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Business transformation in Slovak companies shaped by digital technology adoption, sustainability orientation and strategic resilience

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ABSTRACT

Research background: Digital transformation has become a strategic imperative for companies worldwide, yet the heterogeneity in adoption patterns remains poorly understood, particularly in transitional economies. Existing research predominantly focuses on large economies, whilst small European countries face distinct institutional environments. The interplay between digital maturity, strategic orientation, and economic performance represents a critical knowledge gap.

Purpose of the article: The study aims to identify distinct clusters of Slovak companies based on their attitudes towards artificial intelligence, sustainability orientation, and strategic resilience. The research determines how these clusters differ in technology adoption, perceived barriers, and economic performance outcomes.

Methods: The study employs quantitative research based on a structured survey of 402 Slovak companies conducted between February and July 2025. The methodological framework integrates k-means cluster analysis using twelve indicators. The optimal two-cluster solution was validated through the elbow method and silhouette analysis, with principal component analysis providing visualization. Chi-square tests examined differences between clusters across technology adoption, barriers, and performance indicators.

Findings & Value added: The analysis reveals a fundamental structural divide within Slovak companies, identifying digitally advanced and traditional companies with significantly different profiles. Advanced companies demonstrate substantially higher adoption of Big Data analytics, ERP systems, and e-commerce platforms. Paradoxically, these companies perceive stronger barriers to transformation, including legal and regulatory uncertainty, implementation costs, system integration issues, and financial and network constraints, revealing a paradox of digital advancement. Most significantly, advanced companies report superior economic performance in turnover and EBIT changes. The research contributes novel evidence from a transitional economy, addressing gaps in comparative digital transformation research. Findings provide actionable insights for policymakers and managers navigating transformation complexities.

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INTRODUCTION

The accelerating pace of digital transformation has reshaped the way companies across the globe compete, organise, and create value (Carroll et al., 2023). In contemporary economies, digitalisation no longer represents a peripheral support function but a strategic imperative that permeates all dimensions of business activity (Becker & Schmid, 2020). Technologies such as artificial intelligence (AI), big data analytics, enterprise resource planning (ERP), and electronic commerce platforms have become critical enablers of operational efficiency, innovation, and market responsiveness. Scholars increasingly stress that digital transformation must be understood as an organisational phenomenon rather than a purely technological one, as its outcomes depend heavily on

leadership, culture, and strategic orientation (Angelopoulos et al., 2023; Vial, 2019). This has placed digital maturity at the forefront of academic and managerial debates, raising questions about why some companies succeed in leveraging digital tools while others remain constrained in their transformation trajectories.

The strategic dimension of digitalisation has attracted particular attention, since companies that pursue digital initiatives in an integrated and future-orientated manner appear to outperform those that approach them as isolated projects (Valero-Gil et al., 2024; Skypalova et al., 2025). Existing research highlights that companies with a stronger digital and strategic orientation are more likely to integrate sustainability goals, develop adaptive capabilities, and achieve long-term resilience in turbulent markets (Valero-Gil et al., 2024; Zhang et al., 2022). At the same time, it is widely acknowledged that digital transformation is accompanied by barriers that vary according to the maturity of adoption. Less advanced companies frequently encounter challenges such as lack of managerial support or resource shortages, while more advanced companies face systemic obstacles including regulatory uncertainty, integration with legacy systems, and mounting pressure to secure returns on substantial digital investments (Herceg et al., 2020). This paradox of digital advancement underscores the need to examine not only the drivers but also the constraints of transformation in order to capture the full complexity of the phenomenon.

Another critical debate in the literature concerns the link between digital maturity and economic performance. Although early studies questioned whether technology investments consistently translate into financial gains, more recent evidence suggests that digital orientation enhances both productivity and profitability, particularly when combined with organisational adaptability (Dedrick et al., 2003; Gao et al., 2024). Companies that embed AI and other advanced tools into their strategic core are often better equipped to maintain turnover and profitability under volatile conditions, positioning digital transformation as both an enabler of innovation and a safeguard against performance decline (Kitsios & Kamariotou, 2021). Despite these advances, the literature remains fragmented in its treatment of digital transformation as a multidimensional construct. Most studies examine technologies, barriers, or outcomes in isolation, leaving unanswered how these dimensions interact to create structural divides among companies.

This research gap is particularly pronounced in the context of transitional economies, such as Slovakia, where companies face unique challenges and opportunities in their digital trajectories. Existing studies have focused predominantly on large economies or sector-specific analyses, while small and medium-sized European countries remain underexplored despite their distinct institutional and competitive environments. Moreover, while clustering techniques have been applied in digital transformation research, few studies integrate attitudinal, strategic, and performance dimensions into a single analytical framework. The lack of such integrative perspectives limits our understanding of how companies differentiate themselves in terms of digital readiness and strategic orientation and how these differences translate into economic resilience.

To situate the study within its national context, it is important to note that Slovakia has adopted a 2030 Digital Transformation Strategy and subsequent action plans that position AI, the Internet of Things, 5G, big data analytics and blockchain as engines of future growth and competitiveness. These documents aim to improve everyday life for citizens and support companies through incentives and reduced bureaucracy. Despite these ambitions, persistent administrative burdens, low awareness of financing opportunities, and unclear institutional vision constitute major barriers to the integration of digital technologies. The interplay between ambitious policy goals and practical constraints highlights the distinctiveness of the Slovak transitional economy and underscores the need to investigate how companies navigate digital transformation (International Trade Administration, 2024).

The present study addresses this gap by employing a cluster analysis of Slovak companies based on survey data that capture attitudes towards AI, sustainability, and strategic resilience. By combining these dimensions, the study identifies distinct groups of companies and examines how they differ in their adoption of digital technologies, their perceptions of barriers, and their reported economic performance. This integrative approach allows us to move beyond narrow perspectives and to capture the structural diversity of digital transformation across companies. The novelty of the article lies in linking attitudinal clustering with concrete outcomes in technology adoption, perceived barriers, and performance, thereby demonstrating that digital and strategic orientation jointly shape the trajectory of business transformation.

The main aim of the study is therefore to explain how Slovak companies can be differentiated into meaningful clusters according to their digital and strategic orientation and to assess how these clusters vary in terms of technology adoption, obstacles, and economic resilience. By doing so, the article contributes to both academic debate and managerial practice, offering new evidence from a transitional economy that enriches comparative research on digital transformation. The findings are expected to advance theoretical discussions on the interplay of technology, strategy, and performance while providing actionable insights for companies and policymakers seeking to strengthen digital competitiveness.

THEORETICAL BACKGROUND

In management scholarship, business transformation denotes a comprehensive process of company restructuring that encompasses fundamental changes to strategy, operations, culture, and values, ultimately redefining how a company operates and competes in its environment. Successful transformation requires sophisticated communication strategies and systematic change management to overcome internal resistance and cultivate sta-

keholder support throughout the transformation journey (Mouzas, 2022). Digital transformation should be understood as a critical catalyst within this broader business transformation framework. It involves the strategic integration of digital technologies across all company domains, necessitating fundamental shifts in mindset, culture, and operational processes to fully leverage the potential of digital capabilities (Angelopoulos et al., 2023). Throughout this article, we employ the term business transformation to denote this comprehensive company reconfiguration, while acknowledging that digital transformation currently represents the primary driver of change among Slovak companies.

Digital transformation has emerged as a central theme in management research, reflecting profound technological, organizational, and strategic changes that reshape how companies operate and compete (Elia et al., 2024). Early scholarship viewed digitalization primarily as the adoption of discrete technologies aimed at improving operational efficiency or automating processes. Over time, however, a more comprehensive understanding has developed, in which digital transformation is interpreted as a multidimensional process affecting structures, cultures, and business models (Wessel et al., 2025). Cennamo et al. (2020) define digital transformation as the integration of digital technologies into all areas of a company, leading to fundamental changes in value creation mechanisms and in interactions with stakeholders. This definition underscores that digital transformation cannot be reduced to technological upgrades but must be seen as a systemic change requiring alignment between resources, managerial capabilities, and organizational vision. From this perspective, transformation is not only a question of technological choice but of strategic commitment to continuous adaptation. Bencsik (2024) reinforces this view by arguing that digitalization is both a technological and a managerial challenge, where leadership and organizational culture play decisive roles in enabling or obstructing progress.

The strategic dimension of digital transformation is increasingly recognized as a decisive factor that differentiates companies capable of leveraging technology for competitive advantage from those that remain trapped in incremental change. Marchese et al. (2023) describe advanced companies as those that build dynamic capabilities enabling them to experiment with new digital solutions, adapt organizational structures, and maintain resilience in turbulent environments. Tetteh et al. (2025) similarly emphasize that openness to innovation and willingness to reconfigure resources are essential preconditions for realizing the benefits of digital transformation. This implies that the concept of digital maturity must be understood as more than an index of technological tools adopted; it also includes the company's readiness to strategically exploit these tools. Companies that pursue digitalization with a strategic orientation are more likely to integrate sustainability considerations, develop adaptive cultures, and respond proactively to emerging challenges (Hotkova & Belas, 2025; Miceli et al., 2021). In this sense, digital maturity represents a dynamic and evolving construct, capturing not only technological capacity but also managerial foresight and cultural adaptability.

The literature highlights a wide range of technologies as central to digital transformation, with AI, big data analytics, ERP, and e-commerce platforms receiving particular attention. These tools are frequently discussed as markers of digital advancement because they fundamentally reshape processes and decision-making (Chawla & Goyal, 2021; Paul et al., 2024; Yaqub & Alsabban, 2023). Zulu et al. (2023) show that digital adoption is positively correlated with productivity, while Nagy et al. (2025) provide evidence that companies leveraging AI achieve measurable increases in profitability by optimizing operations and enhancing decision-making processes. Similarly, Pinochet et al. (2021) identify big data analytics as a differentiating factor between digitally advanced and less advanced companies, highlighting its role in enabling real-time analysis and predictive capabilities. The adoption of ERP systems has also been strongly linked with organizational integration and efficiency, as reported by Morawiec & Sołtysik-Piorunkiewicz (2023), who argue that ERP platforms facilitate cross-departmental coordination and support strategic agility. Finally, electronic commerce and online platforms are recognized as key drivers of market responsiveness and customer engagement, contributing to both operational flexibility and new revenue streams (Rasool et al., 2020). Collectively, this evidence suggests that these technologies are not merely operational tools but strategic enablers that fundamentally influence organizational transformation. On this basis, we propose the first hypothesis:

H1: Digitally and strategically advanced companies exhibit significantly higher adoption of digital technologies compared to less advanced companies.

Despite the benefits associated with digitalization, a large body of research points to substantial barriers that impede progress, many of which are deeply embedded in organizational and institutional contexts. Studies repeatedly document financial constraints, lack of managerial support, employee resistance, legal uncertainty, and compatibility issues with existing systems as recurring obstacles (Rahman et al., 2024; Sayem et al., 2022). These barriers are not static but vary in intensity depending on the level of digital maturity. Less advanced companies often face resource shortages, limited expertise, or skepticism from leadership, while advanced companies encounter qualitatively different obstacles as they push the boundaries of adoption (Oldemeyer et al., 2024). Cuéllar & Huq (2022) highlight that digitally advanced companies are more exposed to regulatory compliance pressures, especially when experimenting with AI or blockchain applications. Maratis et al. (2024) observe that integration with legacy systems remains one of the most persistent and costly challenges, often requiring reconfiguration of entire processes. This asymmetry in barriers has been interpreted as a paradox of digital advancement: the more ambitious the digital trajectory, the more complex the constraints. It implies that companies

with higher maturity are not insulated from obstacles but instead face a different configuration of risks, often systemic and institutional in nature. Building on this reasoning, the second hypothesis is formulated:

H2: Digitally and strategically advanced companies perceive stronger barriers to digital transformation compared to less advanced companies.

Another important dimension of the literature concerns the relationship between digital maturity and economic performance. Scholars debate whether digital transformation directly translates into financial gains or whether its benefits are contingent on organizational adaptability. Early studies emphasized the productivity paradox, questioning why information technology investments did not always yield proportional performance improvements (Dedrick et al., 2003). More recent work, however, shows that when digital technologies are embedded within broader strategies of adaptability and innovation, they enhance financial resilience. Romero et al. (2024) argue that the synergies between digitalization and organizational adaptability create long-term advantages, particularly in volatile markets. Guo (2024) found that companies with robust digital infrastructures were better positioned to sustain productivity even during economic downturns. Similarly, Nagy et al. (2025) and Sumarlin & Qosidah (2024) demonstrate that AI can significantly enhance profitability by improving forecasting accuracy and operational efficiency. Research on sustainability adds another layer of complexity, suggesting that companies that combine digitalization with sustainable strategies achieve superior long-term outcomes, as they are able to balance economic, environmental, and social goals (Ciocnitu, 2024; Csiszár & Hernádi, 2024; Valero-Gil et al., 2024). Together, these findings position digital transformation as both an enabler of innovation and a determinant of resilience in the face of market turbulence. Accordingly, the following hypothesis is proposed:

H3: Digitally and strategically advanced companies report superior economic performance compared to less advanced companies.

The heterogeneity of digital transformation across companies, sectors, and regions has led to increasing interest in clustering approaches as analytical tools. Clustering enables researchers to capture structural differences between groups of companies based on attitudes, adoption profiles, or readiness indicators (Casais & Caldas, 2025). Özkan & Gültepe (2024) used clustering to distinguish between companies with high and low ERP adoption, linking technological engagement to performance outcomes. Some recent research suggests gaps between SMEs and larger companies in digital readiness and barriers to adoption, although few studies combine methodologies such as clustering to compare them directly (Hojnik & Huđek, 2023; Packmohr et al., 2023). These approaches highlight that digitalization does not proceed uniformly but creates structural divides between more digitally and strategically advanced companies and those with more conservative orientations. Such divides often reflect broader institutional and cultural contexts. In transitional economies, where resources and managerial capabilities are unevenly distributed, clustering can reveal hidden heterogeneity that would be overlooked by aggregate analyses. This makes clustering particularly valuable for examining Slovak companies, which operate in a context characterized by both opportunities for rapid digital catch-up and structural limitations linked to regulation, financing, and managerial expertise.

Finally, the theoretical debate increasingly emphasizes that digital transformation is not only about individual companies but also about ecosystems and networks. Companies are embedded in broader value chains where digitalization requires coordination across suppliers, customers, and regulators (Okano et al., 2021). Kozak-Holland & Procter (2019) argue that digital transformation is a collective phenomenon that cannot be understood in isolation, as interdependencies create both opportunities and vulnerabilities. For Slovak companies, this perspective is particularly relevant, as many operate as suppliers within international value chains where digital requirements are imposed externally by global partners (Lábaj, 2017). This highlights the importance of examining not only company-level readiness but also systemic factors that shape transformation pathways. A theoretical background that integrates company-level attitudes, strategic orientation, barriers, and performance outcomes thus provides a comprehensive foundation for understanding how digital transformation unfolds in practice.

Previous research sheds light on technology adoption, barriers and performance but rarely combines attitudinal factors such as openness to AI, sustainability orientation and strategic resilience with objective measures of digital adoption and economic performance, and this gap is more pronounced in transitional economies where institutional contexts differ from those in larger countries. To address it, our study proposes three hypotheses labelled H1, H2 and H3 that link digital and strategic advancement to adoption, barriers and economic performance.

RESEARCH OBJECTIVE, METHODOLOGY AND DATA

The primary research objective of the study is to identify and characterize distinct clusters of Slovak companies based on their openness to AI, sustainability orientation and strategic resilience, and to assess how these clusters differ in their adoption of digital technologies, perceived barriers and economic performance. To address this objective, the study employs a quantitative research design aimed at uncovering heterogeneity among Slovak companies in their approaches to digital and strategic transformation. The empirical analysis is based on primary data collected through a structured survey, which enabled the identification of distinct groups of companies and the subsequent examination of their differences in technology adoption, perceived barriers, and economic performance. The methodological framework integrates survey-based data collection with multivariate statistical

techniques, including cluster analysis and chi-square testing.

Data Collection and Sample

Data were obtained through a questionnaire survey distributed to Slovak companies between February and July 2025. The survey targeted companies of different sizes and sectors, ensuring adequate representation of small, medium, and large companies. In total, 528 responses were collected, of which 402 were deemed valid and complete after data cleaning procedures. The participating companies covered a diverse range of industries, reflecting the structure of the Slovak economy. Participation was voluntary and anonymous, and the survey was designed in line with ethical standards for social science research. Table 1 summarizes the sectoral distribution, company size, and length of time in business of the surveyed companies.

Table 1: Characteristics of the surveyed companies

Sector of business based on the predominant share of its revenues	**Manufacturing**	**Commerce**	**Services**	**Construction**
	76	88	116	63
	18.91%	21.89%	28.86%	15.67%
	Transport	**Agro**	**Tourism**	**Other**
	25	10	8	16
	6.22%	2.49%	1.99%	3.98%
	Total: 402 (100%)			
Size of the company by number of employees	**Small**		**Medium**	**Large**
	199		128	75
	49.50%		31.84%	18.66%
	Total: 402 (100%)			
Length of time in business	**Less than 5 years**		**5 to 20 years**	**20+ years**
	61		227	114
	15.17%		56.47%	28.36%
	Total: 402 (100%)			

Source: own research

Survey Instrument and Variables

The questionnaire was structured into several thematic blocks, each focusing on a specific dimension of business transformation. The first block assessed companies' openness to AI through five Likert-scale items (AI1-AI5), capturing perceptions of the benefits and integration of AI solutions. The second block focused on sustainability and resilience orientation, including three items on sustainable practices (SUS1-SUS3) and four items on companies' resilience to competitive pressure, capacity utilization, and distribution (Resilience to Pressure and Resources; RPR1-RPR4). These twelve indicators served as the input variables for the cluster analysis. They capture technological openness, sustainability orientation, and strategic resilience, which together provide a coherent view of a company's digital maturity and its readiness to adopt and benefit from advanced technologies.

Further sections of the questionnaire captured the adoption of specific digital technologies (DT1-DT6), including cloud computing (DT1), Internet of Things (DT2), Big Data analytics (DT3), ERP systems (DT4), digital communication tools (DT5), and e-commerce platforms (DT6). Another block covered barriers to digital transformation (BAR1-BAR9), specifically, high implementation costs (BAR1), security risks (BAR2), integration issues with existing systems (BAR3), legal and regulatory obstacles (BAR4), change in company culture (BAR5), return on investment (BAR6), network limitations (BAR7), employee resistance (BAR8), and lack of managerial support (BAR9). Finally, the survey gathered self-reported measures of economic performance (EP1-EP2), focusing on changes in turnover (EP1) and EBIT (Earnings Before Interest and Tax; EP2), along with basic company characteristics such as size (Q1), sector (Q2), and length of time in business (Q3).

Cluster Analysis

To uncover underlying patterns in the data, a cluster analysis was conducted using the k-means algorithm. The analysis was based on the standardized values of the twelve attitudinal indicators (AI1-AI5, SUS1-SUS3, RPR1-RPR4). The optimal number of clusters was determined through a combination of the elbow method and silhouette analysis, both of which indicated that a two-cluster solution provided the best fit. For visualization purposes, a principal component analysis (PCA) method was applied, enabling the projection of multidimensional data into a two-dimensional space and illustrating the separation of companies across clusters.

Statistical Testing

Following the cluster analysis, chi-square (χ^2) tests of independence were applied to examine whether the distribution of responses across clusters differed significantly for digital technologies (DT1-DT6), barriers (BAR1-BAR9), economic performance indicators (EP1-EP2), and company characteristics (Q1, Q2, and Q3). This procedure allowed the identification of specific dimensions in which companies in the advanced cluster diverge from their less advanced counterparts. All chi-square tests met the assumptions regarding expected cell frequencies, with no cells falling below the minimum value of five. Statistical significance was evaluated at the 5% level.

Ethical Considerations and Limitations

The study adheres to the ethical guidelines for research involving human participants. Respondents were assured of anonymity, and data were used solely for academic purposes. Despite its contributions, the study is subject to certain limitations. The reliance on self-reported survey data may introduce subjective bias, and performance measures such as turnover and EBIT are based on managers' perceptions rather than audited financial records. Moreover, the analysis is confined to Slovak companies,

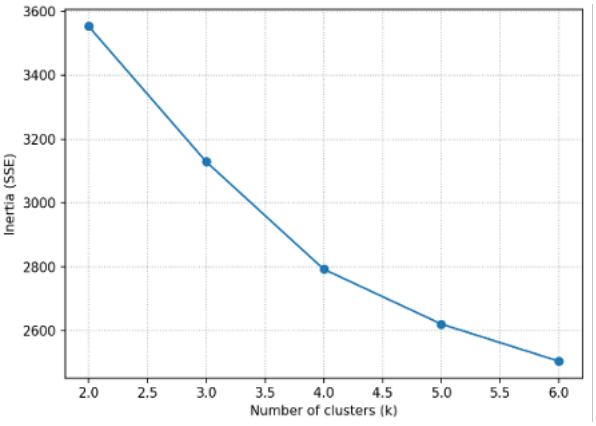
which may limit the generalizability of results to other national contexts. Nonetheless, the methodological approach provides a robust framework for examining the interplay between digital maturity, strategic orientation, and business performance.

RESULTS AND DISCUSSION

Cluster Validation (Elbow, Silhouette, and PCA)

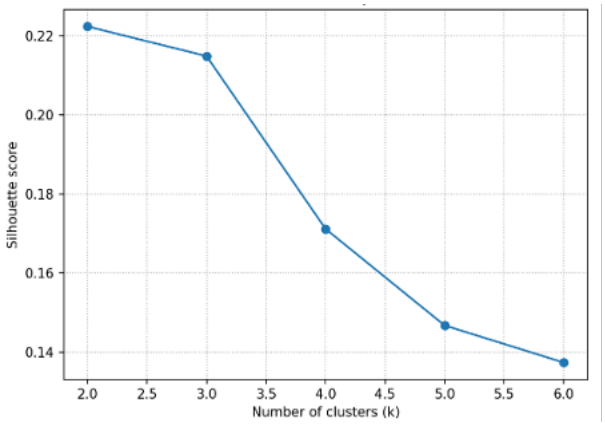
Figure 1 presents the results of the elbow method applied to evaluate the optimal number of clusters in the dataset. The curve shows a steep decline in the within-cluster sum of squares between two and three clusters, after which the rate of decrease slows down considerably. This inflection point indicates that the most meaningful partition of the data occurs when the number of clusters is set at two. Beyond this value, the improvement in model fit is marginal, which suggests that adding additional clusters would not substantially increase the explanatory power of the model. The elbow criterion therefore supports the interpretation that the dataset is best described by a two-cluster solution.

Figure 1: Elbow method results for cluster validity



Source: own research

Figure 2: Silhouette score by number of clusters

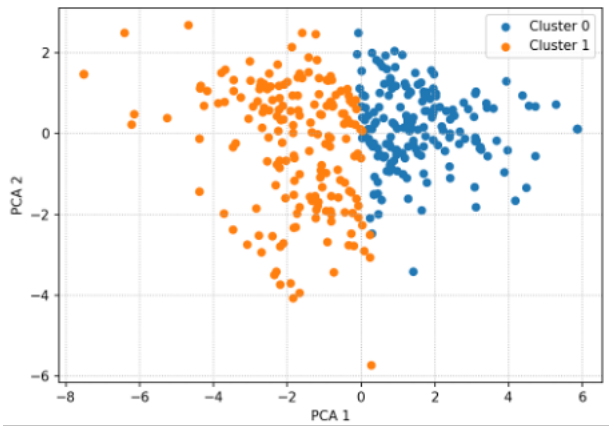


Source: own research

Figure 2 provides complementary evidence through the silhouette method, which assesses the cohesion and separation of clusters. The silhouette scores reach their maximum at two clusters, indicating that this solution provides the best balance between internal homogeneity and external distinctiveness. While the value remains relatively high for three clusters, it declines substantially for larger partitions. These results confirm that the two-cluster solution is the most appropriate, as it produces the highest silhouette score and thus the most coherent separation of companies within the sample. Together with the elbow method, the silhouette analysis provides a robust justification for proceeding with two clusters in the subsequent analysis.

Figure 3 illustrates the separation of the two identified clusters using a two-dimensional PCA. This visualization provides an intuitive representation of the data structure by projecting multidimensional information onto two synthetic axes. Although the axes of the principal components do not have a direct substantive interpretation, they capture the maximum possible variance in the dataset and thus allow the spatial distribution of observations to be meaningfully represented. The plot confirms that the two clusters are well distinguished, with observations from Cluster 0 located predominantly on the right-hand side and observations from Cluster 1 concentrated on the left-hand side of the scatterplot. The clear spatial distinction between the groups provides additional evidence that the two-cluster solution is appropriate and that companies within each cluster share common patterns of responses. This visualization therefore complements the statistical evidence from the elbow and silhouette methods by demonstrating that the separation of companies is not only statistically supported but also observable in the data structure itself.

Figure 3: Two-dimensional PCA visualization of clusters



Source: own research

Cluster Characteristics

Table 2 reports the mean values of the variables used for clustering. Companies grouped in Cluster 0 show consistently higher values across all indicators, with average scores ranging from 3.45 to 4.00 on a five-point Likert scale. These results indicate that Cluster 0 represents companies that demonstrate stronger openness to AI, higher levels of sustainable orientation, and greater resilience in terms of competitive pressure, capacity utilization, and distribution. In contrast, Cluster 1 companies report systematically lower values, with means between

Table 2: Mean values of clustering variables by cluster

Cluster	AI1	AI2	AI3	AI4	AI5	SUS1	SUS2	SUS3	RPR1	RPR2	RPR3	RPR4
0	3.69	3.73	3.55	3.66	3.69	3.86	4.00	3.96	3.45	3.72	3.99	3.90
1	2.38	2.20	2.23	2.39	2.56	2.86	2.96	3.05	2.76	2.95	3.10	3.19

Source: own research

2.20 and 3.19, suggesting a more traditional profile characterized by limited readiness for digital transformation and lower alignment with sustainability-orientated strategies.

The differences between the two clusters highlight a structural divide within Slovak companies. Cluster 0 can be interpreted as digitally orientated companies that actively engage with new technologies and are better prepared to withstand competitive and operational challenges. For the sake of clarity, these companies will be referred to throughout the results section as digitally and strategically advanced companies. Cluster 1 represents companies with a more conservative orientation, where attitudes toward AI adoption remain cautious and organizational preparedness is weaker. These findings correspond with earlier research by Firican (2023), who emphasized that digital transformation is not only a technological but also an organizational and cultural process, often driven by strategic openness and managerial readiness. Similarly, studies by Saputra et al. (2022) and Sharma et al. (2024) confirm that companies with higher levels of digital maturity tend to integrate sustainability and resilience more effectively into their business models. Our results thus reinforce the argument that companies combining openness to AI, sustainability, and competitive resilience exhibit broader organizational readiness and long-term adaptability.

The strong association between digital orientation and resilience observed in Cluster 0 aligns with findings from Li & Jin (2024), who reported that companies at advanced stages of digital transformation are more likely to experiment with AI, adopt sustainable practices, and leverage digital tools to enhance operational flexibility. On the other hand, the lower scores of Cluster 1 mirror observations by Fernandes & Burcharth (2024), who noted that many traditional companies remain stuck in early stages of transformation, perceiving digital technologies as disruptive rather than integrative. This divide within our sample therefore reflects a broader global phenomenon, where digitally proactive companies establish competitive advantages through both technology adoption and organizational agility, while traditional companie´s risk being left behind in increasingly dynamic environments.

Digital Technology Adoption (H1)

Chi-square tests reveal statistically significant differences in the adoption of several digital technologies between the two clusters, as presented in Table 3. The results confirm that the more advanced cluster (Cluster 0) exhibits consistently higher adoption rates across almost all technologies compared to the less advanced cluster (Cluster 1). The differences are particularly pronounced for Big Data analytics (DT3, p-value < 0.001), enterprise resource planning systems (DT4, p-value < 0.001), and electronic commerce platforms (DT6, p-value < 0.01). These findings highlight that companies in Cluster 0 not only display higher engagement with advanced technologies but also demonstrate a stronger orientation towards integrated digital infrastructures. On the other hand, no significant difference was identified for the Internet of Things (DT2), suggesting that its adoption may still be relatively balanced across different types of companies, potentially due to sector-specific limitations or investment constraints.

Table 3: Adoption of digital technologies by cluster (Chi-square test results)

Variable	Cluster 0	Cluster 1	χ^2	p-value
DT1	0.3731	0.2736	4.1041	0.0428
DT2	0.3035	0.2537	1.0025	0.3167
DT3	0.3582	0.1443	23.3258	0.0000
DT4	0.3632	0.1990	12.6052	0.0004
DT5	0.3930	0.2836	4.9005	0.0268
DT6	0.4428	0.2985	8.3606	0.0038

Source: own research

This evidence confirms the first research hypothesis (H1), and the observed pattern aligns with previous empirical studies. For example, Orero-Blat et al. (2025) emphasize the role of Big Data analytics as a differentiating factor for companies with higher levels of digital maturity, while Nour (2023) reports that the implementation of ERP systems is strongly associated with superior organizational performance in digitally orientated companies. Similarly, research by Sharma et al. (2023) confirms that electronic commerce and online platforms represent a fundamental driver of digital transformation, enhancing both internal efficiency and market responsiveness. The fact that these technologies show significant differences between clusters suggests that they can be regarded as core markers of digital orientation within Slovak companies.

Overall, these results indicate that cluster differentiation is not merely a statistical artefact but also reflects fundamental divides in the technological backbone of Slovak companies. The fact that Big Data, ERP systems, and electronic commerce emerge as the most distinctive technologies underscores their role as critical markers of digital orientation and long-term competitiveness. Rather than representing incremental tools, these technologies appear to function as tipping points that separate digitally proactive companies from their more traditional counter-

parts, offering a clear roadmap for where digital policy and managerial investment should concentrate.

Perceived Barriers (H2)

The analysis of perceived barriers reveals that digitally and strategically advanced companies report significantly stronger obstacles across several critical dimensions, as summarized in Table 4. The chi-square tests indicate robust differences for implementation costs (BAR1, p-value < 0.05), integration issues with existing systems (BAR3, p-value < 0.05), legal and regulatory obstacles (BAR4, p-value < 0.05), return on investment (BAR6, p-value < 0.05), and network limitations (BAR7, p-value < 0.05). These results suggest that higher digital maturity does not necessarily reduce the number of obstacles but rather exposes companies to a more complex and demanding environment in which new technologies amplify existing constraints.

Table 4: Perceived barriers by cluster (Chi-square test results)

Variable	Cluster 0	Cluster 1	χ^2	p-value
BAR1	0.2836	0.1841	5.0125	0.0252
BAR2	0.3234	0.2786	0.7567	0.3844
BAR3	0.2587	0.1493	6.7562	0.0093
BAR4	0.2338	0.1045	11.0624	0.0009
BAR5	0.1940	0.1343	2.1935	0.1386
BAR6	0.2935	0.1940	4.8712	0.0273
BAR7	0.2687	0.1343	10.4516	0.0012
BAR8	0.2388	0.1891	1.1982	0.2737
BAR9	0.1692	0.1294	0.9599	0.3272

Source: own research

This phenomenon can be interpreted as a paradox of digital and strategic advancement. Companies that push the boundaries of technology adoption encounter challenges that are qualitatively different from those experienced by less advanced companies. While traditional companies may struggle primarily with resource limitations or managerial resistance, digitally and strategically advanced companies must cope with legal uncertainty, system integration issues, and the increasing pressure to secure returns on substantial digital investments. Previous studies have highlighted similar patterns. Alex-Omiogbemi et al. (2024) observed that companies with stronger digital adoption face heightened concerns related to regulatory compliance, while Maratis et al. (2024) found that integration with legacy systems represents one of the most persistent barriers to digital transformation. In line with Jilke's (2020) findings, the results further suggest that organizational readiness alone is not sufficient to overcome barriers if technological complexity and regulatory uncertainty intensify in parallel.

In contrast, several barriers did not show statistically significant differences between the groups, such as security risks (BAR2), changes in company culture (BAR5), resistance of employees to change (BAR8), or lack of managerial support (BAR9). This implies that companies perceive these barriers similarly, irrespective of their level of digital maturity. The absence of differentiation in these areas may indicate that they represent fundamental challenges inherent to digital transformation rather than issues that intensify with higher levels of adoption. Such findings are consistent with prior studies highlighting that organizational culture, managerial commitment, and employee attitudes remain universal obstacles that affect companies independently of their technological orientation (Aarthi & Suganthi, 2024; Nambiar & Parmar, 2024).

The findings confirm the second research hypothesis (H2), demonstrating that digitally and strategically advanced companies perceive stronger barriers to digital transformation than their less advanced counterparts. Importantly, the results reveal that these obstacles are not simply more numerous but qualitatively different in nature. While companies with limited digital maturity tend to be constrained by internal factors such as resources or managerial support, advanced companies confront systemic challenges related to regulation, system integration, and financial risk. This shift underscores a paradox of advancement, whereby progress in digitalization amplifies exposure to institutional and technological complexity. Such evidence highlights the need for companies to complement digital ambition with robust governance and risk management, and it signals to policymakers that the frontrunners of digital transformation require targeted support to address the heightened pressures that accompany their pioneering role.

Economic Performance (H3)

Table 5 summarizes the results for economic performance (EP) indicators. Both turnover (EP1, $\chi^2 = 24.99$, p-value < 0.001) and EBIT change (EP2, $\chi^2 = 21.80$, p-value < 0.001) reveal statistically significant differences between the two cluster groups. The distribution of responses shows that companies in the digitally and strategically advanced group more frequently report stable or increasing performance, while less advanced companies exhibit a higher concentration in the categories reflecting decline. These results confirm the third research hypothesis (H3).

Table 5: Economic performance indicators by cluster (Chi-square test results)

Variable	χ^2	p-value
EP1	24.9892	0.000
EP2	21.7957	0.000

Source: own research

The findings contribute to the growing body of literature examining the relationship between digital transformation, strategic orientation, and company performance. Several studies have emphasized that digital adoption enhances operational efficiency, customer reach, and organizational agility, all of which translate into improved financial outcomes. Gal et al. (2019) showed that digital capabilities are strongly correlated with productivity gains, while Goi (2023) highlighted that companies leve-

raging digital technologies report measurable increases in profitability through optimization of processes and decision-making. Similarly, Lesnussa et al. (2023) argue that the economic benefits of digitalization stem from synergies between technology adoption and organizational adaptability. Our results endorse these perspectives by demonstrating that Slovak companies with a more advanced digital and strategic orientation are more likely to maintain or improve both turnover and EBIT even in challenging market conditions.

Altogether, the results indicate that digital and strategic advancement is not only a driver of technological capability but also a determinant of economic resilience. Companies with this profile appear better positioned to mitigate downturns and capitalize on opportunities for growth. This finding underscores the dual role of digital and strategic transformation as both an enabler of innovation and a safeguard against performance volatility.

Structural Characteristics (Robustness Check)

Table 6 summarizes the results for company size (Q1), sectoral orientation (Q2), and length of time in business (Q3). None of the chi-square tests reached statistical significance (all p-values > 0.05), which suggests that these structural characteristics are distributed relatively evenly across the two clusters. The absence of significant differences implies that the heterogeneity identified in previous analyses is not driven by variations in size, sector, or company age. Instead, the results confirm that cluster differentiation stems primarily from companies' digital and strategic orientation rather than from basic structural attributes. This outcome strengthens the validity of the clustering approach by showing that the observed disparities in technology adoption, perceived barriers, and performance are not merely reflections of underlying company demographics.

Table 6: Chi-square results for company characteristics

Variable	χ^2	p-value
Q1	5.6929	0.0581
Q2	10.7170	0.1514
Q3	5.1155	0.0775

Source: own research

CONCLUSION

The study successfully achieved its primary aim of differentiating Slovak companies into meaningful clusters based on their digital and strategic orientation and assessing how these clusters vary in terms of technology adoption, perceived barriers, and economic performance. The research employed k-means cluster analysis on twelve indicators related to AI adoption, sustainability orientation, and strategic resilience, revealing a fundamental structural divide within the Slovak business landscape.

The analysis identified two distinct clusters of companies with markedly different profiles. The digitally and strategically advanced cluster (Cluster 0) demonstrated consistently higher mean values across all clustering variables, ranging from 3.45 to 4.00 on a five-point Likert scale, whilst the traditional cluster (Cluster 1) exhibited systematically lower values between 2.20 and 3.19. This dichotomy reflects a clear separation between companies that actively embrace digital transformation and those maintaining more conservative approaches to technological and strategic change.

The empirical findings provided robust support for all three research hypotheses. First, digitally and strategically advanced companies exhibited significantly higher adoption rates of critical digital technologies, particularly Big Data analytics ($p < 0.001$), ERP systems ($p < 0.001$), and electronic commerce platforms ($p < 0.01$). These technologies emerged as core markers of digital orientation, functioning as tipping points that separate digitally proactive companies from their traditional counterparts.

Second, the study revealed a paradox of digital advancement, whereby companies with higher digital maturity perceived stronger barriers to transformation across multiple dimensions, including implementation costs ($p < 0.05$), integration issues with existing systems ($p < 0.05$), legal and regulatory obstacles ($p < 0.05$), return on investment concerns ($p < 0.05$), and network limitations ($p < 0.05$). This counterintuitive finding suggests that digital advancement exposes companies to qualitatively different and more complex challenges, predominantly systemic and institutional in nature, rather than reducing the number of obstacles encountered.

Third, the research confirmed that digitally and strategically advanced companies achieved superior economic performance, with statistically significant differences in both turnover and EBIT changes. These results demonstrate that digital and strategic advancement functions not merely as a driver of technological capability but as a determinant of economic resilience and competitive advantage.

Importantly, the cluster differentiation was not attributable to basic structural characteristics, as company size, sectoral orientation, and length of time in business showed no statistically significant differences between clusters. The results strengthen the validity of the clustering approach by confirming that the observed disparities stem primarily from companies' digital and strategic orientation rather than demographic factors.

The study contributes novel evidence from a transitional economy context, addressing significant gaps in comparative digital transformation research. The findings advance theoretical understanding of the interplay between technology adoption, strategic orientation, and performance outcomes. Building on these results, several practical implications emerge for both policymakers and business practitioners. For managers, successful transformation requires not only investment in advanced technologies but also the strengthening of digital skills, integration capabilities, and risk-management practices. Closer collaboration with research institutions and the sys-

tematic development of internal competencies may help companies mitigate integration and regulatory challenges. Policymakers should support digitally advanced companies through clearer regulatory frameworks and accessible financing instruments, while assisting less mature companies in overcoming capacity constraints. By combining targeted managerial initiatives with well-designed public measures, stakeholders can reinforce the national digital ecosystem and amplify the performance benefits identified in this study.

Limitations and Future Research Directions

Despite its contributions, present research is subject to several important limitations that warrant acknowledgement. Firstly, the reliance on self-reported survey data may introduce subjective bias, particularly regarding performance measures such as turnover and EBIT changes, which are based on managers' perceptions rather than audited financial records. Future studies would benefit from incorporating objective financial data to validate these self-reported performance indicators.

Secondly, the analysis is confined to Slovak companies, which may limit the generalizability of results to other national contexts, particularly those with different institutional environments, regulatory frameworks, or levels of economic development. Cross-national comparative studies would enhance understanding of how cultural and institutional factors influence digital transformation patterns across different transitional economies.

Thirdly, the cross-sectional nature of the data prevents examination of temporal dynamics and causal relationships. Longitudinal research designs would enable investigation of how companies transition between clusters over time and the factors that facilitate or hinder such movement, providing deeper insights into transformation trajectories.

Future research should explore several promising directions. First, the paradox of digital advancement warrants further investigation through qualitative studies that can illuminate the mechanisms underlying why more advanced companies perceive stronger barriers. Second, research examining the role of external factors, such as supply chain relationships and regulatory environments, would enhance understanding of the ecosystem dynamics influencing digital transformation. Third, sector-specific analyses could reveal industry-specific patterns that may be obscured in aggregate studies. Finally, intervention studies evaluating the effectiveness of different support mechanisms for companies at various stages of digital maturity would provide valuable guidance for policy development and managerial practice.

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