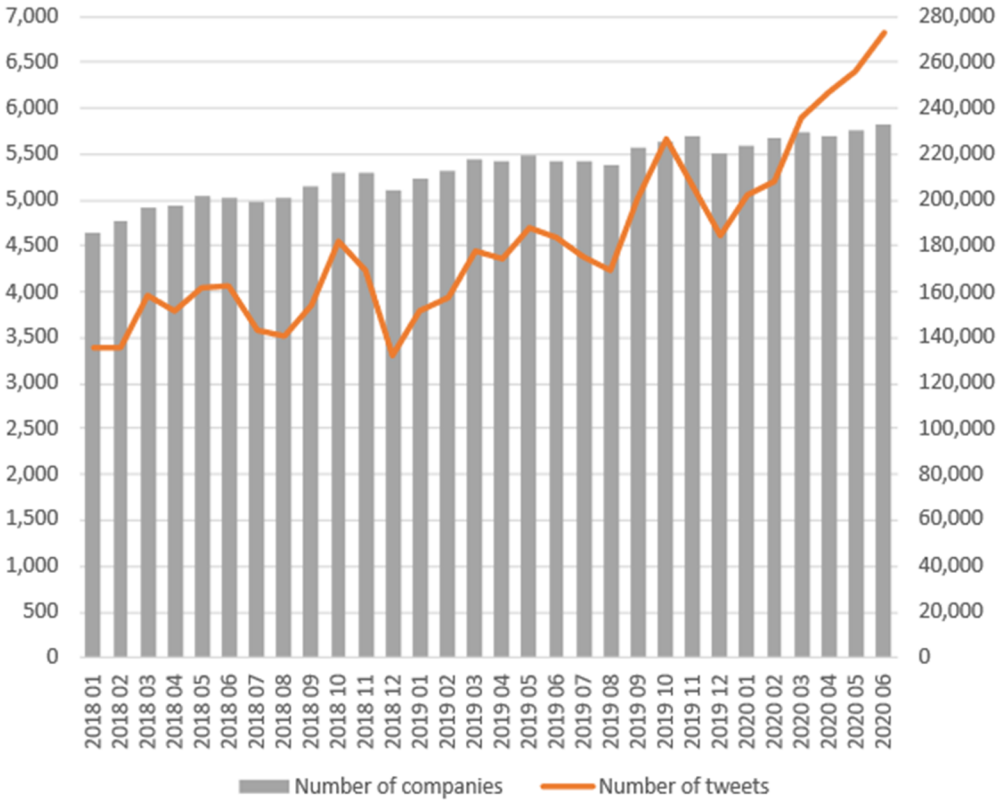

Figure 1. Number of tweets posted and number of companies (in thousands) tweeting between January 2018 and June 2020

Note: The scale on the left represents 'units' and refers to number of companies – total number of companies having a Twitter account; the scale on the right represents 'units' and refers to: the number of tweets – the total number of tweets published by companies active on Twitter.

Source: own elaboration based on Twitter/X data and EquityRT.

Figure 2 provides insights into the share of active Twitter-using companies relative to the total number of listed companies in each market. In our European-focused analysis, countries belonging to the EU Customs Union, Schengen Area, and the UK are presented distinctly, while other companies listed on EU capital markets but generating income elsewhere are grouped into categories such as other European, US & Canada, Americas, Africa, Asia, Australia, and Oceania. This stratification is pivotal in addressing the complexities arising from companies concurrently listed on multiple stock exchanges without dedicated Twitter accounts for each exchange.

Our analysis revealed that the number of companies registered in the US & Canada but quoted in Europe stands at 6 557, with 52% of them possessing a Twitter account, a figure somewhat lower than the report by Kim *et al.* (2022) for S&P 1 500 firms. Within Europe, companies hailing from Ireland (62%), Finland (61%), the United Kingdom (56%), and France (54%) claim the highest proportion of Twitter account holders, while countries like Slovakia, Lithuania, and Bulgaria exhibit figures below 10%. Interestingly, no companies listed in Estonia were found to have a Twitter account or provide a relevant link on their websites. Notably, Eastern European companies, except those in Finland and the Czech Republic, demonstrated markedly lower Twitter account ownership and usage, likely reflecting the comparatively underdeveloped technological landscape in these regions. In contrast, Northern and Western European countries actively utilize social media to establish and nurture lasting business relationships.

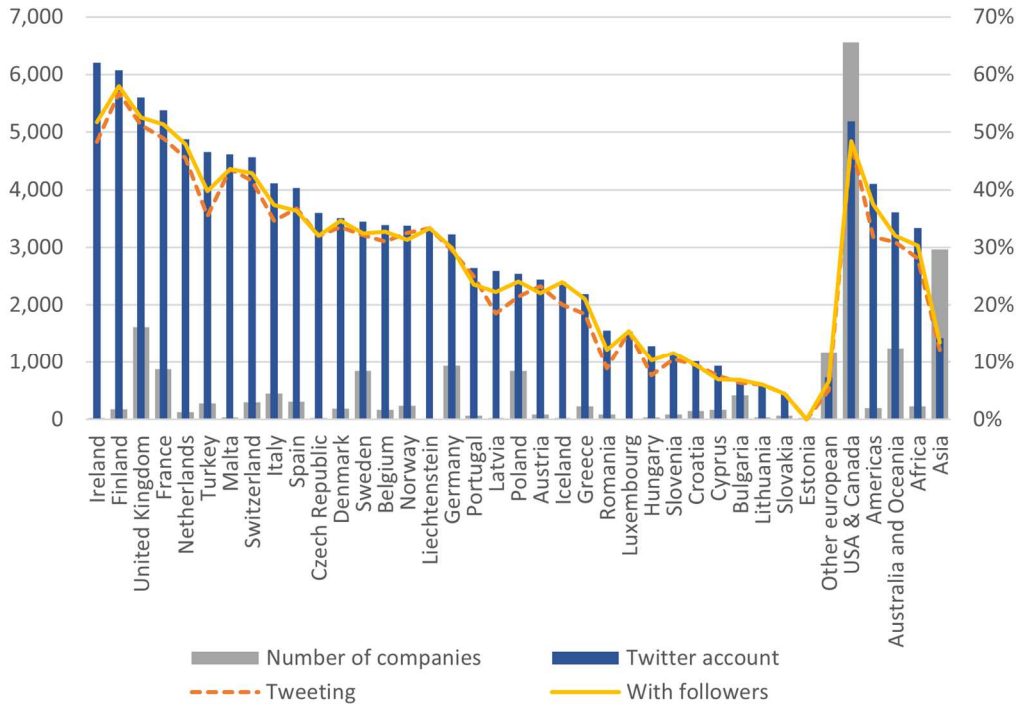

Figure 2. Corporate Twitter activity broken down by countries

Note: The scale on the left represents 'units' and refers to: number of companies – the total number of companies, both having and not having a Twitter account; The scale on the right represents 'percentages' and refers to: (1) Twitter account – number of companies with a Twitter account / total number of companies; (2) Tweeting – number of companies actively tweeting / total number of companies; (3) With followers – number of companies with followers / total number of companies.
Source: own elaboration based on Twitter/X data and EquityRT.

In our examination of Twitter engagement among European public companies, we considered the volume of tweets posted during the research period (Figure 3). We employed box plots, a staple in descriptive statistics, to identify mean values, data set dispersion, and skewness signs. The right-skewed distribution observed in Figure 3 implies a concentration of data toward lower values. Consequently, further analysis leaned toward the median as a more representative metric, as the mean can overestimate less common values. Notably, we observed the highest average activity (median) in the Czech Republic, potentially attributable to the market size and the Czech stock exchange's strategy of welcoming dual listings. However, it is essential to acknowledge that entities like Erste Bank and VIG, among the largest companies listed there, don't consider the Prague Stock Exchange their primary market. Therefore, our sample contained only 25 Czech companies. If we exclude the Czech Republic, Spanish companies emerge as the most active on Twitter, with a median of one thousand posts during the research period, double the figures for Portuguese, German, and Slovenian companies.

Shifting our focus to measure corporate Twitter activity by the number of followers, akin to Bank *et al.* (2019) and Blankespoor *et al.* (2014), we noted that Spain records the highest mean number of followers, while European-listed companies primarily operating in the Americas exhibit the highest median follower count (Figure 4). Within Europe, Luxembourg stands out with the highest median. However, its inclusion is contingent on a small sample size (2 companies) and should be considered separately. Among European companies with their primary revenue generation in Europe, Spain and the Netherlands lead in median followers. This observation resonates with findings by de Oliveira Santini *et al.* (2020), suggesting that Twitter is twice as effective as other social media platforms in enhancing customer engagement, satisfaction, and positive emotions. In this context, the median number of followers for publicly traded European companies underlines the potential benefits of investing more in Twitter as an informational tool for building customer engagement relative to other platforms like Facebook and blogs. Notably, various companies have successfully leveraged Twitter to boost customer engagement and achieve wider dissemination, exemplified by Telepizza in Spain with 34 836

810 followers, and Sport Lisboa E Benfica-Futebol, Futebol Clube Do Porto – Futebol Sad in Portugal, with 1 302 095 and 1 240 223 followers, respectively, among other examples.

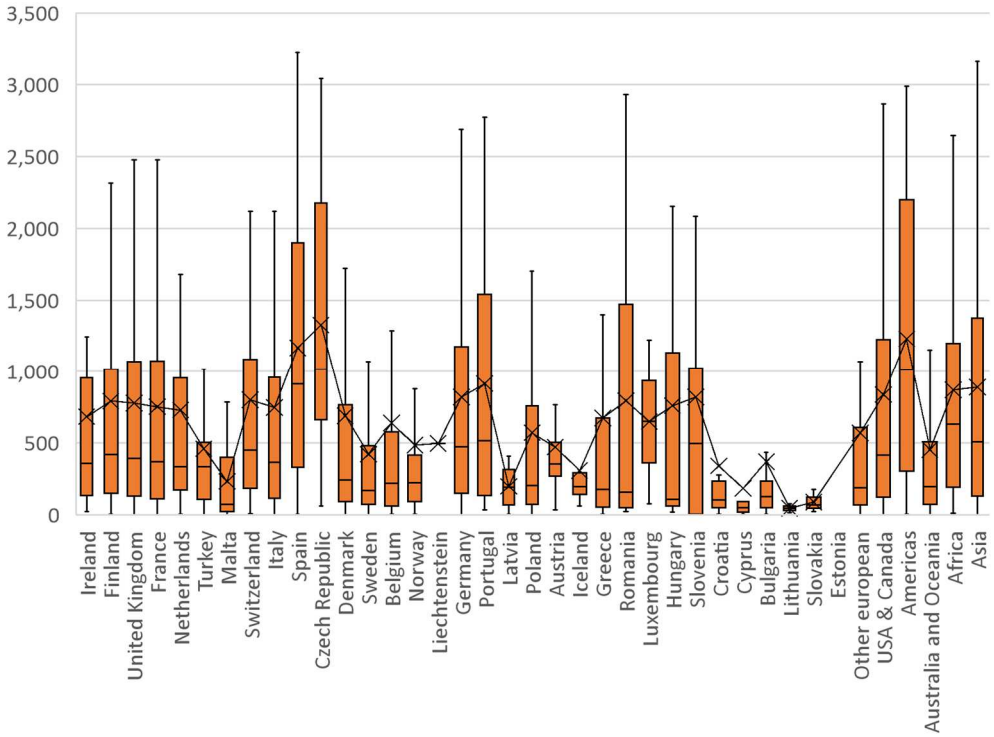

Figure 3. Corporate Twitter activity measured in the number of published tweets over the research period
Note: The median is represented by the line dividing the box into two parts. The mean is marked with an x. The box part of the box plot covers the middle 50% of the values in the data set. Whiskers extend from the top of the box to the largest data point within 1.5 times the interquartile range (IQR) and from the bottom of the box to the smallest data point within 1.5 times the IQR. Data points outside this range are considered outliers and are shown as small filled-in circles. Values outside this range have been omitted.
Source: own elaboration based on Twitter/X data and EquityRT.

Our analysis delves into sectoral affiliation (Figure 5), revealing that the Medical Care sector comprises the largest representation, with 2 324 companies. Nevertheless, the computer software & services sector stands out, boasting 1 484 companies, of which 858 (59%) maintain active Twitter accounts, generating 894 668 tweets. This surge in activity aligns with the sector's pronounced growth in the global economy during the research period, underpinned by a surge in IT sector performance. Importantly, this period also coincided with the onset of the COVID-19 pandemic and subsequent economic disruptions, which did not adversely affect IT sector companies, as highlighted by Gartner's report (2020) of average annual growth in the global IT market from 2012 to 2019. Furthermore, 2020 marked the beginning of the COVID-19 lockdowns and the resulting economic disruptions. The IT sector companies were one of the few that did not experience adverse effects of that situation. Al Guindy (2021) draws similar conclusions. Computer software & services and communication services tend to tweet more, whereas industries such as steelworks and mining are less active. Customer services stands out against the others where the number of Twitter-active companies in this sector and the average number of tweets posted are below average for the entire population. The lowest level of activity in terms of the number of accounts they have, the published tweets, and the number of followers exhibited by companies involved in real estate and textile & apparel. Companies that operate in these industries should use social networking sites for marketing purposes.

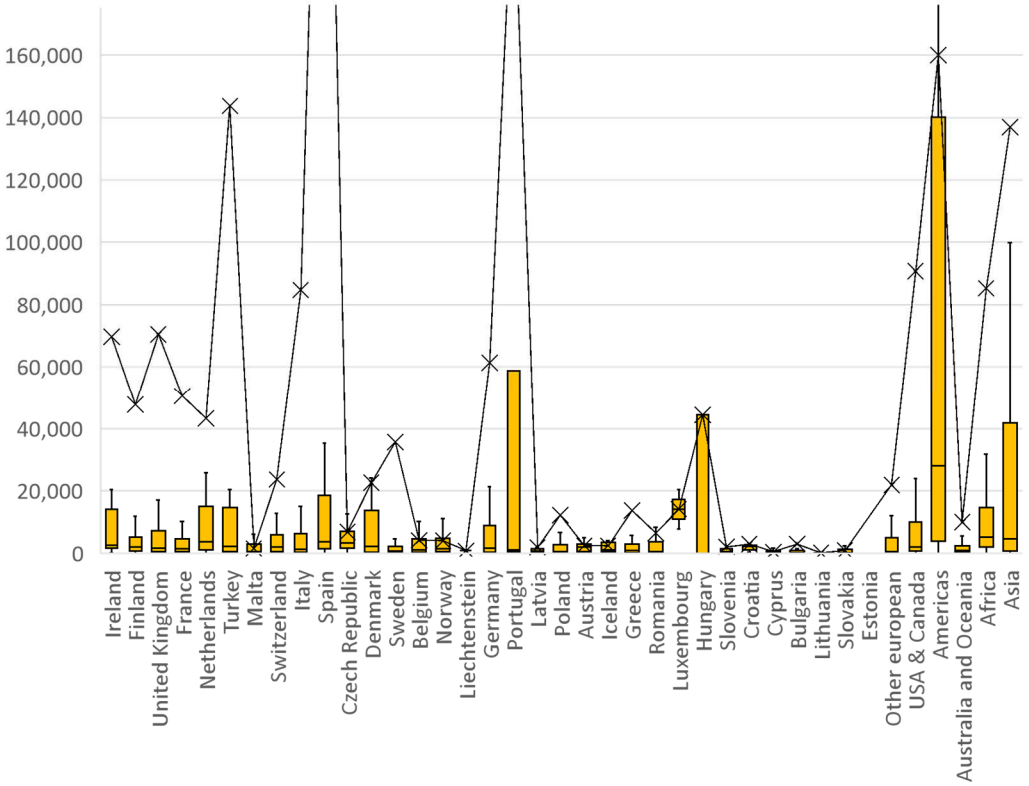

Figure 4. Corporate Twitter activity measured in the number of followers at the end of the research period

Note: Values outside the chart area: mean for Spain = 344k, mean for Portugal = 221k, upper whisker for Americas = 300k.

Source: own elaboration based on Twitter/X data and EquityRT.

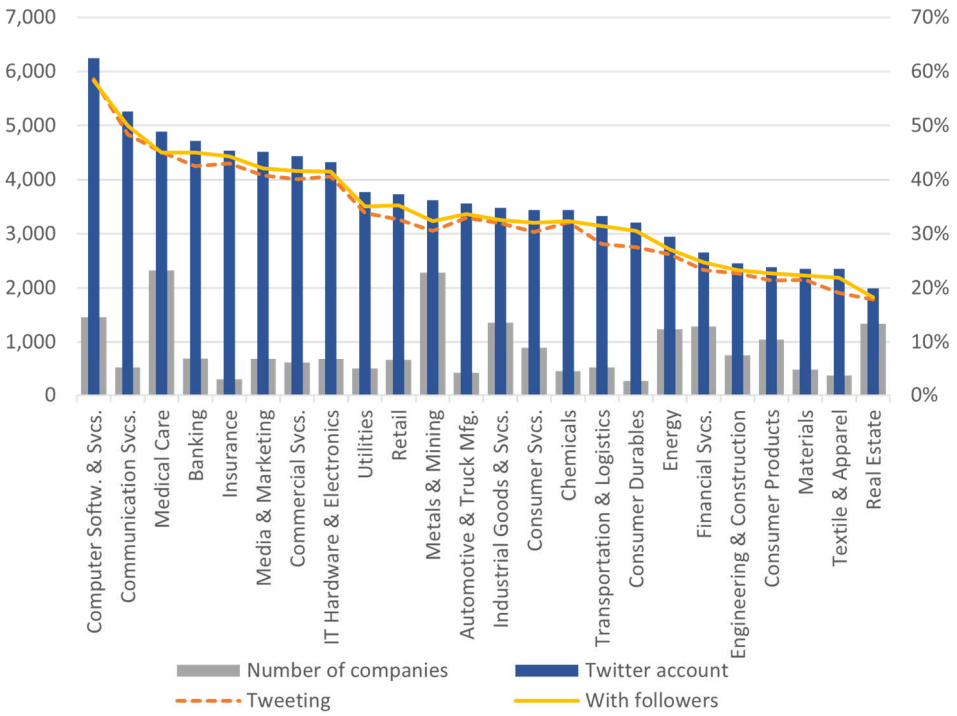

Figure 5. Corporate Twitter activity broken down by sectors

Note: The scale on the left represents 'units' and refers to: the number of companies – total number of companies, both having and not having a Twitter account; The scale on the right represents 'percentages' and refers to (1) Twitter account – number of companies with a Twitter account / total number of companies; (2) Tweeting – number of companies actively tweeting / total number of companies; (3) With followers – number of companies with followers / total number of companies.

Source: own elaboration based on Twitter/X data and EquityRT.

According to Li *et al.* (2013), companies engage in social media because this form of electronic word of mouth is approximately twenty times more effective than marketing events and thirty times more effective than media appearances, which is linked to firm profits and shareholder value. This finding is not restricted to any industry but we can generalize it across industries (Pansari & Kumar, 2017). However, intangible features characterize service environments, which are more varied than manufacturing contexts (Zeithaml *et al.*, 1985). Consequently, to develop customer relationships and engage clients, companies that provide services must disclose more details. It also refers to consumer electronics industry, retail banking, and insurance (Pansari & Kumar, 2017). Our results (Figure 6) support conclusions drawn mainly on US datasets. In our sample, the most active sectors on Twitter were retail, banking, insurance, and consumer services, while metals & mining, industrial goods & services, and energy were inactive. However, Twitter activity in consumer durables appears to be very low, which is surprising given that, according to Gallup, fully-engaged shoppers in the consumer electronics industry make 44% more visits per year to their preferred retailer than actively disengaged shoppers, which translates to customer value and subsequently affects firm value. We also discovered that medical care sector's Twitter activity decreased significantly during the pandemic period.

In the next cross-sectional analysis (Figure 7), we explored the number of followers as a proxy for customer engagement. Customer engagement is known to significantly impact firm performance. In our sample, the most popular sectors on Twitter in terms of followers were retail, banking, insurance, and consumer services, while metals and mining, materials, and medical care garnered fewer followers. Notably, transportation & logistics and textile & apparel stood out, as they host fewer Twitter-active companies, with below-average numbers of tweets posted, yet their messages draw substantial followers. We may attribute this phenomenon to the nature of information disseminated by these companies. Entities in these sectors appear to utilize social networking sites primarily for marketing purposes. Forbes (2018) reports that 40% of consumers follow their 'favourite' brands on social media, with 25% of those followers making purchases from these brands.

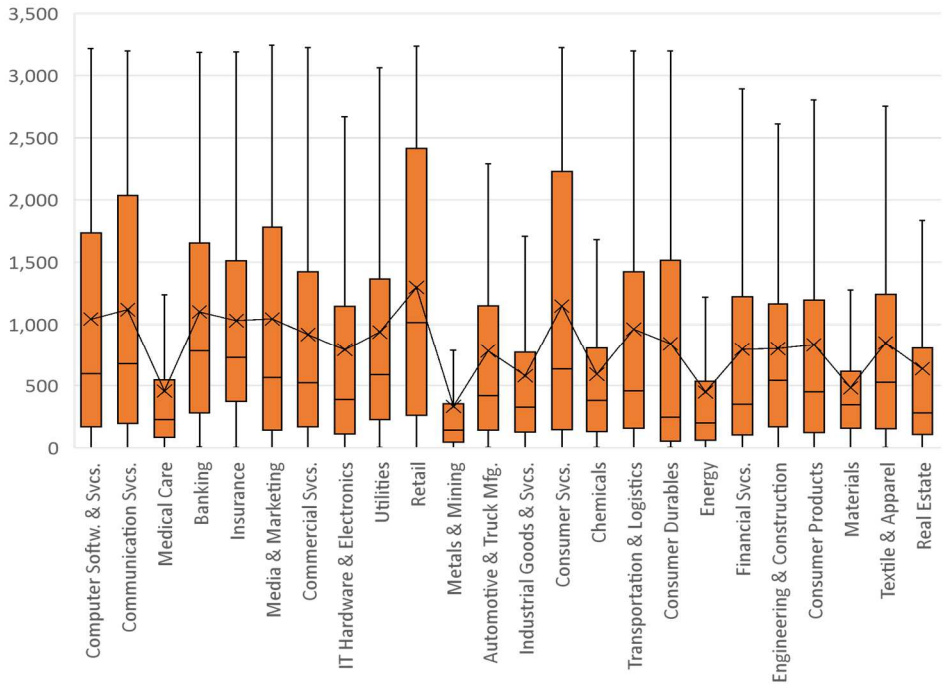

Figure 6. Corporate Twitter activity measured in the number of published tweets over the research period broken down by sectors

Note: The median is represented by the line dividing the box into two parts. We marked the mean with an x. The box part of the box plot covers the middle 50% of the values in the data set. Whiskers extend from the top of the box to the largest data point within 1.5 times the interquartile range (IQR) and from the bottom of the box to the smallest data point within 1.5 times the IQR. Data points outside this range are considered outliers and are shown as small filled-in circles. Values outside this range have been omitted.

Source: own elaboration based on Twitter/X data and EquityRT.

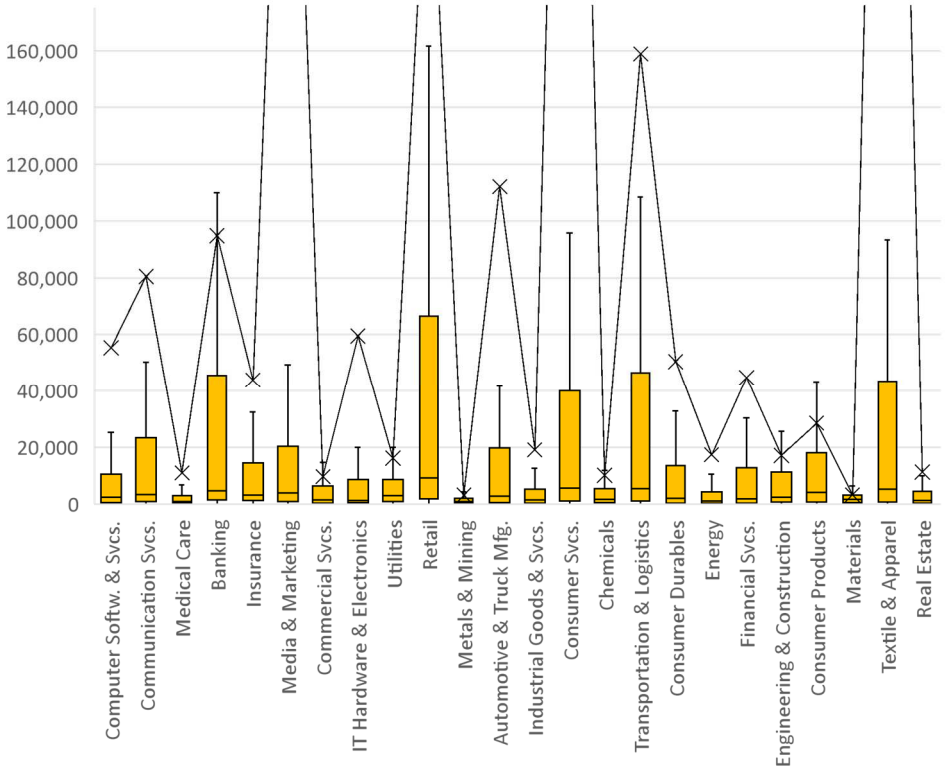

Figure 7. Corporate Twitter activity measured in the number followers at the end of the research period broken down by sectors

Note: Means outside the chart area: media & marketing = 349k, retail = 249k, consumer svcs. = 481k, textile & apparel = 511k.
Source: own elaboration based on Twitter/X data and EquityRT.

Financial Characteristics of Tweeting European Listed Companies

This section delves into financial characteristics of European-listed companies active on Twitter, focusing on firm size (capitalization, total assets), profitability (EBIT, return on equity ratio and return on assets ratio), firm value (P/BV and P/E ratio), and leverage (debt ratio). Table A2 in the Appendix presents the sample distribution and provides data on Twitter activity, focusing on the number of tweets and followers, categorized by different quintiles of selected variables.

Figure 8 presents the share of companies engaged in Twitter activity, divided into individual quintiles based on various financial metrics. The findings regarding firm size indicate the existence of a relationship between having an account on Twitter/X and the size of the company. While a significant number of larger firms, particularly in terms of capitalization and total assets, have embraced Twitter for corporate communications, a substantial proportion of smaller companies have not. Notably, nearly 85% and 70% of small companies have not adopted Twitter, as measured by capitalization and total assets, respectively.

Regarding P/E ratios, approximately 50% of companies with both the highest and lowest ratios have Twitter accounts. The third quintile stands out as the least active in adopting Twitter. In terms of expected return on equity, nearly 50% of companies with the highest ratios have embraced Twitter, whereas only 30% of companies in the first quintile of P/E ratios have done the same (Figure 9).

The relationship between profitability and Twitter adoption is not straightforward, as companies with both high and low profitability, measured by ROA and ROE ratios, exhibit Twitter activity. However, when profits are measured by EBIT, more than 50% of companies in the lowest quintile of earnings generated from its core business activities have a Twitter account and are actively tweeting. Interestingly, companies with higher levels of indebtedness are more likely to have adopted Twitter.

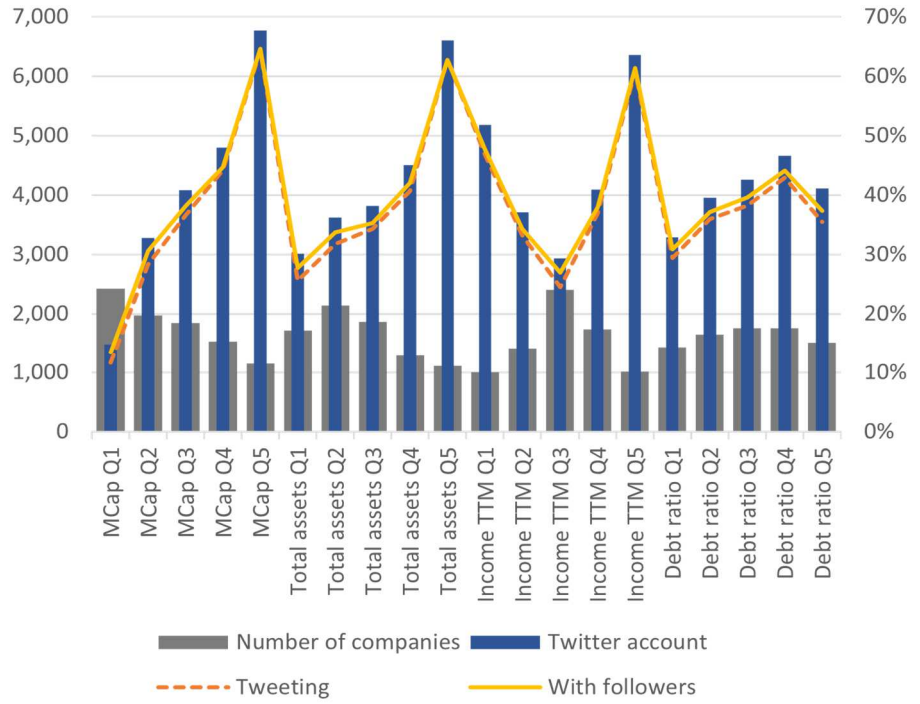

Figure 8. Activity on Twitter, measured in the number of companies and published tweets, in quintiles based on market capitalization, total assets, EBIT (Income TTM), and debt-to-equity ratio

Note: The scale on the left represents 'units' and refers to: number of companies – total number of companies, both having and not having a Twitter account; The scale on the right represents 'percentages' and refers to: (1) Twitter account – number of companies with a Twitter account / total number of companies; (2) Tweeting – number of companies actively tweeting / total number of companies; (3) With followers – number of companies with followers / total number of companies.
Source: own elaboration based on Twitter/X data and EquityRT.

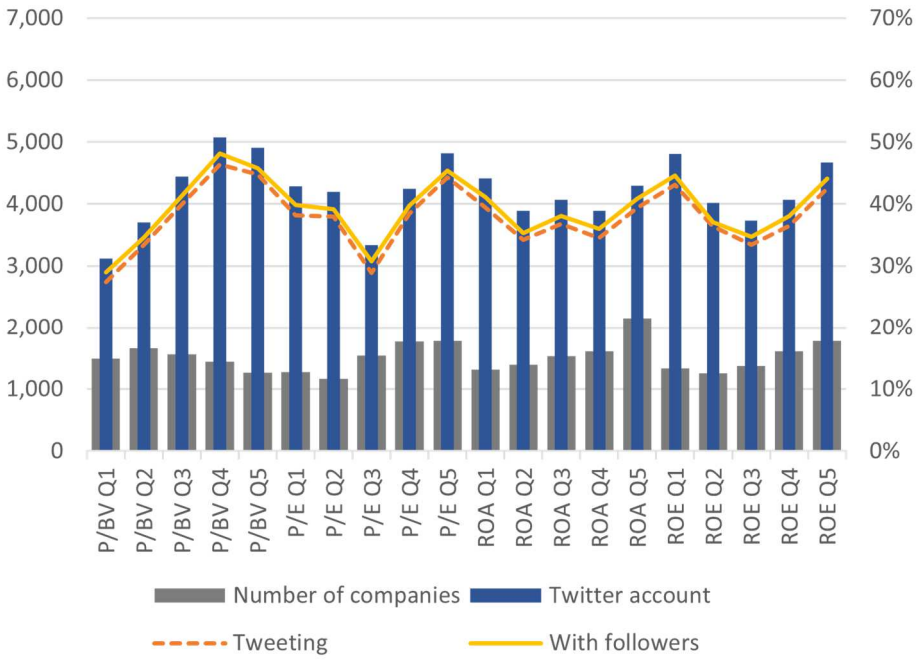

Figure 9. Activity on Twitter, measured in the number of companies and published tweets in quintiles based on P/BV, P/E, ROA, and ROE

Note: The scale on the left represents 'units' and refers to: number of companies – total number of companies, both having and not having a Twitter account; The scale on the right represents 'percentages' and refers to: (1) Twitter account – number of companies with a Twitter account / total number of companies; (2) Tweeting – number of companies actively tweeting / total number of companies; (3) With followers – number of companies with followers / total number of companies.
Source: own elaboration based on Twitter/X data and EquityRT.

Subsequently, we analysed corporate Twitter activity based on the number of published tweets (Figure 10) and the number of followers (Figure 11) for each financial measure. As indicated by market capitalization, larger companies tweet significantly more, with the largest entities tweeting approximately eight times more than the smallest ones. Notably, the largest companies are significantly more efficient in terms of followers, with an average of 16 times more followers and up to 21 times more followers at the median, than the smallest companies in the sample. A similar pattern emerges when analyzing disclosure and dissemination relative to total asset size quintiles. However, it is essential to note that larger companies extensively covered by analysts and those with high levels of institutional ownership might not always benefit from Twitter activity. Smaller companies with fewer analyst followers and institutional holdings are more likely to gain from tweeting financial information as a substitute information source (Al Guindy, 2021).

Interestingly, companies with higher levels of debt exhibit greater activity both in terms of the quantity of published information and the number of followers. However, in the case of EBIT, this relationship is not monotonic, as both companies generating the highest losses and those characterized by the highest operating income publish the most tweets and have the largest number of followers. It is important to focus on medians due to outliers and skewness in the distributions, especially concerning the number of followers.

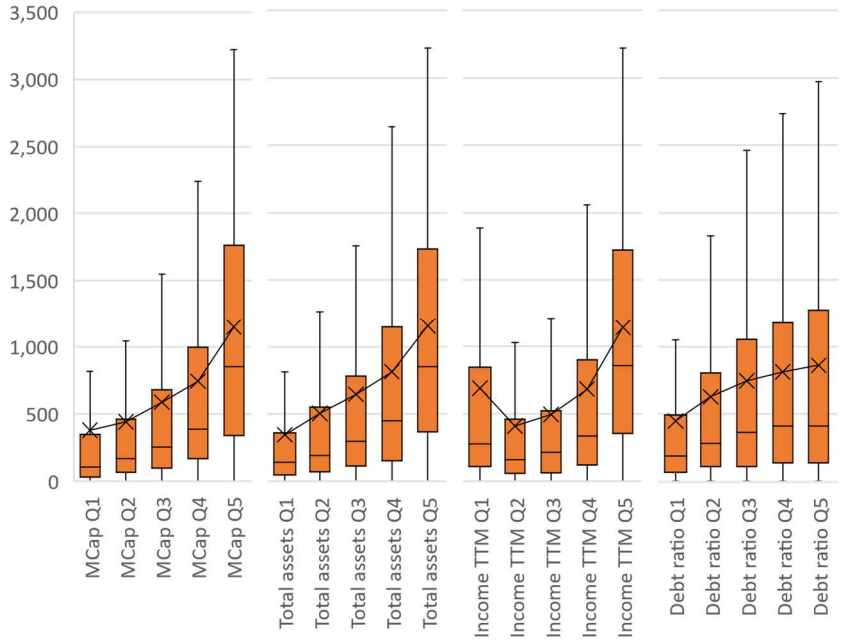

Figure 10. Activity on Twitter, measured in the number of published tweets, in quintiles based on market capitalization, total assets, EBIT, and debt-to-equity ratio

Note: The line dividing the box into two parts represents the median. We marked the mean with an x. The box part of the box plot covers the middle 50% of the values in the data set. Whiskers extend from the top of the box to the largest data point within 1.5 times the interquartile range (IQR) and from the bottom of the box to the smallest data point within 1.5 times the IQR. Data points outside this range are considered outliers and are shown as small filled-in circles. Values outside this range have been omitted.
Source: own elaboration based on Twitter/X data and EquityRT.

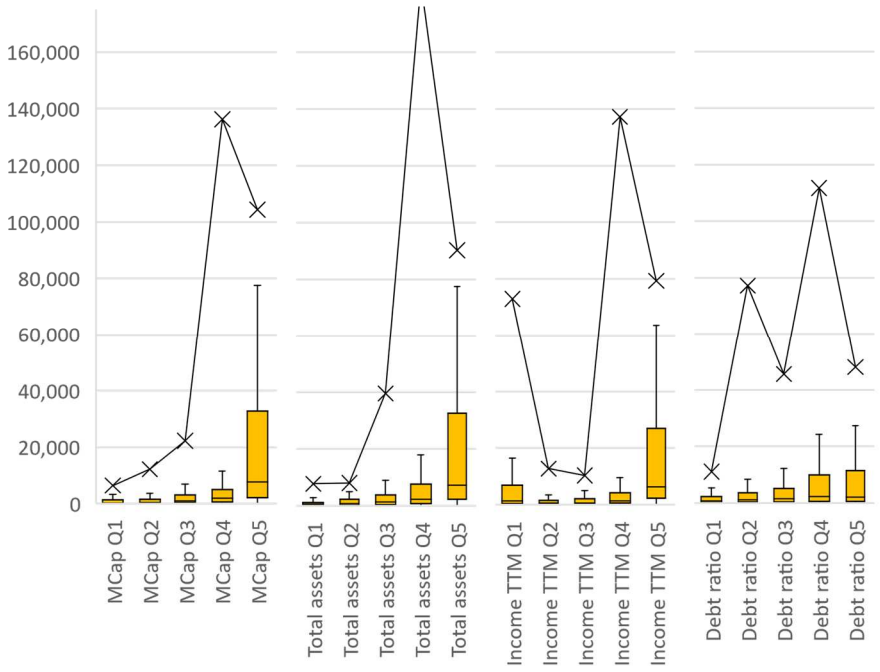

Figure 11. Activity on Twitter measured in the number of followers, in quintiles based on market capitalization, total assets, EBIT, and debt-to-equity ratio

Note: The line dividing the box into two parts represents the median. We marked the mean with and x. The box part of the box plot covers the middle 50% of the values in the data set. Whiskers extend from the top of the box to the largest data point within 1.5 times the interquartile range (IQR) and from the bottom of the box to the smallest data point within 1.5 times the IQR. Data points outside this range are considered outliers and are shown as small filled-in circles. Values outside this range have been omitted. Mean outside the chart area for Total assets Q4 = 184k.

Source: own elaboration based on Twitter/X data and EquityRT.

Figures 12 and 13 present descriptive statistics for P/BV, P/E, ROA, and ROE measures. In the case of P/BV ratios, the mean values of published tweets showed minor differences across individual quintiles, though a decreasing trend is evident. Similarly, median tweet volumes showed subtle changes in the quantity of published tweets depending on quintile placement. Companies with higher long-term growth potential tend to publish fewer tweets compared to those with book values higher than market values. This pattern holds true for follower counts as well.

For the P/E ratio, both the average and median of tweets increase, peaking in the fifth quintile for the average and the fourth quintile for the median. Companies valued at a premium due to anticipated profit potential tend to publish more tweets. As investor expectations for future earnings growth rise, follower counts also significantly increase.

Companies incurring losses tend to tweet less than profitable counterparts, especially concerning ROA and ROE metrics. Conversely, entities with high profitability, particularly those in the fifth quintile, exhibit lower levels of Twitter activity than those generating lower returns. The third quintile showcases the highest average and median values for both ROE and ROA, with similar patterns observed for follower counts.

These findings underscore the nuanced relationship between financial characteristics and Twitter activity among European-listed companies, highlighting the influence of size, profitability, and valuation metrics on social media engagement.

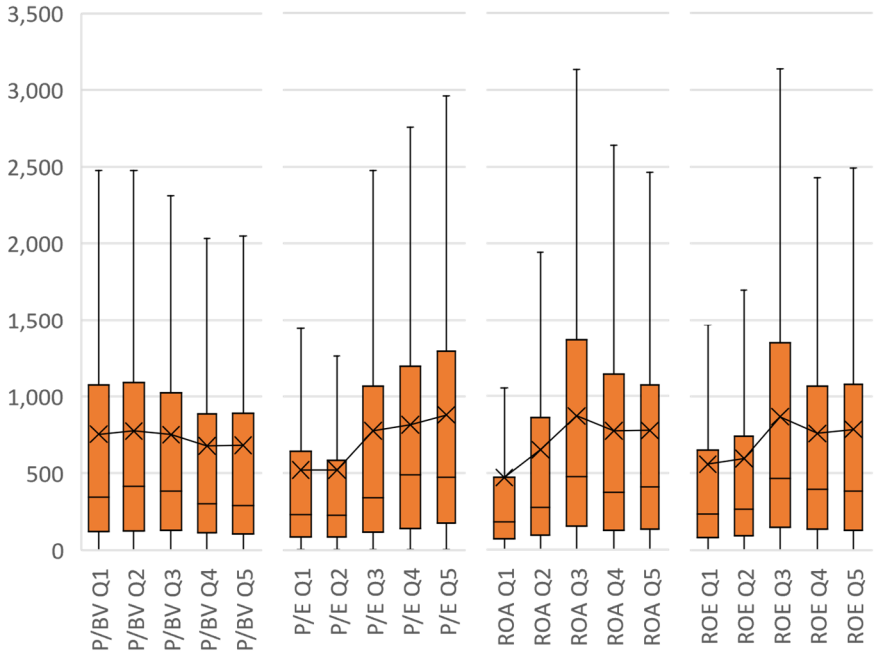

Figure 12. Activity on Twitter, measured in the number of published tweets, in quintiles based on P/BV, P/E, ROA, and ROE

Note: The line dividing the box into two parts represents the median. We marked the mean with and x. The box part of the box plot covers the middle 50% of the values in the data set. Whiskers extend from the top of the box to the largest data point within 1.5 times the interquartile range (IQR) and from the bottom of the box to the smallest data point within 1.5 times the IQR. Data points outside this range are considered outliers and are shown as small filled-in circles. Values outside this range have been omitted.
Source: own elaboration based on Twitter/X data and EquityRT.

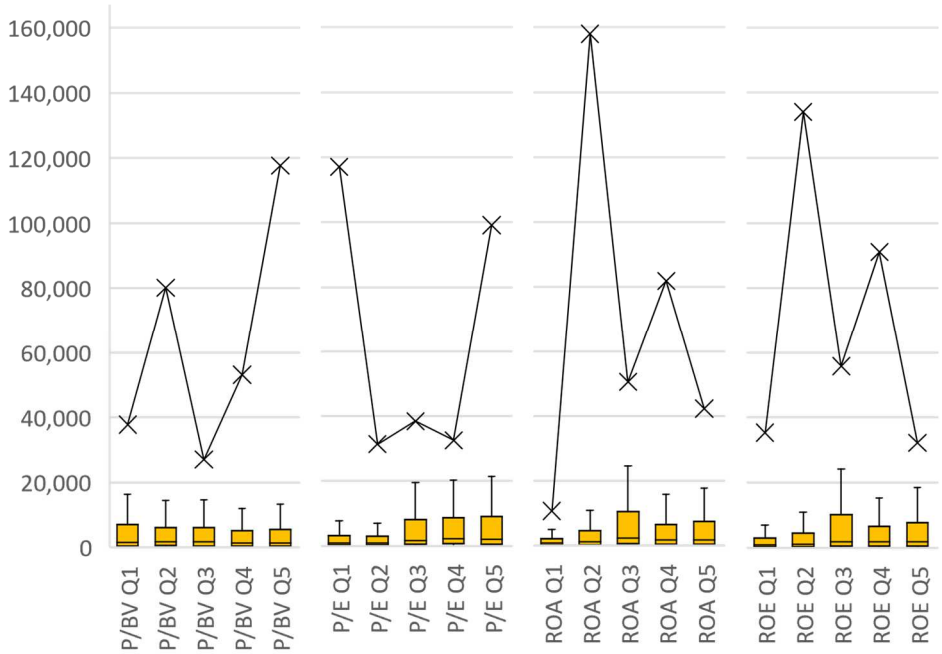

Figure 13. Activity on Twitter measured in the number of followers in quintiles based on P/BV, P/E, ROA, and ROE

Note: The line dividing the box into two parts represents the median. We marked the mean with and x. The box part of the box plot covers the middle 50% of the values in the data set. Whiskers extend from the top of the box to the largest data point within 1.5 times the interquartile range (IQR) and from the bottom of the box to the smallest data point within 1.5 times the IQR. Data points outside this range are considered outliers and are shown as small filled-in circles. Values outside this range have been omitted.
Source: own elaboration based on Twitter/X data and EquityRT.

CONCLUSIONS

This article aimed to explore the extent to which Twitter has been adopted for corporate communication purposes in the European context and to determine whether the profitability of European listed firms is linked to their use of Twitter. Using a large, novel dataset comprising nearly 5.5 million tweets from 41 European stock exchanges, we provided a comprehensive overview of the social media activity of 21 319 listed companies. Noteworthy, the rules and procedures governing corporate communication in the European Union are more strict in the European Union compared to the United States. Companies may post their news on social media, but only after it has first made it available via a regulatory information service. As a result, we confirmed our first hypothesis (H1) that the level of Twitter/X adoption for corporate communication in companies listed in Europe is lower than in the North American ones. This is especially visible in the case of companies listed on the stock exchanges of Eastern Europe, most likely reflecting the comparatively underdeveloped technological landscape in these regions.

Larger companies (H2) are more likely to have a Twitter/X account and engage in more activity. This is because they have more resources, such as marketing budgets and public relations teams, and that their customers come from a variety of geographical regions and industries, making social media an effective tool for reaching this diverse audience.

The relationship between profitability and Twitter adoption (H3) is not clear, as companies with both high and low returns on assets and equity (ROA and ROE ratios) engage in Twitter activity. However, when profits are measured by EBIT (Income TTM), more than half of companies in the lowest quintile of earnings from core business activities have a Twitter account and actively tweet. Interestingly, in the case of EBIT, the relationship between profitability and activity, as measured by the quantity of published information and the number of followers, is not monotonic, as both companies generating the highest losses and those with the highest operating income publish the most tweets and have the greatest number of followers.

Growth companies (in terms of P/BV and P/E ratio) are more likely to use Twitter/X for corporate communications (H4). However, roughly half of the companies with the lowest ratios have Twitter accounts. The third quintile is the least active in adopting Twitter. For the P/E ratio, both the average and median number of tweets rise, peaking in the fifth quintile for the average and the fourth for the median. Companies that are valued at a premium due to their anticipated profit potential tend to tweet more. As investors' expectations for future earnings growth rise, so do follower counts.

Interestingly, companies with higher levels of debt (H5) are more likely to have adopted Twitter and exhibit greater activity, both in terms of published information and number of followers. We also found that the use of Twitter is more prevalent in certain industries, such as technology and consumer goods, and that larger firms tend to have more Twitter followers.

The implications of our research suggest that companies should consider adopting social media as part of their communication strategy to enhance their financial performance. Our study contributes to the understanding of social media's role in corporate communication and its potential impact on the financial performance of European listed firms.

For European companies, while the use of Twitter is not mandatory, several stock exchanges and regulatory bodies actively encourage adopting social media platforms to enhance market transparency and improve communication with investors.

Firstly, growth-oriented companies, particularly those with high P/BV and P/E ratios, should implement a media strategy focused on regularly informing the market about their activities and progress. Investors are more interested in firms that consistently share information on Twitter, as demonstrated by a substantial number of followers. Secondly, companies with higher levels of debt are advised to leverage social media platforms like Twitter to increase transparency and build trust with investors and financial institutions. Enhanced media activity can be a tool for fostering confidence among stakeholders, especially for firms seeking external financing. Lastly, regarding the relationship between Twitter usage and financial performance measured by EBIT, companies should consider tailoring their social media strategies based on their operational profitability. While the

correlation is not entirely clear—both high and low EBIT companies show increased activity on Twitter. Profit-generating firms might enhance their social media presence to maintain stakeholder engagement and attract new investors. Conversely, companies with lower operational profits can use Twitter to boost visibility and create a competitive advantage.

With the advent of social media as a means for companies to convey information to investors, this article shows that firms can attain tangible benefits. Notably, 'marginalized' firms that have historically been overlooked by traditional media are the most likely to benefit from the democratizing influence of social media.

This study is subject to limitations. First, the relatively short study period, dictated by the availability of archival Twitter data[2], means that our results may be specific to the time frame or sample used. Consequently, further research covering a longer period is needed to build confidence in the generalizability of the findings. Second, web scraping relies on the completeness and accuracy of the official websites from which data was collected. Companies that do not maintain their websites or that update their Twitter/X accounts infrequently may have been underrepresented in our dataset. Moreover, the absence of a centralized European database for corporate social media accounts introduces the possibility that some firms using unofficial Twitter/X accounts or not publicly linking them may have been missed. This could lead to selection bias, particularly among smaller firms or those based in less technologically advanced countries.

Some observations were excluded from the final analysis due to incomplete financial data for some companies. This ensures consistency between the financial and Twitter datasets but may reduce sample representativeness, especially for Eastern European firms. Thus, the results should be interpreted carefully, especially when generalizing beyond the final sample companies.

Our analysis was also limited to Twitter/X as a social media platform and did not explore the role of other platforms, such as LinkedIn or Facebook, which may also play a critical role in corporate communication strategies. Furthermore, the study is constrained by regulatory differences between regions, particularly between the European Union and the United States, which might affect the generalizability of the results. Additionally, we did not consider the impact of industry-specific practices and corporate strategies on social media adoption and usage patterns.

Another limitation is that we did not analyse the topics in the companies' tweets, as our analysis was strictly quantitative. Lower levels of Twitter activity might be attributed to a company's communication strategy, where social media is used selectively, for example, only for operational updates or marketing purposes. This suggests that a company's overall Twitter engagement may not fully reflect its investor communication efforts. Consequently, future research could expand on this by incorporating qualitative analysis of tweet content to provide deeper insights into the nature of corporate social media activity.

While this study primarily focuses on a descriptive analysis of Twitter/X activity among European firms, future research could investigate potential causal mechanisms. One possible explanation is that firms active on Twitter/X may leverage social media for more transparent and frequent communication, which can reduce information asymmetry and potentially lower the cost of equity (Vitolla *et al.,* 2020). Moreover, firms that use Twitter to engage with customers and investors might experience enhanced brand loyalty and customer satisfaction (de Oliveira Santini *et al.,* 2020), which could translate into better financial performance in the long run. However, establishing a direct causal relationship between Twitter/X activity and financial outcomes requires further empirical investigation, as such relationships might be industry-specific and time-dependent (Bank *et al.,* 2019). Future studies could use time-lagged models to assess the long-term effects of social media engagement on profitability, growth, and leverage.

Finally, further studies could investigate the role of regulatory environments in shaping disclosure and dissemination strategies. More detailed research on Twitter's potential to substitute for traditional communication channels would also be beneficial. Examining how companies' Twitter activity

[2] As stated in Twitter's developer documentation, the API provides access to only the most recent 5 000 followers and up to the latest 3 200 tweets from a user.

evolves and how these changes correlate with shifts in business fundamentals could provide valuable insights into the relationship between social media presence and corporate performance.

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Appendix

Table A1. Twitter activity in number of tweets and followers

	N	Tweets					Followers				
		N	Mean	Q1	Median	Q3	N	Mean	Q1	Median	Q3
Country	21 319	7 107 (33.3%)					7 341 (34.4%)				
Ireland	29	14 (48.3%)	683	133	360	954	15 (51.7%)	69 715	1 710	2 551	14 204
Finland	176	100 (56.8%)	792	151	420	1 017	102 (58.0%)	47 770	708	1 961	5 168
United Kingdom	1 616	828 (51.2%)	778	130	392	1 070	849 (52.5%)	70 459	562	1 634	7 194
France	875	428 (48.9%)	752	112	368	1 075	449 (51.3%)	50 617	496	1 520	4 639
Netherlands	123	56 (45.5%)	729	171	336	957	59 (48.0%)	43 345	1 122	3 621	15 065
Turkey	279	99 (35.5%)	460	109	334	504	111 (39.8%)	143 757	457	2 203	14 596
Malta	39	17 (43.6%)	232	24	74	402	17 (43.6%)	1 575	167	571	3 019
Switzerland	296	123 (41.6%)	800	184	452	1 088	127 (42.9%)	23 671	588	2 059	5 993
Italy	447	155 (34.7%)	747	115	364	958	167 (37.4%)	84 751	351	1 221	6 280
Spain	305	112 (36.7%)	1 168	329	912	1 900	111 (36.4%)	343 811	1 447	3 674	18 629
Czech Republic	25	8 (32.0%)	1 328	664	1 016	2 176	8 (32.0%)	6 880	1 569	3 401	7 064
Denmark	185	62 (33.5%)	690	93	242	768	64 (34.6%)	22 687	291	2 212	13 810
Sweden	840	270 (32.1%)	422	75	169	481	272 (32.4%)	35 671	260	671	2 126
Belgium	171	53 (31.0%)	639	61	221	578	56 (32.7%)	4 185	356	1 171	4 641
Norway	243	79 (32.5%)	485	91	222	416	76 (31.3%)	4 091	557	1 439	4 777
Liechtenstein	3	1 (33.3%)	497	497	497	497	1 (33.3%)	824	824	824	824

	N	Tweets					Followers				
		N	Mean	Q1	Median	Q3	N	Mean	Q1	Median	Q3
Germany	933	275 (29.5%)	821	150	472	1 175	279 (29.9%)	61 346	357	1 616	8 881
Portugal	68	17 (25.0%)	914	134	514	1 542	16 (23.5%)	220 832	510	1 078	58 758
Latvia	27	5 (18.5%)	197	70	192	314	6 (22.2%)	1 909	376	636	1 542
Poland	843	181 (21.5%)	572	71	203	757	203 (24.1%)	12 294	92	506	2 822
Austria	86	20 (23.3%)	471	268	353	506	19 (22.1%)	2 530	547	2 056	2 892
Iceland	25	5 (20.0%)	307	142	195	293	6 (24.0%)	2 458	539	1 015	3 425
Greece	233	43 (18.5%)	675	55	178	673	49 (21.0%)	13 751	153	948	2 999
Romania	90	8 (8.9%)	795	49	159	1 470	11 (12.2%)	6 534	155	550	3 707
Luxembourg	13	2 (15.4%)	649	363	649	936	2 (15.4%)	14 181	11 015	14 181	17 347
Hungary	39	3 (7.7%)	760	63	109	1 131	4 (10.3%)	44 483	20	45	44 508
Slovenia	86	9 (10.5%)	821	3	496	1 025	10 (11.6%)	2 116	302	530	1 520
Croatia	148	14 (9.5%)	340	51	103	234	14 (9.5%)	2 928	1 067	2 229	2 509
Cyprus	172	13 (7.6%)	184	20	50	92	12 (7.0%)	458	28	104	747
Bulgaria	422	27 (6.4%)	370	50	127	236	29 (6.9%)	3 046	95	197	977
Lithuania	33	2 (6.1%)	47	31	47	62	2 (6.1%)	151	92	151	209
Slovakia	68	3 (4.4%)	88	44	67	122	3 (4.4%)	897	142	197	1 303
Estonia	22	0 (0.0%)					0 (0.0%)				
Other European	1 173	59 (5.0%)	569	67	189	610	77 (6.6%)	21 961	68	546	5 023
USA & Canada	6 557	3 144 (47.9%)	837	124	418	1 224	3 175 (48.4%)	90 757	631	2 098	9 939
Americas	195	62 (31.8%)	1 230	303	1 012	2 201	73 (37.4%)	159 979	3 967	28 085	140 138
Australia and Oceania	1 240	383 (30.9%)	453	73	197	508	397 (32.0%)	9 991	354	858	2 458
Africa	231	65 (28.1%)	871	193	631	1 198	70 (30.3%)	85 307	1 997	5 228	14 699
Asia	2 963	362 (12.2%)	889	130	509	1 376	400 (13.5%)	136 967	774	4 644	41 799
Industry	21 098	7 088 (33.6%)					7 320 (34.7%)				
Computer Softw. & Svcs.	1 464	858 (58.6%)	1 043	171	600	1 737	853 (58.3%)	55 334	564	2 317	10 472
Communication Svcs.	519	251 (48.4%)	1 118	198	677	2 038	259 (49.9%)	80 509	851	3 407	23 429
Medical Care	2 324	1 048 (45.1%)	457	85	228	547	1 046 (45.0%)	11 043	392	983	2 986
Banking	697	296 (42.5%)	1 100	282	782	1 654	314 (45.1%)	94 936	1 406	4 605	45 461
Insurance	291	125 (43.0%)	1 030	375	729	1 512	129 (44.3%)	43 906	1 293	3 173	14 516
Media & Marketing	689	281 (40.8%)	1 044	144	565	1 781	290 (42.1%)	348 981	984	3 917	20 346
Commercial Svcs.	609	244 (40.1%)	918	169	523	1 424	253 (41.5%)	9 680	394	1 456	6 412
IT Hardware & Electron-ics	680	276 (40.6%)	792	113	391	1 147	282 (41.5%)	59 550	444	1 263	8 636
Utilities	499	169 (33.9%)	938	226	588	1 364	175 (35.1%)	16 210	961	3 044	8 598
Retail	656	214 (32.6%)	1 298	264	1 013	2 416	231 (35.2%)	249 058	1 801	9 290	66 599
Metals & Mining	2 281	696 (30.5%)	334	45	144	355	738 (32.4%)	3 211	349	850	1 991

	N	Tweets					Followers				
		N	Mean	Q1	Median	Q3	N	Mean	Q1	Median	Q3
Automotive & Truck Mfg.	410	135 (32.9%)	783	143	419	1 148	138 (33.7%)	112 241	505	2 788	19 882
Industrial Goods & Svcs.	1 363	436 (32.0%)	581	125	328	772	444 (32.6%)	19 183	404	1 461	5 269
Consumer Svcs.	894	271 (30.3%)	1 148	145	635	2 229	286 (32.0%)	481 355	1 050	5 701	39 994
Chemicals	439	141 (32.1%)	594	129	380	804	142 (32.3%)	10 160	584	1 638	5 432
Transportation & logis-tics	519	146 (28.1%)	961	159	459	1 422	163 (31.4%)	158 886	1 136	5 502	46 418
Consumer durables	262	72 (27.5%)	841	53	247	1 516	80 (30.5%)	50 403	335	2 117	13 476
Energy	1 237	324 (26.2%)	449	61	201	536	336 (27.2%)	17 404	285	1 080	4 381
Financial svcs.	1 286	299 (23.3%)	796	103	352	1 222	317 (24.7%)	44 799	323	1 932	12 801
Engineering & construc-tion	755	171 (22.6%)	803	170	542	1 165	176 (23.3%)	17 143	629	2 499	11 328
Consumer products	1 048	224 (21.4%)	832	124	451	1 197	238 (22.7%)	28 573	800	4 117	18 064
Materials	475	102 (21.5%)	484	158	346	616	106 (22.3%)	3 230	471	1 747	3 163
Textile & apparel	361	69 (19.1%)	848	155	529	1 243	79 (21.9%)	510 953	676	5 225	43 542
Real estate	1 340	240 (17.9%)	638	108	282	805	245 (18.3%)	11 274	385	1 337	4 404

Source: own study.

Table A2. Twitter activity in quintiles of selected variables

		Tweets					Followers				
		N	Mean	Q1	Median	Q3	N	Mean	Q1	Median	Q3
P/BV	7 407	2 817 (38.0%)					2 920 (39.4%)				
P/BV Q1 (0.0 – 0.7)	1 491	408 (27.4%)	753	120	346	1 074	432 (29.0%)	37 762	341	1 601	6 986
P/BV Q2 (0.7 – 1.3)	1 657	554 (33.4%)	774	124	415	1 089	574 (34.6%)	80 175	529	1 762	6 110
P/BV Q3 (1.3 – 2.5)	1 556	621 (39.9%)	750	127	385	1 021	643 (41.3%)	27 003	425	1 648	6 135
P/BV Q4 (2.5 – 6.4)	1 442	669 (46.4%)	677	112	302	885	694 (48.1%)	53 159	406	1 386	5 100
P/BV Q5 (6.4 – 16 250 000.0)	1 261	565 (44.8%)	682	105	290	888	577 (45.8%)	117 749	420	1 277	5 605
P/E	7 522	2 840 (37.8%)					2 947 (39.2%)				
P/E Q1 (-9 026 951 – -11)	1 272	485 (38.1%)	521	84	230	640	507 (39.9%)	117 049	285	948	3 241
P/E Q2 (-11 – -1)	1 163	442 (38.0%)	521	84	226	581	456 (39.2%)	31 359	266	895	2 981
P/E Q3 (-1 – 8)	1 544	446 (28.9%)	775	117	339	1 064	475 (30.8%)	38 448	437	1 733	8 137
P/E Q4 (8 – 21)	1 764	679 (38.5%)	815	142	490	1 194	702 (39.8%)	32 540	657	2 279	8 781
P/E Q5 (21 – 589 347)	1 779	788 (44.3%)	878	174	474	1 290	807 (45.4%)	99 079	605	2 022	9 009
ROA	8 001	2 962 (37.0%)					3 073 (38.4%)				
ROA Q1 (-1 280 064 – -88)	1 309	517 (39.5%)	471	71	184	471	538 (41.1%)	10 739	275	804	2 187
ROA Q2 (-88 – -10)	1 390	476 (34.2%)	651	96	278	859	491 (35.3%)	157 968	321	1 246	4 641
ROA Q3 (-10 – 6)	1 535	565 (36.8%)	870	155	476	1 366	584 (38.0%)	50 530	628	2 322	10 605
ROA Q4 (6 – 26)	1 613	557 (34.5%)	773	129	376	1 144	580 (36.0%)	81 884	454	1 809	6 633
ROA Q5 (26 – 778 365)	2154	847 (39.3%)	777	136	410	1 072	880 (40.9%)	42 305	544	1 741	7 446
ROE	7 343	2 830 (38.5%)					2 932 (39.9%)				

		Tweets					Followers				
		N	Mean	Q1	Median	Q3	N	Mean	Q1	Median	Q3
ROE Q1 (-680.81 – -0.11)	1 332	574 (43.1%)	559	82	236	651	594 (44.6%)	35 341	302	924	3 003
ROE Q2 (-0.11 – 0.00)	1 249	454 (36.3%)	595	96	265	739	463 (37.1%)	134 078	326	1 153	4 564
ROE Q3 (0.00 – 0.03)	1 375	459 (33.4%)	867	149	467	1 348	478 (34.8%)	55 792	476	1 874	10 201
ROE Q4 (0.03 – 0.09)	1 610	588 (36.5%)	758	138	396	1 068	613 (38.1%)	91 110	608	1 838	6 505
ROE Q5 (0.09 – 714.55)	1 777	755 (42.5%)	785	128	383	1 079	784 (44.1%)	32 282	534	1 850	7 718
MCap	8 920	2 931 (32.9%)					3 059 (34.3%)				
MCap Q1 (0 – 7 795)	2 419	281 (11.6%)	379	34	106	350	325 (13.4%)	6 446	68	359	1 508
MCap Q2 (7 797 – 44 132)	1 977	560 (28.3%)	442	67	168	462	604 (30.6%)	12 258	149	496	1 591
MCap Q3 (44 158 – 216 755)	1 843	674 (36.6%)	589	100	257	681	703 (38.1%)	22 224	378	1 049	3 061
MCap Q4 (216 852 – 1 385 252)	1 531	677 (44.2%)	745	168	386	998	684 (44.7%)	136 226	697	1 947	5 079
MCap Q5 (1 385 489 – 31 956 050 635)	1 150	739 (64.3%)	1 150	343	853	1 763	743 (64.6%)	104 337	2 140	7 700	32 797
Total assets	8 110	2 977 (36.7%)					3 089 (38.1%)				
Total assets Q1 (0 – 11 986)	1 715	439 (25.6%)	346	50	143	361	476 (27.8%)	7 715	118	436	1 165
Total assets Q2 (11 995 – 85 468)	2 137	678 (31.7%)	504	71	194	551	720 (33.7%)	7 912	233	743	2 152
Total assets Q3 (85 593 – 489 982)	1 862	639 (34.3%)	646	115	296	780	656 (35.2%)	39 529	416	1 231	3 848
Total assets Q4 (490 058 – 2 914 242)	1 283	522 (40.7%)	813	152	451	1 148	539 (42.0%)	184 151	766	2 221	7 646
Total assets Q5 (2 915 335 – 4 179 806 612)	1 113	699 (62.8%)	1 154	368	852	1 729	698 (62.7%)	90 296	2 329	7 224	32 621
Income TTM	7 561	2 783 (36.8%)					2 888 (38.2%)				
Income TTM Q1 (-10 879 938 422 – -4 895 766)	1 001	469 (46.9%)	689	111	276	847	478 (47.8%)	72 945	498	1 461	6 966
Income TTM Q2 (-4 888 751 – -315 490)	1 409	468 (33.2%)	410	58	162	460	483 (34.3%)	12 774	192	587	1 563
Income TTM Q3 (-314 821 – 7 056 869)	2 404	589 (24.5%)	495	62	215	524	647 (26.9%)	10 376	161	608	2 088
Income TTM Q4 (7 065 272 – 96 364 076)	1 734	640 (36.9%)	684	122	334	901	658 (37.9%)	137 148	542	1 466	4 187
Income TTM Q5 (96 371 269 – 59 143 674 872)	1 013	617 (60.9%)	1 142	355	857	1 722	622 (61.4%)	79 326	2 264	6 263	26 936
Debt ratio	8 110	2 977 (36.7%)					3 089 (38.1%)				
Debt ratio Q1 (0.0 – 0.3)	1 438	423 (29.4%)	449	70	191	495	444 (30.9%)	11 084	229	719	2 289
Debt ratio Q2 (0.3 – 0.5)	1 649	593 (36.0%)	628	113	284	805	612 (37.1%)	77 242	407	1 205	3 660
Debt ratio Q3 (0.5 – 0.6)	1 760	673 (38.2%)	747	112	364	1 055	696 (39.5%)	45 662	438	1 565	5 193
Debt ratio Q4 (0.6 – 0.8)	1 754	753 (42.9%)	812	138	410	1 179	774 (44.1%)	111 754	513	2 280	10 002
Debt ratio Q5 (0.8 – 14 073.1)	1 509	535 (35.5%)	861	140	411	1 276	563 (37.3%)	48 158	542	2 056	11 482

Source: own study.

Authors

The contribution share of authors is equal and amounted to 25% for each of them.
KBK – conceptualization, analysis and interpretation, writing – original draft , CG – critical review, writing – review & editing , JC – methodology, formal analysis, visualization , RG – data curation, data analysis, writing – review & editing.

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The authors declare that the submitted text is free of AI/GAI usage. All content has been prepared solely by the authors without the assistance of generative tools.

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Foretelling or foresight? Accounting-based bankruptcy prediction models and earnings quality in the case of Polish listed companies

Barbara Grabińska, Konrad Grabiński

ABSTRACT

Objective: The article aims to examine the relationship between bankruptcy risk and earnings quality in designing accounting-based bankruptcy prediction models. The models classify companies (firm-year observations) into two groups with high or low (no) bankruptcy risk. We investigated the difference in earnings quality between those two groups.

Research Design & Methods: We used quantitative research methods, such as descriptive statistics, correlation analysis (Pearson's and Spearman's rank correlation), and Welch ANOVA. The study sample consisted of firm-year observations of companies listed in the Warsaw Stock Exchange for 17 years (2007-2023) ranging from 5 004 up to 5 688 firm-year observations. We employed five accounting-based bankruptcy prediction models specific to the Polish context and two metrics of earnings quality: accrual and real earnings management. We estimated the proxy of accrual earnings management using the modified Jones model and real earnings management with the Roychowdhury model. We estimated the bankruptcy risk using five prediction models and then analyzed as a continuous (in correlation analysis) and dichotomous variable (Welch ANOVA).

Findings: The research results demonstrate that companies classified by company failure models as high bankruptcy risk are associated with lower earnings quality. The results of the Welch ANOVA analysis are consistent across all combinations of accounting-based prediction models and earnings quality proxies used in the study research. The findings imply that a high bankruptcy risk is associated with managers engaging in more intensive accrual and real earnings management. The results suggest managers are more inclined to influence reporting numbers and operational activities to achieve desired goals.

Implications & Recommendations: Scholars should consider diminishing the quality of earnings associated with higher bankruptcy risk in designing and developing future accounting-based bankruptcy prediction models. Financial statement users like investors, financial analysts, financial auditors, and other stakeholders should also consider earnings quality. The study provides an avenue for future research by calling for research across earnings quality and bankruptcy prediction models.

Contribution & Value Added: The study contributes to a better understanding of the relationship between accounting-based bankruptcy prediction models and how they estimate bankruptcy risk and earnings quality. As far as we know, earnings quality has not been considered a factor in the design of models for bankruptcy prediction.

Article type:	research article
Keywords:	bankruptcy prediction; accounting-based prediction models; earnings quality; accrual earnings management; real earnings management; bankruptcy risk
JEL codes:	M41, O16, G33

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INTRODUCTION

Accounting provides a variety of tools useful to the entity's management. One set of tools refers to so-called company failure models or models for bankruptcy prediction or financial health prediction models (FHPM). These models aim to assess the bankruptcy risk. However, they also indicate the company's financial health or condition (Bolek & Gniadkowska-Szymańska, 2022; Olszewska & Turek, 2018). We may trace the beginnings of this approach to the 30-es of the twentieth century when the global financial crisis took a severe toll, causing the bankruptcy of numerous companies, unemployment, and other social problems. Since then, many practitioners and scholars have praised FHPMs for their wide range of usability, decision-making process, and relative ease of application. The first models, like that developed by Fitzpatrick (1932), Merwin (1942), Tamari (1966) and Beaver (1966), employed univariate ratio analysis. The breakthrough was an Altman model (Altman, 1968) based on multiple discriminant analysis. In 1977, Altman *et al.* improved the prior model by introducing a measure of earnings stability (Altman *et al.*, 1977). Next came models developed by scholars like Springate, Zmijewski and Ohlson. The academic world and practitioners soon realised that the models' effectiveness is specific not only to the industry but also to the country (Prusak, 2018). Therefore, the field developed a variety of models considering country-specific settings. For example, at least several models have reasonable predictive power in Poland.

A subset of FHPMs built on accounting numbers reported in financial statements is referred to as accounting-based prediction models (ABPMs). We chose to use ABPMs due to their wide acceptance in economic practice in Poland. These models are typical in that they are based mainly on data generated by accounting and presented in financial statements. Therefore, the quality of the model's results depends on the quality of the reported financial statements. The paper's novelty is in investigating the relationship between bankruptcy risk (financial health) and earnings quality. We theorised that the quality of the earnings may influence the predictive power of the ABPMs. Therefore, future models should consider earnings quality when interpreting ABPMs' results.

We hypothesised that the group of firm-year observations characterised by the high risk of bankruptcy displays lower earnings quality than those with lower or no bankruptcy risk. The study employs two earnings quality concepts: accruals earnings management (AEM) and real earnings management (REM). To estimate AEM, one must use the modified Jones model and REM with the Roychowdhury model. The research design applies five popular ABPMs in Poland to determine bankruptcy risk. We employed correlation analysis and Welch ANOVA to test the main hypothesis.

Our sample consisted of companies listed on the Warsaw Stock Exchange that have been in operation for 17 years (2007-2023). The sample size ranges from 5 004 (when we considered the REM variable) up to 5 688 firm-year observations (in the case of the AEM variable). We chose Poland as the research sample due to the following reasons: a relatively large number of ABPMs in place and used by practitioners (*i.e.,* accountants, financial auditors, analysts), a large number of companies listed in the stock exchange (from 351 companies in 2007 up to 410 in 2023 in the main market) and finally Poland is one of the fastest developing countries in Europe in the last 30 years. Poland is a post-communist economy, one of the Central and Eastern European (CEE) countries and as an EU member since 2004, it was upgraded in 2018 to the status of a developed market by FTSE Russell. Therefore, Poland is an example of a success story, at least from the economic perspective. This type of research would probably be very difficult or impossible to conduct in any other CEE country.

Our findings suggest that managers of companies with a high risk of bankruptcy tend to engage in accrual and real earnings management. Consequently, those companies' earnings quality is significantly lower than those with lower or no bankruptcy risk. The results may be important for the development of future ABPMs as well as for financial statement users like financial analysts or financial auditors. The improvements in ABPMs' accuracy may prevent bankruptcies and stabilise economic development. Thus far, stakeholders do not fully recognise the significance of earnings quality in the decision-making process. Likewise, scholars avoid this issue while investigating bankruptcy prediction models.

The remainder of the article is structured as follows. Section 1 will provide a literature review and hypothesis development. It will begin with the concept of financial health and accounting-based bankruptcy models and end with a theoretical framework and metrics of earnings quality. Section 2 develops the research design, methodology, and sample characteristics. Section 3 will present results and discussion. The last section will conclude the most important results of empirical research.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The first part of the literature review will address the issue of financial health and accounting-based bankruptcy models. The concept of financial health is not well-developed in the literature. Usually, it is taken as an axiomatic concept referring to an entity's finances, *i.e.,* expenses, savings, debt, investments, etc. For this study, we defined financial health as the entity's ability to survive in the competitive market, generate sustainable profit, pay its liabilities on time, and be sufficiently liquid and solvent. More specifically, it is an ability to generate enough profit to meet necessary expenses. A deeper understanding of financial health refers to the nature and quality of the capital and the way it is managed and can reproduce itself. We should understand capital from a multi-context perspective, such as financial, economic, social, intellectual, human, and many more. Financial information reported in financial statements and visible at the financial ratios level is a proxy (estimate) of some key capital characteristics, like growth and productivity. The important aspect of this concept is the opposite – an unhealthy entity – declining, decaying, and nodding to its fall. Financial health is of utmost interest to company stakeholders in the decision-making process. Most notably, a worse financial condition implies a bankruptcy risk.

The evolution of bankruptcy models is long and dates back to 1930s, when univariate models used individual financial ratios to signal financial distress. Thirty years later, in his seminal study, Altman (1968) applied multivariate statistical methods to formulate the Z-score model, which happened to be a pivotal moment in history. Developing bankruptcy prediction models leads to applying logistic regression (Ohlson, 1980), discriminant analysis, and AI techniques, including neural networks and machine learning (Hekanaho *et al.*, 1998; Zięba *et al.*, 2016). Wilson and Sharda (1994) provide empirical evidence suggesting that bankruptcy models based on neural networks had an accuracy of 96% compared to 91% of traditional MDA models. In recent decades, they have brought new developments based on deep learning models (Jones *et al.*, 2017).

Prusak (2018) provides an extensive research review into bankruptcy models with a special emphasis on CEE countries. He distinguishes at least several approaches like rough set theory, cash management methods, catastrophe theory, multicriteria decision aid methodology, case-based reasoning, data envelopment analysis, multidimensional scaling, concepts based on the entropy theory, pattern recognition method, the self-organizing map method, bankruptcy trajectories and opinions of auditors relating to the going-concern assumption.

Various methods are used to predict bankruptcy. Korol (2010) distinguishes three main groups: statistical, theoretical, and computational intelligence. The first statistical group encompasses MDPs, logit and probit models, and decision trees. The crucial area of statistical methods is the optimal selection of financial indices from the perspective of predictive power. The final product of the process is a single output metric describing financial health or bankruptcy risk, depending on the decision's purpose.

The important issue is the source of information that populates the model. From this perspective, the most popular are accounting-based models, where data are extracted from financial statements and financial ratios. Market-based models use stock market information, mainly stock prices. The next evolutionary step is the hybrid model class, which combines various methodologies and data sources. They integrate accounting-based and market-based information (Li & Faff, 2019).

Market-based models display advantages in using current market information (*i.e.*, Merton's model) reflecting real-time investors' expectations. For the same reason, they are deemed to incorporate market expectations for future cash flows, which are assumed to be reflected in stock prices. The strength is also a weakness, as they are exposed to stock-market fluctuations. Therefore, they implicitly assume market efficiency, which is not always true. As a result, Li and Faff (2019) recommend relying more on market-based rather than accounting-based information during the financial crisis.

Scholars praise accounting-based bankruptcy models for numerous advantages. The most important is the ease of application and the ability to reduce the wide variety of financial ratios to a single metric. The former addresses the issue of data availability – access to the financial statement and populating the model with the reported numbers. For these reasons, accounting-based models are widely used in accounting practice by managers, investors, creditors, financial auditors, or accountants. They often reveal specific problems that need to be addressed in financial management. The simplicity of the models makes them easy to understand and apply. Lastly, their predictive power is usually acceptable for decision-making compared to other methods.

On the other hand, scholars criticise the accounting-based models for ignoring key information related to the entity's competitiveness, market position, growth opportunities, managerial experience, macroeconomic factors, etc. They use historical data, which may be outdated during a crisis or rapidly changing market conditions. Therefore, their effectiveness is not constant over time. Another limitation is industry and country specificity. They require a linear assumption between the Z-Score parameter and the financial health, which is a significant limitation. Finally, interpreting the so-called 'grey zone' is one of the methods' imperfections (Pilch, 2021).

Many studies show that the failure process can take many years, in extreme cases, up to eight years (Ooghe & Prijcker, 2008). It is considered a systematic process with some predictive ability over time. Regarding financial variables, the predictive ability is high for a one-year horizon. However, it disappears quickly after that (Du Jardin, 2015). For this reason, using non-financial variables is important (Altman *et al*., 2016). However, the application is limited when it comes to cross-country study. The main challenge is to improve prediction models by improving the accuracy and extending the horizon period (Altman *et al.*, 2010). Our study contributes to this line of research by providing insight into the impact of earnings quality on the prediction models. We conjecture that earnings quality is an important parameter influencing ABPMs' accuracy and prediction power.

Reisz and Perlich (2007) argue that standard accounting-based prediction models in short horizons (one or two years before bankruptcy) are superior to market-based models in accuracy. There is a plethora of prediction models in place. However, there is no widely accepted theoretical foundation for selecting financial ratios used in the model (Balcaen & Ooghe, 2006), even though some theories are applied (*i.e.,* cash-flow theory or option pricing). Consequently, the selection process of models' variables is sample and country-specific and difficult to generalise. Bellovary *et al.* (2007) provide an extensive literature review covering 150 studies from 1965 to 2004. They documented the application of more than 750 financial ratios and models using up to 57 variables. However, the number of variables is not correlated with the model's accuracy. Simple models, especially accounting-based, are considered superior to more complicated ones (Balcaen & Ooghe, 2006), mostly due to the problem of multicollinearity.

In the Polish context, the development of bankruptcy models started relatively late, in the early 1990s. The political and institutional change from central planning to a market-based economy played a crucial role. The first Polish models were adaptations of foreign models, mainly Altman's Z-score. In the mid-90s, scholars started to use more refined models based on multidimensional discriminant analysis (MDA) with more reference to the specificity of the Polish economy. Later on, academics incorporated macroeconomic indicators and specific firm-level characteristics. The attention switched to sector-specific models, adjusting to different business environments (Prusak, 2019). Currently, the most frequently used models predominantly rely on financial indicators. However, newly developed models incorporate additional information like economic cycle indicators (*e.g.*, economic growth, labour market status, inflation) or non-financial indicators like market value ratios (Pawełek *et al.*, 2020). Zvarikova *et al.* (2017) conclude that in Poland, over 60 models have been developed since the beginning of 90es. The most popular are models of Mączyńska, Pogodzińska and Sojak, Hadasik, Wierzba, Hołda and Prusak, Gajdka and Stos, Maślanka and 'Poznanski model.' There are predominantly accounting-based models which use information reported in financial statements. It translates to ease of application and popularity among practitioners while assuring an acceptable predictability level.

The second part of the literature review addresses the research design's theoretical framework and earnings quality metrics. Earnings quality is a cornerstone in accounting theory and empirical research. We may trace the concept's origins can to the 1930s in Graham and Dodd's book *Security*

Analysis (Graham & Dodd, 1934). However, in 1960s, there was a breakthrough in the field. The seminal works of Ball and Brown (1968) and Beaver (1968) revolutionised the landscape of accounting research. Their contributions based on the assumption that accounting information is useful when it influences investors' behaviour. Investors react to financial statements by changing share prices on the stock market or trade volume. Many years later, Lev defined earnings quality as the power of correlation between the accounting income reported in financial statements and the stock market returns (Lev, 1989). However, in the literature, there is no widely accepted definition of earnings quality (Nelson & Skinner, 2013). Consequently, there are at least a dozen proxies for earnings quality, and only the most important ones are persistence, predictability, smoothing, value relevance, or accruals (earnings management).

Dechow *et al.* (2010) provide a wider perspective on earnings quality, stressing that high-quality earnings provide more information on attributes and context for making specific decisions by specific users. The quality is determined firstly by the intrinsic economic fundamentals of the entity and secondly by the quality of the accounting system, *i.e.*, the reliability of accounting numbers. The latter depends on managerial discretion, professional judgment, audit quality, and accounting regulations. The challenge for accounting research is to separate the first – innate factor from the second one. However, scholars widely accept the importance of earnings quality but they do not always appreciate its usefulness in decision-making. This is probably due to the measurement problem and the variety of metrics. We conjecture that using ABPMs for measuring health conditions may be affected by earnings quality, and the results may be biased due to lower low-quality earnings.

Francis *et al.* (2006) classify earnings quality metrics into accounting-based and market-based categories. The former includes earnings persistence, earnings predictability, accruals, and earnings smoothness. It is based on information reported in financial statements and estimated using regression. The latter refers to value relevance or timeliness. They estimate using stock market parameters like share prices, market returns, trading volume, and accounting data. Each of these metrics captures different attributes of earnings quality.

Earnings management is one of the most widely used proxies for earnings quality. It intends to capture intentional management activity aimed at limiting earnings fluctuations over time with the opportunity provided by accrual accounting. Empirical research provides evidence suggesting that accrual accounting produces more useful reported numbers than cash accounting. Generally, it leads to the conclusion that accrual-based earnings are more informative and better depict underlying economic performance.

Earnings management (EM) is often described as a managerial intentional influence on key reported financial items. Healy and Wahlen (1999) define EM as the modification of reported accounting profits made by managers or insiders to misinform stakeholders or achieve goals embedded in managerial contracts. The essence of accounting, like professional judgment or accounting estimates, allows for adopting subjective treatment and shaping reporting numbers. Schipper (1989) provides three possible ways of EM perception. She denotes the 'white' layer of earnings management. The discretion embedded in financial reporting allows management to signal the true financial situation of the reporting entity. The opposite 'black' version of EM depicts managerial behaviour as misleading, allowing managers to obtain unjustified benefits at the expense of shareholders and other stakeholders. The last 'grey' perspective implies signalling true information and obtaining higher benefits from managerial contracts.

Earnings management operates in two distinctive dimensions: accrual and real. Accrual earnings management (AEM) arises from innate (fundamental) economic performance and the quality of financial reporting. Analysts divide total accruals into normal and abnormal accruals, using the latter as a proxy for accrual earnings management. There are two interpretational layers. The first one adopts the view that the higher the absolute value of abnormal accruals, the lower the quality of financial reporting (*i.e.,* the quality of accounting profit). The second one distinguishes between income-increasing and income-decreasing earnings management. The measurement of earnings management is evolving, and there are at least several important models, *e.g.*, Healy (1985), Jones (1991), and the modified Jones model as proposed by Dechow *et al.* (1995) or Dechow and Dichev (2002).

Roychowdhury (2006) defines real earnings management (REM) as a departure from the normal course of action. Consequently, the structure and timing of transactions are modified, resulting in achieving financial goals as management desires. He provides the following examples: increasing sales by a more aggressive sales policy (*i.e.,* lower prices, longer payment terms), increasing the production volume above the market demand, which allows allocating fixed costs over the higher number of products or reducing advertisement or R&D costs. Therefore, real earnings management manifests itself by increasing production costs and decreasing administrative, advertising, and R&D expenses.

Earnings volatility is another aspect of earnings quality. From the stock market perspective, companies presenting less volatile earnings are rewarded with lower capital costs. For this reason, managers are motivated to smooth the earnings, even at the cost of long-term shareholder value (Graham *et al.,* 2005). Smoothed earnings allow for the maintenance of market valuation, credit rating position, and company's and managar's reputation. Reporting volatile earnings is detrimental to the company (*i.e.,* higher cost of capital, lower market capitalization) and the manager. Tucker and Zarowin (2006) conclude that only companies with good fundamentals and growth opportunities have the luxury of earnings management.

We conjectured that financial problems are an important factor affecting earnings quality. Managers tend to maintain the appearance of a stable financial situation either by influencing reported earnings or by structuring and timing transactions. Therefore, we hypothesised:

H1: High bankruptcy-risk companies are accompanied by more intensive accrual earnings management.

H2: High bankruptcy-risk companies are accompanied by more intensive real earnings management.

To test the hypotheses, we used correlation analysis and Welch ANOVA, which we will present in the following sections.

RESEARCH METHODOLOGY

We conjectured that financial problems are an important factor affecting earnings quality. Managers tend to maintain the appearance of a stable financial situation either by influencing reported earnings or by structuring and timing transactions. Therefore, we hypothesised that companies characterised by a high risk of bankruptcy display lower earnings quality than those with lower or no bankruptcy risk. From this perspective, controlling earnings quality also constitutes an important factor to consider in developing future ABPMs. We tested the hypothesis by investigating the co-occurrence of lower earnings quality with the high risk of bankruptcy. We intended to investigate the correlation relationship and not the causation. We used correlation analysis and Welch ANOVA.

We selected five popular accounting-based bankruptcy prediction models in Poland, for which the interpretation threshold was exactly zero (Table 1). It means the Z-score values below zero suggest high bankruptcy risk and above zero otherwise. One of the most praised was the Mączyńska model, which scholars often use to gauge the financial health of companies (Prusak, 2019). The model adapts O. Jacobs's model to the Polish economic environment. However, the other models are also popular and are often used in practice. For each model, we calculated the Z-score based on the financial statements of companies listed on the Warsaw Stock Exchange.

We used two metrics of earnings quality: accrual earnings management (AEM) and real earnings management (REM). We proxied AEM by the modified Jones model (Dechow *et al*., 1995). We started by calculating total accruals ($TAC_{i,t}$) to determine the difference between the profit (net income) and cash flows from operations. Then, we determined discretionary accruals ($DA_{i,t}$) for company i in year t as the difference between total accruals and the non-discretionary accruals ($NDA_{i,t}$). We estimated the cross-sectional model for every firm-year observation in the sample with reference to the group of 10 similar observations chosen from the same year, industry, and most similar size (proxied as total assets). Overall, we regressed a group of 11 firm-year observations using the modified Jones model as follows:

Table 1. Description of accounting-based bankruptcy prediction models (variables codes in brackets)

Mączyńska model (Z_MACZ)		
Z_MACZ = 1.5*X1 + 0.08*X2 + 10.0*X3 + 5.0*X4 + 0.3*X5 + 0.1*X6		
X1 = (gross profit + depreciation) / liabilities X2 = assets/liabilities and provisions for liabilities X3 = gross profit/assets X4 = gross profit/sales revenue X5 = inventories/sales revenue X6 = sales revenue/assets	very good financial condition, no risk of bankruptcy	Z > 2
	good financial condition, no risk of bankruptcy	1 < Z < 2
	worse financial condition, no risk of bankruptcy	0 < Z < 1
	risk of bankruptcy	Z < 0
Mączyńska and Zawadzki model (Z_MA_ZA)		
Z_MAC_ZAW = 9.498*X1 + 3.566*X2 + 2.903*X3 + 0.452*X4 – 1.498		
X1 = EBIT / assets X2 = equity/assets X3 = (net income + depreciation & amortization) / liabilities X4 = current assets / current liabilities	no risk of bankruptcy	Z > 0
	high risk of bankruptcy	Z < 0
Wierzba model (Z_WIERZ)		
Z_WIERZ= 3.26*X1 + 2.16*X2 + 0.3*X3 + 0.69*X4		
X1 = (EBIT – depreciation&amortization) / assets X2 = (EBIT – depreciation&amortization) / sales revenues X3 = current assets/liabilities X4 = working capital/assets	no risk of bankruptcy	Z > 0
	high risk of bankruptcy	Z < 0
Hadasik model (Z_HAD)		
Z_HAD = 0.365425*X1 – 0.765526*X2 – 2.40435*X3 + 1.59079*X4 + 0.00230258*X5 + 0.0127826*X6 + 2.36261		
X1 = current assets / current liabilities X2 = (current assets – stock) / current liabilities X3 = liabilities/assets X4 = working capital/assets X5 = receivables x 365 / sales revenue X6 = stock x 365 / sales revenue	no risk of bankruptcy	Z > 0
	risk of bankruptcy	Z < 0
The Poznan model (Z_POZN)		
Z_POZN = 3.652*X1 + 1.588*X2 + 4.288*X3 + 6.719*X4 – 2.368		
X1 = net income/assets X2 = (current assets – stock) / current liabilities X3 = (equity + non-current liabilities) / assets X4 = gross profit/sales revenues	no risk of bankruptcy	Z > 0
	risk of bankruptcy	Z < 0

Source: own study based on literature review (Hamrol *et al.*, 2004; Mączyńska *et al.*, 2018; Pilch, 2021; Wierzba, 2000).

$$\frac{TAC_{i,t}}{A_{i,t-1}} = \beta_{1,j}\left(\frac{1}{A_{i,t-1}}\right) + \beta_{2,j}\left(\frac{REV_{i,t}-\Delta REC_{i,t}}{A_{i,t-1}}\right) + \beta_{3,j}\left(\frac{PPE_{i,t}}{A_{i,t-1}}\right) + \varepsilon_{i,t} \quad (1)$$

in which:

$TAC_{i,t}$ - total accruals determined as net income minus cash flows from operations for i-company in t-year;

$A_{i,t-1}$ - change in sales revenue for i-company in t-year;

$\Delta REV_{i,t}$ - change in receivables for i-company in t-year;

$\Delta REC_{i,t}$ - gross property, plant and equipment for i-company in t-year;

$PPE_{i,t}$ - gross property, plant and equipment for i-company in t-year.

Second, with the use of beta coefficients estimated from the above model, we estimated non-discretionary accruals ($NDA_{i,t}$) as follows:

$$NDA_{i,t} = \beta_{1,j}\left(\frac{1}{A_{i,t-1}}\right) + \beta_{2,j}\left(\frac{REV_{i,t}-\Delta REC_{i,t}}{A_{i,t-1}}\right) + \beta_{3,j}\left(\frac{PPE_{i,t}}{A_{i,t-1}}\right) + \varepsilon_{i,t} \quad (2)$$

Finally, we determine $AEM_{i,t}$ as the proxy for accrual earnings management by subtracting $NDA_{i,t}$ from $TAC_{i,t}$, which were residuals from the first model:

$$AEM_{i,t} = \left(\frac{TAC_{i,t}}{A_{i,t-1}}\right) - NDA_{i,t} \quad (3)$$

We also used our research design's second earnings quality metric, $REM_{i,t}$ – real earnings management. We used the Roychowdhury model (Roychowdhury, 2006) to determine abnormal cash flows from operations. We applied the same procedure for selecting the peer group for each firm-year observation. To determine the proxy for REM, we used the cross-sectional model for every firm-year observation as follows:

$$\frac{CFO_{i,t}}{A_{i,t-1}} = \beta_{1,j}\left(\frac{1}{A_{i,t-1}}\right) + \beta_{2,j}\left(\frac{REV_{i,t}}{A_{i,t-1}}\right) + \beta_{3,j}\left(\frac{\Delta REV_{i,t}}{A_{i,t-1}}\right) + \varepsilon_{i,t} \quad (4)$$

in which:

$CFO_{i,t}$ - cash flows from operations of i-company in t-year;

$REV_{i,t}$ - sales revenue for i-company in t-year;

Then, we used beta coefficients from the model to estimate non-discretionary cash flows from operations ($NFCO_{i,t}$) as follows:

$$NFCO_{i,t} = \beta_{0,j} + \beta_{1,j}\left(\frac{1}{A_{i,t-1}}\right) + \beta_{2,j}\left(\frac{REV_{i,t}}{A_{i,t-1}}\right) + \beta_{3,j}\left(\frac{\Delta REV_{i,t}}{A_{i,t-1}}\right) + \varepsilon_{i,t} \quad (5)$$

in which:

$CFO_{i,t}$- cash flows from operations of i-company in t-year;

$REV_{i,t}$- sales revenue for i-company in t-year;

Finally, we determined the proxy for real earnings management ($REM_{i,t}$) as the discretionary cash flows from operations as follows:

$$REM_{i,t} = \left(\frac{CFO_{i,t}}{A_{i,t-1}}\right) - NCFO_{i,t} \quad (6)$$

Based on the accounting-based bankruptcy prediction models and two proxies of earnings quality, the dataset contained seven key variables. Table 2 presents their descriptive statistics. We winsorised all variables at the top and bottom of one percentile to neutralise the impact of outliers. The sample covered 17 years (2007-2023) and, depending on the variable, contained from 5 004 (the REM variable) up to 5 688 firm-year observations (the AEM variable). We examined banks and financial institutions from the sample due to their financial reporting specificity.

Table 2. Descriptive statistics of variables accounting-based bankruptcy prediction models and accrual and real earnings management

Variable	Obs.	Mean	Median	Std. Dev.	Min	25%	75%	Max	Skewness
(1) AEM	5 688	0.190	-0.003	1.567	-3.023	-0.133	0.126	5.508	1.667
(2) REM	5 004	-0.048	-0.047	0.233	-4.780	-0.112	0.013	4.455	-0.784
(3) Z_MACZ	5 532	7.481	5.727	7.889	-15.463	3.887	8.991	53.110	2.581
(4) Z_MA_ZA	5 553	2.033	1.876	5.900	-25.991	0.620	3.451	30.604	0.063
(5) Z_WIERZ	5 117	0.005	0.575	3.839	-28.308	0.074	1.038	6.750	-5.350
(6) Z_HAD	5 193	2.548	1.710	4.401	-7.786	0.988	2.873	31.147	3.938
(7) Z_POZN	5 641	6.254	4.526	12.722	-33.149	2.755	7.015	98.55	4.345

Source: own study based on data extracted from the ORBIS database.

The means and medians of proxies for earnings quality, AEM, and REM were very close to zero value (Table 2). The skewness of the AEM variable was high and positive, while REM is moderate and negative. The variability, as measured by the standard deviation, was relatively high. In the case of ABPMs, the variability coefficients were lower but still higher than the mean values. The values of the Mączyńska model were the most symmetric, indicating low skewness, while the values of the other models were highly skewed. The median and means of the Z-score model were positive, indicating no bankruptcy risk in most firm-year observations.

RESULTS AND DISCUSSION

For each ABPM, we calculated the number of firm-year observations above and below zero to learn how each prediction model divides the sample between firm-year observations with high bankruptcy risk and the others (Table 3). The Table presents the 'optimism' of each ABPM model, suggesting that the Wierzba model is the most conservative by suspecting almost 23% of the sample to be at high bankruptcy risk. Conversely, the Mączyńska model is the most liberal and suspects only 3%. The difference presented in Table 3 is a problem of type I and type II errors and the accuracy of ABPMs.

Table 3. Firm-year observations with high (Z < 0) and no bankruptcy risk (Z > 0)

Variable	Obs.	Z < 0	Z > 0	% of risk failure
(1) Z_MACZ	5 532	191	5 341	3.45%
(2) Z_MAC_ZAW	5 553	1 019	4 534	18.35%
(3) Z_WIERZ	5 117	1 160	3 957	22.67%
(4) Z_HAD	5 193	353	4 840	6.80%
(5) Z_POZN	5 641	360	5 281	6.38%

Source: own study based on data extracted from ORBIS database.

We used the correlation analysis to test the main hypotheses. We did not investigate the causality between the quality of reported earnings and the ABPMs' results. The question was whether the higher bankruptcy risk is accompanied by lower earnings quality. Table 4 presents the results of the first correlation analysis.

Table 4. Pairwise correlations: Pearson (lower triangle) and Spearman (upper triangle)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) AEM	1.000	-0.267***	-0.041	0.093***	0.122***	0.112***	0.050**
	–	(0.000)	(0.131)	(0.000)	(0.000)	(0.000)	(0.015)
(2) REM	-0.142***	1.000	0.263***	0.372***	0.258***	0.545***	0.188***
	(0.000)	–	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
(3) Z_MACZ	-0.012	0.248***	1.000	0.436***	0.326***	0.022	0.545***
	(0.375)	(0.000)	–	(0.000)	(0.000)	(1.000)	(0.000)
(4) Z_WIERZ	0.023*	0.405***	0.389***	1.000	0.700*	0.214***	0.645***
	(0.084)	(0.000)	(0.000)	–	(0.000)	(0.000)	(0.000)
(5) Z_POZN	-0.012	0.306***	0.231***	0.516***	1.000	0.241***	0.372***
	(0.385)	(0.000)	(0.000)	(0.000)	–	(0.000)	(0.000)
(6) Z_HAD	0.046***	-0.149***	0.017	0.047***	-0.178***	1.000	0.037
	(0.001)	(0.000)	(0.229)	(0.001)	(0.000)	–	(0.251)
(7) Z_MA_ZA	0.030**	0.136***	0.654***	0.504***	0.223***	0.073***	1.000
	(0.023)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	–

Note: p-values in brackets and *** p<0.01, ** p<0.05, * p<0.1;
Source: own study based on data extracted from the ORBIS database.

Pearson correlation evaluates the linear relationship between two continuous variables, while the Spearman correlation evaluates the monotonic relationship, which means that two variables tend to change together, but not necessarily at a constant rate. In Table 4, correlation coefficients were of limited values. We recorded the highest values recorded between Z-scores of the Mączyńska-Zawadzki model and Wierzba model (Spearman corr. coef. of 0.700 and Pearson of 0.516), and Mączyńska-Zawadzki model and Poznanski model (Spearman corr. coef. of 0.645 and Pearson corr. coef. of 0.504), and Mączyńska model and Poznanski model (Spearman corr. coef. of 0.545 and Pearson corr. coef. of 0.654). As we considered the correlation coefficients, they were of moderate values; however, in most cases, p-values were equal to zero, suggesting a strong significant relationship. All the correlation coefficients were positive. However, we found significant differences in how ABPMs perceive bankruptcy risks and financial conditions.

Table 5 presents content similar to Table 4, but with one difference. We use absolute values of AEM (absAEM) and REM (absREM). In this case, the correlation coefficients between the absAEM and the absAEM with Z-scores values of ABPMs are even lower than in Table 4. However, in most cases, p-values were equal to zero, suggesting a strong significant relationship.

Table 5. Pairwise correlations: Pearson (lower triangle) and Spearman (upper triangle). Absolute values of AEM and REM

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) AbsAEM	1.000	0.478***	0.137***	-0.099***	-0.051**	-0.092***	0.053***
	–	(0.000)	(0.000)	(0.000)	(0.011)	(0.000)	(0.007)
(2) AbsREM	-0.142***	1.000	0.012	-0.126***	-0.032	-0.036	-0.002
	(0.000)	–	(1.000)	(0.000)	(0.297)	(0.349)	(1.000)
(3) Z_MACZ	0.134***	0.078***	1.000	0436***	0.326***	0.022	0.545***
	(0.000)	(0.000)	–	(0.000)	(0.000)	(1.000)	(0.000)
(4) Z_WIERZ	-0.061***	-0.047**	0.389***	1.000	0.700*	0.214***	0.645***
	(0.000)	(0.001)	(0.000)	–	(0.000)	(0.000)	(0.000)
(5) Z_POZN	-0.125***	-0.202***	0.231***	0.516***	1.000	0.241***	0.372***
	(0.000)	(0.000)	(0.000)	(0.000)	–	(0.000)	(0.000)
(6) Z_HAD	0.062***	0.052***	0.017	0.047***	-0.178***	1.000	0.037
	(0.000)	(0.000)	(0.229)	(0.001)	(0.000)	–	(0.251)
(7) Z_MA_ZA	0.086***	0.032**	0.654***	0.504***	0.223***	0.073***	1.000
	(0.000)	(0.023)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: p-values in brackets and *** p<0.01, ** p<0.05, * p<0.1;
Source: own study based on data extracted from the ORBIS database.

To investigate the relationship between ABPMs and earnings quality, we recoded the Z-scores to a dichotomous variable in the following way:

- the value of one for firm-year observation, where the Z-score was below zero, implying a high bankruptcy risk,
- the zero value for firm-years observation, where the Z-score value was above or equal to zero, implying the no or low bankruptcy risk.

The recoding of variables allowed us to proceed with the ANOVA analysis to determine whether there are significant differences between the means. We constrained the analysis to the absolute values of AEM and REM for interpretation reasons. The intensity of earnings management is important and not a direction. High intensity (an absolute value of AEM or REM) implies low earnings quality and the opposite. The dataset is imbalanced – a small number of high bankruptcy risk firm-year observations compared to those of no risk of bankruptcy. This probably is one of the main reasons for unequal variances (heteroscedasticity) between groups (Table 3). Bartlett's test (p-value < 0.05) in the majority of cases (Z-scores and earnings quality) implies the problem of unequal variances between groups. Therefore, it is not advisable to use a regular one-way ANOVA. The results may not be reliable as they become more prone to Type I errors (false positive). We decided to use Welch's ANOVA, which is more robust to heteroscedasticity and differences in sample sizes across groups and helps to reduce Type I errors. It also uses a different method to calculate degrees of freedom. Overall, Welch ANOVA allows for obtaining more reliable results.

Table 6 presents the results of Welch ANOVA of the absAEM variable concerning two groups of firm-year observations: high risk and no/low risk of bankruptcy. The results of the F-stat suggested a high variability between group means compared to the variability within groups. The very low p-value implies statistically significant differences in the groups' means. The post-hoc Bonferroni test displayed a p-value of zero in all combinations, suggesting that observed differences in means of high risk of bankruptcy and no risk of bankruptcy are statistically significant, and it is highly unlikely to have occurred by chance. The firm-year observations with high bankruptcy risk came with lower quality of earnings (higher values of absAEM). The findings suggested that high bankruptcy risk was associated with managers engaging in discretionary earnings management techniques.

Table 7. Results of Welch ANOVA and Bonferroni test of absREM and a group of high-risk and no-risk firm-year observations

Variable absREM	Risk of bankruptcy	Mean	Std. Dev.	Freq.	F-stat	p-value	Bonferroni test
(1) Z_MACZ	0 (no)	0.108	0.166	4 726	39.716	0.000	0.305
	1 (yes)	0.413	0.602	155			p-value = 0.000
(2) Z_MA_ZA	0	0.099	0.156	1 013	87.452	0.000	0.106
	1	0.204	0.328	883			p-value = 0.000
(3) Z_WIERZ	0	0.093	0.12	3 504	59.535	0.000	0.081
	1	0.174	0.33	1 029			p-value = 0.000
(4) Z_HAD	0	0.105	0.165	4 278	22.982	0.000	0.108
	1	0.213	0.396	313			p-value = 0.000
(5) Z_POZN	0	0.109	0.172	4 659	38.418	0.000	0.158
	1	0.267	0.446	308			p-value = 0.000

Note: Z-scores < 0 are coded as one and zero otherwise.
Source: own study.

Table 7 presents the results of Welch ANOVA of the absREM variable with respect to the same two groups of firm-year observations as above. The high values of F-stat and very low p-values lead to the same conclusions as in the case of the absAEM variable. Therefore, it suggests that firm-year observations with a high risk of bankruptcy came with lower earnings quality. Since we investigated the correlation relationship, not the causation, we may conclude that higher bankruptcy risk causes lower earnings quality. However, without direct empirical evidence, we may only speculate that managers of companies with a high risk of bankruptcy engage in real earnings management techniques, *i.e.*, influence real business operations and related cash flows. The consequences may be even more harmful than accrual earnings management.

Our results corroborate Garcia-Lara *et al*.'s (2009) findings. Based on the UK firm-year observations covering 1998-2004, they concluded that accruals manipulation is more pronounced in *ex-post* bankrupt firms. Similarly, Campa and Camacho-Minano (2015), based on the sample of Spanish SMEs, provide empirical evidence suggesting upward earnings manipulation of bankrupt firms as compared to non-bankrupt firms. We provide another argument supporting the call of Séverin and Veganzones (2021) to use earnings management information to improve the bankruptcy prediction models. Their study was conducted on the French SMEs. Thus far, we do not know of any application of this concept in other countries or at the level of larger, publicly listed companies.

CONCLUSIONS

The study aimed to investigate the relationship between earnings quality and bankruptcy risk as estimated by accounting-based prediction models. We used a sample of Polish-listed companies due to the popularity of ABPMs in Poland among practitioners and scholars and the fact that the academic community developed at least several interesting models of sufficient accuracy. Therefore, applying a set of models designed for the specificity of the Polish economic context was possible. The simplicity of ABPMs' use makes them a useful tool in the hands of managers, accountants, financial auditors or investors. It is especially important in the case of emerging economies characterised by a lower level of institutional development. Poland exemplifies an economic success story as it was upgraded in 2018 to the status of a developed market and, simultaneously, a post-communist CEE country, an EU member. Many other CEE countries share a similar heritage, history, and institutional background. Therefore, scholars may generalise the results and apply them to the CEE countries and other emerging economies.

Based on the literature review, we posited two hypotheses. The first conjecture was that high-bankruptcy-risk companies were accompanied by more intensive accrual earnings management. The correlation analysis shows a weak but statistically significant correlation between bankruptcy risk and accrual

earnings management as proxied by AEM and absolute AEM values estimated with the modified Jones model. In the correlation analysis, we applied applies Pearson and Spearman rank correlations. Overall, 7 out of 10 combinations of AEM and ABPMs were statistically significant, and in the case of absAEM (absolute values of AEM) all were statistically significant. Further investigation involved the application of Welch ANOVA, which demonstrated that the group of firm-year observations classified as high bankruptcy risk iwass accompanied by a more intensive accrual earnings management compared to no or lower-risk bankruptcy risk firm-year observations. Therefore, it implies that a higher bankruptcy risk is assisted by managerial behaviour intended to influence reporting numbers. We can only speculate whether it is the white, grey, or black version of earnings management and whether the discretion embedded in financial reporting regulations is used by managers to signal the true financial problems or just the opposite – to cover them up. To sum up, empirical evidence supports the first hypothesis.

The second hypothesis conjectured that high-bankruptcy-risk companies are accompanied by more intensive real earnings management as estimated by the Roychowdhury model. The correlation analysis showed a weak or moderate correlation between REM and bankruptcy risk as measured by five ABPMs. However, in all cases, the correlation was statistically significant (as measured by Pearson and Spearman rank correlation). In the case of absREM, the results were similar in the case of the Pearson correlation coefficients, while the Spearman rank correlations showed statistical significance only in the case of the Wierzba model. The Welch ANOVA analysis supported the conjecture that the group of firm-year observations classified as high bankruptcy risk was accompanied by a more intensive real earnings management. Therefore, it implied that a higher bankruptcy risk is assisted by managerial behaviour aimed at influencing operational activities and departing from the normal course of action to achieve desired goals. It involves changing business decisions and, consequently, the timing and amounts of the firm's cash flows. Thus, the study provides empirical evidence supporting the second hypothesis.

The higher risk of bankruptcy is associated with more intensive accrual and real earnings management, which translates into lower earnings quality. Therefore, the reliability and usefulness of reported numbers were diminished. Moreover, ABPMs are based on reported numbers, and the issue of earnings quality should be considered in the development of future bankruptcy prediction models. Finally, awareness of the relationship between earnings quality and bankruptcy risk may be important for financial statement users, investors, financial analysts, or financial auditors. From this perspective, a decline in earnings quality may be interpreted as a potential sign of increased bankruptcy risk.

From a policymaking perspective, academics should continue their efforts to develop financial ratios that effectively capture the broad concept of earnings quality, including measures of accrual-based and real earnings management. Professional accounting and auditing bodies should consider promoting those metrics to facilitate their widespread adoption. Furthermore, there is a clear need to educate investors, shareholders, and auditors on the significance and application of such measures. The study's limitations include the following: the research design used only five ABPMs and only two metrics of earnings quality (accrual and real earnings management) and it did not investigate the other aspects of earnings quality (*i.e.,* earnings predictability or earnings response coefficient). Moreover, the study investigated the relationship between key variables of interest without causation analysis. The study focused on the intensity of earnings management (accrual or real) without investigating income-increasing or income-decreasing techniques. This was a single-country study, thus generalizability may be impeded by differences in legal and regulatory frameworks, institutional backgrounds, *etc*. The study does not suggest how the concept of earnings quality may be implemented in designing new ABPMs. Those limitations constitute an avenue for future research.

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Use of Artificial Intelligence

Our text is free of AI/GAI usage.

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The role of innovation in the internationalisation process of Slovakian businesses

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ABSTRACT

Objective: The article aims to examine the relationship between innovation and export performance among Slovak firms. In particular, we investigated whether innovative activities, including process and product/service innovations, significantly enhance export intensity, and how firm size moderates this relationship.

Research Design & Methods: This study adopted a quantitative research design to examine the relationship between innovation and export performance among Slovak firms. We based the empirical analysis on a sample of 292 firms, whose secondary data included measures of export performance and innovation indicators. The analysis employed both descriptive statistics and the Mann-Whitney U test. We performed data analyses using Excel and Statistica.

Findings: The empirical results revealed that innovative firms, regardless of their size, exhibited substantially higher export intensity compared to non-innovative counterparts. Specifically, small innovative companies exported an average of 19.34% of their total sales versus 8.33% for non-innovative ones; the difference increases for medium-sized firms (44% vs. 17.96%) and large companies (57.26% vs. 40.85%). Moreover, further analysis highlighted that firms implementing process innovations achieved markedly higher export sales, while those combining both process and product/service innovations experienced a synergistic boost in export performance. The Mann–Whitney U test confirmed that these differences are statistically significant, reinforcing the notion that innovation is a pivotal driver of international market success.

Implications & Recommendations: The findings suggest that policymakers and business leaders should prioritize fostering innovative practices to enhance export performance, especially among medium and large enterprises. To capitalize on innovation as a growth engine, recommendations include increased support for R&D, streamlined access to funding for innovative projects, and the development of strategic programs aimed at integrating process and product innovations simultaneously. Such measures are expected to contribute to improved competitiveness and greater international market expansion for Slovak firms.

Contribution & Value Added: The novelty of this article lies in its targeted focus on Slovak enterprises – a mid-sized economy – using a robust quantitative approach that integrates World Bank Enterprise Surveys data with the application of the Mann–Whitney U test. Unlike prior studies that primarily focus on larger economies, this research provides context-specific insights into the interplay between innovation and export performance in Slovakia, offering nuanced evidence on how different innovation types and firm sizes interact to shape international competitiveness.

Article type:	research article
Keywords:	product innovation; process innovation; internationalisation; export performance; quantitative analysis; international competitiveness; Slovakia
JEL codes:	F14, O31

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INTRODUCTION

The role of innovation in the internationalisation process of Slovak businesses is a topic of significant theoretical and practical relevance. In an era of globalization and intensifying international compe-

tition, innovation serves as a critical driver of competitive advantage for firms. Ivanova (2017) indicates that the small and medium-sized enterprise (SME) sector in Slovakia faces significant challenges in accessing external funding, primarily due to stringent financial capacity assessment criteria. Furthermore, the primary source of innovation financing for Slovak enterprises remains internally generated profits. For Slovakia's economy, which is highly open to foreign trade, understanding the impact of innovation on export performance is particularly crucial. This study contributes to the broader discourse on the relationship between innovation and international expansion, offering valuable insights for economic policy and business practice.

The novelty of this article lies in its integration of quantitative analysis using World Bank Enterprise Surveys (WBES) data for Slovakia with the application of the Mann-Whitney U test, which is particularly suitable for non-normal and unequal group distributions. Unlike prior studies, which have often focused on large economies, we addressed the specific context of Slovak firms, accounting for their size structure and innovation levels. Furthermore, the article advances the literature by empirically testing hypotheses regarding export performance differentials between innovative and non-innovative firms.

The primary objective of this study was to examine the relationship between innovation and export performance among Slovak enterprises, with particular attention to firm size and the types of innovations implemented. Specifically, we sought to answer the following research questions:

RQ1: Is there a statistically significant difference in export performance between innovative and non-innovative firms in Slovakia?

RQ2: How does firm size moderate the relationship between innovation and export activity?

RQ3: Which types of innovations (process or product) exert a stronger influence on firms' international competitiveness?

The article is structured into five sections. Following this introduction, a literature review outlines the theoretical foundations of the innovation-internationalisation nexus. Next, the research methodology is presented, including data sources and statistical tools. Subsequent sections detail the empirical findings and their discussion, while the concluding remarks summarize key insights, policy implications, and directions for future research.

This study enhances the understanding of innovation's role in firm internationalisation, particularly in the context of mid-sized economies such as Slovakia. The findings may inform policymakers and business leaders in designing strategies to foster innovation and enhance export performance.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Schumpeter (1934) introduced the concept of innovation into economic literature. He viewed it as the implementation of new or improved solutions concerning products, methods of production, forms of trade, raw materials, semi-finished goods, or the organization of processes. Similarly, Kotler (1997) defines innovation as an idea, product, or technological component that has been implemented and presented to customers, who perceive it as new. According to Lumpkin and Dess (2001), innovativeness constitutes one of the fundamental components of entrepreneurship at the organizational level.

The literature offers a wide range of studies dedicated to exploring the relationship between innovativeness and internationalisation. Researchers examining this phenomenon emphasise that innovation constitutes a key value in value creation and export performance, regardless of firm size. It can serve as a significant driver of export development both in the case of large multinational corporations (Barłożewski & Trąpczyński, 2021) and small and medium-sized enterprises (Oliinyk *et al.*, 2023).

Numerous empirical studies indicate that the relationship between the internationalisation process of a firm and the level of innovativeness of its solutions is complex and bidirectional (Damijan *et al.*, 2010; Wach, 2016; Moreno-Menéndez, 2018; Ahi *et al.*, 2022; Głodowska *et al.*, 2023). This suggests that internationalisation may both stimulate the development of a firm's innovative capabilities and, conversely, result from the firm's prior engagement in innovation-related activities (Daszkiewicz, 2016; Wach, 2016).

The first direction of this interdependence – frequently described in the literature as 'learning by exporting' – refers to a scenario in which a firm's involvement in international markets leads to enhanced innovation capacity. Through interactions with foreign markets, customers, business partners, and competitors, firms acquire new knowledge, skills, and experiences that can be subsequently utilised in the development and implementation of innovative solutions across products, processes, organisational structures, and marketing strategies (Boso *et al.*, 2013; Cieślik *et al.*, 2016, Freixanet & Rialp, 2022). From this perspective, internationalisation acts as a catalyst for innovation, broadening firms' perspectives and exposing them to novel technological and organisational opportunities.

The second direction of the relationship assumes reverse causality, whereby a firm's level of innovativeness constitutes a key determinant of its propensity and ability to internationalise. In this view, companies that possess advanced, original solutions – whether product-related, technological, or organisational – are better positioned to enter foreign markets successfully and to gain competitive advantage through innovation. Empirical findings (Chen *et al*., 2018) support this approach. They demonstrate that innovation – particularly technological innovation – enhances the likelihood of international expansion by facilitating firms' adaptation to diverse market conditions and the expectations of foreign customers.

Moreover, the study by Wach and Daszkiewicz (2023) demonstrates that research and development (R&D) activities are a significant driver of internationalisation among high-tech firms. The presence of an internal R&D unit and the allocation of financial resources to R&D substantially increase both the geographic scope of expansion and the level of firms' transnationality. These findings emphasise the importance of innovation intensity in enhancing firms' capabilities for successful entry into foreign markets. Similar conclusions can be drawn from the study conducted by Almodóvar *et al*. (2021) among Spanish enterprises.

The close relationship between a firm's innovativeness and its internationalisation is reflected in the thesis that entry into a foreign market can be regarded as a form of innovation (Kosała, 2015). Moreover, it may also serve as a source of innovation, inspiring further innovative activities in the areas of product, process, organisational structure, or marketing (Wach, 2014). A positive correlation between firm innovativeness and internationalisation has also been confirmed in numerous empirical studies conducted across various national contexts. For instance, research by Cieślik *et al.* (2018) highlights that both product and process innovations significantly increase the likelihood of export success among Chinese enterprises. Similar patterns are observed in the study by Bertarelli and Lodi (2018), who examined firms from several European Union member states that were formerly part of the communist bloc. Their findings underline the strategic importance of innovation as a driver of international market expansion.

The pro-export function of innovation is further reinforced by evidence from a range of other country-specific studies. In the United Kingdom Ganotakis and Love (2011) demonstrated a clear link between innovative activity and increased export performance. Comparable conclusions were drawn in Portugal by Rua (2018), in Italy by Brancati *et al.* (2018), in Germany by Bernardini *et al.* (2018) and in Australia by Palangkaraya (2012). Research among Romanian enterprises in the ICT sector (Burciu *et al.*, 2023) confirmed the positive relationship between innovation and enterprise internationalisation. Collectively, these studies provide robust cross-country evidence that innovation plays a pivotal role in enhancing a firm's export capacity and competitiveness in international markets.

The findings of survey-based research by Ayllón and Radicic (2019) indicate the presence of complementarity only in terms of contemporaneous effects while providing no evidence to support a causal relationship between previously implemented product and process innovations and the current export activity of firms. Bigos and Michalik (2020) and Bigos and Wach (2021) also demonstrated the positive impact of specific types of innovation on the increase in export activity of individual enterprises. In his empirical study conducted among Polish enterprises, Brodzicki drew similar conclusions. He highlights a pronounced heterogeneity among Polish manufacturing firms in terms of both innovation and internationalisation intensities. His findings further substantiate the strong interdependence between these two dimensions and confirm the directional impact of innovation on the degree of firms' international engagement (Brodzicki, 2017).

These prior empirical results allowed us to assume the following research hypotheses:

H1: Innovative firms that strategically invest in process innovations or product improvements achieve significantly superior export performance, underscoring the pivotal role of innovation in enhancing international market competitiveness.

To examine this hypothesis in greater detail and account for the possible heterogeneity of innovation effects, we developed a set of auxiliary (sub)hypotheses. These hypotheses aimed to disentangle the distinct contributions of product and process innovations, their potential synergistic effects, and the moderating role of firm size:

H1a: A company that has implemented process innovations achieves a statistically higher level of exports compared to companies that have not invested in such innovations.

H1b: Companies that invest in improving products or implementing product/service innovations achieve higher export sales intensity than those that do not.

H1c: Companies implementing process and product/service innovations at the same time achieve even higher export intensity than companies using only one of these forms of innovation.

H1d: The effect of innovation on export sales intensity is moderated by firm size – innovation effects are particularly strong in medium and large firms.

RESEARCH METHODOLOGY

In this study, we sourced the primary empirical data from the World Bank Enterprise Surveys (WBES) for the Slovak Republic on a representative sample of 292 companies (World Bank, 2023). We conducted a systematic review of the extant literature using academic databases such as Scopus, Web of Science, and Google Scholar to ensure that only peer-reviewed and methodologically rigorous studies informed the research framework. Given that the dataset did not satisfy the assumptions of normality and exhibited unequal group sizes between innovative and non-innovative firms, we employed the Mann-Whitney U test as the most appropriate inferential statistical method to assess whether firms exhibiting innovation differ significantly in export performance compared to non-innovative firms. This nonparametric test is particularly advantageous when the underlying data do not meet the assumptions of normality, especially in cases where the distribution is markedly skewed relative to the mean and when the assumption of equal group sizes is not satisfied and this test does not require that the data be normally distributed (Mann & Whitney, 1947). The test proceeds by ranking all observations from both groups together and then computing the U statistic for each group using the formula:

$$U = R - \frac{n(n+1)}{2} \tag{1}$$

in which:

R - the sum of the ranks for a given group;

n - the number of observations in that group.

To standardize the U statistic for hypothesis testing, we calculated the following Z score:

$$Z = \frac{U-\mu_U}{\sigma_U} \tag{2}$$

with the mean μ_U and the standard deviation σ_U of the U distribution defined as:

$$\mu_U = \frac{n_1 n_2}{2};\ \sigma_U = \sqrt{\frac{n_1 n_2 (n_1+n_2+1)}{12}} \tag{3}$$

in which n_1 and n_2 are the sample sizes of the two independent groups. The resulting Z value and its corresponding p-value facilitated the assessment of statistical significance.

The variables employed in the analysis included the percentage of total sales exported directly, the percentage of total sales exported indirectly, firms that introduced a process innovation, and firms that introduced new or improved products or services. In addition to the Mann-Whitney U test, we computed basic descriptive statistics to provide a comprehensive overview of the data distribution. This combined approach, integrating both inferential and descriptive statistical methods ensured a robust examination of the relationship between innovation and export performance.

RESULTS AND DISCUSSION

The analysis of the empirical data revealed several findings regarding the innovation profiles and export performance of Slovak firms. As illustrated in Figure 1, only 4.11% of the surveyed firms reported engaging in process innovations, 6.85% declared product or service innovations, and 10.27% implemented both types of innovations. Consequently, a striking 78.87% of the sampled enterprises did not report any innovation-related investments.

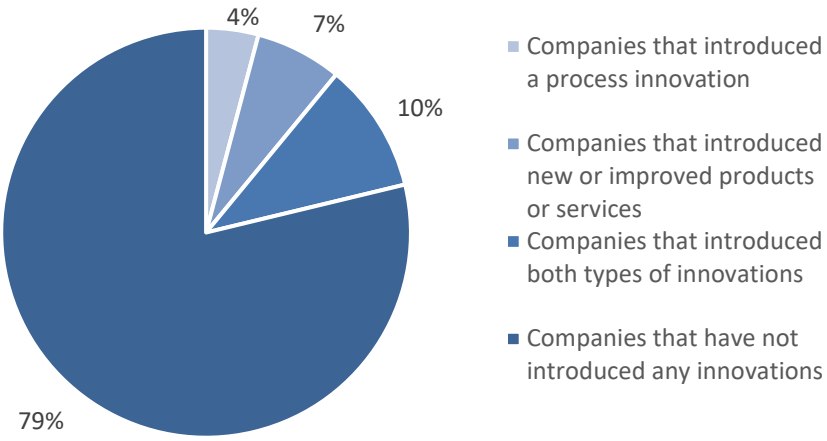

Figure 1. Share of innovative companies in the structure of enterprises in Slovakia
Source: own elaboration based on data from the World Bank Enterprise Surveys.

Export sales accounted for 20.7% of the total sales of Slovak firms. Internationalised companies accounted for 43% of all Slovak firms, and the largest number, 26% of all companies surveyed, were companies that indirectly exported at least part of their sales, as shown in Figure 2 below.

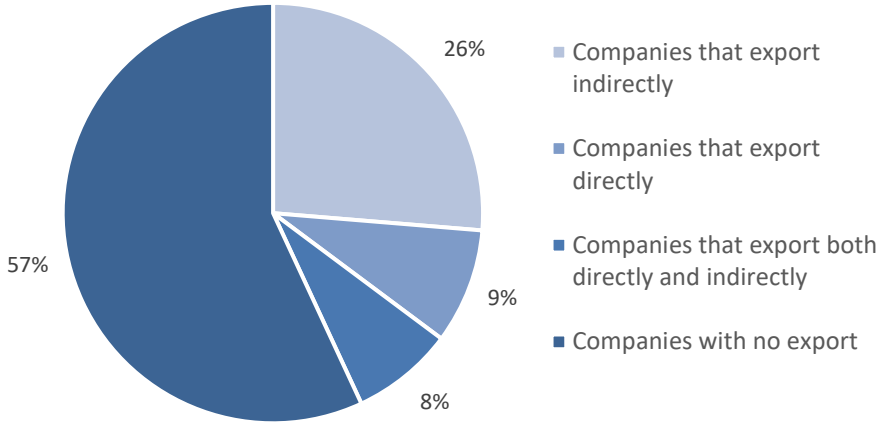

Figure 2. Share of internationalised companies in the structure of enterprises in Slovakia
Source: own elaboration based on data from the World Bank Enterprise Surveys.

For this study, we classified firms as innovative if they reported at least one type of innovation (either process or product/service). This classification enabled a direct comparison between innovative and non-innovative firms concerning their export performance.

Figure 3 below shows the average share of exports of innovative and non-innovative companies by their size.

Small innovative companies exported an average of 19.34% of their total sales, compared to only 8.3% for their non-innovative counterparts. The difference was even more pronounced among me-

dium-sized companies, where innovative firms exported 44% of their total sales, compared to 17.96% for non-innovative firms. Among large companies, innovative firms showed the highest export intensity, with 57% of their exported sales, compared to 40.5% for non-innovative firms.

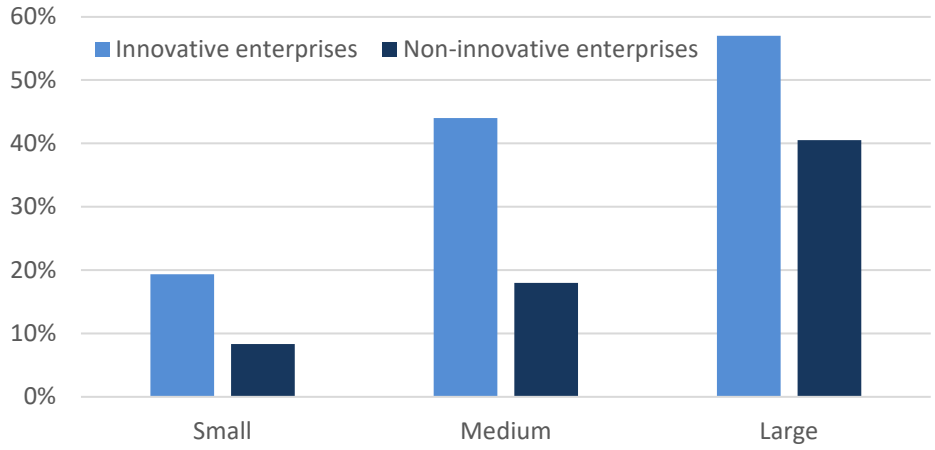

Figure 3. The average share of exports of innovative and non-innovative companies by their size
Source: own elaboration based on data from the World Bank Enterprise Surveys.

This pattern strongly supports the idea that innovation is positively associated with export intensity across all firm sizes. Notably, the export performance gap between innovative and non-innovative firms widened as firm size increased. While small innovative firms exported more than twice as much as their non-innovative peers, this difference grew even further among medium and large companies. These findings suggest that firm size moderates the effect of innovation on export performance, which directly supports hypothesis H1d. In particular, medium and large firms appear to leverage innovation more effectively to expand their presence in international markets, benefiting from economies of scale, greater resources, and more structured international strategies.

Table 1. Average export intensity (%) by firm size and innovation status

Firm size	Innovative firms (%)	Non-innovative firms (%)
Small	19.34	8.33
Medium	44.00	17.96
Large	57.26	40.85

Source: own study based on data from the World Bank Enterprise Surveys.

These results reinforce the moderating role of firm size in the relationship between innovation and export intensity, emphasizing that larger innovative firms experience the strongest export advantages. The observed patterns were consistent with previous findings by Damijan *et al*. (2017), who explored the relationship between firms' export status and various types of innovation activities. While aggregate data indicated that innovation outcomes generally improve with firm size, their study revealed that the impact of exporting on innovation is particularly strong among medium-sized firms. We may attribute this to the fact that medium-sized enterprises possess greater technological absorption capacities than small firms, while still maintaining a level of flexibility that allows them to adapt more swiftly to the demands of international markets compared to large corporations (Cai *et al*., 2020).

To assess the differences between the international activities of innovative and non-innovative companies, we used the Mann-Whitney U test. Table 2 shows the obtained parameters.

Table 2. The obtained parameters from the performed Mann-Whitney U test

U	Z	p-value	Z adjusted	p-value
5536	-2.701	0.007	-2.989	0.0028

Source: own study in Statistica.

The U statistic represents the sum of the ranks for the group with the lower export performance (in this case, non-innovative firms). The non-innovative firms tend to occupy lower positions compared to their innovative counterparts which suggests that non-innovative firms generally exhibit lower export levels. The Z statistic is a standardized measure that shows how many standard deviations the observed U is from the expected U under the null hypothesis (which posits no difference between the groups). Z = -2.70 means that the observed U was approximately 2.70 standard deviations below the mean U. The negative sign further indicates that non-innovative firms, on average, perform worse in export activities compared to innovative firms. The adjusted Z statistic accounts for potential issues such as tied ranks and provides a more accurate reflection of the test outcome. With a value of -2.98, the adjusted Z further reinforces the finding that non-innovative firms have significantly lower export performance. The more negative adjusted Z indicates an even stronger deviation from the expected value under the null hypothesis. A p-value is below the conventional significance level which confirmed that the difference in export performance between innovative and non-innovative firms was statistically significant.

Figure 4 below shows the differences in export activity between innovative and non-innovative companies. This chart shows the distribution of export values (the vertical axis) for both groups (the horizontal axis), considering the median, quartiles, and potential value outliers.

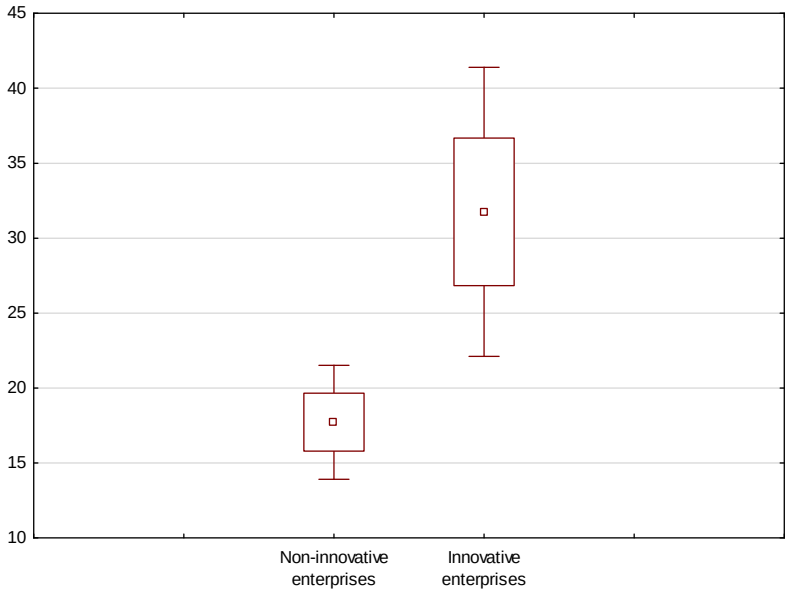

Figure 4. Export activities of innovative and non-innovative companies
Source: own elaboration based on data from the World Bank Enterprise Surveys.

The results highlight that despite a relatively low prevalence of innovation among Slovak firms, those that are innovative exhibit markedly superior export performance. This effect is most pronounced among medium and large enterprises. The empirical findings, corroborated by both descriptive statistics and the Mann–Whitney U test, lend strong support to the hypothesis that innovation is a key driver of export success in the Slovak context.

Furthermore, the analysis offers robust empirical support for hypotheses H1a, H1b, and H1c. Firms that implemented process innovations achieved an average export intensity of 37.60%, significantly outperforming firms that did not invest in such innovations (17.86%). Similarly, companies that introduced product or service innovations reported an average export intensity of 31.74%, compared to 18.42% among firms without product innovations. These findings confirm that both types of innovation, independently, are positively associated with stronger export performance, consistent with H1a and H1b. Additional insights from firms operating in EU countries similar to Slovakia – such as Poland and Hungary – indicate that process innovations are particularly critical for maintaining competitive advantages on international markets, especially in medium-high technology sectors (Cieślik & Michałek, 2017). Further support comes from the case of Moroccan SMEs, where scholars found that

licensing foreign technologies (a form of process innovation) enhances export intensity by facilitating know-how absorption and production standardization (Haddoud *et al*., 2023).

Regarding product innovations, evidence from Portuguese enterprises shows a strong correlation between the introduction of new goods or services and higher export intensity (Ricardo, 2024). Similarly, studies from emerging markets, including countries in Latin America, emphasise that product innovations enable firms to tailor their offerings to the diverse needs of foreign consumers, thereby contributing to increased export shares (Heredia *et al*., 2019).

More strikingly, firms that simultaneously implemented both process and product innovations reached an average export intensity of nearly 40%, whereas firms that introduced only one type of innovation (either process or product) achieved a significantly lower average of 24.13%.

Table 3. The obtained parameters from the performed Mann-Whitney U test

Innovation Status	Average Export Intensity (%)
With process innovation	37.6
Without process innovation	17.86
With product/service innovation	31.74
Without product/service innovation	18.42
With both types of innovation	39.9
With only one type of innovation	24.13
Without any innovation	17.8

Source: own study based on data from the World Bank Enterprise Surveys.

This pattern substantiates H1c, indicating that the combined effect of multiple innovation types creates a synergistic boost in export outcomes, surpassing the effect of either innovation implemented in isolation. Suárez and Guisado-González (2014) identified a similar relationship in the Spanish manufacturing sector, where firms implementing both product and process innovations achieved higher performance and were better prepared to respond to international market demands. Their findings also indicated that companies combining these two innovation strategies reached higher export intensity, particularly among medium-sized enterprises in medium-high technology industries. Scholars have observed comparable evidence in other contexts as well, for instance, Polish firms from the machinery sector that implemented both product and process innovations recorded, on average, 31% higher export intensity compared to those applying only one type of innovation. This further supports the notion that synergistic innovation strategies significantly strengthen a firm's international competitiveness (Cieślik *et al.,* 2016). This trend is now also observable among Slovak firms, reinforcing the relevance of dual innovation strategies in enhancing export potential across different national contexts.

CONCLUSIONS

We aimed to examine the relationship between innovation and export performance among Slovak firms by employing quantitative analysis on WBES data and the Mann–Whitney U test. The empirical results indicate that innovative firms demonstrate significantly higher export intensity compared to non-innovative firms, with the gap widening in relation to firm size; small, medium, and large firms exhibit progressively greater differences, thereby validating the proposed hypotheses. Firms engaged in process innovations, product/service innovations, or both, outperform their non-innovative counterparts, with the synergistic effect of dual innovation further elevating export performance. These findings underscore the critical role of innovation as a driver of international competitiveness, suggesting that supportive policies such as enhanced R&D investments, streamlined funding mechanisms for innovation projects, and strategic integration of process and product improvements could substantially benefit firms and the broader economy.

Notwithstanding these valuable insights, we must acknowledge certain limitations. The study relied on a sample of 292 firms and secondary survey data, which may constrain the finding's generalisability. Moreover, the cross-sectional design restricted causal interpretations of the innova-

tion-export relationship. Measurement issues inherent in self-reported innovation and export metrics could also introduce biases into the analysis.

Future research should consider longitudinal designs to better capture the dynamic nature of innovation and its long-term impact on international market performance. Comparative studies across different mid-sized economies could enhance understanding of contextual factors affecting the innovation-internationalisation nexus. Furthermore, employing advanced statistical methodologies and incorporating qualitative case studies would further refine the insights into the mechanisms by which innovation shapes export outcomes.

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War-induced relocation of high-tech companies: Spatial perspectives from Ukraine and Poland

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ABSTRACT

Objective: The article aims to assess the scale and direction of the relocation of Ukrainian high-tech companies following the Russian invasion in February 2022, with a particular emphasis on comparing the relocation processes within Ukraine and those from Ukraine to Poland. The article seeks to identify the strategies, challenges, and outcomes associated with these relocations, offering insights into the broader implications of such movements for both the Ukrainian and Polish economies.

Research Design & Methods: This study employs a mixed-methods design, incorporating both quantitative and qualitative approaches. It analyses available data from official Ukrainian and Polish statistics and includes interviews with representatives from regional military administration offices in Ukraine, municipal offices in Poland, support institutions, and relocated IT companies. Descriptive statistics and thematic analysis are used to assess the relocation processes, challenges, and outcomes.

Findings: The study shows that the Russian invasion of Ukraine led to significant relocation of high-tech companies, representing IT sector. Western Ukrainian regions like Lviv and Zakarpattia became key hubs with 78% of relocated companies resuming operations. In Poland, Ukrainian high-tech firms constitute 7.1% of all high-tech companies, with Warsaw, Krakow, and Wroclaw as top destinations, however the concentration measures are the highest in regions neighbouring Ukraine. The relocation faced distinct challenges in both countries, including infrastructure in Ukraine and legal issues in Poland, underscoring the adaptability of Ukrainian businesses and various relocation strategies.

Implications & Recommendations: The study highlights the resilience of high-tech companies relocating within Ukraine and to Poland. The presence of Ukrainian firms in Poland suggests opportunities for deeper economic integration, encouraging targeted policies to support innovation and collaboration.

Contribution & Value Added: This article offers a novel analysis of the relocation of high-tech companies from Ukraine during the war, focusing on comparative experiences in Ukraine and Poland. It fills a gap in the literature by providing insights into the strategies and challenges faced by these companies in wartime and the support of state and regional institutions and administration.

Article type:	research article
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INTRODUCTION

The relocation of Ukrainian businesses forced by Russia's aggression needs to be considered within a broad geopolitical context. Ukraine is the second-largest country in Europe, situated to the east of the EU countries. Its area constitutes 5.4% of the total area of Europe, and its population – 5.5%. The modern Russian-Ukrainian war began in April 2014, when 7% of Ukrainian territory, including

parts of the Donetsk and Luhansk regions and Crimea, was temporarily occupied. In February 2022, the full-scale Russian invasion of Ukraine began. The war in Ukraine has brought about a series of significant consequences for business operations.

Primarily, these consequences relate to restricted access to territories. As of July 2023, a total of 18% of Ukraine's territory is occupied, including the Autonomous Republic of Crimea, as well as parts of the Luhansk, Donetsk, Kharkiv, Zaporizhzhia, and Kherson regions (DeepStateMap, 2023).

Secondly, the war has caused enormous damage, amounting to more than USD 143.8 billion (at replacement cost). Residential buildings (37.3% or USD 53.6 billion) and infrastructure (25.2% or USD 36.2 billion) accounted for the largest share of total direct damages. Business asset damages amount to at least USD 11.3 billion and continues to grow. Many industrial and civil infrastructure facilities have been mined and destroyed. War damage has affected a significant proportion of industrial resources. The most affected or destroyed industrial facilities include Ilyich Iron and Steel Works and Azovstal (Mariupol), Motor Sich (Zaporizhzhia), Zorya-Mashproekt (Mykolaiv), Ukrainian Energy Machines (Kharkiv), Avdiivka Coke Plant (Avdiivka) in the chemical industry, Philip Morris Ukraine (Kharkiv) in cigarette production, and Antonov (Kyiv, Hostomel) in aircraft manufacturing.

Thirdly, the war exacerbates Ukraine's existing demographic problems. Ukraine's population decreased by more than 9% in the ten years preceding it. Due to the full-scale invasion, more than 9 million Ukrainians, predominantly women with children and the elderly, left the country (United Nations, 2023). Poland has become a leader in accepting Ukrainian refugees. In March 2022, official statistics recorded 3.2 million Ukrainians in Poland, including pre-war residents and migrants (UMP, 2022). Approximately 900 thousand Ukrainians found refuge in Germany, 391 thousand in the Czech Republic, and around 150 thousand in Turkey and Italy. Moreover, Moldova, Romania, and Slovakia took 80 thousand refugees (EBRD, 2022).

Destruction, occupation of territories, and migration have caused fundamental changes in the country's economy. Massive bombing attacks posed a real threat to the civilian population, and the destruction of energy infrastructure caused significant problems in the electricity supply, leading to total blackouts. Companies have faced the need to relocate assets and staff to ensure security and business continuity. The full-scale war has also prompted the relocation of businesses from temporarily occupied territories, areas of active fighting, and regions under the threat of shelling to relatively more secure locations. The nature of such a move and the approaches to its implementation varied. The relocation received support from the Ukrainian government and other host countries, and depended primarily on the financial capacity of entrepreneurs, the willingness to relocate, and a complex of subjective factors – all of which have been carefully examined and analysed in this study.

The article focuses on the relocation processes of the Ukrainian high-tech sector, which is traditionally dominated by IT companies – in 2021, they accounted for 40% of high-tech firms (State Statistics Service of Ukraine, 2022). The IT sector was a strong element of the Ukrainian economy and became crucial during wartime. The IT enterprises are vital contributors to the nation's economic landscape. In 2021, the IT sector provided gainful employment to 285 thousand skilled professionals, accounting for 4% of Ukraine's Gross Domestic Product (GDP) and 35% of service exports. This burgeoning industry thrives within five key IT clusters in Kyiv, Kharkiv, Lviv, Odesa, and Dnipro, each characterised by well-established institutional support and robust infrastructure (IT Ukraine Association, 2021). During the war, the sector transformed into a strong volunteer front, standing at the forefront of designing, developing, and applying military technologies, and establishing reliable and effective actions in cyberspace (Mukhina, 2023).

The dynamics of the IT ecosystem were driven by endogenous factors (such as IT infrastructure, regulation, and managerial standards) and exogenous factors, including the compulsory migration of businesses from the occupied Autonomous Republic of Crimea, and the Donetsk, and Luhansk regions in 2014. With the escalation of the war in February 2022, numerous high-tech companies opted to relocate their operations within Ukrainian borders, while others took preventive measures to move their activities abroad.

There is a scarcity of research on business relocation in response to conditions of uncertainty and security threats. We can distinguish subsets of studies focusing on relocation in different contexts, such

as 1) shifting geopolitical circumstances exemplified by events such as Brexit (Bilbao-Ubillos & Camino-Beldarrain, 2021; Oxley, 2020; Sohns & Wójcik, 2020) or Catalonia's referendum (Méndez-Suárez, 2021); 2) challenging or precarious economic environments, as exemplified by episodes like the economic crisis in Greece (Kapitsinis, 2018; 2019); 3) natural disasters (Linnenluecke *et al.*, 2011) and 4) wartime scenarios and military actions. The latter category encompasses both historical investigations, elucidating relocation experiences during the Cold War era, for instance, as well as a notably smaller body of research dedicated to contemporary instances of relocation associated with ongoing wars in regions such as Syria (Salmon *et al.*, 2018) or Ukraine (Korovkin *et al.*, 2018). The relocation of Ukrainian high-tech businesses since 2014 remains a largely unexplored topic. According to news sources, small businesses from Sevastopol, Donetsk, and Luhansk have relocated to Odesa, Kyiv, and other cities and countries. While some research has shed light on the emigration of IT specialists, providing insight into the situation of the high-tech sector, the primary reason for this group's departure after 2014 was the sense of threat. According to data from March 2022, most IT industry specialists have relocated to the Lviv and Ivano-Frankivsk regions, as well as Poland and Germany (Ippolitova, 2022).

The article addresses the limited research on business relocation under conditions of uncertainty and security threats, focusing on the Ukrainian high-tech sector. It examines the scale and directions of business relocation resulting from Russia's aggression in February 2022, as well as the mechanisms, strategies, and challenges involved. The article is divided into four sections. The first reviews literature on business relocation during wartime, highlighting the lack of studies on corporate relocation in contemporary wars, particularly in high-tech sectors. The second section outlines the data and methods used to analyse internal relocations and cross-border movements, particularly to Poland. The third section presents findings, including an analysis of relocation patterns, strategies employed by firms of different sizes, and comparisons between Ukraine and Poland. The final section summarises the research findings and identifies areas for further study, addressing gaps in understanding high-tech relocation during wars.

LITERATURE REVIEW

A literature review indicates a scarcity of research on corporate relocation in response to security threats, revealing four identifiable categories of situations analysed: geopolitical change, economic uncertainty, natural disasters, and wartime, which de facto aggregates the aforementioned threat situations.

The first category of research analyses the impact of geopolitical change on business relocation. Studies by Sohns and Wojcik (2020) and Bilbao-Ubillos and Camino-Beldarrain (2021) examine how the UK's decision to leave the European Union affected the fintech and high-tech industries, respectively, while Méndez-Suárez (2021) analyses the conditions under which companies decided to relocate following the Catalan referendum. The authors indicate that the choice of relocation destination depends on several company characteristics, including their position within the network of business connections and the sector represented. For example, financial companies chose to relocate to highly developed countries such as France, Germany, and Ireland to maintain access to the European market, while companies representing other sectors opted for less developed markets where they could secure more favourable business conditions.

In the second category, research focuses on company relocations triggered by the economic crisis. Kapitsinis (2018; 2019) conducted a comparative analysis of the relocation patterns of Greek small and medium-sized enterprises (SMEs) to Bulgaria before and after the economic crisis. The results highlight the strong correlation between business mobility and factors internal to the firm, such as size, sector, and entrepreneurial strategy. Kapitsinis (2018; 2019) indicates that the relocation was driven by a stronger reaction to the crisis of the Greek economy and by the frequent relocation of companies seeking survival rather than growth opportunities.

The third category of studies examines the impact of climate change on relocation. As research by Linnenluecke *et al.* (2011) indicates, climate change events such as droughts, floods, or sea level rise can lead to disruptions in a company's supply chains, customer base, or resource pool. Understanding

the implications of climate-related disruptions is of paramount importance for both companies and decision-makers in developing strategies to mitigate these risks and ensure business continuity.

The fourth and main part of this particular category of research consists of articles relating to relocations caused by military action and war threats. This group includes both historical articles, such as those on relocation during the Cold War, and much rarer studies on contemporary wars in Syria or Ukraine. The literature on corporate relocation during war highlights a complex and multifaceted process, as pointed out by Mulska *et al.* (2023). They emphasise that the relocation of companies during war occurs under difficult and dangerous conditions of deteriorating security, economic crisis, and humanitarian catastrophe. The process involves various forms of relocation, including full or partial, internal or external relocation, each with unique challenges and considerations. Legal and organisational issues take centre stage in this discourse, often focusing on emergency measures to relocate operators' production facilities from regions affected by ongoing military operations to safer areas (Korobka, 2023). As Vashkiv (2022) explains, the primary reasons for such relocations are the imperatives of maintaining business operations, ensuring the safety of employees, and protecting valuable assets.

The external relocation, particularly to areas characterised by stable political conditions, is a recurring theme in the literature, as noted by Salmon *et al.* (2018). For example, companies forced to cease operations in Syria due to the war have typically relocated to neighbouring countries in safe zones with stable economic conditions, such as Lebanon, Turkey, and Jordan, as well as to Gulf countries, such as the United Arab Emirates and Qatar. This strategic choice is motivated by the desire to create a secure environment conducive to business continuity. However, external relocation of the IT sector, especially to countries such as Poland, is a cause for concern in the context of Ukraine. Several sources, including Mulska *et al.* (2023) and Vasyltsiv *et al.* (2022) and The Economist (2022), highlight the perception of this trend as a potential threat to Ukraine's economy, finances, and innovation ecosystem.

Moreover, the literature analyses the various challenges accompanying relocation processes in Ukraine. These challenges include economic disruption due to the termination of internal and interregional economic ties, organisational obstacles due to the lack of suitable business locations, difficulties in establishing engineering networks, and inadequate social infrastructure for relocated workers. Demographic challenges arise from the shortage of qualified specialists for the disassembly and assembly of complex equipment and the loss of workforce potential due to migration. In addition, logistical challenges come to the fore, including blocking and disrupting supply chains and sales logistics, as well as the complex and lengthy transportation of equipment to relocation sites.

To shed light on practical strategies, the literature utilises case studies, exemplified by Polunina (2022), offering valuable insights into how companies navigate the complex terrain of relocation during armed conflict. Together, these findings highlight the nuanced and multifaceted nature of corporate relocation in wartime, with implications for legal, organisational, economic, demographic, and logistical issues, as well as the critical importance of strategic planning and case-based insights in this challenging context.

Building on the insights from the literature, the article focuses on the largely unexplored topic of high-tech business relocation during wartime, with particular emphasis on Ukraine following the Russian invasion in February 2022. It aims to assess the scale and direction of these relocations, highlighting both internal movements within Ukraine and cross-border relocations to Poland, while exploring the strategies, challenges, and outcomes associated with these processes. The study tests two hypotheses: (1) that security, legal, administrative, and institutional conditions collectively influence the strategies and challenges encountered by high-tech companies in the process of relocation; and (2) that the spatial dimension of relocation is shaped by the combined effects of security imperatives, the feasibility of remote work, proximity to technological ecosystems, and geographic proximity to Ukraine, particularly in the context of relocation to Poland.

By addressing these aspects, the article contributes to the understanding of wartime corporate relocation, offering insights into its implications for both the Ukrainian and Polish economies, and for broader theoretical perspectives on relocation under extreme uncertainty.

RESEARCH METHODOLOGY

Assessing the scale of Ukrainian business relocation within Ukraine and from Ukraine to Poland presents a challenge. Access to data sources is limited, and the process under study is extremely dynamic. For this reason, we used a multifaceted approach combining desk research and various data sources to comprehensively investigate the phenomenon of corporate relocation. We conducted the study using a comparative approach, analysing the situation of relocated enterprises both within Ukraine and from Ukraine to Poland. The temporal scope of the study covers mainly the period of February 2022 to December 2022. However, some of the information obtained is more recent. Firstly, we conducted a secondary source analysis, reviewing both academic literature and newspaper articles to gain insight into the broader context of corporate relocation, particularly in situations of insecurity and war. This literature review provided a basis for understanding the key factors and challenges associated with such business relocations during wartime.

The study considered sparse quantitative data on state-supported relocation initiatives and high-tech companies published by the Ministry of Economy of Ukraine and the State Statistical Service of Ukraine. Data from DOU.ua regarding IT specialists and IT companies were also used. We analysed the scale and characteristics of the relocation of companies from Ukraine to Poland based on data from the Central Economic Information Centre (COIG) regarding companies with Ukrainian capital and data from the Central Register and Information on Business Activity (CEDIG) regarding sole proprietorships established by Ukrainians. The data were pre-processed and made available by the Polish Economic Institute (PIE). These datasets enabled us to conduct a detailed examination of the economic activities and movements of Ukrainian entrepreneurs and companies in Poland.

Moreover, between December 2022 and July 2023 the several in-depth interviews were conducted with officials from 13 Regional Military Administration Offices (Kyiv, Lviv, Ternopil, Rivne, Lutsk, Ivano-Frankivsk, Uzhhorod, Khmelnytskyi, Vinnytsia, Zaporizhia, Odesa, Sumy, and Kherson), as well as with five representatives of Municipal Offices responsible for entrepreneurship development in five big Polish cities Warsaw, Krakow, Wroclaw, Katowice, and Poznan. Moreover, five representatives of support institutions in these cities were interviewed, namely the Polish-Ukrainian Chamber of Commerce, Polish Investment and Trade Agency, Poland Business Harbor, Krakow Technology Park, and Dija. Business Warsaw. Furthermore, interviews were conducted with six IT companies, three of which relocated within Ukraine and another three from Ukraine to Poland (see *Appendix* for a list of institutions). These interviews provided qualitative insights and first-hand perspectives on the challenges and opportunities associated with the relocation of bus inesses with Ukrainian capital. We conducted the interviews in a mixed manner due to the locations and availability of the interlocutors, including face-to-face, online, and written forms.

RESULTS AND DISCUSSION

The Scale of Business Relocation Within Ukraine

Analysing business registrations in Ukraine's regions during the full-scale war (March-April 2022), we can clearly see that there have been substantial shifts in the business attractiveness of Ukrainian territories, with 80% of regions changing their positions in the rankings due to the impact of Russia's invasion. It is evident that the positions of the north-eastern and southern regions, where combat operations took place, deteriorated, while western regions exhibited the opposite trend. In the Donetsk and Luhansk regions, where the war has been ongoing for 10 years, their positions remained relatively stable. The most damaging impact of the full-scale war was observed on the business activity in regions such as Sumy (dropped from 14th to 20th place in the ranking), Mykolaiv (dropped from 12th to 21st place), and Kherson (dropped from 11th to 24th place). Right-bank regions, including Ternopil (rose from 20th to 8th place in the ranking), Cherkasy (rose from 18th to 9th place), Ivano-Frankivsk (rose from 16th to 7th place), and Rivne (rose from 22nd to 13th place in the ranking) demonstrated significant improvements their positions (Decentralization, 2022).

According to the interviews, the dynamism of the relocation process makes it difficult to estimate its scale, particularly in obtaining statistical information on the scale of relocation of IT companies.

Moreover, the scope of state-supported relocation efforts within Ukraine is noteworthy, as reported by the Ministry of Economy of Ukraine in March 2023. A total of 800 companies decided to relocate from regions considered hazardous due to ongoing war and instability and received support under the state relocation programme. The primary region for business relocation encompasses nine specifically designated regions in Western Ukraine, namely Khmelnytskyi, Chernivtsi, Ivano-Frankivsk, Lviv, Rivne, Ternopil, Vinnytsia, Volyn, and Zakarpattia, which have been identified by the state as the safest due to their considerable physical distance from the ongoing war zones.

The Lviv region stands out as a major destination, hosting 192 of the relocated businesses, reflecting its attractiveness as a secure business environment. Moreover, the Zakarpattia region has accommodated 116 companies, further emphasizing the importance of regional stability. The resilience and adaptability of these enterprises are evident as they navigate the challenges posed by the ongoing war and prioritize the safety and continuity of their operations. Impressively, 78% of these 800 businesses successfully transitioned to their new locations, resuming their operations with a renewed sense of security. The majority of these companies are large enterprises operating in the wholesale and retail sector (40%) and manufacturing industry (30%) (such as LLC 'Pozhmyshyna,' LLC 'Korum' 'Druzhkivsky Machine-Building Plant,' LLC 'Staleks,' PJSC 'Kramatorsk Heavy Machine Building Plant'). Among the relocated firms, nearly 7% are involved in information and telecommunication (Mulska *et al.,* 2023).

However, some companies opted to safeguard their assets by temporarily suspending their operations. Interestingly, approximately 650 firms reconsidered their relocation plans as a result of positive developments, including the de-occupation of territories such as Kyiv, Kharkiv, and Kherson. This change in circumstances led them to remain in their current locations. Moreover, 44 businesses have decided to return to their original workplaces, benefiting from improved security conditions in areas such as Kharkiv, Chernihiv, and Sumy. These dynamic shifts in relocation patterns reflect the complex and evolving situation within Ukraine, as businesses respond to changing security and economic factors (calculated based on data from the Ministry of Economy of Ukraine, *Appendix*, Institution 1).

There is no direct statistical data on the extent of relocation of high-tech firms. The largest relocated and partially relocated firms include GlobalLogic, EPAM, Sigma Software, Luxoft, and Intellias, among others, which relocated within Ukraine and abroad by creating new offices or using existing branches as a base (DOU.ua).

The most important relocation regions within Ukraine are the Lviv region, which has seen a significant increase in the number of IT companies (41%); the Uzhhorod region, which attracts relocators due to its security and proximity to the border (an increase of 387 IT professionals and 369%); and the Ternopil region, where 4 IT companies and 277 professionals have settled (a 298% increase). However, regions under occupation and close to the front line have experienced significant losses. For example, the Kharkiv region lost 10 IT companies (40%) and more than 10 thousand employees (79%), while the Mykolaiv and the Zaporizhzhia regions lost 802 (83%) and 251 (91%) IT specialists respectively (DOU, 2020; 2021; 2023).

Table 1. Dynamics of changes in the number of IT companies and specialists in the largest cities of Ukraine, 2020-2023

City	2020		2021		2023	
	Companies	Specialists	Companies	Specialists	Companies	Specialists
Kyiv	45	25 623	44	31 767	44	21 773
Kharkiv	21	10 057	25	13 700	15	2 837
Lviv	23	10 938	22	13 905	31	15 191
Odesa	15	2 389	17	3 276	15	2 418
Dnipro	13	2 720	15	3 634	15	2 792
Vinnitsa	9	1 500	11	1 462	12	1 644

Source: own study based on data from (DOU, 2020; 2021; 2023).

The war in Ukraine has reshaped the landscape of business activity across its regions, with profound implications for economic development and stability. The relocation of businesses, particularly in the IT sector, underscores the adaptive response of enterprises to ensure operational continuity amidst challenging circumstances. Regions such as Lviv, Uzhhorod, and Ternopil have emerged as new hubs for business, benefiting from their perceived security and strategic locations. Meanwhile, areas directly affected by the war experienced significant setbacks, emphasizing the dynamic nature of economic migration in response to changing geopolitical realities. As Ukraine navigates these complexities, the resilience of its business community remains pivotal in shaping its future trajectory.

The Scale of Business Relocation from Ukraine to Poland

One way to gauge the extent of this phenomenon is through an analysis of the number of enterprises with Ukrainian capital operating in Poland. Based on data from Statistics Poland as of January 2023, it becomes evident that Ukrainian enterprises are playing a significant role in the country's economic landscape. They constitute 25% of all foreign capital enterprises in Poland, surpassing even Germany, which stands at 10%. A substantial 19% of these Ukrainian enterprises were established in the year 2022, underlining their dynamic growth. These entities exhibit diversified sectoral involvement, with a substantial presence in retail (22%), construction (19%), and the transport and warehousing sector (14%). Information and communication activities contribute 7% to their operational profile.

Geographically, Warsaw emerges as the predominant location, housing 33.6% of these enterprises, followed by Krakow at 10%, and Wroclaw at 8%. Furthermore, the number of enterprises established in 2022 recorded a remarkable 9% increase compared to the preceding year, signifying a robust growth trajectory. Intriguingly, the most substantial year-on-year expansion was observed in 2015, with an impressive growth rate of 121%.

The magnitude of the relocation phenomenon from Ukraine to Poland is striking. According to data from the Central Register and Information on Economic Activity as of December 2022, Ukrainians. Established a significant number of sole proprietorships in Poland in 2022. The figures reveal that a remarkable 15.9% of sole proprietorships of Ukrainian origin were registered within this timeframe. Noteworthy, a staggering 97.6% of these registrations occurred between March and December, demonstrating a substantial and rapid increase, approximately 12 times higher than those registered in February. This influx of Ukrainian entrepreneurs contributed significantly to the overall business landscape in Poland, accounting for 5.7% of all companies established in the country in 2022. These statistics reflect the relocation of Ukrainian businesses to Poland in response to the ongoing war in Ukraine. This development is indicative of the resilience and adaptability of Ukrainian entrepreneurs who have sought opportunities and stability in Poland amidst the challenging circumstances in their home country (Figure 1).

According to the NACE Rev. 2 classification, which categorises businesses based on their research and development (R&D) intensity, 2 534 high-tech Ukrainian firms established themselves in Poland. This influx accounted for 15.9% of all Ukrainian businesses registered in Poland that year. Notably, these Ukrainian high-tech companies constituted 7.1% of all high-tech firms registered in Poland in 2022. It's important to highlight that 5.7% of all companies established in Poland in 2022 had Ukrainian capital, signifying that the share of Ukrainian high-tech companies in Poland exceeded the overall share. This data underscores Poland's growing appeal as a destination for high-tech enterprises and the significant contribution of Ukrainian firms to Poland's technological landscape and innovation.

The majority of the 2 543 Ukrainian IT firms that registered in Poland in 2022, comprising 74% of these firms, are primarily involved in software-related activities, specialising in software development, including web and mobile applications, and software solutions. Moreover, around 13% of these firms focus on IT consultancy activities, offering expertise in IT infrastructure, cybersecurity, and technology strategies. The remaining 12% encompass a diverse range of fields, including IT services, hosting, internet portals, video production, and post-production processing (Figure 2).

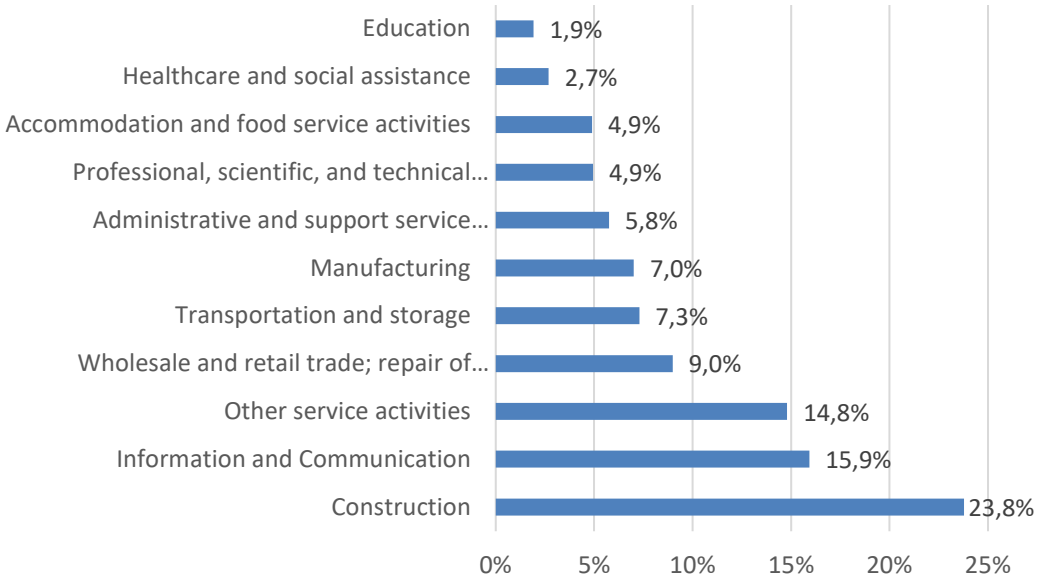

Figure 1. Ukrainian firms by sector or business activity, 2022
Source: The Central Register and Information on Economic Activity, Statistics Poland 2022, https://www.coig.com.pl/wykaz_lista_firm-z-ukrainskim-kapitalem_w_polsce.php

The Location Quotient (LQ) analysis of Ukrainian IT firms' presence in various Polish regions reveals significant disparities (Figure 3). Małopolskie, known for its robust IT ecosystem, exhibits the highest LQ value of 2.05, signifying a substantial concentration of Ukrainian IT companies compared to the national average. Meanwhile, Podkarpackie and Lubelskie, both bordering Ukraine, follow closely with LQ values of 1.95 and 1.69, respectively, highlighting their strategic appeal to Ukrainian IT firms due to their proximity to the Ukrainian border. Łódzkie shows a moderate concentration with an LQ of 1.29, while Mazowieckie, including Warsaw, maintains a presence below the national average with an LQ of 0.90. Most other regions display LQ values below 1, indicating a lower concentration of Ukrainian IT firms compared to the national average. These variations reflect the influence of geographical proximity, business environment, and policies on the location choices of these companies.

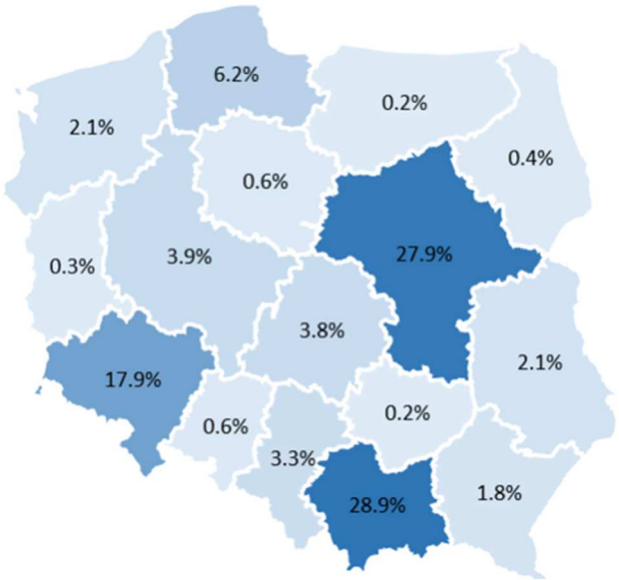

Figure 2. The regional share of high-tech Ukrainian companies registered in Poland in 2022
Source: own elaboration based on data from the Central Register and Information on Economic Activity provided by the Polish Economic Institute.

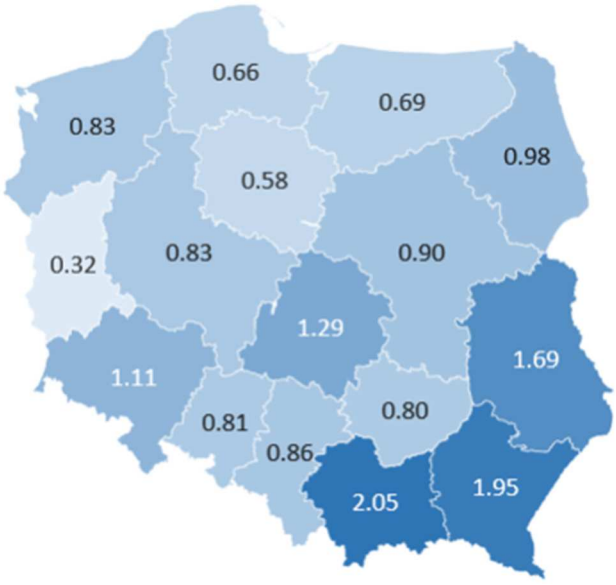

Figure 3. The location quotient of high-tech Ukrainian companies registered in Poland in 2022
Source: own elaboration based on data from the Central Register and Information on Economic Activity provided by the Polish Economic Institute.

The Relocation Mechanisms in Ukraine and from Ukraine to Poland

Common Features of Relocation Mechanisms in Poland and Ukraine

Drawing from the interviews, we can assert that the relocation processes within Ukraine and from Ukraine to Poland share several features. Firstly, in both countries, the relocation processes were supported by favourable legal conditions. The State Relocation Programme launched on 25 March 2022 in Ukraine (Ministry of Economy of Ukraine, 2022) aims to rebuild the economy by relocating businesses from war-affected or nearby territories to safe backline regions in Western Ukraine. The state programme encompassed several key initiatives, prominently including the seamless registration of business relocations to new locations, facilitating the efficient relocation of workers, and providing businesses with the invaluable prospects of preferential taxation or state loans through the State Programme 'Affordable Loans 5-7-9%' implemented with the support of the President and the Government of Ukraine. The programme simplifies access to bank lending for enterprises, offering the opportunity to receive a loan at a reduced interest rate through state compensation of interest rates to the level of 5%, 7% and 9% per annum for loans in national currency. The compensation interest rate (rate for the client) depends on the purpose of financing, the amount of annual income from business activities, and the number of jobs created.

At the same time, in Poland, the Special Act is in force (Sejm of Poland, 2022), referring to a specific legislative measure aimed at assisting Ukrainian citizens affected by the Russian aggression. This act encompasses various provisions, including facilitating the attainment of legal residence in Poland, the establishment of new business activities, changes in tax residency, and granting access to EU loans and grants. The Special Act, implemented on 12 March 2022, specifically addresses the provision of assistance to Ukrainian citizens affected by the armed conflict. Its objectives include facilitating the acquisition of legal residence in Poland, enabling the establishment of new business activities, facilitating changes in tax residency, and granting access to EU loans and grants.

Moreover, the favourable legal conditions were accompanied by an immediate response from state and regional institutions, government agencies, and public organisations. In Ukraine, the regional military offices play a crucial role. Since March 2022, the provincial offices across Ukraine have been transformed into 25 regional military offices, which are responsible for coordinating with the military command, defence, civil defence, public safety, and order. In the regional military administrations of Ukraine, specialists were appointed within the departments of economics to provide direct support to

relocated enterprises through close collaboration with other departments of the administrations, local communities, and civil organisations. The assistance provided to relocated businesses focused on finding suitable premises, connecting to infrastructure, addressing the transportation of assets, employees, and their families, as well as offering support for psychological and social adaptation in the new location (interviews, companies 1-3, institutions 7-8).

'We have a fairly open administration; they have worked in business and have known each other for many years. We focus specifically on what is needed, and we provide help where necessary... As regional authorities, we offer assistance and support but do not insist – everything is voluntary... Overall, we have good cooperation with all clusters' (interview, institution 7).

'Our strength lies in the fact that, as an investment team, we are positioned at the intersection of business needs, and the interests and needs of the community and the region as a whole' (interview, institution 8).

While in Poland, the existing bodies and agencies aided in the main relocation challenges. The Polish-Ukrainian Chamber of Commerce (PUIG), established in 1992, actively supports companies relocating from Ukraine to Poland. PUIG provides entrepreneurs with information on the local market, laws and regulations, making it easier to adapt to the Polish business environment. The Chamber also offers training and facilitates the establishment of contacts with business partners in Poland. 'Usually, relocation practices with us are very quiet; however, I must say that we adopt the position ... that no one here is waiting for you with their product, everything is already here. If you want to enter the market, get to know the market, find your place, or decide to leave' (interview, institution 21). Most of PUIG's activities during the war were directed at manufacturing companies, not high-tech companies, so the aid was short-term. 'These are manufacturing companies, for example, producing sweets or canned goods. Moreover, these are training companies' (interview, institution 21). 'Individual cases include either family businesses (for example, chocolate manufactories) or smaller production plants' (interview, institution 18).

In contrast, let us look at the government programme in Poland. Business Harbour (PBH), launched in 2020, aims at enabling individual IT specialists, start-ups, and IT companies from the high-tech or highly specialised manufacturing sector to quickly relocate to Poland. At the same time, it is not a programme dedicated exclusively to Ukrainians, it was created in 2020 as an initiative of the Chancellery of the Prime Minister and the Ministry of Development and Technology in cooperation with the Ministry of Foreign Affairs, the Polish Investment and Trade Agency, the Polish Agency for Enterprise Development, the Startup Hub Poland Foundation, and the Software Development Association Poland (SoDA) IT Services Employers' Organisation. Initially, it supported Belarusian companies, but in 2022, it extended its support to companies from other post-Soviet countries: Armenia, Azerbaijan, Belarus, Georgia, Moldova, Russia and Ukraine.

'The Wroclaw Agglomeration Development Agency was directly approached by several companies, particularly from the ICT sector; a significant number of enquiries also came to us through the Polish Investment and Trade Agency and their 'Poland. Business Harbour' programme' (interview, institution 18).

'The main objective of the Poland Business Harbour programme, in addition to providing broad support, was to facilitate obtaining a Poland Business Harbour – type national visa. This visa essentially allows smooth passage to Poland. Individuals holding these visas as part of their corporate relocation needed neither a residence permit nor permission to undertake professional work. During the duration of this visa, typically the first year, they could immediately take up employment in Poland. We issue so-called visa recommendations, which are then forwarded to ministries, consulates, or visa centres' (interview, institution 22).

Participants of the PBH Programme Business Path receive assistance in the visa application procedure and can also rely on free support in obtaining macroeconomic, human resources, and sector reports, assistance in finding the optimal location for an investment or office, facilitating contacts with government and local government institutions, organising site visits and meetings with stakeholders, providing information on public funding, and identifying potential business partners. The programme was expanded as a result of the war in Ukraine to include dedicated training for Ukrainian businesses fleeing the war (for example, a series of training courses on 'Relocation from A to Z' conducted in 2022).

'We are Ukrainian firms with a strong presence in Poland, but we are also firms that have been newly established in Poland. We are start-ups that have been founded in Warsaw, and we are firms that have launched typical ventures in Poland. Currently, we have about 15 active projects involving Ukrainian firms, but we can say that since the beginning of the war, there have been about 10 projects at the relocation stage, meaning they are exploring the possibility of establishing a company in Poland' (interview, institution 22).

Moreover, the Diia Agency established a branch in Warsaw, as an extension of one of the most widespread business support institutions in Ukraine under the Ministry of Digital Transformation of Ukraine. It began its operations on 18 May 2022 in response to the demands of the current military situation, migration, and the relocation of business entities. It provides professional consultations on legal matters, accounting, taxation, auditing, recruitment of skilled personnel, and other issues related to the management and development of entrepreneurial activities in Poland for Ukrainian citizens and small and medium-sized businesses in Ukraine. In summary, these institutions have provided access to information and comprehensive support of a legal, logistical, organisational, and psychological nature. 'In addition to the main types of business consulting for Ukrainians abroad, we offer a lot of interesting information, including general cases, news, and information for those who decide to register as entrepreneurs, as well as trainings' (interview, institution 23).

Another common feature was the high level of collaboration in the relocation process. This collaboration was evident on many levels, starting from business organisations and clusters to company branch networks, and even family and social networks, which were particularly important in the case of SMEs.

'We still began with the needs of the entrepreneur. We had a database of resources... we shared direct phone numbers to the facilities' owners. The relocants made their own choices and arrangements. Then came the process of establishing infrastructure. We launched a Telegram channel to search for facilities. We approached strong players in the region who acted as psychologists for the relocators, simply talking to them in a genuine way. Scaling up within Ukraine during the war, I saw companies entering foreign markets, not only within Ukraine, and for them, it was a kind of bridge that all the big companies actually needed. Now, there is a completely different dynamic. They are looking at how they can not only save their business but also improve their economic model' (interview, institution 8).

Lastly, it is noteworthy that a common characteristic of the relocation processes, both within Ukraine and from Ukraine to Poland, was the arduous task of conducting operations amidst the unique and challenging war conditions. These circumstances were characterised by the complex psychological states experienced by entrepreneurs and employees, which were unquestionably more severe in Ukraine compared to Poland.

Differences in the Relocation Mechanisms Between Poland and Ukraine

Despite some common features, the relocation processes in Ukraine and Poland differ in many aspects and on many levels. Firstly, there are two distinct approaches to relocation. In Ukraine, the emphasis is on maintaining and developing the domestic IT sector, which was regarded as a strategic sector during the war. The reasons for this are manifold. Firstly, there is financial support for war efforts and innovations in the military-tech sector.

In Poland, the relocation of firms from Ukraine is regarded as FDI and support for innovation ecosystems. The following quote from an interview (interview, institution 18) illustrates this point: 'Companies that decided to relocate and accomplished it quickly found their place in the local market and contributed to the development of the local business ecosystem. Some of these companies joined existing regional associations, such as IT Corner or SoDA. These companies also started participating in increasingly frequent events, such as meetups, conferences, trade fairs, *etc.* The presence of new IT entities in the local market enriched our local ecosystem.'

The processes themselves were also organised in different ways. In Ukraine, a centralised approach was adopted due to Marshal Law, with assistance provided through the PROZORO platform (Ministry of Economy of Ukraine, Ministry of Infrastructure of Ukraine), logistical support for asset and employee

relocation (Ukrposhta, Ukrzaliznyca), and on-site adaptation (regional military administration). In Poland, apart from organisations with a nationwide reach, a decentralised approach prevailed. This meant that each city prepared support for relocated Ukrainian businesses in its way.

For example, in Warsaw, there was no significant involvement of the Municipal Office in the relocation processes, with institutions directly dealing with foreign enterprises, such as the Polish Investment and Trade Agency and Polish-Ukrainian Chamber of Commerce, being more involved. In Wroclaw. However, 'as the local agency for the relocation of foreign companies,' the Investor Support Department, Business Support Centre of the Wroclaw Agglomeration Development Agency 'has been actively involved in the relocation of foreigners to Wroclaw' (interview, institution 18).

These contrasting approaches illustrate not only the distinct strategic priorities of each country but also their varied methods of supporting and integrating businesses relocating from Ukraine, reflecting broader economic and geopolitical contexts. Understanding these differences is crucial for all stakeholders aiming to optimize support frameworks and foster sustainable economic growth in both regions.

Varied Challenges Faced by Relocated SMSs in Poland and in Ukraine

Moreover, as reported by the interviewees, the challenges related to high-tech SMSs relocation vary between Ukraine and Poland (Table 2). In Ukraine, businesses encounter critical issues such as securing suitable premises with reliable utilities like electricity, heating, and internet amidst the backdrop of military mobilisation and ongoing war. Furthermore, psychological strain among employees and the threat of material damage due to military actions pose significant hurdles. Ensuring business continuity under wartime conditions adds another layer of complexity, requiring measures such as alarm systems and proximity to bomb shelters.

Table 2. Specific challenges of relocated SMEs: Insights from interviews

Ukraine	Poland
1. Renting premises with proper electricity, heating, and internet connection. 2. Availability of electric generators. 3. Military mobilisation of employees. 4. Complex psychological state of people. 5. Destruction of material assets due to military actions. 6. Ensuring business continuity and employee safety during wartime (availability of alarm notifications, proximity to bomb shelters, or compliance with the 'two-wall rule').	1. Correct choice of form of economic activity during company registration. 2. Need to conduct thorough market analysis. 3. Adjustment to the EU tax system and significant level of bureaucratisation. 4. Adaptation to the business culture in Poland. 5. Lower intensity of conducting economic activities. 6. Need to ensure transparency of activities – exclusion of corrupt elements. 7. Language barrier. 8. Adaptation of employees and their families in a foreign country.

Source: own study based on the interviews.

Support in Poland focuses on differences in legal regulations, business culture (transparency, taxes), and language. Conversely, SMEs relocating to Poland encounter challenges more aligned with navigating legal frameworks, adapting to EU tax standards, and managing bureaucratic procedures. The adjustment to Polish business culture and overcoming language barriers also feature prominently. The emphasis on transparency and the exclusion of corrupt practices further distinguishes the challenges faced by businesses in Poland.

This comparative analysis underscores the diverse operational landscapes SMEs navigate when relocating between Ukraine and Poland, shaped by unique socio-economic contexts and regulatory environments.

Companies' Relocation Strategies

Specificity of IT Companies' Relocation

We can analyse the importance of the Ukrainian IT sector during the war in military, economic, volunteer, product, and cyber terms (Mukhina, 2023). Firstly, more than 7 000 IT specialists joined the Ukrainian army (about 3% of the total). These include former software and product design engineers in infantry, artillery, and airborne brigades. Secondly, the IT sector is a strong and stable element of the Ukrainian economy, showing high resilience to war risks due to its specific characteristics. According to the National Bank of Ukraine, in 2022, IT companies paid USD 1 billion in taxes to the state budget and attracted USD 350 million in investments. Thirdly, the IT sector provides voluntary financial support for Ukraine's armed forces. High and stable incomes allow IT professionals to contribute significant funds to help Ukraine through individual contributions (monthly salaries often exceed USD 3 000, which is five to six times higher than the average salary in the country). As of March 2023, the IT industry has contributed more than USD 500 million to the country's victory over Russian invaders. Fourthly, the IT sector has focused some of its activities on developing technological solutions and products that save lives and provide an edge in military operations. Successful and socially useful examples of tools developed as a result of the Russian invasion include the interactive map that provides an up-to-date and detailed visualisation of military operations (DeepStateMap.Live), alert applications (Alert), and a machine learning-based missile defence system (Zvook). Fifthly, IT specialists are fighting in virtual space. Their mission is both to repel Russian cyberattacks and to take countermeasures.

According to the interviews, IT company relocation has its characteristics. First of all, relocating an IT company is less complicated because these companies require specialised equipment, warehouses, and production spaces to a lesser extent than other companies, such as manufacturing. The IT business primarily requires access to computers, a stable power source, and the internet, as servers are usually located abroad. Therefore, employees can, at least for some time, work from home or in coworking spaces (interviews, institutions 9, 11, and 15). Another factor explaining the specificity of the relocation of Ukrainian IT companies is their prior experience of operating in an international environment, which is richer than the experience of companies from other sectors. Retaining current clients from different countries favours the fluidity of business operations (interviews, institutions 8, 14, 16, and 24). The experience of Ukrainian IT companies is due to high professional competence and business English skills. Furthermore, young IT professionals are highly prepared to start their business in new conditions and understand the benefits of such a move (stability, comfort, official salary in Europe, *etc.*). An interview at Polish-Ukrainian Chamber of Commerce confirms this: 'Indeed, people who leave are valuable people in economic life because they are entrepreneurs who can function … beyond borders' (interview institution 21). Ukrainian IT professionals are highly valued abroad, so it is easier to confirm their qualifications and professional skills compared to other industries (interviews, institutions 7, 8, and 12).

The high degree of adaptability and self-determination is attributed to the limited support provided to such companies by various support institutions, owing to their high level of independence and rapid adaptation in areas of relocation (interviews, institutions 15 and 18). 'Those entrepreneurs who can manage on their own go to Warsaw, because those who have their own companies will find a way to manage, one way or another' (interview, institution 15).

Favourable conditions for foreign IT professionals in Poland have streamlined procedures for foreign IT specialists, facilitating the process of obtaining work permits and integrating into the local business environment. Poland offers special working conditions for foreign IT specialists, particularly from other post-Soviet countries, which is crucial when preparing a package of documents to obtain a work permit abroad. 'The programme implemented by the Polish Investment and Trade Agency, Poland Business Harbour, has been a great help. It was instrumental in handling the formalities related to relocation to Poland, such as obtaining appropriate visas, *etc.*' (interview, institution 18).

'Our work is to assist Ukrainian companies that are forced to relocate to Poland or are planning to relocate to Poland. The Poland Business Harbor programme is mainly designed for high-tech compa-

nies that relocate not only from Ukraine but also from other countries. The main purpose of this programme, in addition to providing broad support for these companies, was the ability to obtain a national D-type visa. This visa essentially allowed for a very smooth transition to Poland ... Individuals who held this visa as part of company relocation needed neither a residence permit nor permission to undertake professional activities. During the visa's validity, typically the first year, we could take up employment in Poland immediately' (interview, institution 22).

Each relocation is a unique economic and social phenomenon, and the impact on an IT firm can vary depending on the specific circumstances. Planning and coordination of the relocation process are essential to maximise the benefits and mitigate potential negative impacts. There are differences in the planning, coordination, and financing of the relocation process between large and small IT companies.

Strategies for Relocation of Small IT Rirms

The interviews allowed us to distinguish several features of the relocation strategies of small Ukrainian firms under wartime conditions. The foundation is prioritizing employee safety during wartime relocation. Entrepreneurs and business owners took necessary steps to reduce risks for themselves and their employees by implementing emergency evacuation measures: 'The most important thing now is to preserve the remaining potential of the firm and the talent pool we have (…) the region we chose is calm, safer, and therefore allows us to work productively, unlike the eastern regions' (Company 2). Owners have also worked to re-register their businesses in new locations and secure internally displaced person status for employees to restore operational processes and maintain team integrity. For example, employees were provided with workspace during the relocation, rented hotel accommodations for themselves and their families, and received financial assistance for adaptation (Company 1).

Another essential feature of wartime relocation strategies is a short-term planning horizon, evident in the tendency among employees to continue working with an expectation of return. This mindset is often accompanied by psychological strain due to the ongoing threats to life and health, sudden forced relocation, and drastic changes in personal and professional plans. Firms typically remain in a 'wait-and-see' mode regarding future developments and outcomes of the conflict: 'As for new opportunities for the company's development in a new location, we do not talk about it' (Company 2).

For companies that relocated abroad, an additional feature involves adapting to differences in the legal framework between Poland and Ukraine. Establishing a new business entity, changing tax residence, and legalizing employee activities through relevant legal mechanisms in Poland were mandatory to continue business operations. Owners often encountered challenges in restoring team integrity and adapting to the numerous and slow-paced bureaucratic processes: 'We chose Poland as the place of relocation because it has the simplest tax legislation and comfortable conditions for starting a business. The downside is the significant bureaucracy in the state authorities and their slowness' (Company 4).

A prevailing feature of these firms' relocation strategies is cost-cutting; however, some new opportunities have also been recognized. Lower operational costs and existing family and business ties were significant factors in selecting a new location. Company 3 noted: 'We expressed a desire to move to Rivne, a much smaller city. Here, we were satisfied with much lower prices for apartments for employees and office rent' (Company 3). Company 6 similarly shared: 'Together with my family, we moved to a small town in Poland, where all logistical issues are easier to resolve. We work online. We gathered information bit by bit (…), and there have been no significant changes' (Company 6).

Additionally, some respondents identified benefits from relocating to EU countries. A notable case involved a double relocation, where the owner initially left Donetsk in 2014 for Rivne, later moving to Poland and establishing a business there during the full-scale invasion. 'The choice to relocate to Poland came about spontaneously in the early summer of 2022. I left with my family, and the adaptation process was difficult for them. Since we also have family members in other European countries, we will most likely make a third relocation' (Company 5). Another company observed: 'there is some positive momentum because we are in Europe. We have the opportunity to consider where to move forward and how to develop' (Company 6).

The interviews allowed also to identify the factors determining the choice of a particular relocation site. The dominant elements in this respect were randomness, combined with the use of existing con-

tacts, both business and personal, and, in the case of relocation to Poland, the vision of a change in the concept of business operation concept – *i.e.* using the threat as an opportunity for a new way of operating the company – played a major role. Based on the knowledge gained we formulated four types of relocation strategies implemented by small and medium-sized businesses. These are as follows:

1. Strategy for maintaining and restoring business operations (for firms that have been severely or partially affected by the hostilities) (Company 2 and 3).
2. Diversification strategy (entering new markets, including export markets) (Company 4).
3. Cost-cutting strategy (to reach or maintain business operations at a level that is viable during a full-scale war) (Company 6).
4. Strategy to revive the business in a radically new environment (Company 5).

Strategies for the Relocation of Large IT Companies

Based on desk research, we identified several distinctive elements characteristic of the relocation strategies implemented by large companies with more than 1 500 IT employees. Firstly, strategic preparedness emerged as a crucial aspect of relocation strategies of these companies. GlobalLogic, EPAM, and SIGMA Software demonstrated their preparedness by implementing well-coordinated plans. These plans involved close collaboration with hotels and transportation companies to ensure a seamless transition for their employees.

Secondly, business continuity was a top priority for these IT firms. GlobalLogic's notable efforts included organising the evacuation and relocation of 14 000 employees from various regions in Ukraine. To support their employees during this transition, the company established a 24/7 helpline and provided financial assistance. EPAM also prioritised business continuity, offering financial support to its employees and successfully resuming project work without interruptions.

Thirdly, agile adaptation was a shared approach. These firms relocated specialists within Ukraine to ensure uninterrupted operations. Moreover, some firms, including SIGMA Software, expanded internationally by establishing branches in locations such as Burgas (Bulgaria), Lisbon (Portugal), New York (USA), Prague (Czech Republic), Stockholm (Sweden), and Hungary. This agile approach allowed the firms to diversify their presence and mitigate risks.

Fourthly, accommodation management played a crucial role in facilitating the relocation process. Luxoft, GlobalLogic, and EPAM implemented effective practices in this regard. Luxoft established an accommodation team that assisted over 140 employees and their families in finding suitable housing. Similarly, GlobalLogic and EPAM ensured smooth accommodation logistics for their relocated employees, minimising disruptions during the transition. Furthermore, future expansion plans were considered by some firms. EPAM planned to open new offices in Poland, while Itellias aimed to establish new offices and development centres in various locations (Polunina, 2022).

These expansion initiatives demonstrated the firms' growth vision and confidence in adapting to new markets. The relocation of large IT firms was part of important strategic decisions aimed at achieving various goals, primarily saving employees and preserving business units. Beforehand, we. thoroughly evaluated the relocation decisions with a rapid but consistent assessment of potential locations. The main criteria for making a relocation decision, in addition to safety, included developed infrastructure, tax advantages, economic stability, a robust business ecosystem, and the availability of a highly skilled workforce, among others.

Relocation requires consideration of socio-cultural aspects. Firms provided support to their employees to help them adapt to the new location. One of the key factors for IT firms' relocation is access to highly skilled and talented workers. Companies sought regions or cities with a significant concentration of tech professionals.

Furthermore, IT companies have considered relocating to countries where tax policies are favourable to their business, such as Poland. Some regions or countries offer special tax conditions to attract investment and business. Relocation has provided large IT firms with the opportunity to expand their global presence by accessing new markets where the demand for technology may be greater. By making strategic relocation decisions and consistently adapting both firms and employees in a reasonable

manner, choosing a strategy that is adaptive to the situation, can help large IT firms maximise the benefits of relocation and reduce the potential risks.

CONCLUSIONS

The study revealed the multifaceted nature of the relocation of Ukrainian IT companies during Russian aggression of Ukraine. Interestingly, the proactive large-scale relocation that began before the full-scale war, indicating the severe security challenges these companies faced and the precautionary measures they took to safeguard their operations.

Different sets of rules and factors shape the relocation patterns within Ukraine and from Ukraine to Poland. In Ukraine, government programmes and regional marketing strategies played critical roles in identifying host regions and competing for relocation volumes. Conversely, in Poland, institutions such as the Polish-Ukrainian Chamber of Commerce (PUIG) and the Polish Investment and Trade Agency (PAIH) facilitated the relocation process. In both cases: Poland and Ukraine, the attractiveness of recognised regional IT ecosystems, particularly in cities such as Krakow and Warsaw in Poland and Lviv in Ukraine, played an important role. These regions, characterised by well-established business networks and personal connections, have become attractive locations for relocating IT companies, however, the concentration measures are the highest in regions neighbouring Ukraine. The importance of existing business networks of family and friends used by companies in the relocation process and the serendipity of some relocations should also not be overlooked. The findings underscore also the importance of flexible and adaptive strategies in business relocation during crises. Smaller SMEs tend towards short-term planning, reacting pragmatically to the dynamic situation, whereas larger companies show strategic adaptability.

Recommendations and Implications

The relocation of Ukrainian IT companies in response to Russia's aggression has complex and multifaceted implications at organisational, regional, and national levels. At the organisational level, the primary motivation for relocation was to secure business operations, protect employee welfare, and preserve corporate assets. The strategic decision to relocate a company unlocks access to new markets in the European Union, diversifying revenue streams. Relocated IT companies integrate into established innovation and economic ecosystems, fostering synergies that stimulate growth. Moreover, these facilitate access to new sources of grants and credit, supporting sustainable business growth.

At the regional level, these relocations revitalise innovation ecosystems and contribute to regional budgets. In Poland, the relocated IT entities are treated as foreign investors and their presence is assessed in positive terms as a factor strengthening regional economies and demonstrating investment attractiveness. Research has not revealed any significant competition between Polish regions in terms of attracting Ukrainian IT companies. The situation is different in Ukraine, where the backward regions, where relocated companies are located, compete to attract relocated companies by offering incentives to stimulate regional development.

At the national level, while relocation helps preserve Ukraine's vital IT sector, it also poses challenges such as brain drain and economic weakening due to reduced tax revenues. However, in the long term, these relocations could result in positive outcomes as Ukrainian companies better adapt to the EU framework, enhancing transparency and corporate governance standards, thus supporting Ukraine's economic convergence with the EU.

Despite the significant criticism of the relocation of Ukrainian IT companies abroad, several concurring arguments can be identified. The first is related to the complexity of the relocation process. Many companies, despite their physical presence in Poland, still carry out similar work remotely, serving the same markets. Secondly, the dynamics of relocation processes are very high, we are aware on the multiple relocations of the companies long term effects are speculative. Thirdly, in the long term, relocations to countries such as Poland can bring positive results. With the experience gained in Poland, Ukrainian companies are likely to better adapt to the EU legal framework and business culture,

increasing transparency and corporate governance standards. Such adaptation has the potential for Ukraine's long-term convergence with the economic and regulatory framework of the European Union.

Effective support for the relocation of small IT firms requires, first and foremost, continuous monitoring of relocation processes and regular assessments of the evolving needs of these businesses. Insights from this monitoring can inform targeted support measures, allowing governments and regional authorities in both Ukraine and Poland to enhance infrastructure, offer tax incentives, and create favourable business environments. Additionally, international cooperation, especially with the EU, could aid in aligning business practices with European standards, promoting long-term economic stability and growth.

Research Limitations

The study focused on companies that physically relocated either within Ukraine or to Poland, excluding those that continue to operate remotely, which poses a limitation in capturing the full scope of the phenomenon. Moreover, the dynamic nature of the war and the ongoing relocations make it challenging to provide a comprehensive analysis of long-term effects. The reliance on interviews and limited available data also introduces potential biases, limiting the findings' generalisability.

Suggestions for Further Studies

Future research should explore the long-term economic impacts of these relocations on both the Ukrainian and Polish economies. It would be valuable to assess how relocated companies adapt to new legal and business environments over time and how these relocations influence the broader IT ecosystem in both countries. Comparative studies involving other war-affected regions could also provide deeper insights into the global dynamics of business relocation under similar conditions.

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Appendix: List of interviews

Table A1. List of interviewed companies and their characteristics

Company designation	Characteristics based on the interviews	Date
Ukraine		
Company 1	Relocated from Kyiv (UA) to Ivano-Frankivsk (UA) The employees of the relocated IT company's department were provided with a secure workplace and rented hotels for the relocated employees and their families.	10 March 2023
Company 2	Relocated from Dnipro (UA) to Ternopil (UA) Complicated psychological state of workers, the constant expectation of return.	20 March 2023
Company 3	Relocated from Kyiv (UA) to Rivne (UA) Relocation due to familiarity with the new facility and low cost of living.	22 March 2023
Poland		
Company 4	Relocated from Kyiv (UA) to Wroclaw (PL) Small company, operating in the field of software and information and computer technology services. After relocation, the owner had problems with the legalisation of workers not from Ukraine but from other foreigners.	21 March 2023
Company 5	Relocated from Rivne (UA) to Poznan (PL) Small company, engaged in data processing, website management, service activities in the field of information and computer technologies, and Internet portals. The owner of the company as an individual relocated at the beginning of the war from Donetsk to Rivne, since the full-scale war his second relocation already as the owner of the company from Rivne to Poznan took place.	12 April 2023
Company 6	Relocated from Lviv (UA) to Czerwonak (PL) Small company, engaged in activities related to software, IT consultancy, data processing, and website management. After relocation, only remote work was organised.	18 April 2023

Source: own study.

Table A1. List of interviewed institutions

Institution Designation	Interviewee/Department	Date
Ukraine		
Institution 1	Ministry of Economy of Ukraine, First Deputy Minister	09 January 2023
Institution 2	Sumy Regional Military Administration, specialist of the Department of International Cooperation and Economic Policy	25 November 2023
Institution 3	Zaporizhzhia Regional Military Administration, First Deputy Head of the Regional Military Administration	05 December 2022
Institution 4	Kyiv Regional Military Administration, Head of the Economic Department	07 December 2022
Institution 5	Kherson Regional Military Administration, Director of the Department of Economic Development	15 December 2023
Institution 6	Odesa Regional Military Administration, specialist of the Department of Economic Policy and Strategic Planning	16 December 2023
Institution 7	Rivne Regional Military Administration, specialist of the Department of International Cooperation and European Integration	19 December 2022
Institution 8	Lviv Regional Military Administration, Head of Investment Attraction Department	21 December 2022
Institution 9	Ternopil Regional Military Administration, Director of the Department of Economic Development and Trade	12 January 2023
Institution 10	Vinnytsia Regional Military Administration, Specialist of the Department of International Cooperation and Regional Development	20 January 2023
Institution 11	Volyn Regional Military Administration, Deputy Head of the Economic Department	25 January 2023
Institution 12	Khmelnytskyi Regional Military Administration, Department of Economic Development	17 February 2023
Institution 13	Ivano-Frankivsk Regional Military Administration, Deputy Head of the Regional State Administration for Digital Development, Digital Transformation and Digitalisation	03 March 2023
Institution 14	Zakarpattia Regional Military Administration, specialist of the Department of Regional Development	25 April 2023
Poland		
Institution 15	Municipal Office, Warsaw, specialist of the Economic Development Office with the Entrepreneurship Centre in Warsaw City Hall	15 December 2022
Institution 16	Municipal Office, Cracow, specialists of the Investor Service Department in Cracow City Hall	11 January 2023
Institution 17	Municipal Office, Katowice, Head of Investor Support Department, Business Incubator, Deputy Head of Investor Support Department	21 February 2023
Institution 18	Municipal Office, Wroclaw, Head of Investor Support Department, Business Support Centre of Wroclaw Agglomeration Development Agency	25 May 2023
Institution 19	Municipal Office, Poznan, Specialist of Investor Service Office	20 June 2023
Institution 20	Polish Investment and Trade Agency, Warsaw, Project Department Expert	09 December 2022
Institution 21	Polish-Ukrainian Chamber of Commerce, Warsaw, Director of Business Consultancy Centre (Business Relocation Centre) Polish-Ukrainian Chamber of Commerce	12 December 2022
Institution 22	Poland Business Hurbor, Warsaw, Trade Programme Experts and Experts of Poland Business Harbor	16 December. 2022
Institution 23	Dija Business Warsaw, expert of the Dija Business centre in Warsaw	18 January 2023
Institution 24	Cracow Technology Park, Vice President of the Management Board of the Cracow Technology Park	23 January 2023

Source: own study.

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Use of Artificial Intelligence

AI/GAI tools were used in a limited and non-substantive capacity. Specifically: 1. an automatic transcription tool integrated with Google Docs was used to transcribe recorded interviews; 2. ChatGPT was used for linguistic proofreading of the manuscript. No AI tools were involved in data analysis, interpretation, or the formulation of research conclusions.

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Investigating factors in the implementation of customer relationship management in Polish enterprises

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ABSTRACT

Objective: The article aimed to determine the factors of the implementation and functioning of customer relationship management (CRM) in Polish enterprises, whether they see the benefits and whether they can identify the reasons for choosing specific software and its supplier in the field of CRM systems, and whether the collected data is subjected to effective analyses. The research problem is to determine the determinants of the implementation and operation of the CRM system in Polish enterprises. Due to the lack of detailed research on this topic among Polish enterprises and the emerging need for more and more frequent use of the CRM system, the article attempts to examine this issue.

Research Design & Methods: We formulated five research hypotheses adequate to analysing the research problem described in the literature sources. We conducted research using a survey questionnaire with the participation of a professional research panel. We surveyed 261 enterprises. We examined the relationships using the chi-square test (with Yates' correction). We assessed relationship strength using Cramer's V coefficient. Furthermore, we evaluated the strength and direction of the relationship using the Gamma coefficient. We subjected the data collected during the research to statistical analysis in Statistica TIBCO 13.3 software.

Findings: Research has shown that larger enterprises and those with a greater reach are more willing to use CRM IT systems. Enterprises that have incurred investment expenditure in the last three years also use these systems. The article also has theoretical implications. They allowed us to reveal certain phenomena in organisations and mechanisms. This can serve to create universal theoretical business models.

Implications & Recommendations: The article shows business practitioners how vital the application of the CRM system and its constant updating in the light of the latest trends are for their success. Moreover, in theoretical considerations, researchers indicate that companies notice numerous benefits after implementing CRM, such as the ability to make effective business decisions and increased customer loyalty. However, as mentioned in the article, many CRM implementations are fraught with the risk of failure.

Contribution & Value Added: The article discusses using CRM systems in business, which are essential in building lasting customer relationships in a rather saturated market. The article is dedicated mainly to practitioners but also to scientists deepening the topic of using CRM.

Article type: research article

Keywords: CRM; enterprise; IT system; business; customer

JEL codes: E22, L86, M15

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INTRODUCTION

In the 2020s, enterprises faced numerous challenges associated with, for example, increasingly demanding customers and increasingly competitive markets. One of the most critical differential values in companies that survive in an increasingly dynamic and competitive market today is their capacity for innovation and adaptation to the environment (Guerola-Navarro *et al*., 2021). Implementation of CRM

conception becomes such a solution. The CRM system used for managing customer relationships is increasingly becoming indispensable for organisations aiming to maintain groups of loyal customers. The genesis of CRM conception indicates that it emerged from the enterprise's internal needs and the evolution of marketing from a transactional to a relational approach. Enterprises stopped treating customers as petitioners and have begun to be partners with whom it is worth building lasting relationships. They began to notice such benefits from CRM. If appropriately implemented, CRM technologies may improve data gathering and analysis of critical client relationships, improving strategic and project-level decision-making (Preece *et al*., 2015). Similarly, customers have begun to notice that CRM allows them to gain additional advantages from establishing a relationship with an enterprise and increase their satisfaction. However, it seems essential to check the status of CRM implementation in enterprises and the determinants of CRM functioning in organisations. To generalise the research conclusions, we used the example of Polish enterprises. The CRM conception began to emerge in Poland around 2004. It seems likely that Polish enterprises should already have some experience with it. Having analysed the literature, we decided to formulate some hypotheses on the subject and determine which Polish enterprises are most likely to implement the CRM system, whether they perceive the benefits and can identify the reasons for choosing a particular software and its supplier in terms of CRM systems, and whether the collected data is subjected to effective analysis. In the era of sustainability, the conception of customer relationship management is still fundamental and can benefit enterprises. However, it requires support from appropriate technological solutions, which makes companies successful. Solutions of this type can be expensive, so it is worth checking whether companies use them skilfully and effectively, whether they have equal access to them, and whether it depends on the company size.

It seems important to investigate the CRM determinants in enterprises to understand the current state of the above phenomenon. Due to the lack of detailed research on this topic among Polish enterprises, as well as the emerging need for more and more frequent use of the CRM system, the article attempts to examine this issue. The article presents the results of its research on CRM implementations in enterprises, which is so essential in building lasting relationships with customers in a rather saturated market, showing business practitioners how vital the application of the CRM system is and its constant updating in the light of the latest trends for their success. Given the above, the study aimed to determine the factors of the implementation and functioning of CRM in Polish enterprises, whether they see the benefits and whether they can identify the reasons for choosing specific software and its supplier in the field of CRM systems, and whether the collected data is subjected to effective analyses. We formulated five research hypotheses. The study was cognitive. We intend to continue to use the collected data for further analyses.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The CRM concept combines people, processes, and technology to effectively manage customers and benefit the company and customers. The extensive availability of CRM systems, both domestic and foreign companies, with different functional features, makes the choice of CRM software rather problematic. During its selection, companies are mainly guided by substantive and functional criteria, but importantly, the systems can be replicable or dedicated exclusively to individual company needs (Siu, 2016). How does this convert CRM systems usage in the SME sector? Numerous domestic and foreign research conducted to date prove that a relationship exists between company size and CRM use (Chromčáková *et al.*, 2017; Reicher *et al.*, 2015; Pohludka & Štverková, 2019; Dalla *et al.*, 2018), essentially the larger the companies, the greater the interest in using CRM as the current research will indicate. Previously, several researchers have also suggested that CRM implementation in the SME sector has a slow adoption rate, with more than half of all adoptions failing (Ismail *et al.,* 2007; Reijonen & Laukkanen, 2010). Several researches suggest that SMEs lack the knowledge, understanding and ability to implement CRM applications (Özgener & İraz, 2006). Scholars conducted most CRM research in large organisations, and few studies have examined CRM adoption in SMEs (Nguyen & Waring, 2013; Krasnikov *et al.*, 2009). However, since then, a lot has changed, and currently, the SME sector is eagerly reaching for modern technological solutions, including systems and software to support the enterprise's work.

Regardless of their industry, SMEs can achieve many benefits by adopting CRM. As researchers predict, companies increasingly appreciate the advantages of using tools such as CRM (Arsić *et al*., 2018) because they contribute to building competitive advantage and increase productivity or long-term relationships with customers, and their trust is the most valuable currency, and in the digital age, technological tools are simply irreplaceable (Chang *et al.*, 2014; Dalla Pozza *et al.*, 2018; Santouridi & Veraki, 2017). Over the years, the trend and intensity of modern technology use for customer service have changed dramatically. Research conducted over a decade ago (Statistics Poland examined the use of ERP and CRM information systems by Polish enterprises, CSO, 2010) showed that only one in ten enterprises in Poland used an ERP and CRM system. However, more commonly used by Polish enterprises were and are CRM systems, both those for collecting, storing customer information and providing access to it to other enterprise units, which served over 17% of companies in the last year and those for analysing customer information for marketing purposes, which served over than 13% of companies. The CSO research also indicated that the use of systems in this class largely depends on the company's size. In 2009, less than 18% of all enterprises used CRM systems. Among small and medium-sized enterprises, their use is much lower – only 5% of small and 20% of medium-sized companies used CRM systems in 2009, but already more than 50% of large companies. In 2010, the overall CRM usage declined to 16.4% and appeared as follows: large companies (45%) used CRM most often, while medium-sized companies (27%) and small companies (15.8%) used it less often (CSO, 2010).

Another study conducted by the Central Statistical Office (CSO) on the use of information and communication technologies in enterprises in 2015 (CSO, 2015) on a sample of 18 000 Polish enterprises showed that an ERP or CRM system was used by one in five and one in four enterprises, respectively (most often by large enterprises). More precisely, the percentage of ERP or CRM software packages used was 24.9% of small enterprises, 58% of medium-sized enterprises and 88% of large enterprises. Noteworthy, SMEs are unlikely to hire specialists with digital competencies. Such people are employees in less than 7% of small and 29% of medium-sized companies, compared to 73.5% of large companies in Poland (Report PARP, 2018). The IDC Report (International Data Corporation) from 2023, commissioned by Salesforce, analyses various aspects of Polish companies' implementation and use of CRM systems. It includes an assessment of the adoption level of CRM technology, the key benefits for enterprises, their challenges, and forecasts for the future. The study showed that more and more Polish companies are implementing CRM systems to improve customer relationship management, increase sales efficiency and better adapt offers to customer needs. According to the IDC report, approximately 68% of companies in Poland use CRM systems, and this number is expected to grow. Entrepreneurs value CRM, particularly in the trade, financial and service industries, where they enable the collection and analysis of customer data, which allows them to tailor the offer to their needs and increases service satisfaction (Report *CRM market research reports by IDC*, 2023). Moreover, research conducted by Gemius for the Polish Chamber of Information Technology and Telecommunications in 2023 indicates that Polish companies use CRM systems mainly to manage sales (87%), marketing (78%) and customer service (75%). The popularity of these systems is due to their ability to integrate with other tools and platforms, which allows for more effective management of data and business processes (Report E-commerce w Polsce*,* 2023).

Generally, SMEs have more limited financial, human or knowledge resources than corporations. Consequently, they have limited resources for budgeting IT projects (Rostek *et al.*, 2012). We may find the reasons for the CRM used by larger companies in several aspects, like: (1) there is a belief among entrepreneurs that these programs are designed only for large companies, (2) entrepreneurs perceive such an investment as too costly, (3) lack of reliable knowledge about various technologies and software (including free software) enabling access to CRM functions, (4) lack of knowledge about positive experiences of other entrepreneurs operating in the SME sector, (5) lack of knowledge about the full functional scope of CRM-class systems and the potential benefits of their implementation in a small business.

Considering the literature considerations, we formulated the following research hypotheses:

H1: Larger enterprises are more inclined to use CRM information systems.

H2: Enterprises that have incurred investment expenditures in the last three years have implemented a CRM system.

H3: Enterprises that have implemented CRM perceive benefits from implementing this system.

H4: Enterprises that have implemented CRM can identify the reasons for choosing a particular software and its supplier regarding CRM systems.

H5: The data collected within the CRM system is subjected to effective analysis in enterprises.

The first hypothesis we formulated and verified, reads as follows: Larger enterprises are more inclined to use CRM information systems. The IDC Report indicates that the adoption of CRM systems is higher in large companies that appreciate the benefits of integrating customer data and optimising sales processes (Report CRM market research reports by IDC, 2023). However, analyses conducted by Salesforce show that large enterprises see CRM as a strategic tool for increasing customer loyalty and improving sales results (The State of CRM, 2023). Gartner's research also indicates a higher use of CRM systems in large organisations than in small and medium-sized companies, mainly due to the complexity of operations and greater financial resources (Gartner's Magic Quadrant Reports, 2023). Nowadays, the problem is not the tools' availability but their clever selection from among the possible solutions. This is because large companies, with their expanded structure, a larger number of employees, or greater market reach, also have greater needs and relationships to coordinate. A CRM system will help them adapt their organisation to the customer's needs, facilitate customer relationships and thus help increase revenue, improve marketing activities, and positively affect the company's image (Kumar *et al.*, 2018; Macdonald *et al.*, 2016). Undoubtedly, originally, mainly large and medium-sized companies used this type of solution, which resulted primarily from the number of customers served, the specific nature of contacts with customers and the financial capacity to implement CRM-class information systems. However, nowadays, small companies are also increasingly reaching for this type of IT solution, properly adapted in technological and functional terms for this group of enterprises' needs. It is obvious that reaching for modern solutions, including IT systems, constitutes a long-term decision designed to generate profits (Korzyński *et al*., 2023). Therefore, entrepreneurs should treat the implementation of CRM systems as an investment. The interest in CRM systems is fundamental and caused primarily by the high return on such an investment, as well as the increased level of transparency in all business processes (Bai & Qin, 2016). However, it is worth noting that the investment concept is associated with the principle of profitable investment. For CRM implementation, the achievable effects may be both soft and hard. Equally important, changing the work organisation and implementing any computer system is fraught with risk. Hence, many IT projects have never been completed. The CRM system is not easy to implement; it involves issues that are difficult to measure, *i.e.*, the previously mentioned soft elements. Nevertheless, SME companies, especially the larger ones, recognise its potential and possibilities.

The research conducted and the verification of the second research hypothesis: Enterprises that have incurred investment expenditures in the last three years have implemented a CRM system – will prove the above relationship, showing that investment expenditures in the last three years related to the implementation of CRM by the surveyed companies. Apart from a successful investment, CRM has many benefits and opportunities, like building positive customer relationships, including pre-sales, during-sales and post-sales functions (Abdul-Muhmin, 2012; Santouridis & Veraki, 2017; Nguyen *et al.*, 2007). It is worth mentioning that to buy and implement an optimal CRM system, it is necessary to conduct a thorough analysis of the SMEs' needs to make a successful investment. The system's implementation team should agree on implementation goals and develop a vision of what the company should look like after CRM implementation. Constantly increasing competition, manifested in modern business conduct, has made many SME companies from various industries realise the importance of retaining their customers (Santouridis & Veraki, 2017). CRM is supposed to perform its role in the company, which is to concentrate on maintaining profitable relationships with customers through all available communication channels and here front-office applications – supporting sales, marketing and customer service – and back-office applications – helping to integrate and analyse customer data with a view to customer satisfaction and fulfilment in the relationship with the company – are essential. Tracking customer behaviour according to tastes and needs is motivating enough for an SME company to implement CRM systems. Using this information, companies can create and develop improved products

and services and increase knowledge about customers by analysing their buying behaviour through various channels (Mithas *et al.,* 2005). Customer satisfaction has always interested researchers, with literature indicating that many benefits are associated with its achievement, including an increased customer retention rate (CRR). Therefore, examining the possible impact of CRM practices on customer satisfaction can provide SME managers with the necessary information regarding developing and implementing effective CRM strategies. Enterprises that have implemented a CRM system see benefits in various areas of the company, including (1) marketing (including increased marketing department efficiency), (2) sales (including customer segmentation, individualised tailoring of sales/service offerings), (3) company organisation in general (including company structure optimisation and operation procedures ordering, task completion time speed, more efficient communication) and (4) better service quality, which ultimately leads to (5) building exceptional customer relationships and increased customer satisfaction (Preece *et al*., 2015; Abdul-Muhmin, 2012; Meng, 2012; Bohling *et al.*, 2006). According to the above, the CRM system gives a competitive advantage to SMEs, improving the company's collection of information about customers to customise products and services to meet their demands, which consequently leads to the formation of a company's positive opinion and its products. Conducted self-research mostly confirms the third research hypothesis (Enterprises that have implemented CRM perceive benefits from implementing this system), thus indicating the awareness of the surveyed enterprises about the possibility of benefiting from the implemented CRM system.

Working in the CRM system is always directly related to work efficiency. The more complex and elaborate the system is both on the front-end, *i.e.*, the user side, and on the back-end, the more difficult it is to work efficiently and quickly on this kind of platform (Lin *et al*., 2010). SME enterprises deciding on a CRM system are already making a more conscious choice by comparing and testing different systems beforehand, especially within their design and ease of use. The most important thing is that the system should correspond to the business's priority needs and that the company's operating model, *i.e.*, industry and work specifics, should be able to be integrated into the system fundamentally. Currently, SMEs have several options for acquiring and implementing a CRM information system, *i.e.*, they either invest in a dedicated system (that meets the company's needs), otherwise 'customised,' or invest in the purchase of an 'out of the box' system, *i.e.*, a ready-made solution. Choosing will certainly not be easy, and equally worth considering is that implementing a CRM system is, on the one hand, a project of implementing a new tool in a company, and on the other hand, a process that requires changing habits and departing from the routine, often inept habits of employees. Each SME implementing the system must ensure that the employee is properly trained and motivated to operate the system, as well as monitor his work on an ongoing basis (the system's analytical module provides such an option). The effect of training employees to work with the implemented CRM system is, first of all, to make employees aware that the actions they take in the system also affect other people and relationships within the company. Therefore, the CRM system allows for building relationships with external and internal customers (Abbott, 2003; Aliyu & Nyadzayo, 2018). SME enterprises generally follow various guidelines to select the optimal software that meets their assumptions and expectations, *i.e.*, (Yapanto *et al*., 2021; Wach, 2020; Bohling *et al.*, 2006; Wang & Feng, 2012): (1) does the system provide the ability to manage the customer base and monitor sales efficiently? (2) does it provide the ability to create quickly needed reports, analysis of sales and customers, and workflow in general? (3) does it speed up the working time of the teams involved? – and so on. However, the choice of a system provider is most often dictated by criteria such as (1) the price of the software (Krasnikov *et al.*, 2009), (2) the opinion of other customers about its functionality (Becker *et al*., 2009), (3) the supplier's position in the market (Bull, 2003), (4) the program's ease of use (Jafari Navimipour & Soltani, 2016), (5) the speed of its implementation (Krasnikov *et al*., 2009), (6) integration with existing systems and hardware (Bose, 2002), (7) the ability to cooperate with applications (Valsecchi, 2007), (8) or the security of data in the system (Anshari *et al*., 2019). The research conducted and the results obtained analysed, provided opportunities to verify the fourth hypothesis (Enterprises that have implemented CRM can identify the reasons for choosing a par-ticular software and its supplier in terms of CRM systems), resulting in a reasonably rational evaluation and selection by the surveyed enterprises of the right CRM system and its supplier.

We performed data collection in the CRM system through operational and interactive CRM. We collected data in data warehouses. However, no effective CRM system will fulfil its tasks if the data is not adequately processed and analysed. This is what analytical CRM does. Analytical CRM systems aim to provide a better understanding of customers' behaviours and needs. It is an enabler that allows organisations to establish stronger customer relationships by analysing customer information and providing a complete view of the customer (Farhan *et al.*, 2018). Statistical and data mining methods used in CRM analytical systems can be instrumental in improving customer relationships. Some researchers report that 70-80% of CRM implementations are unsuccessful (Deshmukh *et al*., 2020; Bush *et al*., 2005; Finnegan & Currie, 2010; Wilson *et al*., 2007). This carries vast losses for implementing organisations, therefore all measures are required to avoid failure. As early as 2000, scholars noted that many enterprises had invested heavily in the infrastructure for operational CRM (call centre technology, funnel management systems, campaign management technology, loyalty cards) without having any coherent strategy for analytical CRM. Scholars and specialist suggested that the reason for CRM implementation failure was primarily due to a lack of experience in running a company in a free-market economy and using CRM analytical capabilities. In addition, data inaccuracy or defectiveness can be a problem (Turban *et al*., 2008). This article examines whether Polish companies properly use customer data they collect. Therefore, we decided to provide the following fifth hypothesis: **H5:** The data collected within the CRM system is subjected to effective analysis in enterprises.

RESEARCH METHODOLOGY

Materials and Methods

The survey was conducted in January 2023 using a questionnaire with a professional research panel. The population described consists of Polish enterprises from various sectors and industries. In 2022, the number of non-financial enterprises increased by 4.2% y/y, reaching 2 356.0 thousand entities in 2021 (CSO, 2023). We surveyed 261 enterprises. In the case of the research conducted for the article, micro-enterprises and sole proprietorships accounted for a total of 39.0%; small – 30.0%; medium – 10.0%; and large ones – 10.0%. Thus, in this case, we may treat the sample selection as purposeful. The sample of 261 enterprises selected for the study, with a confidence level of 95%, a fraction size of 0.3 (we estimate that approximately 30% of enterprises were in contact with CRM) and with the assumed maximum error of 6%, was sufficient. Table 1 shows the structure of the survey sample.

Table 1. Research sample characteristics

Enterprise size	**Micro**	**Small**	**Medium**	**Large**	**One-person**
Sample size	76 (29%)	77 (30%)	57 (22%)	26 (10%)	25 (10%)
Type of business conducted	Industrial activities	Service activities	Commercial activities	Construction activities	Other
Sample size	38 (15%)	163 (62%)	35 (13%)	22 (8%)	3 (1%)
Operation period of the current business	Less than a year	1-5 years	6-10 years	Over 10 years	
Sample size	3 (1%)	66 (25%)	51 (20%)	141 (54%)	
Enterprise coverage	Local	Regional	National	International	
Sample size	61 (23%)	64 (25%)	89 (34%)	47 (18%)	
Amount of investment expenditure in the last 3 years	Lack of expenses	Up to PLN10000 (2305.42EUR)	From PLN 10001 (2305.65 EUR) to PLN 100000 (23054.22 EUR)	From PLN 100001 (23054.45 EUR) to PLN 500000 (115271.12 EUR)	Over PLN500001 (115271.35 EUR)
Sample size	33 (13%)	43 (16%)	96 (37%)	42 (16%)	47 (18%)

Source: own study.

The questionnaire consisted of five metric questions and 20 substantive questions on the determinants of CRM implementation in companies in terms of both CRM philosophy and software. At the same time, part of the questionnaire was addressed only to enterprises that have implemented

CRM and part to those that have not yet implemented this system. The results of the responses to the screening question: 'Do you have a CRM information system for customer relationship management?' shows that 90 out of 261 companies surveyed have implemented a CRM system, 142 companies out of 261 have not, and 29 responses were 'I don't know.'

Respondents answered questions about the advantages of implementing a CRM system, reasons for choosing a CRM provider, and reasons for implementing a specific CRM by using a 5-point Likert scale. Prior to analysis, we ranked variables, with 1 indicating negligible benefit/marginal reason and 5 indicating significant benefit/very important reason. To assess the consistency of the blocks of questions on benefits, reasons for choosing delivery, and reasons for implementing a CRM system, we performed a reliability analysis and calculated Cronbach's alpha reliability coefficient. For questions about the benefits of implementing a CRM system, the Cronbach's alpha was 0.91, for questions about the reasons for choosing a supplier, the Cronbach's alpha was 0.89, and for questions about the reasons for implementing a CRM system, the Cronbach's alpha was 0.86. This indicated high question reliability.

We examined the relationship between enterprise size and having a CRM system, the relationship between enterprise coverage and having a CRM system, and the relationship between the number of investment expenditures in a business in the last three years and having a CRM system using the chi-square test (with Yates' correction when there were classes of less than 10 in the Table). We assessed relationship strength using Cramer's V coefficient. Moreover, we assessed the strength and direction of the relationship using the Gamma coefficient.

We subjected the data collected during the research to statistical analysis in Statistica TIBCO 13.3 software. We adopted a significance level of $p = 0.05$ in all analyses.

RESULTS AND DISCUSSION

Based on the answers given in the questionnaire, to verify **hypothesis one (H1)**, we counted the indications given by respondents in the question about having a CRM system, with a division by company size. Table 2 presents the results. In total, 29 people answered 'I don't know' and we did not include these answers in the summary.

To verify hypothesis one, we analysed the relationship between enterprise size and the use of the CRM IT system using the chi-square test of independence. We made the null hypothesis of independence between the questions against the alternative hypothesis that the variables are dependent. Based on the results of the chi-square test ($\chi2(4) = 35.05$, $p < 0.001$), we rejected the null hypothesis in favour of the alternative hypothesis indicating the relationship exists. This allowed us to conclude that smaller enterprises were less likely to implement the CRM information system, while larger enterprises were more likely to implement the CRM information system.

Table 2. Contingency table: Enterprise size vs presence of CRM system (percentages counted in rows)

Enterprise size	CRM IT system		
	Yes (%)	No (%)	Total
Micro	18 (26%)	51 (74%)	69
Small	29 (41%)	41 (59%)	70
Medium	29 (62%)	18 (38%)	47
Large	13 (59%)	9 (41%)	22
One-person	1 (4%)	23 (96%)	24
Total	90	142	232

Source: own study.

Graphically, we present the relationship in the three-dimensional histogram below (Figure 1). This positively verified **hypothesis one (H1)** regarding enterprise size. In one-person enterprises, 96% of companies have not introduced the CRM, in microenterprises, 74% of companies did not have CRM, in small enterprises, 59% of companies did not have the CRM, while 62% of medium enterprises and 59% of large enterprises had the CRM. Overall, 39% of companies have the CRM. Cramer's V coefficient of

0.37 indicated a medium relationship and a negative Gamma value of -0.14 indicated that smaller companies were less likely to have the CRM system, while larger companies were more likely to have one.

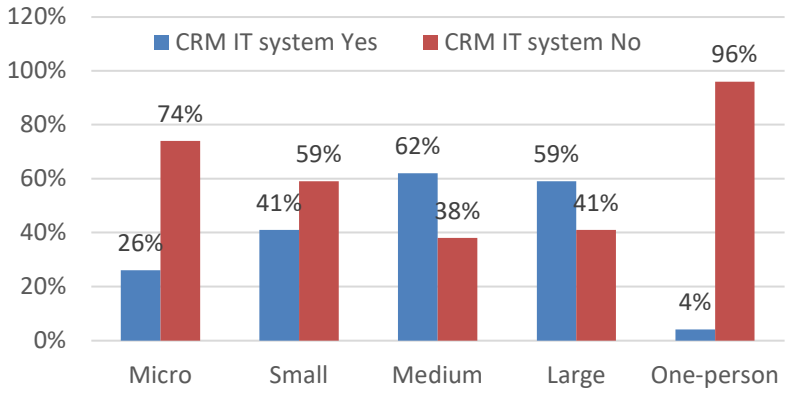

Figure 1. 3D histogram: Enterprise size x CRM IT system for customer relationship management
Source: own elaboration.

Before verifying **hypothesis two (H2)**, we counted respondents' answers to the question of whether the company had a CRM system, split by the amount of investment expenditure in the last three years. Table 3 presents the results (Table 3).

Table 3. Contingency table: The amount of investment expenditure vs CRM system presence (percentages counted in rows)

Amount of investment expenditure in the last 3 years	CRM IT system		
	Yes (%)	No (%)	Total
Lack of expenses	0 (0 %)	31 (100%)	31
Up to PLN 10000 (2305.42 EUR)	8 (20%)	32 (80%)	40
From PLN 10001(2305.65 EUR) to PLN 100000 (23054.22 EUR)	38 (47%)	43 (53%)	81
From PLN 100001 (23054.45 EUR) to PLN 500000 (115271.12 EUR)	20 (54%)	17 (46%)	37
Over PLN 500001 (115271.12 EUR)	24 (56%)	19 (44%)	43
Total	90	142	232

Source: own study.

Based on the results of the chi-square test ($\chi 2(4) = 36.72$; $p < 0.001$), we rejected the null hypothesis of independence in favour of the alternative hypothesis indicating the existence of a relationship. This confirms the observation that the greater the company's investment expenditures were, the more often the company had a CRM information system. Thus, we positively verified **hypothesis two (H2)**. No company that had not invested in development in the last three years had a CRM system. Cramer's V coefficient of 0.40 indicated medium dependence, while a negative Gamma value of -0.53 indicated high dependence, and as investment expenditure in the company increased, the number of companies without a CRM system decreased. The verification of **hypothesis three (H3)** was initiated by counting the responses regarding the benefits perceived by respondents after the implementation of the CRM system (Table 4). Respondents rated the particular benefits using a 5-point Likert scale, where 1 – meant a small benefit, and 5 – a very large benefit.

Noteworthy, over half of the respondents perceived all of the listed benefits. From the calculated averages and medians, we can also observe that the perceived benefits were important to respondents. Thus, we positively verified **the third hypothesis**. The most frequently mentioned benefit of implementing a CRM system was an increase in sales (as many as 81% of respondents gave this answer), while the least frequent answer was lower customer fluctuation (56% of respondents). According to respondents, lower customer fluctuation reported the least often, was also the least important benefit of those listed ($M = 3.5$, $Mdn = 3.0$). The mean values of the importance ratings for all other benefits exceed 3.8, with a median of 4.0.

Table 4. The benefits of IT CRM system implementation and basic statistics of CRM system benefit ratings for those who gave an affirmative answer for a particular benefit

Benefits	Yes (%)	No (%)	I don't know (%)	Mean	Mdn	Min	Max	SD
Increasing sales	73 (81%)	11 (12%)	6 (7%)	4.0	4.0	1.0	5.0	0.97
Increasing the marketing department's efficiency	70 (78%)	14 (15%)	6 (7%)	3.8	4.0	1.0	5.0	1.00
Better offer matching to the customer	68 (76%)	16 (17%)	6 (7%)	3.9	4.0	1.0	5.0	1.05
Better customer segmentation	67 (74%)	17 (19%)	6 (7%)	3.9	4.0	1.0	5.0	1.04
Effectively dealing with complaints and claims	67 (74%)	16 (18%)	7 (8%)	3.9	4.0	1.0	5.0	0.99
Ability to personalise an offer for a specific customer	67 (74%)	17 (19%)	6 (7%)	4.0	4.0	1.0	5.0	0.96
Increasing customer profitability	66 (73%)	16 (18%)	8 (9%)	3.8	4.0	1.0	5.0	0.99
Increased whisper marketing reach	66 (73%)	14 (16%)	10 (11%)	3.8	4.0	1.0	5.0	1.04
Increasing the customer numbers	65 (72%)	18 (20%)	7 (8%)	4.0	4.0	1.0	5.0	0.98
Better PR	63 (70%)	19 (21%)	8 (9%)	3.9	4.0	1.0	5.0	0.94
Ability to predict customer behaviour	61 (68%)	21 (23%)	8 (9%)	4.0	4.0	1.0	5.0	0.97
Increasing customer loyalty	56 (62%)	22 (24%)	12 (14%)	3.9	4.0	1.0	5.0	1.05
Increasing employee loyalty	51 (57%)	26 (29%)	13 (14%)	4.0	4.0	1.0	5.0	0.97
Lower customer fluctuation	50 (55%)	28 (31%)	12 (14%)	3.5	3.0	1.0	5.0	0.97

Source: own study.

To verify hypothesis 4 **(H4)**, we counted the number of responses for each question regarding the reasons for choosing a CRM system supplier (Table 5) and the reasons for choosing a specific CRM system software (Table 6). Respondents rated these reasons using a 5-point Likert scale, where 1 indicated a marginal reason, 5 a very important reason.

Table 5. Questionnaire results for questions about reasons for choosing a CRM system provider and basic statistics for the main reasons for choosing a CRM system provider

Results	Scale					n	Mean	Mdn	Min	Max	SD
	1	2	3	4	5						
Simpleness of using the program	4	2	20	39	35	90	3.9	4.0	1.0	5.0	0.99
The security level of the system due to the sensitive data stored in it for the company	2	7	17	38	26	90	3.9	4.0	1.0	5.0	0.99
Declared functionality in line with my expectations	3	3	23	37	24	90	3.8	4.0	1.0	5.0	0.97
Supplier's market position	2	4	23	43	18	90	3.8	4.0	1.0	5.0	0.89
Readiness of the CRM system to cooperate with the applications used in the company	3	4	22	43	18	90	3.8	4.0	1.0	5.0	0.94
Ability to use your existing computer equipment after system implementation (no need to purchase new equipment before implementation)	3	5	27	31	24	90	3.8	4.0	1.0	5.0	1.02
Attractive CRM system price	5	4	22	37	22	90	3.7	4.0	1.0	5.0	1.06
Declared implementation speed	5	8	21	36	20	90	3.6	4.0	1.0	5.0	1.10
The software was recommended to me by a friend/acquaintance using the same solution	5	10	22	40	13	90	3.5	4.0	1.0	5.0	1.05

Source: own study.

Respondents perceived all of the reasons listed in the questionnaire for choosing a supplier as quite important (respondents rated most responses in each case – 4). The findings of the answers to this question, together with the statistical analysis, allowed us to conclude that the respondents were fully aware of and could identify the reasons for choosing a CRM system provider, which confirms the first part of hypothesis four. As in the case of supplier selection, all the reasons listed in the questionnaire were perceived by respondents as fairly important (respondents rated most responses, in any case, at 4). Noteworthy, the relatively least important reason was that the previous program did not meet respondents'

expectations. This may result from the fact that the implemented CRM system is the first such system in the company. The above data allowed us to positively verify the second part of hypothesis 4 **(H4**).

Table 6. Questionnaire results for questions about the reasons for implementing a CRM system and basic statistics for the main reasons for implementing a CRM system in a company

Reasons	Scale					n	Mean	Mdn	Min	Max	SD
	1	2	3	4	5						
The previous program didn't meet my expectations	7	15	27	30	11	90	3.3	3.0	1.0	5.0	1.12
Until now, I couldn't create the reports I needed, or the time to generate them was too long	2	11	27	33	17	90	3.6	4.0	1.0	5.0	1.01
I couldn't create the analysis I needed on sales, customers, etc., or the time to generate it was too long	1	8	27	36	18	90	3.7	4.0	1.0	5.0	0.93
I wanted to manage my employees' time more effectively	1	5	31	36	17	90	3.7	4.0	1.0	5.0	0.88
I wanted to manage customer relations more effectively	1	6	28	38	17	90	3.7	4.0	1.0	5.0	0.89
I wanted to organise the document flow in the company	3	6	24	38	19	90	3.7	4.0	1.0	5.0	0.99
I wanted to monitor sales processes in the company	1	7	25	29	28	90	3.8	4.0	1.0	5.0	0.99
I wanted to have all the information needed for the company functioning in one place (*e.g.*, offers, orders, delivery confirmations)	1	3	24	42	20	90	3.9	4.0	1.0	5.0	0.84

Source: own study.

To verify hypothesis five **(H5)**, we asked respondents whether the data collected in their companies' CRM system served to perform market analysis and whether the customer data collected in the CRM system was subjected to analysis that yields measurable results for the organisation. The answers to these questions are presented in the charts below. In the vast majority of cases, according to the respondents, the company analysed the collected data, which produced measurable results for the company. This allowed us to positively verify **hypothesis five**.

For Statistics Poland, we conducted several analyses of information systems used in enterprises. In these analyses, CRM is often combined with ERP, an approach that is not entirely consistent with the purpose of such systems. CSO results from 2018 show that 88% of large enterprises used a CRM or ERP system, among medium-sized enterprises, it was 58%, and among small enterprises, it was only 24.9% (Becker, 2018). This confirmed the research results from this article. Scholars have studied the reasons that encourage enterprises to implement CRM more than once both in Poland and worldwide (Pohludka & Štverková, 2019). Researchers indicate that companies see numerous benefits after implementing CRM, such as the ability to make effective business decisions and increased customer loyalty. However, as has already been mentioned in the article, many CRM implementations are fraught with failure risk. Good planning and the appropriate approach to implementation can reduce them. It is also important to effectively process the data obtained from CRM systems for company management purposes.

This article adds value by providing a comprehensive analysis of the factors affecting CRM implementation in Polish enterprises. It highlights the practical benefits of CRM systems and underscores their importance in modern business environments.

Some researchers focus on other aspects of CRM in the enterprise, such as improving communication. For example, research conducted by Ukrainian researchers in 2023 indicates the need for CRM compliance with internal corporate policy (Berestetska *et al*., 2023). Other studies show improvements in customer satisfaction and experience after introducing CRM into the enterprise. Scholars determined that the desktop interface solution may improve this CRM's ease of use and user satisfaction, thereby benefiting the real estate industry through strengthened connections and more straightforward oversight of professionals' performances (Ferreira *et al*., 2023).

CONCLUSIONS

A combination of organisational size, technological readiness, strategic alignment, market dynamics, and regulatory considerations shape the implementation of CRM systems in Polish enterprises. Larger firms with complex operations, robust IT infrastructure, strong management support, and a proactive

approach to market and regulatory challenges are more likely to successfully implement CRM systems. These factors collectively contribute to the effective adoption and utilisation of CRM technologies, enabling enterprises to enhance customer relationships and achieve competitive advantage.

This article presents research results and an analysis of the determinants of CRM system implementation in enterprises. We aimed to determine which enterprises implement a CRM system most often, whether they perceive the benefits and, whether they can identify the reasons for choosing a particular software and its supplier for CRM systems, and whether the collected data is subjected to effective analysis. We achieved this purpose. We positively verified all the hypotheses posed in the article.

The practical implications of this article directly relate to the subject under consideration. Enterprises that have implemented CRM systems are current customers for these system providers, thus expanding their knowledge and allowing them to better customise their products and offerings. Enterprises that have not implemented CRM are potential customers for such products, and thus, their suppliers can get some clues about attracting possible beneficiaries.

These considerations also have theoretical implications. They allow for revealing certain phenomena in organisations and mechanisms. We can use this to create universal theoretical business models. The conducted research constitutes a certain contribution to the science of management and quality. It treats CRM as a specific part of enterprise management with a tool-oriented approach. However, we are aware that the research primarily focused on larger enterprises, potentially overlooking the unique challenges and opportunities faced by SMEs. While the research focused on Polish enterprises, the findings may not be fully generalisable to other regions with different economic, cultural, and regulatory environments. Moreover, rapid advancements in CRM technologies mean that some insights may become outdated quickly as new features and capabilities are introduced.

The authors of this article intend to continue using the collected data for further analysis. Their subject of interest may be entities that have not implemented CRM and their motivations and actions. The research identified 142 such entities from the entire research sample. Further work on this research material may include consideration of customer-oriented organisational culture, the correct definition of CRM in an organisation, or the lack of perceived benefits of CRM by entrepreneurs.

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Use of Artificial Intelligence

The authors declare that the text is free of AI/GAI usage.

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The smart village concept from 1.0 to 4.0 in the context of ICT entrepreneurship development in the Polish villages

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ABSTRACT

Objective: The article aims to show the development process of smart villages from 1.0 to 4.0, analogous to the smart cities development, along with indicating the conditions of this process. Moreover, the goal was to examine how ICT enterprises influence the development of smart villages at the 1.0 level in rural areas and what their connections are with other sections of economic activity (based on the example of Poland).

Research Design & Methods: The study used statistical data from Statistics Poland (GUS). We used methods of cartographic presentation of data on the share of technology enterprises (Section J 62) and support enterprises (Section J63) in the total number of enterprises in rural areas in Poland, as well as changes in the share of these companies in Poland in 2012-2023. We analysed the enterprise structure in municipalities characterised by a high share of ICT enterprises according to the type of municipality (functional urban, border, and other). We used the network analysis method to identify ICT enterprises' links with other economy sectors.

Findings: The ICT enterprises have numerous linkages with other sections, indicating their key role in providing the ICT technologies necessary for the smart villages development. We also found that rural municipalities with the highest share of ICT firms located in close proximity to cities have a high concentration of firms providing business-related services and services to residents. In the border municipalities with the highest share of ICT companies, we identified a high share of the sections responsible for administration and defence, tourism, and agriculture, while a distinctive feature of the other municipalities is the high share of companies involved in transport and storage management.

Implications & Recommendations: Among the actions to support the further development of smart villages, we identified the following: strengthening the links between ICT entrepreneurship and other key economic activities for smartification processes, expanding ICT infrastructure, supporting local initiatives through funding and advice, promoting education and training in new technologies for villagers, and encouraging cross-sectoral cooperation through the creation of platforms for the exchange of knowledge and experience.

Contribution & Value Added: We may consider the smart villages concept in analogy to the smart city concept as an innovation organising spatial structures according to a new pattern. We present the development of smart villages from 1.0 to 4.0 in analogy to the development of the smart city, together with a presentation of the conditions of this process related to the specificity of rural areas.

Article type:	research article
Keywords:	smart villages; entrepreneurship; rural areas; ICT; smartification processes; network analysis
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INTRODUCTION

Smart villages are rural areas and local communities that, based on their own resources and new opportunities, leverage digital technologies, telecommunications, innovations, and knowledge to im-

prove the life quality, enhance public services for citizens, better utilize resources, reduce environmental burdens, and create new opportunities for local products and improved processes (EU Action, 2019). In the literature, there is a view that research on smart cities can contribute to the development of research on smart villages (Adamowicz & Zwolińska-Ligaj, 2020; Visvizi & Lytras, 2018a; Visvizi & Lytras, 2018b). Digital technologies significantly impact the development of smart cities through digitization. These technologies can also help build digital and smart villages, provided that authorities establish appropriate network and communication infrastructure in rural areas (Malik *et al.*, 2022). Rural residents need better digital connectivity due to their distance from growth poles. However, research on developed countries shows that the availability and quality of infrastructure are greater in cities than in rural areas, and this difference is deepening (Salemink *et al.*, 2017).

The concept of smart villages represents an innovative approach to the complexity of local rural development, illustrating current dynamic development processes and civilizational challenges (Wolski, 2018). Similarly to the concept of a smart city, a smart village constitutes an ecosystem composed of various elements aimed at improving the quality of life for the community and the rural environment, engaging various stakeholders (Syaodih, 2019). This means that the concept of a smart village is an innovation based on a sustainable approach to village-level planning, promoting knowledge-based development through continuous human resource education as an integral part of village resource development, particularly in encouraging the development of rural areas perceived as part of more complex spatial structures. Such an approach is justified in the context of network-based information system development and the virtualization of socio-economic life (Maja *et al.*, 2020).

We may consider the concept of a smart village as analogous to the concept of a smart city as an innovation organizing spatial structures according to a new pattern, initially based on information technologies. In the initial phase of evolution, similarly to Smart City 1.0, technology creators encourage the administration of rural settlement units (*e.g.*, rural municipalities, rural counties) to adopt their technologies so as to achieve greater efficiency in managing rural entities. However, rural areas are often not even prepared to use these technologies or to properly assess what is actually beneficial from the perspective of achieving the goals of the local community. An example of this can be the implementation of modern public service solutions using digital technologies. Therefore, the manifestation of a given rural unit entering this phase is the development of local specialization in IT entrepreneurship. We may treat specialization in this field as a sign of the emerging phenomenon of Smart Village 1.0. It involves creating the potential necessary for the actual implementation of digital solutions for the socio-economic development of a given rural area. We will present the analysis of this stage of smart village development in the empirical part of this work using the example of rural areas in Poland.

The next stage, analogous to Smart City 2.0, involves the creation of Smart Village 2.0 through the activation of local government actions, which, as a result of their own innovative initiatives, create pro-development solutions for the rural community in the form of special programs and projects that serve the implementation of modern technologies in various areas of rural life. An example of this could be the implementation of programs dedicated to the local community aimed at improving living conditions and the sustainable development of the rural area, for example, by using the Internet of Things to improve lighting and monitor key infrastructure elements.

A more advanced stage of smart village development could be Generation 3.0, analogous to Smart City 3.0. This stage is characterized by the fact that citizens take on a key role in local development supported by modern IT technologies. In the third-generation smart village, residents begin to co-create their innovative environment, their habitat.

In the phase of creating Smart Village 4.0, analogous to this phase of city development, the creation of smart villages should be based on conscious actions aligned with sustainable development. These could include, for example, social projects: equality-focused, social inclusion, affordable housing, etc. (Korneluk *et al.*, 2019). Attention is also drawn to the potential for networking (Kinelski, 2022).

For the wide application of communication and information resources, as well as computer techniques in rural areas, it is essential to have a broad group of knowledge workers, enabling the use of the technological potential for local development management. It is also necessary to attract specific

geographical market interest from providers of modern communication and information infrastructure, who primarily see cities as large markets. On the other hand, however, the diffusion of innovation often has not only a hierarchical character but also shows characteristic spatial directions from centres to peripheries. Therefore, Smart Village 1.0 can develop in a place where such solutions are introduced thanks to personal contacts between ICT solution providers and business or public clients.

In the next phase of smart village development, the significant importance of the attitudes of local and regional authorities, *i.e.* the institutional environment, which has the power to set the direction of rural municipality development, spatial planning principles, and public space investments, comes to the fore. It is essential to adjust the volume and technological level of planned smart services to the actual opinions and citizens' needs (Lee & Lee, 2014; Novotný *et al.*, 2014) to address local priorities and citizen requirements.

Therefore, the institutional environment, which is largely conditioned by the quality and adequacy of legal regulations to actual development needs, as well as by the level of awareness of modern technologies and openness to them by decision-makers, such as city mayors, supportive local leaders, or even regional councils or city councils, is also a key resource for smart village development. Such resources are characteristic in the development of smart cities (Smart City 2.0).

The local community, *i.e.*, residents and other stakeholders living or operating in the intelligent rural area, is the key resource for the development of Smart Village 3.0. It is only at this stage that the proactive nature of local community self-organization becomes apparent, with their needs reflected in the organization of public life, adopted solutions regarding housing, health infrastructure, or related to the leisure sector.

Therefore, making capital-intensive investments requires social consensus, trust, and cooperation among all stakeholders, from entrepreneurs to residents to representatives of local and regional administration. This requires openness to inclusiveness needs and engagement in networking (Smart Village 4.0).

The considerations in the article encompass both theoretical and empirical sections. The theoretical part analyzes the development process of smart villages from version 1.0 to 4.0, analogous to the evolution of smart cities, while identifying the conditions influencing this process. Furthermore, the specific characteristics of rural areas in the context of the smartification process are presented, emphasizing the diversity of such areas. The empirical part utilizes statistical data from the Central Statistical Office of Poland (GUS). The analysis examines the share of technological enterprises (section J 62) and support enterprises (section J 63) in the total number of businesses in rural areas of Poland, as well as changes in the share of these enterprises in Poland during the years 2012–2023, complemented by cartographic representations. The study also investigates the structure of enterprises in municipalities characterized by a high share of ICT enterprises, categorized by municipality type (urban functional, borderland, and others). Subsequently, a network analysis method is applied to identify the connections between ICT enterprises and other sectors of the economy. The discussion that follows explores entrepreneurship development in rural areas based on modern technologies and the concept of smart villages. The article concludes with a summary of the findings from the conducted research.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The Specificity of Rural Areas and The Process of Smartification

There is a distinction between developing a smart city and modelling a smart village due to the different characteristics of these areas, as well as the distinct priorities and needs of cities compared to rural areas. The concept of smart villages should be more rooted in local conditions and resources, as well as in the external (primarily urban) demand for products from rural areas (Ranade *et al.*, 2015). Unlike smart cities, information and communication technologies (ICT) in smart villages are only significant to the extent that they promote human development, such as education, employment, and health (Murty & Shankar, 2020). Another study highlights environmental factors as distinguishing features of smart villages, alongside ICT infrastructure, human capital and education, and social and relational capital (Fajrillah *et al.*, 2018).

The contribution of new technologies to smart villages primarily occurs through the installation of new infrastructure, whereas in the smart city concept, the emphasis is directly on new technologies. One reason for the differing focus on the development of smart cities and smart villages is the significantly lower availability of infrastructure in rural areas (Fennell *et al.*, 2018). The development of the Internet of Things (IoT) – a foundation of smart city development – can also contribute to the growth of smart villages. However, while we may characterize IoT applications in smart cities by their density in everyday life, reflecting the structural features of densely populated cities, smart villages supported by IoT typically represent a system of dispersion and scarcity (Cvar *et al.*, 2020).

According to Polish authors, social innovations play an important role in the smart village concept, as they can drive positive changes in rural areas (Kalinowski *et al.*, 2021). Moreover, these authors point to other differences between the smart city and smart village concepts due to the specific characteristics of these areas. They emphasize that the goal of a smart city is to increase territorial competitiveness, improve resource efficiency, and enhance the quality of life in response to rapid technological changes, innovations, and environmental challenges. Therefore, access to modern technologies and human capital, with a special role for private entities and city authorities, are fundamental factors in smart city development. In contrast, the main issues in rural areas are demographic problems, limited access to public services, and low social activity. Hence, the key goals of smart villages include improving living conditions, retaining residents, digitization, and developing social capital. Local leaders, non-governmental organizations, and local authorities are crucial in smart village development, with social capital, local heritage, and the promotion of digital and social innovations being the main development factors.

Noteworthy, significant diversity characterizes rural areas. Implementing smart village solutions is much more challenging in peripherally located rural areas (often struggling with depopulation) than in areas close to large cities (Paniagua, 2020). Peripheral rural areas often have relatively low endogenous development potential due to factors such as limited access to markets and resources, dispersion, an ageing population, a low level of education among residents, and weaker access to services (*e.g.*, educational or health services) compared to cities. Therefore, one of the main goals of smart village development is to improve the attractiveness and satisfaction of living in rural areas, create jobs, and ensure access to infrastructure (including digital) and services to prevent the migration of young people to cities (Park & Cha, 2019). In the context of smart village development, building specialized connections with urban supply and demand, as well as implementing place-based policies (*e.g.*, regional innovation systems, clusters, public-private partnerships, and focus on selected sectors or niches), is crucial (Naldi *et al.*, 2015). Moreover, the level of advancement in the multifunctional development of these units is of great importance in the development of smart villages in peripheral rural areas. Quantitative research conducted in a peripheral region of Poland (Lublin Voivodeship) showed a relationship between the level of potential for intelligent development of territorial units and the degree of diversification in the functional structure of local economies (Zwolińska-Ligaj *et al.*, 2018).

Despite the differences between the smart city and smart village concepts, there are many connections between them, and changes in cities impact rural areas and vice versa (Kalinowski *et al.*, 2021). In this context, the evolution of the smart city from concept 1.0 to 4.0 and its possible implementation in the development of smart villages seems interesting. This aspect has not been studied in the literature. Although the term village 4.0 can be found, synonymous with the digital village, it is understood as the use of digitization technologies (*e.g.*, IoT, big data, and AI) in smart villages to integrate them into the digital network (Malik *et al.*, 2022).

The main objective of the article is to show the development process of smart villages from 1.0 to 4.0, analogous to the development of smart cities, along with indicating the conditions of this process. Moreover, the goal is to examine how ICT enterprises influence the development of smart villages at the 1.0 level in rural areas and what their connections are with other sections of economic activity (based on the example of Poland). As part of this goal, we formulated the following research hypothesis:

H1: Smartification of villages, considered as a diffusion process, is reflected in a greater degree of specialization in services driven by entrepreneurship in the ICT sector.

RESEARCH METHODOLOGY

The conceptualization of research on smart villages in the context of ICT enterprise development and their connections with other economic activities can provide valuable insights into the dynamics and development potential of these areas. To verify the hypothesis, we conducted statistical data analyses regarding the structure of enterprises in rural municipalities.

We analysed the location of enterprises operating in smart villages, with a particular focus on the PKD 2007 sections J62 (programming, consultancy, and related activities) and J63 (information service activities). This analysis identified the share of technology and supporting companies in the total number of enterprises in these areas, reflecting their level of innovation and digital technology adoption. Subsequently, we conducted in-depth analyses on municipalities characterized by a high share of ICT enterprises in the structure of economic entities, in terms of the co-occurrence of enterprises from other sectors. This allowed for the preliminary identification of connections between ICT companies and other industries, depending on the type of municipality. The next step was to assess changes in the development of sectors J62 and J63 in smart villages. Such an analysis helps understand the trends and challenges faced by ICT enterprises in rural areas. We will present the results on cartograms.

Next, we examined the connections between sections J62 and J63 with other economic activities using network analysis methods. This method identified which economic sectors are linked to ICT enterprises, which may indicate cooperation, dependencies, or the flow of knowledge and innovation between different industries. Such connections may be crucial for developing synergies between the ICT sector and other branches of the economy, supporting the sustainable development of smart villages. This comprehensive approach to studying smart villages provides valuable information for formulating policies that support the development of these areas in the context of the growing importance of information and communication technologies.

As part of the research tools, we used JASP software for network analysis, allowing for the visualization and analysis of connections between different variables. The empirical part of the study included data collected from public databases of the REGON (National Official Business Register) from the Statistics Poland (GUS) concerning business activities in Poland, particularly from sections J62 and J63 and other related sections, in 2023. In the network analysis, we defined variables (percentage of enterprises in a given section) as nodes, and correlations between them as edges. Then, using the EBICglasso method, we extracted the most important connections, resulting in a clear network. The analysis of node centrality (betweenness, closeness, degree) allowed for identifying key sectors connected with J62 and J63.

RESULTS AND DISCUSSION

When analysing the spatial distribution of ICT enterprises in Poland, several significant patterns and spatial regimes emerged. First and foremost, the regions surrounding Warsaw, Wrocław, Poznań, Kraków, and Rzeszów exhibited the highest index values, indicating a strong concentration of ICT enterprises in these areas. As the largest city and economic hub of the country, Warsaw attracts many companies from the ICT sector. Wrocław, known for its dynamic technological development, and Kraków, a major academic and technological centre, also stand out with a high share of ICT enterprises. We observed a similar trend in Poznań and Rzeszów, where the ICT sector is growing rapidly. In contrast, rural and less urbanized areas, characterized by a low share of ICT enterprises, are dominated by traditional industries. This spatial dichotomy reflects the broader economic and demographic disparities, where technological development is concentrated in more urbanized and well-connected regions. The moderate index values observed in areas such as the vicinity of Gdańsk, Szczecin, and Lublin are also noteworthy, suggesting that these local centres of technological development could become future ICT hubs. The map clearly shows a spatial division in the distribution of ICT enterprises in Poland, where major urban agglomerations serve as centres of concentration for technology companies, while peripheral areas significantly lag behind in terms of the share of ICT enterprises (Figure 1).

Table 1 presents the average shares of enterprises in selected groups of municipalities with a high degree of ICT development in 2023 and the overall structure of enterprises in rural areas in Poland. We divided the studied municipalities into three groups: functional urban, border, and others. Functional urban municipalities include those located within areas designated for Integrated Territorial Investments (ITI); border municipalities include those situated directly on the national border and their immediate vicinity; the remaining municipalities comprise units that do not belong to either of the two categories.

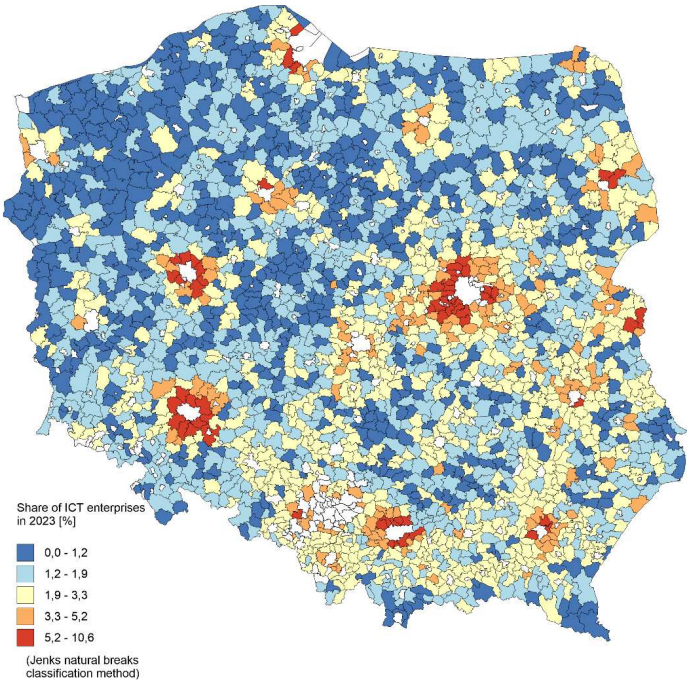

Figure 1. The share of ICT enterprises in the total number of enterprises by municipality in Poland in 2023
Source: own elaboration.

Rural and urban-rural municipalities with a high share of ICT enterprises located within the areas designated for Integrated Territorial Investments in Poland exhibited an above-average share of enterprises from Section M according to the Polish Classification of Activities (PKD, 2007), which includes professional, scientific, and technical activities. This is associated with the provision of business-related and research-scientific services to entities located within the city. We observed a similar pattern with the high share of enterprises from Section K (financial and insurance activities) and Section N (administrative and support service activities) in these types of municipalities. Municipalities located near major cities also have a relatively high share of entities providing services to residents, such as healthcare and social assistance (Section Q), education (Section P), and repair and maintenance of computers and personal and household goods (Section S, Division 95).

Border municipalities with a high share of ICT enterprises are also characterized by a relatively high share of enterprises from Section O (public administration and defence, compulsory social security) in the total number of entities, which is related to their specificity and the current geopolitical situation on Poland's eastern border. Moreover, in border areas, we identified a significant share of enterprises from Section B (mining and quarrying), Section A (agriculture, forestry, hunting, and fishing), Section D (electricity, gas, steam, and air conditioning supply), Section I (accommodation and food service activities), Section R (arts, entertainment, and recreation), and Section S, Division 94 (activities of membership organizations). In the remaining studied municipalities, we recorded an above-average share of entities from Section M, Section N, as well as Section S, Section P, and Section H (transportation and storage).

The map illustrating changes in the share of ICT companies in Poland between 2012 and 2023 clearly shows the spatial variation of this sector (Figure 2). The highest values of the indicator are concentrated around large urban agglomerations such as Warsaw, Wrocław, Poznań, Kraków, Rzeszów, Olsztyn, and Bydgoszcz. Due to their infrastructure availability, educated workforce, and favourable

Table 1. Average values of enterprise shares in selected groups of municipalities with a high level of ICT development in 2023

Section according to PKD 2007	Functional	Border	Others	Rural areas overall
Number of municipalities	129	13	80	2175
A	1.123	5.598	2.153	3.988
B	0.086	0.245	0.131	0.137
C	9.214	7.405	9.245	9.934
D	0.235	0.303	0.194	0.231
E	0.329	0.304	0.395	0.407
F	14.356	18.829	19.849	21.139
G	20.234	16.595	20.721	19.806
H	5.900	6.083	6.730	6.376
I	2.548	4.017	2.347	2.923
J	5.238	3.971	4.035	1.909
J (div. 62)	4.890	3.738	3.726	1.751
J (div. 63)	0.348	0.233	0.309	0.158
K	2.256	1.873	1.608	1.748
L	3.149	2.452	1.424	2.887
M	12.013	5.201	7.382	5.817
N	3.843	2.291	3.498	2.938
O	0.390	3.362	1.785	1.710
P	3.546	2.580	3.141	2.905
Q	6.275	4.222	3.964	4.141
R	1.714	2.535	1.967	1.996
S (div. 94)	2.202	8.130	4.479	4.397
S (div. 95)	0.615	0.453	0.557	0.494
S (div. 96), T (divs. 97, 98)	3.551	2.894	3.608	3.362

Source: own study.

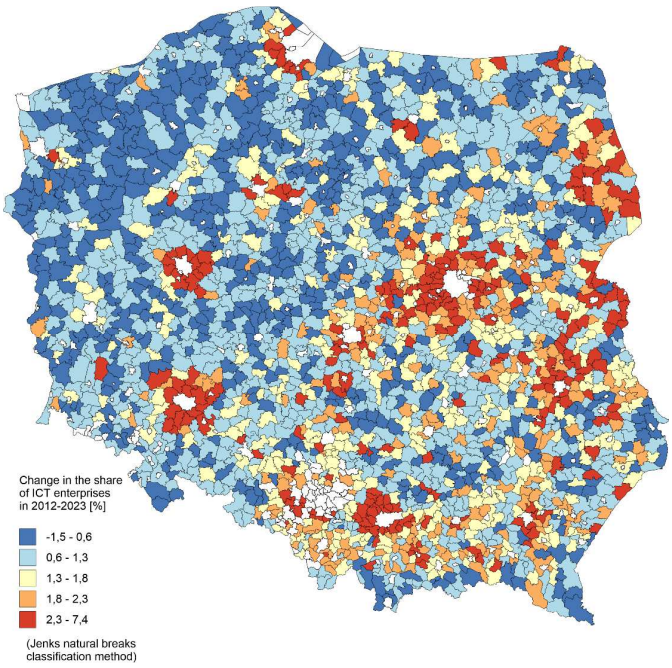

Figure 2. Changes in the share of ICT companies in the total number of companies by municipalities in Poland from 2012 to 2023

Source: own elaboration.

economic conditions, these regions attract a significant number of ICT firms. In contrast, rural and less urbanized areas, marked in blue on the map, show a significantly lower share of ICT companies, resulting from limited access to resources and lower investment levels in technological infrastructure. Cities such as Gdańsk, Szczecin, and Lublin display moderate indicator values, suggesting the presence of local technology development centres that may play a larger role in the future. The overall picture reveals a dichotomy between highly urbanized centres and peripheral regions, reflecting economic and demographic trends in Poland over the past eleven years.

Analysis of the Development Level of the Smart Village Concept in Rural Areas Based on Network Analysis Results

Network analysis is a statistical method used to examine relationship structure between variables represented as nodes connected by edges. It allows for the visualization and interpretation of complex data sets by constructing networks that highlight the connections and interactions between observed variables. This method supports various types of networks, such as correlation networks, partial correlation networks, and more advanced models like EBICglasso and Mixed Graphical Models. Scholars use this approach in fields requiring the analysis of complex interdependencies among multiple variables, offering a robust framework for both visualization and statistical inference.

Network analysis of variables is an advanced method for studying the structure of relationships between variables in a data set. In this context, variables are represented as nodes and the relationships between them as edges. We focus on analysing the connections between sections J62 and J63 and other sections, using various centrality measures. The following Tables present the results of the network analysis tables (Table 2, Table 3, Table 4) and the network diagram (Figure 3).

Table 2. Network summary

Number of nodes	Number of non-zero edges	Sparsity
26	271 / 325	0.166

Source: own study.

Table 3. Centrality measures per variable

Variable	Network			
	Betweenness	Closeness	Strength	Expected influence
J section 62	-0.248	0.262	-0.106	0.492
J section 63	-0.617	-1.067	-0.953	1.015

Source: own study.

Table 4. Clustering measures per variable

Variable	Network			
	Barrat	Onnela	WS	Zhang
J section 62	0.981	0.303	1.725	-0.061
J section 63	-1.996	-1.084	0.117	-1.348

Source: own study.

In the context of the development and functioning of a smart village, network analysis is a key tool for understanding the structure and dynamics of interactions between various activity sections. The network includes 26 nodes, representing different economic or functional sections within the smart village, and 271 non-zero edges, indicating a significant number of connections between them.

Centrality analysis revealed different roles and influences of sections within the smart village network. Section J (information and communication) in Division 62 showed moderate levels of centrality. Its betweenness centrality was -0.248, suggesting average mediation in paths between other nodes. Closeness centrality at 0.262 indicated relatively good proximity to other nodes, while strength at -0.106 showed a moderate strength of connections with other nodes. The expected influence at 0.492 suggests a significant impact on the network. Additional centrality measures, such as Barrat (0.981), Onnela

(0.303), WS (1.725), and Zhang (-0.061), also indicated balanced values, confirming Section J62's stable position in the network. In contrast, Section J in Division 63 showed lower centrality levels, suggesting less influence and less intense connections with other sections. Its betweenness centrality was -0.617, closeness centrality was -1.067, and strength was -0.953, indicating weaker and less central connections in the network. Nevertheless, the expected influence at 1.015 suggests that Section J63 had a significant impact in specific contexts. Additional centrality measures, such as Barrat (-1.996), Onnela (-1.084), WS (0.117), and Zhang (-1.348), confirmed this section's marginal role in the network structure.

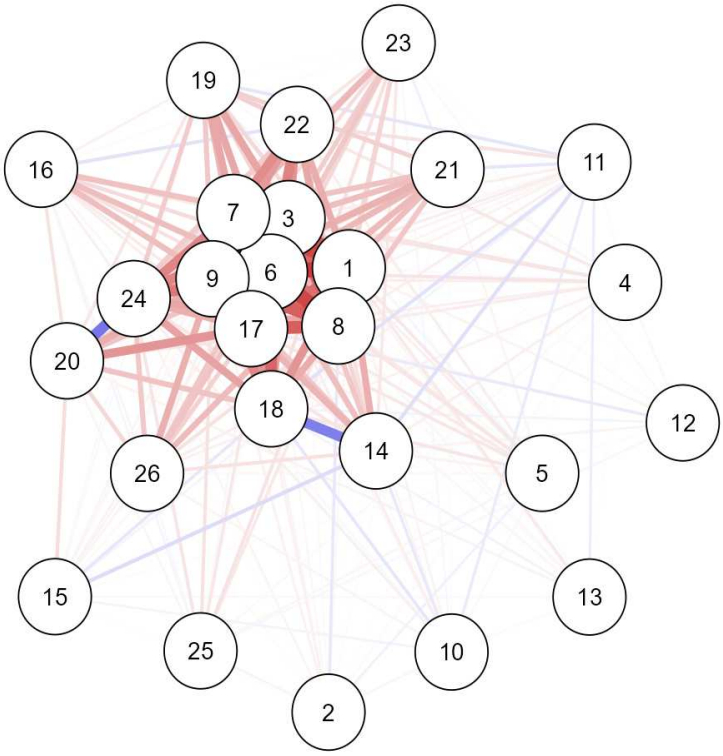

Figure 3. Network diagram

Notation on the network diagram: 1: Section A, 2: Section B, 3: Section C, 4: Section D, 5: Section E, 6: Section F, 7: Section G, 8: Section H, 9: Section I, 10: Section J, Division 58, 11: Section J Division 59, 12: Section J Division 60, 13: Section J Division 61, 14: Section J Division 62, 15: Section J Division 63 16: Section K, 17: Section L 18: Section M 19: Section N, 20: Section O, 21: Section P, 22: Section Q 23: Section R 24: Section S Division 94, 25: Section S Division 95, 26: Section S Division 96 and Section T Division 97 and 98.

Explanations: The line colours on the network diagram represent the type of relationship between variables. Blue lines indicate positive associations, where an increase in one variable is associated with an increase in the other. Red lines denote negative associations, where an increase in one variable is associated with a decrease in the other. The thickness and intensity of the line colour reflect the strength of the association – thicker and more saturated lines represent stronger connections, while thinner and less intense lines indicate weaker relationships.

Source: own elaboration.

Centrality analysis plays a crucial role in identifying the role of individual sections within the network. For instance, Section J62, dealing with information and communication, exhibits moderate centrality levels. Its centrality values, such as betweenness, closeness, and strength, suggest that it was relatively well connected to other sections, confirming its stable position without a dominant role. In contrast, Section J63 in the same division showed lower centrality values, indicating less influence and weaker connections. However, its high expected influence suggests that it may play an important role in specific contexts.

Based on the document analysis, key sections in the context of the Smart Village concept include financial and insurance activities (Section K), wholesale and retail trade (Section G), transport and storage (Section H), professional, scientific, and technical activities (Section M), and real estate activities (Section L). Section K is characterized by high values in betweenness centrality (0.073) and closeness

centrality (0.218), indicating its significant role in information flow and collaboration with other sections, crucial for financing and managing Smart Village projects. Section G shows high values in closeness centrality (0.245) and strength (0.065), suggesting its key role in the distribution and access to goods and services in rural areas. Section H, with significant values in closeness centrality (0.242) and strength (0.052), was important for logistics and goods flow, which is crucial for the effective functioning of rural areas. Section M, with high values in betweenness centrality (0.066) and closeness centrality (0.212), played a significant role in developing and implementing innovative technological solutions within the Smart Village framework. Section L, characterized by high values in closeness centrality (0.237), played a key role in managing space and infrastructure in rural areas.

Sections J62, related to software activities, and J63, related to information services, had numerous connections with other sections, indicating their crucial role in providing the information and communication technologies necessary for Smart Village functioning. The betweenness centrality values for Sections J62 and J63 are 0.057 and 0.054, respectively, while the expected influence values are 0.041 for J62 and 0.036 for J63. Although these values were significant, they were not the highest, suggesting that these sections play a supportive role in the network, facilitating information flow and integrating technology with other sectors.

Conclusions from the analysis indicate that Sections K, G, H, M, and L were dominant in the network, playing a key role in information flow and collaboration among enterprises. Sections J62 and J63, while not dominant, were important as providers of information and communication technologies that support Smart Village functioning by integrating with other key sectors. Integrating these technologies with financial, commercial, transport, professional, and real estate activities is crucial for the sustainable development and effective functioning of rural areas, forming the basis of the Smart Village concept.

In summary, the diversity of centrality values in the network indicated the need for a balanced approach to investment and support. Investing in digital technologies in sections with higher centrality can enhance overall efficiency and integration within the Smart Village, while sections with lower centrality may require specialized support from ICT enterprises to strengthen their connections and impact, contributing to increased coherence and innovation across the Smart Village community.

Network analysis of Sections J62 and J63 revealed significant differences in their positions within the network structure. Section J62 shows moderate centrality values, suggesting it is well-integrated with other sections responsible for rural development. Its betweenness, closeness, and strength centrality values indicate solid connections and influence on other areas, potentially leading to the effective implementation of Smart Village technologies, such as smart resource management, digital public services, and the development of information and communication infrastructure. Section J63, with lower centrality values, may indicate a focus on more specialized and innovative aspects of the Smart Village concept. While its overall impact was smaller, it remained important in specific contexts, such as implementing innovative technological solutions or supporting local initiatives.

Discussion

Smart villages aim to significantly improve the quality of life for residents through enhancements in education, healthcare, infrastructure, and overall community well-being (Mohanty *et al.*, 2020; Singh *et al.*, 2022). A key element of smart village development was the adoption of modern technologies such as electronic sensors, the Internet of Things (IoT), advanced healthcare, innovative education, and digital infrastructure (Singh *et al.*, 2022). Entrepreneurship in smart villages is fostered by small and medium-sized enterprises (SMEs) that create and implement local solutions to local problems, operating under the philosophy of 'I can do it for you,' which means offering services and solutions tailored to the specific needs of the local community (Szanyi-Gyenes, 2019). An example of this is the proposal of the 'smart tourist village' concept as a modern form of rural development, focusing on utilizing rural resources and building tourism infrastructure to attract tourists and boost the local economy through sustainable use of local resources and attractions (Aziiza & Susanto, 2020; Ciolac *et al.*, 2022).

The development of smart villages significantly impacts entrepreneurial activities. Primarily, smart rural development can substantially reduce the migration of people from rural areas to cities and counteract economic threats by rejuvenating rural infrastructure and creating new economic opportunities (Mohanty

et al., 2020). This creates broad opportunities for entrepreneurship, particularly in areas such as precision agriculture, energy diversification, tourism, and innovative enterprises (Visvizi *et al.*, 2019). The implementation of IoT-based smart village initiatives aims to improve residents' quality of life, promote sustainable development, and address socio-economic challenges in rural areas (Bhosale *et al.*, 2023).

Today, new opportunities for entrepreneurial development in rural areas are emerging based on modern technologies, innovations, and new business models, such as those related to circular economy, sharing economy, or bioeconomy. Companies in the ICT sector play a crucial role in this process as carriers of these modern solutions. Importantly, the management of biomass, as well as residues and waste generated in rural areas, creates new locational opportunities for enterprises due to the local nature of their processing (often due to their large volume, *e.g.*, biomass, transport costs, and associated environmental pollution) (Johnson & Altman, 2014).

The challenges and opportunities for entrepreneurs in smart villages are diverse. Challenges include financial constraints, the size of the informal economy, and management issues that limit government aspirations for smart village concepts (Utamajaya *et al.*, 2023). On the other hand, opportunities lie in utilizing digital transformation to modernize traditional aspects of rural areas, especially in agriculture, healthcare, and energy management (Gorain, 2022). Creating a startup ecosystem in smart villages can promote entrepreneurship and economic growth but requires interventions such as new programs and institutional reforms (Mitra *et al.*, 2023).

The role of technology in shaping entrepreneurship in smart villages is crucial. Digital and telecommunication technologies, bioenergy, and the Internet of Things play key roles in driving strategic breakthroughs in rural communities and promoting entrepreneurial activities (Atkočiūnienė & Vaznonienė, 2019; Babin *et al.*, 2022). The use of digital technologies may not always be an essential prerequisite for smart villages, but it can significantly contribute to the sustainable digital transformation of rural areas (Rwakihembo *et al.*, 2024). New digital technologies, such as cloud computing, blockchain, robotics, data analytics, artificial intelligence (AI), IoT, and 5G, create significant opportunities for improving the life quality in smart villages (Gorain, 2022). They enable innovative solutions in areas such as agriculture, healthcare, and infrastructure, which in turn fosters entrepreneurship in rural areas.

In the context of smart villages, entrepreneurship has become a significant research area as technological advancements and innovative approaches to rural space management contribute to transforming traditional communities and local economies. We attempted to identify and analyse the key features of entrepreneurship in smart villages, considering the impact of information technology development on entrepreneurial activities. We analysed both the challenges and opportunities that entrepreneurs face in the context of smart villages, as well as the role of technology in shaping new models of entrepreneurship and development opportunities. The study provides a better understanding of how the integration of modern technologies and innovative solutions can support entrepreneurial development in rural areas, contributing to their sustainable development and increased competitiveness.

In summary, smart village entrepreneurship focuses on improving rural infrastructure, utilizing digital technologies, and supporting local development. Smart rural development can prevent migration from rural areas to cities, create economic opportunities, and address socio-economic challenges. However, it also comes with challenges related to financial constraints and management issues. Technology, particularly IoT and digital innovations, plays a key role in shaping entrepreneurship in smart villages by driving strategic changes and promoting sustainable development.

CONCLUSIONS

Primarily, this study aimed to illustrate the development process of smart villages from 1.0 to 4.0, analogous to the development process of smart cities, along with identifying the conditions influencing this process. The theoretical section indicated that we may consider the concept of smart villages as analogous to the concept of smart cities as an innovation that organizes spatial structures according to a new model. Despite the differences between developing smart cities and smart villages due to the varying specifics of these areas, there are many connections between them. Thus, we highlighted the possible evolution of smart villages from 1.0 to 4.0, similar to the evolution of smart cities. Moreover,

we outlined the conditions for the development of each phase of smart villages. We also emphasised the significant role of ICT enterprises in the development of smart villages, particularly at the smart villages 1.0 level. Furthermore, we identified connections between ICT enterprises and other sectors of economic activity, which was another goal of this study.

The analysis confirmed the hypothesis that the smartification of villages, considered a diffusion process, is reflected in a greater degree of specialization in services stimulated by entrepreneurship in ICT. The analysis revealed that the diffusion of innovations in the form of smart village creation is hierarchical in nature, reinforced by the developmental potential of major urban agglomerations in Poland. This conclusion stems from the spatial concentration of municipalities with the highest level of ICT entrepreneurship development. Complementation of it is the innovation diffusion driven by the above-average development of ICT in municipalities with strategic geopolitical locations (especially along the eastern border of Poland and the European Union). However, to see relatively greater ICT entrepreneurship activity in eastern provinces, which suggests a breaking of the long-term pattern of infectious innovation diffusion in Poland from the southwest to the northeast. We could explain this phenomenon by the impact of public aid for rural areas in eastern Poland, particularly in the field of digitalization. Nevertheless, given the significantly lower interest in the ICT sector in western Polish villages, this phenomenon requires further research.

Hypothetically, we may already be witnessing the effects of stimulating the economy in rural areas of eastern Poland due to the strengthening of geopolitical functions not only in border areas but also in somewhat more distant industrial and service centres supporting the military and defence sectors. Municipalities with the highest level of ICT development, located in border areas (mainly on the eastern border), showed a significantly higher proportion of sections responsible for administration and national defence (Section O), tourism (Section I), and agriculture and related sectors (Section A) compared to other types of municipalities. In this case, a smart village was a consequence of applying ICT technology for defence development and supporting multifunctional rural development. This may signal a process moving from a smart village to a smart city if, as a result of the growth in the economic base of local centres, urbanization increases not only in terms of professional urbanization but also in terms of landscape and static urbanization. Smart villages evolving towards smart cities could become the carriers of these changes.

In municipalities located in the immediate vicinity of large urban centres classified as ITIs (Integrated Territorial Investments), a different kind of stimulation occurs since suburban centres are an integral part of smart cities. Smart cities expand into their supply spheres, where urban functions are succeeded from the core of the agglomeration. We can hypothesize that in this case, we are likely dealing with further stages of smart village development, where subsequent versions 2.0, 3.0, or even 4.0 are possible. This is particularly evident in the ITI of Warsaw, where there is an exceptionally high concentration of rural municipalities with the highest level of ICT entrepreneurship development. High ICT entrepreneurship development is accompanied by significant activity in sectors M and Q, indicating substantial support from local governments in healthcare and social services, as well as in the business ecosystem for business services and scientific and technical activities.

In light of the research findings, we recommend several key actions to further develop the smart village concept:

- Strengthening connections between ICT entrepreneurship and other key areas for smart village processes, such as education, health, and transportation, to ensure better integration and effective implementation of innovations. Improving communication and coordination between these sectors create synergies that will enhance the effectiveness of smart village initiatives and accelerate their implementation in various rural areas.
- Expanding ICT infrastructure to enable extensive use of digital technologies in managing resources and public services. Investments in broadband internet, data management systems, and smart energy grids are crucial to support innovative solutions.

- Supporting local initiatives through funding and advisory services to develop specific, innovative projects tailored to local needs. Providing access to financial resources, expert knowledge, and tools supporting local entrepreneurship can contribute to the sustainable development of rural areas.
- Promoting education and training in new technologies for rural residents to increase their digital skills and prepare them for active participation in smart village initiatives. Educational programs can include courses on ICT management, project management, and entrepreneurship.
- Encouraging cross-sector collaboration by creating platforms for knowledge and experience exchange between local governments, non-governmental organizations, the private sector, and local communities. This approach enables sharing best practices and implementing proven solutions in various local contexts.

Implementing these actions can contribute to the dynamic development of the smart village concept, improving the life quality in rural areas and supporting their sustainable development. Entrepreneurship in smart villages focuses on improving rural infrastructure, utilizing digital technologies, and supporting local solutions to local problems through community participation and active citizen engagement. Smart rural development can prevent migration from villages to cities, provide economic opportunities, and address socio-economic challenges. However, it also involves challenges related to financial constraints and management issues. Technology, particularly IoT and digital innovations, plays a key role in shaping entrepreneurship in smart villages by driving strategic breakthroughs and promoting sustainable development.

Future research could examine the impact of ICT entrepreneurship on the development of smart village 1.0 in other countries, including the EU, along with identifying the connections between this type of entrepreneurship and other forms of economic activity. Moreover, it seems crucial to attempt to study the level of development of smart villages 2.0, 3.0, and 4.0 in Poland and other countries. This requires defining indicators for each stage of smart village development. A potential research limitation in this area could be the availability of statistical data in public statistics.

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Innovation activity in European Union service sector: Similarities or differences?

Kamil Decyk

ABSTRACT

Objective: The article aimed to identify and assess the degree of homogeneity and differentiation of European Union countries regarding innovation activity in individual sections of the service sector.

Research Design & Methods: I developed the research objective using three specific objectives formulated as auxiliary questions. I designed the research in three stages directly correlated with the particular objectives. The research hypothesis assumed that we might group EU countries into internally homogeneous clusters and, simultaneously, externally different in terms of innovation activity in the service sector industries. Firstly, I verified whether innovation activity is homogeneous in individual service sector industries (Levene's test). I considered homogeneous service industries, demonstrating homogeneity in at least eight indicators. In the second step, I identified homogeneous clusters of EU countries in each service industry (cluster analysis). In the last step, I differentiated between clusters of countries (the T-student test). I used the analysis and logical construction method with its inherent analysis and synthesis.

Findings: In the scope of service sector industries, we may group EU countries into clusters that are internally homogeneous and, at the same time, externally diversified in terms of innovation activity. I identified clusters of internally homogeneous countries in four out of five analysed service sections (except for the transportation and storage industry). The highest degree of homogeneity (100%) was characteristic of innovative activity conducted by enterprises in the scientific and technical activities section. The most significant differentiation between the identified clusters of countries was the characteristic of wholesale and retail trade, as well as the repair of motor vehicles and motorcycles industry (G). Regarding innovation activity in each industry, the defined groups of countries were much more internally homogeneous than significantly differentiated. In industry G, both of the phenomena were at an almost identical level.

Implications & Recommendations: Based on the presented research results, it is possible to develop uniform tools and instruments of pro-innovation policy dedicated to countries aggregated within a specific, internally homogeneous cluster of countries. On the one hand, this policy would be universal for countries aggregated in a given cluster. On the other hand, it could contain instruments and tools specific to a given industry. Such a diversified form of pro-innovation policy would contribute, firstly, to increasing coherence in the scope of the implemented assumptions of the EU innovation policy. Secondly, it would ensure that the instruments used in its scope would be targeted and dedicated to specific groups of enterprises. Therefore, the study may constitute a set of information that policy-makers could use. Moreover, the research results and analyses constitute a source for deepening knowledge on the construction of independent strategies by individual countries as part of innovation activities carried out at the level of various service industries.

Contribution & Value Added: The study is consistent with the currently applicable scientific paradigms and strategic assumptions of the EU countries regarding the cohesion of its members, as well as development based on innovation and related activities. To characterise the issue of innovativeness, I used a methodological approach that integrates extensive tools in the field of research methods.

Article type: research article

Keywords: Innovation activity; services sector; EU countries; Ward's agglomerative method

JEL codes: L80, O30, O52

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INTRODUCTION

The study addresses important issues related to innovation activities and integrates them with the services sector, which is no less important from the perspective of the EU economy. The most visible effects of innovation activity are technological and non-technological innovations appearing on the market due to enterprise activities. According to the EU report on innovation policy (Polluveer, 2023), innovations arising from dynamic changes at the international level, although they have been permanently recognised as determinants determining the economic development of countries, have recently become even more important. Importance and role not only in the economy but also in the area of health (in 2020, the COVID-19 pandemic) or the arms industry (apart from the armed conflicts that have occurred so far, in 2022, there was an escalation of the Russian-Ukrainian war).

The political and socio-economic situation in the world forced the intensification or initiation of innovation activities not only by industrial entities, but also, and perhaps above all, service entities. Numerous studies indicate that the service sector industries have suffered the most from the COVID-19 pandemic. On the other hand, innovation activity provides the potential and opportunities for development and survival in new, dynamically changing, complicated, and complex conditions (Huang *et al*., 2020; Ramelli & Wagner, 2020; Gopinath, 2020).

The literature on the subject identifies the key reasons for the destabilization of the economic situation of service entities from the perspective of recent years, which include, among others, collapse on the demand side, interruption of global supply chains, accumulation of product inventories and decline in real incomes. Moreover, factors that negatively impact the situation in service sections include limited opportunities to finance projects for new solutions, regulatory barriers, including self-isolation and social distancing (Serbulova *et al.*, 2020). The new realities of functioning on the market, including, *e.g.,* restrictions on movement, posed a threat in the case of activities related to the provision of catering, hotels (Huang *et al.,* 2020) or transport services, in which the pandemic did not have a negative impact. The negative phenomenon of the pandemic had a beneficial effect, for example, in the activities of Emirates Airlines. The COVID-19 crisis forced the use of an innovative approach to running a business, which resulted in the implementation of the so-called reactive innovations, *i.e.,* in response to the situation resulting from the environment and not entirely dependent on the enterprises themselves. Gopalakrishnan and Kovoor-Misra (2021) In the example, in the above-mentioned Emirates Airlines were used, among others: innovative onboarding procedures, considering passengers maintaining a safe distance (business process innovation). Moreover, the airlines transformed passenger aircrafts into units intended to transport goods – SkyCargo – a product innovation (De Mey, 2020). Thus, the COVID-19 crisis caused a collapse on the demand side in many of the above-mentioned service industries. Still, at the same time, it became an opportunity to diversify activities, expand the range of services and cause a disproportionate increase in demand in other service sections.

The pandemic has naturally created new markets for many services, *e.g.,* those focused on ICT activities. Examples include video streaming and video conferencing companies (Koeze & Popper, 2020). The period of health crisis has become an opportunity for the development and creation of innovative solutions in the field of so-called proactive innovations, not only in the ICT market but also in service industries related to insurance activities or the e-commerce market, *e.g.,* online shopping services (Alan & Köker, 2021). The creation of the mentioned proactive innovations is justified when there is a demand for new products and services on the market, and such a phenomenon occurred during the COVID-19 crisis (Gopalakrishnan & Kovoor-Misra, 2021).

The 'Europe 2020' strategy by the European Commission (EC) demonstrated the importance of the topics discussed in the study. The strategy bases on three priorities with goals:

- intelligent development of the economy – based on knowledge and innovation,
- sustainable development – related to supporting an economy that uses resources efficiently,
- inclusive development – involves supporting an economy that ensures economic, social and territorial cohesion.

Highly diversified levels of effectiveness characterised the Community countries in achieving the goals in terms of the presented priorities. The countries with the highest degree of strategy implementation belonged mainly to the 'old' EU countries, *e.g.,* Sweden, Finland, Denmark, and Austria, as well as new ones, *e.g.,* Slovenia, Czech Republic, Estonia, and Poland. Very bad results in this respect concerned southern Europe, including Greece, Spain, Italy, Romania, and Bulgaria (Kasprzyk & Wojnar 2021).

Currently, in the face of insufficient fulfilment of the provisions of the Europe 2020 strategy and the context of cohesion policy in the field of research and innovation, it seems that there is a need to reformulate the level of requirements and/or the level of their implementation to a lower than international level. In this regard, it is worth considering the objectives, as well as assistance at the EU sectoral level, guided by the strategies adopted for the coming years, including:

- in the field of cohesion policy, investing in a smarter, greener, better connected and more social Europe (2021-2027),
- EU research and innovation policy,
- single market strategy,
- digital single market strategy.

It seems that the above-mentioned innovation activity support strategies have a greater impact on innovation activities in the services field than the Europe 2020 strategy, constituting the second premise for undertaking research.

The aggregation of countries, which is the result of achieving the objective of this study, constitutes potential guidelines and indications that can be used in determining the assumptions of subsequent strategies developed in this area, as well as the innovation policies of individual groups of countries. The work in the scope of this study allowed me to identify the internal homogeneity and cluster of countries differentiation identified in the service sections, considered in terms of innovation activity. Thus, the strategic assumptions, including goals and instruments supporting the achievement of the assumptions of the new EU strategy, can be adapted to the specificity of each service section and extend their application in countries identified as similar in terms of innovativeness.

The third and last indication of the key importance of the issues discussed in the study was that it covered the services sector of EU countries and practically illustrated the level of innovativeness of enterprises providing services representing individual countries. According to the literature, over the last 30 years, the service sector has significantly influenced the world economy (Manohar *et al.*, 2023). Hausman and Johnston (2014) indicate the essence of the service sector in the economy and the growing importance of innovation as determinants of the socio-economic development of countries and regions. Innovativeness has become a key factor in creating a new economic model in developed countries where achieving population and consumption growth is difficult (Churski *et al.*, 2018).

Noteworthy, growth dynamics characterise the service sector, and additionally, in the economies of developed countries, it has a priority because its share in creating economic indicators is high (Guevara-Rosero *et al.*, 2023; Alan & Köker, 2021). The strong position of the service sector is not only the result of technological progress but also plays a key role in consumer needs regarding, *e.g.,* quality, lifestyle and growing customer expectations, including understanding how consumers perceive service innovations, as well as their growing purchasing power (Nair, 2018; Habel *et al.*, 2016; Hsieh & Yuan, 2019).

The World Bank mentions the importance of the services sector (Buckley & Majumdar, 2018) in a report, which notes that the process of transforming the world economy from agricultural to productive has lasted for centuries and is still ongoing in some economies. However, as indicated in the cited source, the service sector is developing more dynamically than the production sector, and the world is undergoing radical changes. Many authors also point to the importance of the service sector in the economy. The studies by Wosiek (2018) and Buckley and Majumdar (2018), presented in 2018, compiling the basic economic values generated by the service and production sectors, clearly indicate the dominant economic importance of the service industries. The cited authors prove that this sector displays a growing trend in the services share in generating GDP (69% in 2016). This is particularly visible in low- and middle-income countries, where in 2015 it was 57%, while in high-income countries it was as much as 67%. Employment level was another measure proving the growing importance of

the service sector. In 2017, over 70% of the workforce was employed in services in most world economies, including the Organization for Economic Co-operation and Development (OECD) countries, and over 80% in high-income countries. Another proof of the key role of the services sector in the development of the economies of countries around the world may be the value of exported services, which in the period 2006-2016 increased by 39.36%, to 4 751 billion USD. At the same time, the production sector saw an increase in the value of exports that was approximately 12 percentage points (percentage points) smaller (27.05%) in 2016, equal to 11 557 billion USD (World Trade Statistical, 2017). The sector data came from before 2018 to illustrate the situation compatible with the period of data analysed in the study, which came from 2018-2020 (data current at the time of writing the text). Moreover, as previously shown, based on numerous studies, the increasing importance of the service sector has been progressing for decades and is a growing trend.

To sum up, innovation activity and innovativeness are extremely important issues in the perspective of overcoming the economic crisis caused by the global problem of COVID-19. The post-pandemic period and the need to stabilise the economic and health situation of the global economy, including the EU, is an appropriate moment to develop updated, sustainable, uniform and common, and at the same time specific and tailored to individual groups of countries, strategy assumptions, and innovation policy. The key issue in this respect may be the establishment of instruments or tools supporting innovation activities, especially for the service sector, which may be facilitated by the results of the analyses conducted in this study. The need to support the service sector relates to its role and significant impact on the economy of individual countries.

The novelty and originality of the issues addressed in the study resulted from seven premises (Alan & Köker, 2021; Osiadacz, 2012):

- for a long time, scholars perceived the service sector as insensitive to innovation and technical progress, therefore it was not an interesting research area,
- innovations in services until 2005 (3rd edition of the Oslo Manual – OM3), were not included in the category of product innovations and were therefore not included in the research on innovation activity,
- there are difficulties in measuring innovativeness in the service sector, because they often result in immeasurable changes of a qualitative (non-technological) nature that are difficult to quantify,
- there is a problem with open access to reliable data/innovativeness indicators characterizing services,
- low level of interest in innovations in the service sector, as they are rarely related to technological progress,
- previous works in the area of the discussed issues are mainly case studies of individual service industries, *e.g.,* works by Sarmah *et al.* (2017), Khan *et al.* (2020) on innovation in hotel services and their co-creation by customers as part of, for example, the concept of user-driven innovation (Wahyudi *et al.*, 2023; Szymańska, 2017), less often concern specific business entities, such as Mercadona (Albors-Garrigos & de Miguel Molina, 2023),
- the study uses a methodology based mainly on quantitative methods – cluster analysis, Ward's agglomerative method at the macroeconomic level, Levene's statistical test, and Student's t-test.

The presented premises regarding the importance of the topic and the degree of novelty allowed for the identification of a research gap. It occurred at the level of innovativeness research, in which the service sector is often omitted. Due to the presented research gap, the aim of the research described in the study was to identify and assess the degree of homogeneity and differentiation of EU countries in terms of innovation activity in individual sections of the service sector. Within the scope of the objective, I defined specific objectives constructed in the form of research questions, which were also the next research stages:

RQ1: Do individual sectors of the service sector of EU countries exhibit homogeneity in terms of the innovation activity of enterprises?

RQ2: Is it possible to identify homogeneous clusters of EU countries in individual service industries, taking the level of innovation activity as a criterion?

RQ3: Were there any significant differences identified between the clusters of countries that occurred in the individual industries?

The study consists of an introduction, which, apart from indicating the significance of the discussed issues from a cognitive point of view, also includes a fragment of the methodology concerning the objectives. The next part will be largely theoretical in nature. It will focus on presenting international literature and justifying the research hypothesis.

The part of the study regarding research methodology presents a sequential approach to the research assumptions along with the methods, tools and research techniques used at each of the three stages. This chapter also presents a set of analysed indicators of innovation activity and defines criteria for assessing the level of homogeneity and significant differentiation.

The rest of the study presents the results of the conducted research analyses. This part also includes a discussion relating to previous research results and conclusions. Conclusions and references support the work's structure.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The literature on the subject contains a multitude of concepts related to the issue of broadly understood innovativeness, as well as various ways of interpreting it. We should consider subsequent editions of the Oslo Manual as the basic source of information in this aspect. The fourth version of this manual from 2018 is currently in force. This source is a collection of all necessary information used for issues related to innovativeness. Moreover, the Oslo Manual contains methodological guidelines for conducting all research conducted at the international level, *e.g.,* by Eurostat, or at the national level, *e.g.,* reports on the innovation activities of enterprises in Poland prepared by the Central Statistical Office – GUS (Oslo Manual, 2018).

At the microeconomic level, innovativeness constitutes an enterprise's tendency to implement innovations and accept new ideas. It may manifest itself in a processual manner, as it is a source of encouraging, experimenting, and supporting changes that may ultimately generate new products, services or technological processes (Imran *et al.*, 2018; Chavez *et al.*, 2020). From the perspective of innovation management, we may define innovativeness as part of an organizational culture with a specific structure, open to new ideas, which functions as a source of solving organizational problems (Jahanshahi *et al.*, 2019).

Due to its specificity, innovativeness is a difficult area for empirical considerations. We may estimate it at the macroeconomic level in the national context. However, it also has a meso- and microeconomic dimension. To define it internationally, we use the summary innovation index (SII), which I will discuss in detail later in this chapter. Moreover, from a macroeconomic perspective, we may also define innovativeness based on various indicators regardless of the SII, *e.g.,* the impact of the number of innovative companies and employment in knowledge-adoptive sectors on GDP, foreign direct investment, the rate of unemployment, the establishment of new companies export and market share (Bazhal, 2017; Zervas *et al.*, 2017).

From the perspective of this study, the methods of measuring innovativeness at the microeconomic level are interesting as they determine the innovativeness advancement of economic sectors. Estimation of innovativeness in this industry sense may come down to the analysis of the innovation activity of enterprises, and the selection of indicators describing this phenomenon depends on the specificity of the empirical research conducted and its scope. The most common areas of research are those related to the innovative potential and/or effects related to the degree of its use at the enterprise level. Scholars may conduct research on these levels separately or integrally (Lin *et al.*, 2020; Mendoza-Silva, 2021; Sandvik *et al.*, 2014). We may describe the innovative potential using quantitative data regarding, for example, expenditure (R&D) the number of patents obtained or applications submitted in this area (Baranskaitė *et al.,* 2022). We can measure the effects of business activities that indicate the level of innovativeness of entities by the number of implemented innovations, the degree of their newness in geographical, market or conceptual terms, and also the length of the innovation life cycle.

Regarding innovation taxonomy, it is essential to indicate the latest edition of the Oslo Manual from 2018 (OM4), which constitutes the methodological basis for research on innovativeness and also informed the methodology used in this study. In OM4, we divided innovations into two categories. Firstly, product innovations, understood as new/significantly improved products or services in terms of one or more properties compared to those previously offered. The second group of innovations consolidates the changes that were made in the OM3 edition, which were of a process, organizational, and marketing nature. Currently, we collectively refer to them as business process innovation and they may be the result of one or more of the six so-called 'business functions,' including production of goods and services, distribution and logistics, development of products and business processes (in OM3 these were process innovations), information and communication systems (ICT), administration and management (in OM3 these were are organizational innovations), marketing, sales and after-sales service – formerly marketing innovations (Oslo Manual, 2018; Oslo Manual, 2005).

The considerations presented so far inspired the development of three premises that formed the basis for the construction of research assumptions, especially the research hypothesis, which assumed that:

H1: EU countries can be grouped into clusters that are internally homogeneous and, at the same time, externally different in terms of innovation activity in the service sector industries.

The factors influencing the research construction were under the influence of three conditions:

- two research trends in terms of patterns of innovation activity,
- estimation of the innovativeness level conducted based on SII, presented in the annual edition of the European Innovation Scoreboard (EIS) 2023 and developed by the European Commission,
- continuation and the need to expand existing research on innovativeness in both the service sector and its sections, treated as specific case studies.

Detailing the presented premises, we should note the two antagonistic research directions used in the field of innovativeness. The first one is based on research on homogeneity in innovative behaviour. It focuses on examining the homogeneity of innovative behaviour of enterprises in various – from the perspective of innovative strategies used – areas of production activity, as well as in the service sector, *e.g.,* on the financial market (Urbankova & Krizek, 2020; Jakimowicz & Rzeczkowski, 2019; Srholec & Verspagen, 2008; Llerena & Oltra, 2002). The second trend of research conducted on innovation activity assumes differences in the innovativeness of enterprises with a wide range of technological advancement defined at high, medium, and low levels (Hirsch-Kreisen *et al.*, 2008).

Another premise justifying the construct of the research hypothesis and the purpose of the research related to the results of the EIS report on the level of innovativeness in EU countries. This document contains basic guidelines containing and defining areas requiring improvement at the level of individual countries. The aim of this report is to strengthen the innovative position of individual countries in the EU and in the world (European Innovation Scoreboard, 2023). On their basis, the EU countries are aggregated into groups with a similar level of innovativeness. The classification is based on SII, which is a constellation of 32 indicators grouped into four sets (framework conditions, investments, innovation activities, impacts) and defining 12 areas. This ranking defines four groups of countries, differentiated by their innovativeness level. Two of them are above and two below the average EU SII, which is 100% as a reference point. In 2023, the largest group of countries (10) represented the so-called 'moderate innovators,' whose SII was in the range of 75-108% of the EU value. Noteworthy, in 2016-2023 in these countries there was identified higher growth of SII than in EU. The highest growth dynamics of SII was observed in the following countries: Estonia (29.3% points), Greece (22.2% points), the Czech Republic (21.0% points), Lithuania (16.7% points) and Italy – 15.6% points (European, 2023). Apart from these countries, the 'moderate innovators' included Slovenia, the Czech Republic, Spain, Malta, Portugal, Lithuania, and Hungary. The smallest group of countries in terms of quantity were the so-called 'innovation leaders,' *i.e.,* countries with the highest innovativeness level. This includes, among others, Denmark, Sweden, Finland and the Benelux countries, where the SII index was above 135% (European Innovation Scoreboard, 2023). Research on innovativeness at the international level is very popular in the literature on the subject, but at the industry level, it is still paucity (Dworak, 2022).

Based on the EIS, the ranking and classification of countries made within its scope (in the scope of the EIS) aggregates EU countries into clusters with similar values of innovativeness indicators. From a cognitive point of view and in the perspective of the data included in the EIS, it is worth considering whether it is possible to conduct a similar study and group countries according to, *e.g.,* the level of innovation activity of individual sections of the service sector, the significant importance of which I demonstrated in the previous part of the study?

The last factor that determined the research assumptions was the need to continue and specify the existing research in the field of innovation activities, both in the service sector in general and at the level of its individual industries. An example is the work of Bielińska-Duszak and Hamerska (2021), in which the authors aggregate industries classified according to NACE (the Statistical Classification of Economic Activities in the European Community into homogeneous ones, in terms of innovation activity clusters. In the above-mentioned studies in the case of service entities, they noted that the best quality of division was achieved when three clusters were created due to the participation of enterprises implementing product or business process innovations. Moreover, they indicate the possibility of further analyses provided by the process of grouping service sections into endogenously similar clusters.

Another excellent example of research that proves the possibility of classifying EU countries into clusters that are homogeneous in terms of innovation activity is the empirical work by Kasprzyk and Wojnar (2021), which covers EU countries. The authors consider homogeneity according to the effectiveness in implementing the assumptions of the Europe 2020 strategy achieved by the Community countries, using, among others, cluster analysis with Ward's agglomeration method.

Based on the considerations presented, we can conclude that the issues discussed in this study, together with the hypothesis, goals and methodology for achieving them, constitute a logical continuation of the research considerations of other authors, draw on the existing scientific achievements, and naturally fits into the gap research.

RESEARCH METHODOLOGY

Considering the theoretical and empirical background of the issues discussed in the previous part of the text, I formulated a research objective, which was to identify and assess the degree of homogeneity and differentiation of EU countries in terms of the innovative activity of individual industries of the service sector. I developed the main goal with specific goals formulated in the form of research questions presented in the introduction. In the context of the presented assumptions, I verified the research hypothesis, which assumed that:

H2: We may group EU countries into clusters that are internally homogeneous and, at the same time, externally different in terms of innovation activity in the service sector industries.

I verified the hypothesis and implemented the main goal using the method of analysis and logical construction designed in four stages/phases, at which time I used a number of supporting methods, techniques, and research tools (Table 1).

The first stage of the described research was the identification of potential homogeneity in the service industries of EU countries in terms of innovation activity, which was characterised using the indicator method. In this phase of the research was used Levene's test, which assumed that the variances in different groups are the same (homogeneous). This is the most powerful test of homogeneity of variance. All indicators in individual service industries were tested. For the purposes of further analyses, I considered homogeneous sections as those in which at least eight indicators showed homogeneity. Based on stage 1, I achieved detailed objective 1.

In the second stage, I used cluster analysis to connect the examined objects and determine the distance between them. One can conduct it using the so-called single or full bond or centre of gravity of clusters. The most important point in cluster analysis was the creation of a matrix of distances between the examined objects. I used the Euclidean distance as a measure of this distance in the research (Decyk, 2024). At this stage, I used Ward's agglomerative method of grouping objects. Its effectiveness is appreciated, especially in economic research. This is due to the fact that among the

available grouping methods, it is the most effective in reproducing the actual structure of economic data (Steinley & Brusco, 2007). This method involves consolidating objects into groups based on the principle of minimizing intra-class variance and combining objects into clusters that guarantee the minimum sum of the squares of the distance from the so-called centre of gravity of the newly created cluster that they create (Łukiewska, 2019). The cut-off point (in this elaboration), which specified the number of clusters, was marked by a straight line, symbolizing the level at which there were relatively large changes in the value of increases in agglomeration distances in the process of combining classes between individual levels of consolidation. The research approach used in the first stage enabled the implementation of the first specific objective.

Table 1. Research procedure

Research stage		Applied research approach	Degree of implementation of methodological assumptions	
1	The identification of the potential homogeneity of service industries in terms of innovation activity	- Levene's homogeneity of variance test (analysis of variation test), - indicator method	first specific goal	main research goal and verification of the hypothesis
2	The identification of clusters of EU countries in the field of service industries, taking the level of innovation activity as the criterion	- cluster analysis with Euclidean distance as a measure of the distance between the examined objects, - Ward's agglomerative clustering method, - dendrogram – graphical interpretation of the results	second specific goal	
3	The identification of significant differences between defined clusters of countries in a given industry	- categorised normality plots – normal distribution of the variable, - Student's t-test – identification of statistically significant differences between clusters	third specific objective	

Source: own study.

In the next step, I analysed the degree of differentiation between the identified clusters. For this purpose, I used Student's t-test, which I proceeded with the verification of the normal distribution of the dependent variable based on categorised normality plots. I tested independent and unrelated variables with a statistical H_0, stating that there were no statistically significant differences in innovation activities between the clusters identified in stage 1. The alternative hypothesis assumed that there were statistically significant differences in the studied phenomenon. I considered groups of countries with statistically significant differences to be those in which at least one indicator differed statistically significantly between two selected pairs of clusters. In accordance with the presented methodological approach, I obtained the answer in the scope of the third specific objective.

As part of the summary of the results obtained in the earlier stages of the research, I estimated the degree of homogeneity of innovation activity in the identified clusters of EU countries and the level of differentiation between them. I determined the homogeneity degree in the scope of individual clusters of countries based on an indicator calculated as the ratio of the number of indicators considered homogeneous (Levene's test) to the total number of indicators – 15. The level of differentiation was expressed as a percentage indicator as the ratio of significantly different pairs of clusters to all possible configurations that could be created by clusters in a given service industry. I performed all analyses and statistical tests using the Statistica 13 program with a significance level of p=0.05.

In addition to quantitative methods, I developed both the theoretical part of the work and the methodological assumptions using analysis and criticism of international literature. It allowed me to systematise the existing knowledge on innovativeness.

I expressed the obtained data in the form of 15 percentage indicators, which were the ratio of enterprises (implementing an innovation project/innovation, introducing innovation/a specific type of innovation/innovation with a specific scale of novelty) to all surveyed entities in a given section.

I determined the choice of meters by the ineffectiveness of using popular metrics in service industries used to measure the level of innovativeness, such as the intensity of research and development (R&D) or the number of patents. Research in the area of the service sector requires more specific and adjusted indicators (Williams & van Triest (2021). The mentioned group of 15 indicators was the subject of research and, at the same time, research material, which included data from 2018-2020 and published by Euroatst (Table 2). I used the latest, available, and comprehensive quantitative data on innovation activity from all EU countries.

Table 2. Summary of the indicators of innovation activity used in the research in the service sector section in the EU countries in 2018-2020

Group of indicators	The specific type of indicator*
Innovation activity index	1. Enterprise innovative efficiency index (IEI). 2. Innovation activity efficiency index (IAEI).
Type of innovations	3. Enterprises which introduced product innovations (PI). 4. Enterprises which introduced business process innovations (PrI).
Types of product innovation	5. Enterprises which introduced product innovations in the form of goods (GIEI). 6. Enterprises which introduced product innovations in the form of services (SIEI). 7. Enterprises which introduced product innovations that were new from the market perspective (MNIEI). 8. Enterprises which introduced product innovations that were new only from the perspective of a given firm (FNIEI).
Types of business process innovation	9. New or improved methods for producing goods or providing services (MPGPS). 10. Logistics (LI). 11. New business practices for organizing procedures or external relations (BPER). 12. New methods of organizing work responsibility, decision making or human resource management (OWHR). 13. New or improved methods for information processing or communication (IPC). 14. New methods for accounting or other administrative operations (AAO). 15. New marketing methods for promotion, packaging, pricing, product placement or aftersales services (MM).

Note: '*' the indicators are expressed as percentages, reflecting the ratio of enterprises conducting innovation activities in a given scope to all enterprises surveyed in a given section.
Source: own study based on Eurostat data.

The subject of the described research was innovative enterprises representing industries in the service sector in individual EU countries and, more precisely, their innovation activities in the broad sense. I analysed all sections of the services sector where data from at least half of the EU countries were available (14 out of 27). Due to the presented limitations and incomplete information, the study included five out of eight industries in the service sector. They included the following industries: G – wholesale and retail trade; repair of motor vehicles and motorcycles; H – transportation and storage; J – information and communication; K – financial and insurance activities; and M – professional, scientific, and technical activities.

RESULTS AND DISCUSSION

Homogeneity of Countries in Terms of Innovation Activities of Individual Branches of the Service Sector

The application of Levene's variance estimation test enabled the use of indicators in a range that begins in the analysed service industries (Table 3). Values of $p \geq 0.05$ indicated that there were no grounds to reject H_0, which states that the variances in the examined objects were homogeneous.

Based on Levene's test, it was possible to identify not only similarity in service sections, but also the indicators in which this occurred. Based on the results, it should be concluded that the most homogeneous innovative activity was identified in section M, where similarity was observed in all 15 analysed indicators. In the case of the remaining service sections examined, the similarities were

slightly lower but also higher. The second equally homogeneous industry was financial and insurance activities – K. I observed internal similarity in 14 indicators. Thus, clusters of countries with a similar level of innovation activity concentrated there. Only in the case of one indicator like enterprises which introduced product innovations that were new only from the perspective of a given company – FNIEI (p=0.0069) – was not significantly homogeneous. The J – information and communication industry was characterised by a slightly lower similarity level, in which the results of Levene's test showed a lack of homogeneity of variance only in the case of 2 out of 15 indicators. These were the percentage of enterprises which introduced product innovations in the form of goods – GIEI (p=0.0186) and FNIEI (p=0.0021). Industry G was characterised by lower significant homogeneity than in the above-mentioned sections, although still high homogeneity, in which I identified similarity in terms of 12 measures. I also identified dissimilarities in new or improved methods for producing goods or providing services – MPGPS (p=0.0024) and new marketing methods for promotion, packaging, pricing, product placement or aftersales services – MM (p=0.0417). I recorded the lowest level of homogeneity in section H. I diagnosed it only in seven tested indicators. Due to the methodology adopted in the study, which assumed that service sections in which at least eight indicators were homogeneous would be considered homogeneous, I omitted industry H in further analyses.

Table 3. Internal homogeneity of the service sector sections in all EU countries in terms of individual indicators of innovation activity in 2018-2020

No.	Type of indicator	Levene's test probability value in the service sector				
		G	H	J	K	M
1	Enterprise innovative efficiency index (IEI)	0.3640	0.1516	0.4257	0.3761	0.2711
2	Innovation activity efficiency index (IAEI)	0.3648	0.0000*	0.3417	0.4668	0.6023
3	Enterprises which introduced product innovations (PI)	0.4285	0.0171*	0.4180	0.3851	0.2864
4	Enterprises which introduced business process innovations (PrI)	0.0209*	0.0603	0.0725	0.2777	0.1463
5	Enterprises which introduced product innovations in the form of goods (GIEI)	0.0453	0.0066*	0.0186*	0.2273	0.3386
6	Enterprises which introduced product innovations in the form of services (SIEI)	0.1123	0.0360*	0.0712	0.0732	0.6447
7	Enterprises which introduced product innovations that were new from the market perspective (MNIEI)	0.2469	0.0001*	0.3804	0.3621	0.6638
8	Enterprises which introduced product innovations that were new only from the perspective of a given firm (FNIEI)	0.3026	0.0872	0.0021*	0.0069*	0.2973
9	New or improved methods for producing goods or providing services (MPGPS)	0.0024*	0.0869	0.6770	0.6132	0.6114
10	Logistics (LI)	0.4080	0.2249	0.5469	0.4345	0.0650
11	New business practices for organizing procedures or external relations (BPER)	0.1042	0.0313*	0.3701	0.1663	0.9549
12	New methods of organizing work responsibility, decision making or human resource management (OWHR)	0.4875	0.2936	0.4887	0.0896	0.2711
13	New or improved methods for information processing or communication (IPC)	0.1561	0.0013*	0.4870	0.4256	0.6023
14	New methods for accounting or other administrative operations (AAO)	0.4807	0.0002*	0.3085	0.4000	0.2864
15	New marketing methods for promotion, packaging, pricing, product placement or aftersales services (MM)	0.0417*	0.4243	0.1762	0.0472	0.1463

Note. '*' statistically significant results at p<0.05 significance level'.
Source: own study based on Eurostat data and Statistica 13 program.

The analysis of Levene's test results allowed me to conclude that individual sections of the service sector in the EU countries were significantly homogeneous in terms of innovation activity. At a later stage of the research procedure, it was interesting to ask whether, in connection with the potentially

demonstrated homogeneity, it is possible to aggregate the EU countries into smaller internally homogeneous clusters, in which it would be possible to apply the same (universal) innovation policy towards members of this cluster and at the same time specific to a given industry.

Therefore, in the next stage of the research procedure, I identified the homogeneity of the innovation activity of the countries within each of the analysed service industries. For this purpose, I used cluster analysis with Euclidean distance, supported by Ward's agglomeration method. Table 4 presents the results of this part of the research process in the synthetic way. This ensured the refinement of the identified homogeneity and allowed for the continuation of the analyses in accordance with the presented research methodology.

Table 4. Clusters of EU countries in which internally homogeneous innovation activity was identified, conducted in 2018-2020, with a distinction made between industries of the services sector

Type of service section	Cluster no	Countries
G	1	Croatia, Czechia, Portugal
	2	Denmark, France, Hungary, Italy, Luxembourg, Sweden
	3	Malta, Poland, Slovakia
	4	Spain, Romania
H	1	Belgium, Netherlands
	2	Bulgaria, Denmark, Hungary, Latvia, Poland, Slovakia, Spain
	3	Austria, Czechia, Finland, France, Germany, Ireland, Italy, Lithuania, Luxembourg, Malta, Portugal
	4	Cyprus, Greece
	5	Slovenia, Sweden
	6	Estonia
	7	Croatia
	8	Romania
J	1	Austria, Belgium, Czechia, Finland, Germany, Greece, Netherlands, Portugal
	2	Denmark, Estonia, France, Italy, Lithuania, Slovenia, Sweden
	3	Croatia
	4	Cyprus
	5	Bulgaria, Hungary, Ireland, Latvia, Luxembourg, Malta, Poland, Slovakia, Spain
	6	Romania
K	1	Belgium, Cyprus, Czechia, Greece, Germany, Portugal, Italy, Austria
	2	Bulgaria, Netherlands, Hungary
	3	Lithuania, Malta, France, Finland, Latvia, Spain, Luxembourg, Poland, Estonia, Sweden, Slovakia, Denmark, Slovenia, Ireland
	4	Croatia
	5	Romania
M	1	Czechia, Portugal, Croatia, Sweden, Italy
	2	Denmark, France
	3	Malta, Poland, Hungary, Luxembourg, Slovakia, Spain
	4	Romania

Source: own study based on Eurostat data and cluster analysis performed using Statistica 13 program.

Based on the cluster analysis, I identified a different number of homogeneous clusters in terms of innovation activity in the surveyed industries, in section G – 4, H – 8, J – 6, K – 5, and M – 4. The research included clusters that constituted one country, for example, in the J industry, such as Croatia, Cyprus, or Romania. Based on the presented analysis results, firstly, we may conclude that in industries where a larger amount of data was available, I identified a greater fragmentation in terms of clusters. For example, in industries G and M. Secondly, the presented results allowed for a preliminary conclusion that the countries forming the single-element groups were not similar in terms of the analysed indicators to any of the other clusters enough to create a homogeneous group with them. A particular lack of homogeneity in relation to other EU countries was visible in Romania, which, in the case of each

industry (except G), formed a separate single-element cluster. This may indicate a significantly different level of innovation activity in the service industries of this country. However, at this research stage, it was not possible to determine whether the level was significantly different. Based on the values of the analysed indicators of the Romanian service industries, we may assess that they were mostly at the lowest or one of the lower levels in the entire EU. One of the reasons for this situation in Romania was undoubtedly the fact that the corporate sector conducted only 29% of research, and the entire Romanian innovation system is based, in general, on the public sector. Moreover, this country was characterised by the second lowest intensity in the implementation of R&D activities – efficiency at the level of 25% of the assumed goal for 2020, which was set at 2% of GDP (Maier & Maier, 2018).

In general, the classification of countries according to the innovation activity of the service sector was similar to the groups of countries defined on the basis of SII (European, 2023). Therefore, we may conclude that, apart from defining the level of innovativeness at the macroeconomic level, SII also reflects the general distribution of innovativeness in the service sector. This phenomenon was most visible in the case of the J industry.

The result of the cluster analysis allows for two-way conclusions. Firstly, the identified clusters of countries were internally homogeneous in terms of innovation activity, which the results of the analyses presented so far have confirmed. The second direction is not clearly defined, although it can potentially be assumed that the clusters of EU countries were externally different. However, at this research stage, it was not possible to make an unambiguous diagnosis, estimate, or draw conclusions about the significance of differences between individual clusters of countries at the level of individual service industries. However, I ensured it with the implementation of the next stage specified in the research approach.

Differences in Countries in Terms of Innovation Activities Carried out in Individual Branches of the Service Sector

To comprehensively implement the main research assumptions, apart from the discussed results regarding the internal homogeneity of country clusters, it was also necessary to define potentially occurring differences between them. I defined these differences within individual industries of the sector by comparing clusters of countries in a peer-to-peer configuration (for example, in G industry, I identified four clusters, so differences could potentially occur in the following six cluster configurations: 1-2, 1-3, 1-4, 2-3, 2-4, and 3-4. Generally, I noted that statistically significant differences between clusters of countries occurred in the vast majority of cases in each section of the service sector examined. However, I observed a diversified level of this differentiation (Table 5).

Table 5. Clusters of EU countries between which statistically significant differences in innovation activity were defined in individual service industries

Service sector section		G	M	K	J
Pairs of clusters between which statistically significant differences were defined	The number of statistically significantly different pairs	6	6	9	12
	% of clusters that are statistically significantly different in the number of all possible cluster configurations	6/6=100	6/6=100	9/10=90	12/15=80

Source: own study.

Based on the presented results, we can conclude that in industries G and M there was the greatest statistically significant difference between the defined clusters of countries. Differences between all examined cluster configurations in the wholesale and retail trade sections; repair of motor vehicles and motorcycles were statistically significant in at least one of the examined indicators. Based on the adopted methodology, 1 out of 2, 3, 4 and 2 out of 3, 4 were considered to be significantly different pairs of clusters – 8/15 indicators that were statistically different (Table 6).

Based on the presented data, we can conclude that cluster 1 (Croatia, Czechia, Portugal) was the most externally diversified in section G. The level of innovation activity in this industry in the above-mentioned countries was the highest. The evidence for it was the highest average values (compared

to the other clusters) of all tested measures. The average values of indicators in Croatia, Czechia, and Portugal were higher than in the countries from clusters three and four at least twice, *e.g.,* PrI indicator, respectively: 50.3% (cluster 1); 25.6% (cluster 3) and 12.5% (cluster 4) or FNIEI, respectively: 28.4%; 8.2%; 8.6%. These data confirmed the existence of significant differences between the mentioned clusters and, therefore, within the industry. Thus, the pro-innovation policy addressed to G industry enterprises should be clearly differentiated in the case of countries representing clusters 1, 3 and 4, and at the same time, as indicated by Levene's test, homogeneous within the clusters of these countries. In the professional, scientific and technical activities industry, similarly to G, I observed that in all compared pairs of clusters, there were statistically significantly different indicators – 100% (Table 5). In this respect, this industry did not differ from G. However, significant differences in the level of innovation activity in M industry were on a relatively smaller scale. Two configurations were considered significantly different clusters: 1 and 3 and 1 and 4 (Table 7).

Table 6. Statistically significant differences in innovation activity between clusters of EU countries in G industry (in the number of indicators studied in the period 2018-2020)

Cluster no.	1	2	3	4
1	X	**9**	**14**	**14**
2	**9**	X	**9**	**14**
3	**14**	**9**	X	3
4	**14**	**14**	3	X

Source: own study based on the results of the Student's t-test and the Statistica 13 program.

Table 7. Statistically significant differences in innovation activity between clusters of EU countries in M industry (in the number of indicators studied in the period 2018-2020)

Cluster no.	1	2	3	4
1	X	3	**14**	**12**
2	3	X	7	2
3	**14**	7	X	3
4	**12**	2	3	X

Source: own study based on the results of the Student's t-test and the Statistica 13 program.

As in the case of the previously analysed industry, the results of the Student's t-test were consistent with the calculations of the average value for individual indicators. Cluster 1 (Czechia, Croatia, Italy, Portugal, Sweden) differed significantly from Romania – cluster 4 (12 significantly different indicators) or group 3 (14 indicators). A significantly higher level of innovativeness (at least 2 times up to 6 times) characterised countries from cluster 1 compared to, for example, 4. I identified the greatest differences in relation to the so-called indicators of innovation activity, *e.g.,* PI (51.8% to 8.6% in Romania), IEI or IAEI. In the configurations between the remaining clusters, I identified no eight or more statistically significant indicators, and therefore, in accordance with the methodology used in the study, I could not classify pairs of these clusters into significantly different ones. In view of the above information, it is justified to design assumptions of a pro-innovation policy that is diversified depending on the cluster of countries and, at the same time, homogeneous within its internal framework.

The level of statistically significant differentiation in the field of innovation activities, identified in the financial and insurance activities section, was lower than in the previously discussed industries. It defined nine pairs of clusters (90%) in which at least one indicator was statistically significantly different (Table 5). Analyzing the results of the Student's t-test, it should be noted that I observed no significant differentiation in the pair of clusters 4 and 5 (Table 8).

Based on the statistics, we can conclude that in K, I observed the greatest disproportions in relation to the other clusters in the countries belonging to group 1 – Greece, Cyprus, Portugal, Czechia, Germany, Belgium, Italy, Austria, which varied significantly in the range of 11 up to 13 indicators. Comparing clusters 1 with 5 (Romania), I observed no significant disproportions in the case of the four tested

measures. Considering in detail the average values of all indicators in clusters 1 and 5, they were characterised by diametrically different levels of innovation activity. Based on the estimated indicators, the countries aggregated in cluster 1 were characterised, on average, by approximately four times higher levels of innovation activity than in Romania. At the same time, group 1 was most significantly differentiated in relation to cluster 3 in the case of 86.7% of the examined indicators. In K industry, I identified a pair of clusters that differed in terms of eight indicators, and this occurred between groups of countries 3 with an average level of innovation activity and 5. As a result of the analysis of data from K industry, we should conclude that the innovation policy applied to countries from clusters 4 and 5 could have a universal character due to the lack of significant differentiation between them. On the other hand, countries from cluster 1 definitely require different strategic assumptions regarding innovativeness, different from other groups of countries. The last industry analysed was information and communication. Based on the data, this was the least diversified industry in terms of innovation activities because it identified the smallest percentage of cluster pairs with statistically significant differences – 80% (Table 5). Furthermore, in industry J, I diagnosed seven cluster configurations and considered them significant from the perspective of the methodology adopted in the study (Table 9).

Table 8. Statistically significant differences in innovation activity between clusters of EU countries in K industry (in the number of indicators studied in the period 2018-2020)

Cluster no.	1	2	3	4	5
1	X	**12**	**13**	2	**11**
2	**12**	X	7	6	3
3	**13**	7	X	7	**8**
4	2	6	7	X	0
5	**11**	3	**8**	0	X

Source: own study based on the results of the Student's t-test and the Statistica 13 program.

Table 9. Statistically significant differences in innovation activity between clusters of EU countries in J industry (in the number of indicators studied in the period 2018-2020)

Cluster no.	1	2	3	4	5	6
1	X	2	5	3	**12**	**13**
2	2	X	**8**	**9**	7	**12**
3	5	**8**	X	0	**8**	0
4	3	**9**	0	X	**8**	0
5	**12**	7	**8**	**8**	X	7
6	**13**	**12**	0	0	7	X

Source: own study based on the results of the Student's t-test and the Statistica 13 program.

In the information and communication section, it is difficult to clearly indicate a cluster that is significantly different from the others. The greatest disproportions occurred in the case of cluster 1 (Czechia, Belgium, Netherlands, etc.). Analyzing this cluster, we should conclude that it was the most diversified compared to clusters 5 and 6 – Romania, which we should consider definitely less innovative, respectively: approximately 0.5 times and even 8 times in the case of Romania and the SIEI indicator. It is worth adding that in the literature on the subject, Maier (2018) notes that J industry in Romania is considered one of the most innovative service industries in terms of the share of innovative enterprises in their total number – 26.0%. Based on the research that is the subject of this study, the most innovative industry in the Romanian service sector, in terms of the mentioned measure, was section J. The difference in this indicator identified in the research between Romania (17.9%) and, for example, Cyprus (79.6%) was over four times higher.

I identified the largest number of significantly different pairs in cluster 5 (Bulgaria, Hungary, Spain, Poland, Slovakia, etc.). Apart from the fact that cluster 5 was significantly differentiated in relation to cluster 1, it also showed differentiation in relation to clusters 3 (Croatia) and 4 (Cyprus). Between

groups 5 and 3 and 4, I diagnosed eight statistically significantly different measures. Analyzing the average values of individual indicators, the significant difference between these groups resulted mainly from the significant disproportion in the indicators relating to individual types of business process innovations (in Table 2, no. 9-15), which were significantly lower in group 5. At the same time, in J industry, group 3, *i.e.,* Croatia, was the most innovative, while slightly worse results emerged for cluster 1, consolidating eight countries. To sum up the analysis concerning section J, the countries aggregated in clusters 3, 4, and 6 were not significantly differentiated from each other. Therefore, the assumptions of the innovation policy towards them could be of a universal nature and similar in scope.

To assess the degree of internal homogeneity of country clusters and the level of differentiation between them, one needs to consider the following in parallel within the service sections studied:

- analyses conducted on the degree of internal homogeneity of clusters of countries,
- the scale of significant differences occurring between defined clusters of countries.

The conducted research proved that the sections of the skateboard of services showcased a much higher degree of internal homogeneity within the defined clusters than by external differentiation between them, as presented in Table 10.

Table 10. Level of similarity of innovation activity within clusters of EU countries (in % of indicators from the 2018-2020 period) and differentiation between them (in % of possible comparisons between clusters in the scope of service industries)

Homogeneity/Diversity	industry G	industry J	industry K	industry M
Homogeneity within clusters (in %)	12/15=80	13/15=86.7	14/15=93.3	15/15=100
Pairs of clusters between which significant differences have been defined	5/6=83.3	7/15=46.7	4/10=40	2/6=33.3

Source: own study based on Table 4 and Tables 6-9.

The professional, scientific and technical activities (M) industry was the most internally homogeneous. At the same time, it displayed the lowest differentiation level – 33.3% (Table 10). As the second sector in this classification, we can consider the K industry, which groups companies active in the field of finance and insurance. Companies from sections J and G demonstrated homogeneity of innovation activity at the level of 86.7% and 80%, respectively.

We recorded the lowest similarity index (46.7%) in H industry. Therefore, it was not the subject of further consideration (Table 3). In this industry, the calculated significant differentiation index was also the lowest – 28.6%. In industry J, significant differences were observed in 7 configurations of country pairs, but this constituted less than half of the potentially possible comparisons (46.7%). Diversity rates for the remaining sections were even lower.

Considering endogenous homogeneity and exogenous diversity simultaneously, we can conclude that the most similar scales of these phenomena regarded G industry. A similarity of 80% meant that as many as 12/15 of the examined indicators of innovation activity were similar to each other in the defined clusters. In this industry, I also identified the greatest differentiation considered significant. It occurred in as many as 83.3% of possible pairs of clusters.

CONCLUSIONS

Based on the presented research material and analyses, I achieved the research goal, which was to identify and assess the degree of homogeneity and diversity of EU countries in terms of innovation activity in sections of the service sector. In this respect, the assumptions of the next three specific objectives were fulfilled. As a consequence of the research procedure used and the results obtained, I drew the following conclusions:

- EU countries' service sectors are characterised by internal homogeneity in terms of innovation activity – objective 1,
- I observed the highest degree of homogeneity in industries M, K, J, G and H.

- we can aggregate the EU countries in terms of individual service sections into homogeneous clusters in terms of innovation activity (countries belonging to them and their numbers are different) – objective 2,
- as a result, it is possible to develop universal assumptions for individual groups of pro-innovation policy supporting the activities of enterprises operating in individual sections of the service sector,
- the greater the data availability, the more fragmented clusters I identified (H, J, K industries),
- clusters of EU countries were generally statistically significantly different – objective 3,
- the most significantly differentiated clusters of countries were those identified in industry G, where I observed the largest number of significantly different cluster pairs,
- I identified the differences between clusters of countries, which allowed me to conclude that the developed innovation policy assumptions may be specific to different clusters of countries in terms of different service industries,
- defined clusters of countries were characterised to a greater extent by the phenomenon of internal homogeneity than by significant differentiation in terms of innovation activity. This may prove a strong concentration of innovativeness indicators at a similar level in the identified clusters of countries,
- I identified similarity and significant differentiation of innovation activity at a similar level in section G, 80% of similar indicators and 83.3% of significantly different pairs of clusters, respectively.

The implementation of the auxiliary objectives ensured the fulfilment of the assumptions of the main objective, which, together with the proposed research approach, enabled a positive verification of the research hypothesis formulated in the study. In the EU there are clusters of similar countries (in terms of service sector innovation activity), which can be combined into internally homogeneous clusters and, at the same time, externally different. Therefore, there were homogeneous countries in which we can group the EU countries into clusters that are internally homogeneous and, at the same time, externally different in terms of innovation activity. The presented results can constitute guidelines for policy-makers in the development of instruments and tools to support innovation activities of a universal nature, common in individual clusters of countries. Such a situation may occur in virtually every of the analysed industries of the service sector due to high homogeneity indicators, with the exception of the H industry. On the other hand, innovation policy instruments may have a specific character due to the fact that they will be directly 'dedicated,' to adapted and dependent on the operating conditions of economic entities in a given industry of the service sector.

From the perspective of the discussed issues, it seems that interesting and future research may aim at developing this issue by:

- developing assumptions of pro-innovation policy in relation to service sector enterprises for individual clusters of countries,
- estimating the level of innovation activity in individual industries of the service sector within defined clusters or regardless of this division,
- an attempt to identify and analyse indicators differentiating the innovation activities of individual clusters of countries in selected service industries,
- identification of similarities and differences between EU countries carried out for each service industry separately, then there will be a possibility of detailed interpretation of individual indicators of innovation activity, and the choice of industry for research may be determined by, for example, the specificity of the development of smart specializations in EU countries, the regional level of a given industry, the date of country's accession Member State to the Community etc.

The presented considerations are subject to certain limitations. These include the fact that the validity of the data used for analyses depends strictly on the date of publication by Eurostat. The second limiting factor is their incompleteness. A research limitation may also be the determination of the cut-off point at the level of the so-called 'significant difference in bonding distance,' which may seem somewhat subjective and which is visualised on the agglomeration graph.

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Use of Artificial Intelligence

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