

Digital transformation and competitiveness of SMEs

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1. Introduction

The theoretical part of the paper focuses on defining the fundamental concepts related to digital transformation processes, digital maturity models, the Digital Economy and Society Index (DESI), and the identification of barriers to digital transformation in SMEs.

1.1 Digital Transformation

In both practice and research, related but conceptually distinct terms are often conflated. Therefore, the concept of digital transformation in small and medium-sized enterprises (SMEs) requires a clear definition. Digitization refers to the mere conversion of analogue information into digital form and represents a basic technical step rather than a strategic change (Aramburu et al., 2021). Digitalisation involves the use of information and communication technologies to improve business processes, customer interactions, or operational efficiency, and typically constitutes a gradual and partial organisational change (Aramburu et al., 2021; Marczevska and Weresa, 2023). In contrast, digital transformation represents a comprehensive strategic reconfiguration of the firm's operations, in which technologies, value propositions, processes, and managerial practices evolve jointly with the aim of creating new business models and strengthening competitiveness (Hassan et al., 2020; Wiesner et al., 2018).

The digital transformation of SMEs can be divided into three main dimensions:

- Technological - the implementation of information and communication technologies (ICT), cloud solutions, IoT, smart automation, and Industry 4.0 tools (Kádárová et al., 2025).
- Human capital - the development of employees' digital skills and competencies and their ability to adapt to new technologies (Romero and Mammadov, 2025).
- Organisational-strategic - the transformation of business processes, innovation management, and strategic planning (Skare et al., 2023).

Small and medium-sized enterprises, which constitute a significant part of EU economies, play a key role in job creation and are important actors in the diffusion of innovation, the enhancement of regional competitiveness, and the strengthening of economic resilience (Brodny and Tutak, 2022; World Bank, 2023). In the current digital era, they face pressure to adapt to new technological conditions in order to remain competitive and maintain their market position (European Commission, 2023).

Digital transformation involves the integration of digital technologies into all areas of business activity, enabling firms to improve efficiency, flexibility, and innovation potential (Romero and Mammadov, 2025).

Given their prevalence and employment structure, SMEs are a natural target of European digitalisation policies, particularly in the

context of the twin transition that links digital and sustainable changes (Brodny and Tutak, 2022; Mohar Bastar, 2023).

The competitiveness of SMEs is measured by productivity, exports, flexibility, the ability to adapt to market changes, and sustainable growth (Kádárová et al., 2025). Digital transformation enables firms to increase process efficiency, reduce costs, and improve access to customers and markets (European Commission, 2023).

In the context of rapid digitalisation and global competition, digital transformation is becoming an increasingly important issue for SMEs in ensuring their future competitiveness and sustainability.

1.2 Digital Maturity Models

The pronounced heterogeneity of SMEs fundamentally affects their ability to adopt and utilise digital technologies. Structural characteristics-including sectoral specialisation, firm size, existing processes, limited research and development capacities, managerial capabilities, and regional differences in infrastructure-explain much of the cross-country variation in digital maturity (Brodny and Tutak, 2022; World Bank, 2023). This heterogeneity also indicates that universal policy instruments are insufficient. Effective support measures must be tailored to sector-specific conditions, firm size categories, and the characteristics of national digital ecosystems (Mohar Bastar, 2023).

Distinguishing between strategic and technological perspectives is essential in SME research. Strategic approaches emphasise managerial vision, the innovativeness of business models, and the development of organisational capabilities, whereas technological approaches focus on infrastructure, tools, and technical implementation (Aramburu et al., 2021; Wiesner et al., 2018). In this context, digital maturity models have become both diagnostic and strategic instruments that allow the monitoring of SMEs' progress through individual phases, from the initial recognition of the need for change, through the adoption and integration of technologies, to deeper transformation

of business models (Petzolt et al., 2022; Wiesner et al., 2018). Validated maturity models tailored to SMEs highlight organisational factors, strategic orientation, and managerial capabilities alongside technical indicators, reflecting the fact that technology alone does not guarantee a successful transformation (Hasan et al., 2020; Petzolt et al., 2022).

1.3 Digital Economy and Society Index (DESI)

The European Commission regularly monitors the level of digital competitiveness across EU member states through the Digital Economy and Society Index (DESI). The index serves to compare EU countries in the areas of the digital economy and society. The monitored indicators reflect the main policy initiatives in digitalisation, particularly the Digital Compass for 2030 across four key dimensions: skills, infrastructure, business digital transformation, and public services. The index makes it possible to assess the overall level of digitalisation within a given member state. Owing to the division of these four dimensions into specific sub-dimensions and indicators, the index also identifies problematic areas that require increased policy attention.

However, Slovakia has for several years been ranked below the EU average, indicating challenges in the adoption of digital solutions, particularly among SMEs.

1.4 Barriers to Digital Transformation in SMEs

Despite the recognised benefits, SMEs face several empirically documented barriers to digital transformation, particularly the lack of digital skills, financial constraints, cybersecurity concerns, and limited managerial capacities.

Conversely, factors supporting successful transformation include managerial commitment, cooperation with external consultants and universities, and effective access to digital technologies (Skare et al., 2023; Kádárová et al., 2025).

Lack of digital skills: Multivariate analyses of large enterprise samples consistently show that available digital skills significantly influence the level of technology adoption (Omrani et al., 2022). A Czech study revealed a negative correlation between digital literacy and progress in transformation, suggesting that the problem lies more in implementation capabilities than in the lack of strategic intent (Civelek et al., 2023). These challenges are further amplified by managerial shortcomings: approximately 20% of Greek SMEs reported that they do not have a designated person responsible for digital transformation, pointing to internal capacity and governance gaps (Kargas et al., 2023).

Financial constraints: The lack of financial resources and limited investment capacity are among the most frequently cited barriers in international comparisons. Empirical findings from Greece as well as policy recommendations confirm that financing is one of the main obstacles to the adoption of new technologies (Kargas et al., 2023; World Bank, 2023). Macro-level efficiency analyses further suggest that limited investment possibilities reduce the real economic benefits of digitalisation for SMEs compared to larger firms (Kyshakevych et al., 2024).

Cybersecurity: Although security concerns regularly appear in studies on SMEs, empirical data on actual security incidents or losses remain scarce. None of the studies identified a significant relationship between security measures and progress in digital transformation, indicating mixed or context-dependent effects (Civelek et al., 2023).

Managerial barriers and resistance to change: Managerial involvement, strategic orientation, and the organisation's cultural readiness repeatedly emerge as decisive factors in successful digital transformation (Kargas et al., 2023; World Bank, 2023; Ojonugwa et al., 2021). Practice-oriented recommendations therefore emphasise the need for targeted development of managerial capacities and systematic training of decision-makers to reduce resistance to change

and accelerate technology adoption (World Bank, 2023).

These findings indicate the need for multi-level interventions: the systematic development of digital skills and clear assignment of responsibilities within the firm, targeted financial instruments, support in the area of cybersecurity, and comprehensive managerial education.

Based on the reviewed literature, digital maturity in SMEs is not determined solely by access to digital technologies, but primarily by organisational readiness, managerial capabilities, and the ability to integrate technologies into core business processes. These theoretical insights provide a framework for interpreting empirical indicators of SME digitalisation, such as those captured by the Digital Economy and Society Index (DESI). In particular, differences in the adoption of ERP systems and cloud computing can be understood as manifestations of deeper organisational and capability-related barriers.

2 Material and methods

The practical part of the article is based on secondary data available in the Digital Economy and Society Index (DESI) and Eurostat databases. We included five indicators in the analysis, capturing key dimensions of the digital transformation of small and medium-sized enterprises (SMEs) in EU member states:

- Cloud computing - measures the share of enterprises using at least one advanced cloud service (ERP, CRM, accounting applications, security applications, database hosting, or cloud platforms for software development).
- SMEs selling online - the share of SMEs that generate at least 1% of their turnover through electronic sales.
- Electronic information sharing (ERP) - the share of SMEs using an ERP system that enables information sharing across different functional areas (e.g., accounting, planning, production, marketing).
- Social media use - the share of SMEs using at least two forms of social media (social

networks, blogs, microblogs, multimedia platforms, wiki tools).

- E-commerce turnover - the share of total SME revenues generated through electronic commerce.

All indicators refer to enterprises with 10 to 249 employees in manufacturing and service sectors, excluding the financial sector. The data analysis was conducted using descriptive and comparative methods, comparing the position of Slovakia with the EU-27 average and V4 countries. The aim was to assess the extent to which the level of digital adoption among SMEs in Slovakia corresponds to the barriers and effects of digital transformation identified in the theoretical framework.

3 Results and Discussion

According to the latest DESI data, there are substantial differences among EU member states in the extent to which SMEs use digital technologies.

3.1 Cloud computing

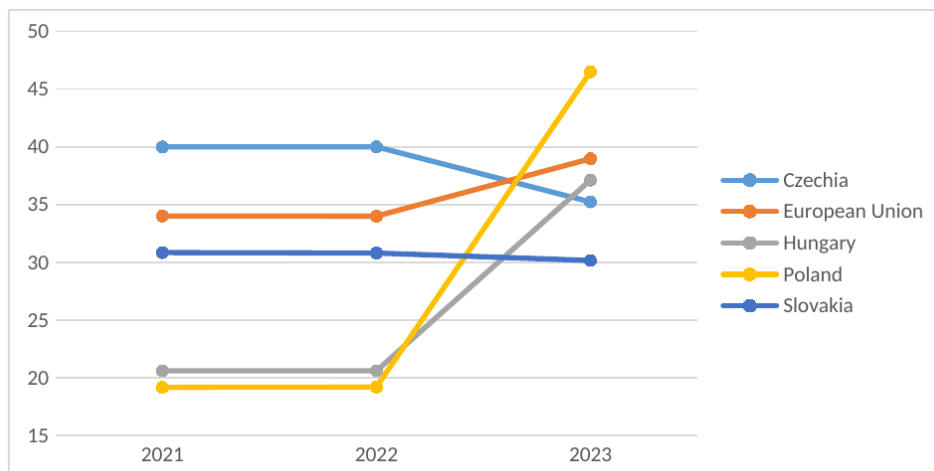
Cloud computing is one of the key indicators of business digitalisation, as it enables rapid scalability, data integration, and reduced costs for IT infrastructure.

The cloud computing indicator measures the share of enterprises using at least one advanced cloud service. These include, in particular, cloud applications for accounting and finance, enterprise information systems (ERP), customer relationship management systems (CRM), security applications, enterprise database hosting, and cloud platforms for developing, testing, and deploying software solutions.

According to DESI data for 2023, cloud services were used by:

- Slovakia: 30.16%
- EU average: 38.97%
- Average of the other V4 countries: 39.62%

Figure 1 » *Cloud computing among SMEs in V4 countries*



Source: DESI

The available data (Figure 1) show that Slovakia uses cloud services to a lesser extent than both the EU average and the other V4 countries. The lower intensity of cloud use indicates more cautious investment by SMEs in technol-

ogies that require process changes as well as a qualified workforce.

3.2 SMEs selling online

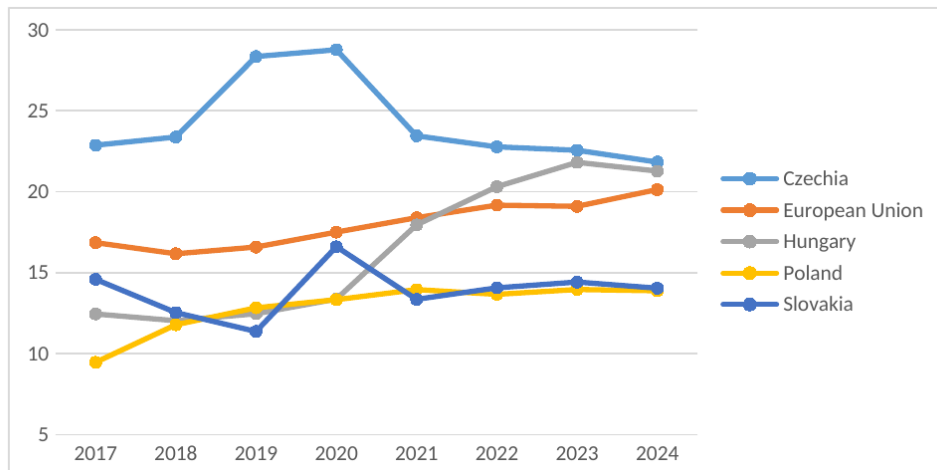
The SMEs selling online indicator captures the share of small and medium-sized enterprises

that generate at least 1% of their turnover through electronic commerce. It is a fundamental measure of the use of digital business models and the ability of SMEs to penetrate the online market, which is one of the key elements of competitiveness today.

According to DESI data for 2024, Slovakia performed below both the EU average and the other V4 countries:

- Slovakia: 14.04%
- EU average: 20.13%
- Other V4 countries: 18.99%

Figure 2 » SMEs selling online in V4 countries



Source: DESI

The data show that Slovakia performs below average in this indicator compared to EU member states and the other V4 countries (Figure 2). This gap suggests that Slovak SMEs use electronic commerce less intensively than their regional and European competitors. This finding is particularly important because online sales represent one of the fastest and most accessible ways for SMEs to expand their markets, increase visibility, and strengthen export performance.

3.3 Electronic information sharing (ERP)

ERP systems are one of the key tools of digital transformation, as they enable the integration of business processes, data consolidation, and efficient interconnection of different functional areas within an enterprise. In the context

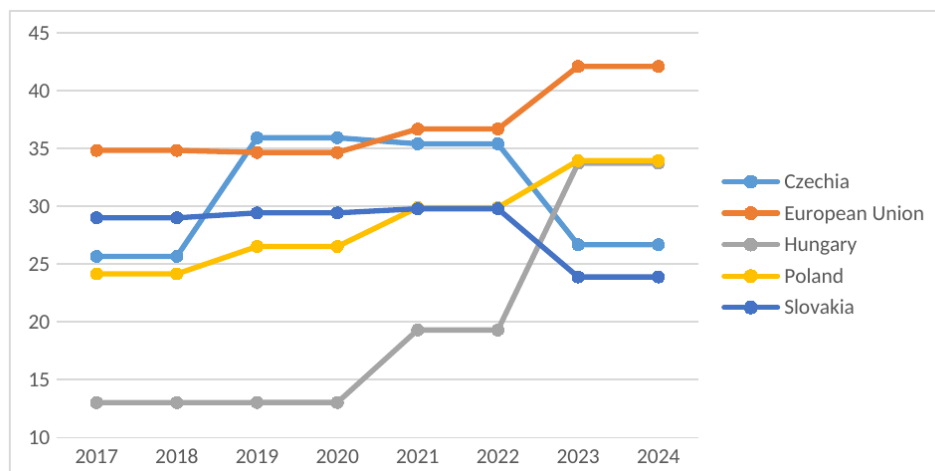
of small and medium-sized enterprises, ERP systems are particularly important for enhancing internal efficiency, transparency, and coordination across accounting, planning, production, logistics, and marketing.

The Electronic information sharing indicator measures the share of SMEs that use an ERP system enabling electronic sharing of business information across these areas, which is a crucial prerequisite for further forms of digitalisation, including automation, data analytics, and advanced process optimisation.

According to DESI data for 2024, ERP systems were used as follows:

- Slovakia: 23.88%
- EU average: 42.09%
- Other V4 countries: 31.44%

Figure 3 » Electronic information sharing (ERP) among SMEs in V4 countries



Source: DESI

The low rate of ERP system use in Slovakia (Figure 3) supports the argument that the technological readiness and investment capacity of Slovak SMEs are weak. ERP systems constitute essential infrastructure for advanced forms of digitalisation; therefore, their limited adoption may restrict the long-term competitiveness of Slovak SMEs, particularly in terms of productivity, innovation, and the ability to respond quickly to market changes.

3.4 Social media use

Social media are among the least costly digital tools, requiring neither substantial changes in business processes nor significant investments in IT infrastructure or specialised competencies. For this reason, they are attractive to SMEs as a first step in digitalising marketing communication and building customer relationships.

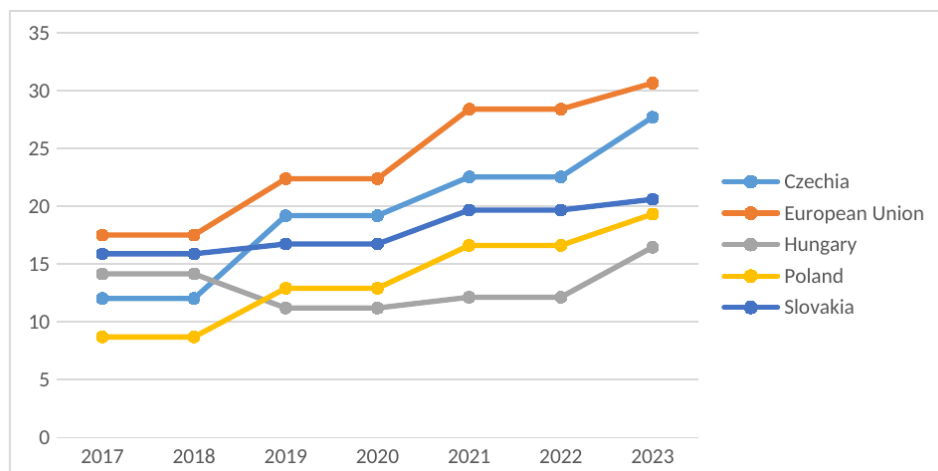
The Social media use indicator reflects the share of SMEs that actively use at least two forms of social media, such as social networks, corporate blogs or microblogs, multimedia-sharing platforms, or wiki tools for knowledge exchange. The enterprise must have an account, profile, or licence required to use the given platform.

According to DESI data for 2023, social media were actively used by:

- Slovakia: 21.15%
- EU average: 30.64%
- Other V4 countries: 21.15%

Slovakia is below the EU average in this area, although its result is comparable to the average of the other V4 countries (Figure 4). This suggests that the use of social media by SMEs is relatively widespread in the Central European region, but not to the same extent as in Western EU countries.

Figure 4 » Social media use among SMEs in V4 countries



Source: DESI

3.5 E-commerce turnover

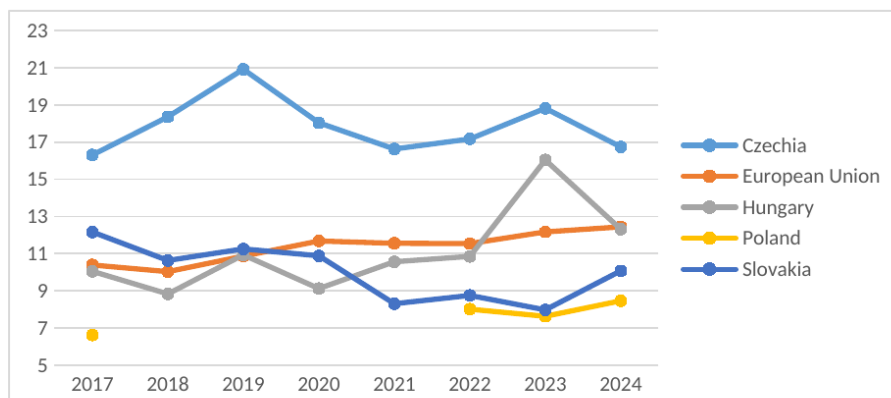
The E-commerce turnover indicator represents the share of total SME revenues generated from electronic sales. This indicator provides a more precise view of the extent to which SMEs are able to monetise their online presence. Unlike the basic e-commerce participation measure (SMEs selling online), which captures only whether a firm sells online, e-commerce

turnover reveals the intensity and commercial significance of digital sales.

According to DESI data for 2024, revenues from electronic sales reached the following levels:

- Slovakia: 10.07%
- EU average: 12.44%
- Other V4 countries: 12.5%

Figure 5 » E-commerce turnover among SMEs in V4 countries



Source: DESI

The graph shows that Slovakia lags behind both the EU average and the average of the V4 countries in this indicator as well (Figure 5). Although the difference is not substantial, it indicates that Slovak SMEs generate a slightly lower share of their revenues through electronic channels compared to their regional competitors.

3.6 Discussion of the Comparative Analysis Results

The results of the V4 comparison show that the digital transformation of SMEs is progressing unevenly and that its pace is strongly influenced by differences in technological readiness, investment capacity, organisational capability, and the level of available digital skills.

First, Slovakia lags behind in technologically and organisationally more demanding forms of digitalisation, which is most evident in the indicators for cloud computing and ERP systems. Both technologies require not only financial investment but also a functional internal infrastructure, stable processes, and the ability of firms to integrate digital solutions across departments.

Second, the Czech Republic emerges as the most digitally advanced country in the V4 region. This difference can be explained by a longer tradition of using information systems, a more developed service ecosystem, higher availability of digital competencies, and stronger technological infrastructure.

Third, Slovakia and the other V4 countries show similar values in technologies with low implementation requirements, particularly in the use of social media and, to some extent, e-commerce. These are tools that are financially accessible and do not require deep process changes or a high level of specialised skills.

Fourth, the gap between the share of SMEs selling online and the share of revenues generated from e-commerce (e-commerce turnover) points to an important aspect of digitalisation: although Slovak SMEs do enter the online space to some extent, they are unable to monetise it fully. This suggests limited digital marketing strategies, weak orientation toward de-

veloping online sales, and insufficient integration of logistics and order-processing functions.

Finally, the overall results show that all V4 countries lag behind the EU average particularly in the more complex forms of digitalisation, especially in areas requiring higher technological, organisational, and investment readiness. Overall, the findings clearly demonstrate that the digital transformation of SMEs is not merely a technical challenge but above all an organisational, competency-related, and strategic one, with differences among the V4 countries reflecting the degree to which enterprises are prepared to progress to higher levels of digital maturity.

Empirical findings from other authors likewise point to substantial differences in the adoption of ICT and the use of digital tools among SMEs across EU countries. Comparative analyses based on Eurostat indicators and composite digital intensity indexes confirm wide disparities between older and newer member states, with Northern European and Benelux countries achieving significantly higher levels of SME digital maturity (Aramburu et al., 2021; Brodny and Tutak, 2022). In 2022, the leaders in digital intensity included Denmark, the Netherlands, Sweden, Finland, Malta, and Belgium, with nearly 40% of SMEs in these countries reaching high levels of digital intensity (Ivanova and Marinov, 2022). The most widespread tools are cloud services, basic e-commerce solutions, and customer relationship management (CRM) systems, whereas integrated enterprise information systems (ERP) and advanced analytical capabilities are used considerably less (Brodny and Tutak, 2022; Kyshakevych et al., 2024). SMEs also lag behind large enterprises over the long term in several indicators of both digital and sustainable transformation (Mohar Bastar, 2023).

Extensive empirical analyses have identified the key determinants of digital technology adoption. A study covering 15,346 SMEs from both EU and non-EU countries showed that technological readiness, existing innovation capacity, available digital skills, and financial resources constitute the main organisational

factors influencing the adoption of digital technologies, while external pressures such as regulation or competition play a relatively smaller role (Omrani et al., 2022). Existing IT infrastructure and organisational absorptive capacity are decisive prerequisites for advancing to more complex forms of digitalisation; enterprises lacking these foundational capabilities have a significantly lower likelihood of progressing to higher levels of digital maturity (Omrani et al., 2022; Petzolt et al., 2022).

A growing body of empirical studies shows that higher digital maturity is associated with more intensive innovation activity, experimentation with business models, and improvements in several indicators of firm performance, although the causal mechanisms have not yet been conclusively confirmed. Digital transformation affects SME competitiveness through several channels: increases in productivity, the development of innovation capacity, strengthened export performance, and the reconfiguration of business models.

Productivity and growth: Country-level models based on Data Envelopment Analysis (DEA) indicate that economies with higher SME digital intensity exhibit better aggregate outcomes in GDP per capita and export indicators. However, the economic benefits of digitalisation are more pronounced for large firms than for SMEs (Ivanova and Marinov, 2022; Kyshakevych et al., 2024). The literature also shows that causal estimates of the impact of specific digital technologies on SME productivity remain limited.

Innovation capacity: Digital maturity is a significant predictor of innovation outcomes. A large German sample (1,077 firms) confirmed that a higher degree of digital transformation is associated with stronger innovation performance, with digitally mature SMEs more frequently bringing new products or services to the market (Hassan et al., 2020). The mechanisms linking digitalisation with innovation include the use of data analytics for idea generation and market monitoring, the integration of digital processes enabling rapid prototyping, and platform-based forms of collaboration that

support knowledge combination (Hassan et al., 2020; Cannas, 2021).

Export performance: Digital tools create opportunities for new sales channels and broader paths to internationalisation. Country-level analyses show that states with a higher share of digitally intensive SMEs and stronger export indicators exhibit different efficiencies in the linkage between digitalisation and export performance. This suggests that the national context and firms' complementary resources moderate the relationship between SMEs' digital investments and their export outcomes (Ivanova and Marinov, 2022; Kyshakevych et al., 2024).

Business model transformation: An empirical study on a sample of 338 European SMEs showed that the use of social media and big data analytics supports business model innovation (BMI) and improves performance, with case studies documenting data-driven changes in value propositions and customer engagement strategies (Bouwman et al., 2018). Assessments of digital maturity in a sample of German SMEs (310 firms) likewise show a relationship between the level of digital maturity and observed changes in business models, providing a framework for systematically formulating strategies (Ojonugwa et al., 2021).

4 Conclusion

The aim of the article was to compare the level of digital transformation of small and medium-sized enterprises in Slovakia with the other V4 countries and the EU average, based on selected DESI indicators. The theoretical part highlighted the importance of digital maturity, technological readiness, organisational processes, and the availability of digital skills for the successful digital transformation of SMEs. The empirical analysis showed that Slovakia lags primarily in areas requiring complex technological implementation and process integration (cloud computing, ERP). By contrast, in technologies with low implementation requirements (social media), Slovakia approaches the V4 average. The best results are achieved by SMEs in the Czech Republic, which confirms the importance of technological

infrastructure and a more developed digital ecosystem.

The results of the analysis showed that the digitalisation of SMEs in Slovakia lags significantly behind the EU average, which represents a major competitive disadvantage for many firms, particularly in areas requiring integrated information systems and cloud-based solutions. However, unless enterprises and public institutions systematically engage in digital transformation, whether through infrastructure development, investment in human capital, or support for the adoption of advanced technologies, the soft digitalisation of Slovakia may lead to a loss of competitiveness, particularly in comparison with firms from countries with higher digital maturity.

On the other hand, there is a real opportunity for Slovak SMEs to make use of current programmes (the Digital Decade, EDIHs, investments from EU funds), increase their digital intensity, and thereby improve their position in both domestic and international markets.

Future research should analyse sectoral differences among SMEs, map long-term digitalisation trends, and identify the factors that enable some firms to achieve higher digital maturity despite regional and financial constraints.

From a practical perspective, the findings suggest several specific directions for supporting SME digitalisation. First, increasing awareness of digital opportunities through centralised information platforms and diagnostic tools for assessing firms' digital maturity may help SMEs better understand the benefits and requirements of advanced solutions such as ERP systems and cloud services. Second, the results underline the importance of accessible advisory and mentoring support, guiding SMEs through the selection and implementation of integrated digital systems and reducing resistance to organisational change. Third, targeted financial instruments such as digital vouchers, simplified grant schemes, or tax incentives, should prioritise investments into ERP and cloud-based technologies, which remain underutilised due to their higher financial and organisational demands. Finally, training programmes should focus not only on basic digital literacy, but particularly on managerial and employee competencies related to process integration, change management, and the effective use of enterprise information systems. Together, these measures may contribute to a more systematic and sustainable digital transformation of SMEs.

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ABSTRACT

The paper examines the level of digital transformation among small and medium-sized enterprises (SMEs) in Slovakia and compares it with Visegrad countries (Czech Republic, Poland and Hungary). Building on current research on digital maturity, technological readiness and the determinants of digitalisation, the article analyses five indicators from the Digital Economy and Society Index (DESI): cloud computing, SMEs selling online, ERP-based electronic information sharing, social media use and e-commerce turnover. The results show significant differences in the adoption of digital technologies within the V4 region. Slovak SMEs predominantly adopt low-cost and easily implementable solutions, such as social media, while lagging in more complex technologies requiring higher organisational and financial capacity, including cloud services and ERP systems. Compared to the V4 average, Slovakia achieves lower values in all indicators except social media use, with the Czech Republic emerging as the regional leader. The findings support theoretical arguments on the importance of organisational capabilities, digital skills and infrastructural preparedness for successful digital transformation.

KEYWORDS

Digital transformation; SMEs; digital maturity; DESI; cloud; ERP; e-commerce; social media; V4 countries.

JEL CLASSIFICATION

L25; M15; O33