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Artificial Intelligence as a Competitiveness Factor for SMEs: A Multidimensional Perspective Integrating Technological, Organizational and Competency Dimensions

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Abstract:

Purpose: *The aim of the article is to identify the key determinants of competitiveness among small and medium-sized enterprises in the context of digital transformation, with particular emphasis on the role of artificial intelligence (AI), managerial capabilities and organizational digitalization.*
Design/Methodology/Approach: *The study is based on logistic regression analysis conducted on a sample of 1013 small and medium-sized enterprises from five European countries: Poland, Slovakia, Spain, Italy and Germany.*
Findings: *In the AI implementation model, international collaboration emerged as a statistically significant predictor of competitiveness, highlighting the importance of global innovation networks in the adaptation and effective use of advanced technologies. In the competency-digitalization model, three factors proved significant: the level of digitalization, managerial readiness to implement AI and innovation orientation. Country-level analyses additionally revealed differences in competitiveness determinants across nations, indicating the role of local institutional conditions and varying levels of digital maturity.*

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Practical Implications: *The findings provide practical guidance for managers and policymakers responsible for shaping digital strategies, demonstrating that effective AI implementation requires not only technological infrastructure but also organizational capabilities and integration with global innovation ecosystems.*
Originality/Value: *The article addresses a research gap concerning the lack of cross-country empirical analyses on the impact of AI implementation on SME competitiveness. The novelty of the study lies in its multidimensional approach, integrating technological, organizational and managerial perspectives within a unified logistic regression framework. The results expand existing knowledge in the fields of artificial intelligence and digital transformation.*

Keywords: *Artificial intelligence, digital transformation, competitiveness, SMEs, international collaboration.*

JEL Classification: *O33, M21, L25.*

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1. Introduction

The dynamic development of artificial intelligence (AI) technologies in recent years has fundamentally reshaped the competitive conditions faced by enterprises, making AI one of the key factors determining operational efficiency, innovativeness and organizational adaptability (Brynjolfsson and McAfee, 2017; Shrestha *et al.,* 2019).

As the scale of implementation increases, encompassing process automation, advanced data analytics and the creation of new business models, the importance of research on the determinants of enterprise competitiveness in the digital economy continues to grow (Dwivedi *et al.,* 2023; Huang and Rust, 2023). This issue is particularly relevant for the SME sector, which is characterized by limited financial and technological resources and, at the same time, a strong need to adapt to rapidly changing market conditions.

Previous studies indicate that although AI can significantly enhance productivity and innovation capacity (Brynjolfsson and McAfee, 2017; Cockburn, Henderson and Stern, 2018), these benefits are not automatic. Their realization depends on a range of technological, organizational and competency-related factors (Davenport and Ronanki, 2018; Raisch and Krakowski, 2021).

As a general-purpose technology, AI requires adequate data infrastructure, integration capabilities and complementary organizational resources to generate business value (Verhoef *et al.,* 2021; Jonathan and Kuika Watat, 2020).

Recent systematic studies emphasize that the effectiveness of AI implementation is strongly dependent on the level of digital maturity within an organization, including technological infrastructure, organizational culture and the ability to manage change (Hinings, Gegenhuber and Greenwood, 2018; Kraus *et al.,* 2022).

At the same time, generative AI systems, such as language models, accelerate innovation processes and enable the creation of new value models (Dwivedi *et al.,* 2023), which further increases the pressure to develop digital and managerial competencies.

Despite the growing number of publications on digital transformation, there remains a lack of empirical studies examining how AI implementation affects enterprise competitiveness in conjunction with digitalization, managerial readiness and innovation orientation.

Recent research highlights that managerial competencies in digital technologies are becoming one of the key determinants of successful AI adoption (Sousa and Rocha, 2019). At the same time, there is a shortage of cross-country studies that would allow for the comparison of competitiveness determinants across different institutional contexts.

The literature increasingly emphasizes the importance of international collaboration and integration with global innovation ecosystems as a condition for effective AI implementation (Chesbrough, 2020; Bogers, Chesbrough and Moedas, 2022). Cross-border cooperation provides access to cutting-edge technological solutions, expert knowledge and external resources, thereby enhancing absorptive capacity and accelerating innovation processes (Zhang *et al.,* 2021; Lee and Trimi, 2022).

In light of these research gaps, the present study seeks to answer the following research questions.

RQ1: *To what extent do factors related to the implementation of artificial intelligence technologies, such as the use of AI tools, collaboration with technology providers, access to financing and international cooperation, influence the likelihood of achieving high enterprise competitiveness?*
RQ2: *To what extent do organizational factors, such as the level of digitalization, managerial readiness to implement AI and innovation orientation, increase the likelihood of achieving high enterprise competitiveness?*
RQ3: *Does the influence of technological, organizational and network-related factors on enterprise competitiveness differ across countries with varying institutional conditions and levels of digital maturity?*
RQ4: *To what extent does international collaboration strengthen enterprise competitiveness in the context of AI implementation, and does its significance differ across countries?*

By addressing these questions, the study integrates technological, organizational and network perspectives within a cross-country logistic regression framework. The aim of the article is to identify the key determinants of enterprise competitiveness in the context of digital transformation, with particular emphasis on artificial intelligence, managerial capabilities and organizational digitalization.

2. Literature Review

2.1 Artificial Intelligence as a Competitiveness Factor

The literature emphasizes that artificial intelligence constitutes a transformational technology capable of reshaping decision-making, operational and innovation processes within enterprises (Brynjolfsson and McAfee, 2017; Shrestha *et al.,* 2019). Cockburn *et al.* (2018) indicate that its applications include both the automation of operational processes and the support of decision-making through predictive analytics, as well as the generation of product and service innovations.

Davenport and Ronanki (2018) note that AI can enhance cost efficiency, improve customer service quality and enable the creation of new data-driven business models. The literature also highlights that small and medium-sized enterprises implement AI technologies under different conditions than large organizations, due to resource constraints, lower process formalization and greater operational flexibility (Li *et al.,* 2018; OECD, 2019).

Recent studies confirm that generative AI systems, including language models, radically accelerate innovation processes and enable the creation of new value models (Dwivedi *et al.,* 2023; Huang and Rust, 2023). It is also noted that organizations capable of integrating AI with business processes achieve higher levels of adaptability and market resilience (Huang and Rust, 2023).

Verhoef *et al.* (2021) emphasize that the benefits of AI implementation are not automatic but depend on complementary organizational resources such as digital infrastructure and managerial competencies. Research also highlights that the practical use of AI tools, including generative systems and machine learning algorithms, is crucial for achieving competitive advantage.

Chesbrough (2020) adds that collaboration with technology providers facilitates the implementation process and enables better alignment of tools with organizational needs, which is particularly important in the SME sector.

Recent studies indicate that AI is becoming not only an operational tool but also a strategic one, influencing decision-making processes and the design of business models (Shrestha *et al.,* 2019). In this context, the importance of research on how AI affects enterprise competitiveness across sectors and countries continues to grow.

2.2 Organizational Capabilities and Digital Maturity

Digital maturity is recognized as a key condition for the effective implementation of AI (Verhoef *et al.,* 2021). The authors emphasize that enterprises with well-developed digital infrastructure are better prepared to integrate technology with business processes, to collect and analyze data efficiently and to scale technological innovations. Teece (2018) notes that digitalization strengthens the dynamic capabilities of organizations, enabling them to identify and exploit new technological opportunities.

Hinings, Gegenhuber and Greenwood (2018) point out that digital maturity encompasses not only technological aspects but also organizational culture, the ability to manage change and the capacity to adapt to new market conditions. Recent systematic studies confirm that a high level of digital maturity is one of the most important factors enabling the effective implementation of AI technologies (Jonathan and Kuika Watat, 2020; Kraus *et al.,* 2022).

The literature also indicates that a high level of digitalization fosters the creation of innovation ecosystems in which enterprises can more rapidly implement AI solutions and better integrate them with business processes. Empirical studies show that firms with high digital maturity more frequently achieve competitive advantage due to their ability to scale technological implementations and adapt them across different areas of activity.

2.3 Managerial Readiness and Technological Leadership

Research indicates that managerial readiness plays a crucial role in the success of AI implementations (Tarafdar *et al.,* 2019). The authors emphasize that managers who understand the strategic potential of artificial intelligence are more likely to support digital transformation, invest in technologies and promote a culture of innovation. Raisch and Krakowski (2021) note that managerial attitudes and competencies determine the extent to which AI translates into competitive advantage.

Recent studies confirm that managerial competencies in digital technologies are becoming one of the key factors determining the success of AI implementation (Sousa and Rocha, 2019). Teece (2018) highlights that technological leadership involves actively promoting new solutions and creating conditions conducive to their adoption within the organization. Similarly, Brock and von Wangenheim (2019) emphasize that leaders' competencies in digital technologies constitute the foundation of effective AI implementation and shape the organization's ability to leverage its potential.

The literature also stresses that managerial readiness includes not only knowledge of technological capabilities but also openness to experimentation, the ability to take risks and support employees in adapting to new tools.

Studies show that organizations in which top management actively supports AI implementation achieve higher levels of innovation and adapt more quickly to market changes.

2.4 International Collaboration and Knowledge Networks

The literature highlights that international collaboration constitutes a key factor enabling the effective implementation of artificial intelligence, as it facilitates the absorption of external knowledge sources (Chesbrough, 2020). Zhang *et al.* (2021) note that cross-border cooperation provides enterprises with access to global technological resources, experts and the latest solutions.

Recent research on open innovation indicates that integration with global knowledge ecosystems significantly enhances enterprises' ability to absorb and implement AI technologies (Bogers, Chesbrough and Moedas, 2022). The authors argue that participation in global innovation networks increases firms' absorptive capacity, enabling them to adopt new technologies more rapidly and accelerate innovation processes (Lee and Trimi, 2022).

Studies also show that integration with international partners facilitates knowledge transfer, reduces implementation costs and increases the effectiveness of AI deployment. The literature emphasizes that international collaboration strengthens organizational resilience to market changes and enables better utilization of global technological trends.

3. Research Methodology

3.1 Research Design

In the study we employed a quantitative research design based on a cross-sectional survey conducted among enterprises operating in five European countries: Poland, Slovakia, Spain, Italy and Germany. The aim of the project was to identify the determinants of enterprise competitiveness in the context of artificial intelligence (AI) implementation and, more broadly, digital transformation.

The choice of a quantitative approach stemmed from the need to analyse relationships between multiple independent variables and a dependent variable, as well as to formulate generalizations based on a diverse sample of enterprises.

Contemporary research on digital transformation and AI indicates that quantitative approaches are particularly useful for analysing complex relationships between organizational, technological and competency-related factors (Jonathan and Kuika Watat, 2020; Kraus *et al.,* 2022). The survey was conducted using the CAWI method in June 2025, which aligns with current recommendations for research on digital technologies that require broad reach and high data comparability (Dwivedi *et al.,* 2023).

3.2 Sample Structure

The study included a total of 1013 enterprises from five European countries. The sample was selected to ensure a relatively even distribution of units across each country. Such a distribution enabled comparisons between entities operating in different economic and cultural systems, thereby increasing the external validity of the study.

The literature emphasizes that cross-country studies are essential for understanding institutional differences affecting AI implementation and digital transformation (Lee and Trimi, 2022; Bogers, Chesbrough and Moedas, 2022). A balanced sample distribution allows researchers to capture diverse contextual conditions, which is consistent with the latest standards in comparative research in management and technology.

A distribution of approximately 200 enterprises per country enabled meaningful comparisons across different institutional environments, enhancing the study's external validity.

Table 1. *Respondents' Profile (N = 1013)*

Categorises	Items	Frequency (N = 1013)	Percentage
Country	Poland	200	19,7
	Slovakia	206	20,3
	Spain	206	20,3
	Italy	200	19,7
	Germany	201	19,8
Size	Micro-enterprise (1–9 employees)	4	0,39
	Small enterprise (10–49 employees)	646	63,77
	Medium-sized enterprise (50–249 employees)	362	35,74
	Large/other	1	0,10
Position	Business owner	169	16,7
	Board member	102	10,1
	Director	168	16,6
	Manager	285	28,1
	Executive	286	28,2
	Other	3	0,3
Field of company	Production	242	23,9
	Trade	209	20,6
	Services	560	55,3
	Other	2	0,2
Years of operation	Less than 2 years	71	7,0
	2–5 years	180	17,8

	6–10 years	165	16,3
	Over 10 years	597	58,9
Assessment of competitiveness	Much less competitive	20	2,0
	Less competitive	67	6,6
	Comparable/difficult to assess	301	29,7
	More competitive	369	36,4
	Much more competitive	256	25,3
Gender	Female	389	38,4
	Male	624	61,6
Education	Basic	10	1,0
	Upper-basic general	75	7,4
	Upper-basic vocational	230	22,7
	University/higher	696	68,7
	Refusal	2	0,2
Field of education	Technical	608	60,0
	Non-technical (Humanities)	325	32,1
	Mixed	80	7,9

Source: *Own study.*

Enterprise Structure: The sample consisted primarily of small and medium-sized enterprises. The largest group comprised small firms (10–49 employees), representing 63.8% of the sample. Medium-sized enterprises (50–249 employees) accounted for 35.7%, while micro-enterprises and large entities appeared only marginally. This distribution reflects the structure of the European SME sector, which plays a key role in innovation processes.

Respondent Position: Respondents represented various levels of organizational hierarchy. The largest groups were department heads (28.2%) and managers (28.1%). A significant share also included business owners (16.7%), directors (16.6%) and board members (10.1%). This indicates that the study reached individuals with real influence on strategic and operational decisions, which increases the credibility of the collected data.

Industry Profile: The sample was dominated by service-sector enterprises (55.3%), followed by manufacturing (23.9%) and trade (20.6%). This distribution reflects contemporary economic trends in Europe, where the service sector plays an increasingly important role.

Firm Age: More than half of the firms (58.9%) had been operating for more than 10 years, indicating an established market position for most entities. The remaining groups included younger enterprises with 2–10 years of experience (34.1%) and the youngest firms (7%).

Competitiveness Assessment: Respondents provided a subjective assessment of their firm's competitiveness. A total of 61.7% considered their companies to be more competitive than their market environment, which aligns with European estimates of SME self-assessed competitiveness. However, the possibility of optimism bias should be acknowledged.

Demographic Characteristics of Respondents: Men constituted the majority of respondents (61.6%), reflecting employment patterns in the SME sector. Most respondents held higher education degrees (68.7%), and 60% reported a technical educational background, which supports reliable assessment of issues related to digital technologies and AI. The average age was 38.6 years, indicating a professionally active and experienced group.

3.3 Operationalization of Variables

Dependent Variable: Enterprise competitiveness was originally measured using a 5-point Likert scale, in which respondents assessed the competitive position of their firm relative to other entities operating in the same sector. The use of perceptual measures of competitiveness is a widely applied approach in research on organizational performance (Venkatraman and Ramanujam, 1986; Richard *et al.,* 2009).

Recent studies confirm that subjective performance measures are as valid as objective indicators, particularly in cross-sectional research and in the SME sector (Kraus *et al.,* 2022; Jonathan and Kuika Watat, 2020). Perceptual Likert scales are also widely used in studies on digital transformation and advanced technologies, including AI, where access to objective indicators is often limited (Gupta and George, 2016; Dwivedi *et al.,* 2023).

For the purposes of the present analysis, this variable was dichotomized by classifying the responses “rather more competitive” and “definitely more competitive” as a high level of competitiveness, which is consistent with methodological recommendations for logistic regression (Hosmer, Lemeshow and Sturdivant, 2013; Menard, 2010).

Independent Variables: We selected independent variables based on a literature review that identified four key areas determining the effectiveness of artificial intelligence implementation and its impact on enterprise competitiveness.

In the first model, which focused on technological implementation, variables related to the practical use of AI tools, collaboration with technology providers, international cooperation and access to financing for AI implementation were included. These factors reflect both the organization’s ability to absorb new solutions and its capacity to integrate external sources of knowledge (Chesbrough, 2020; Bogers *et al.,* 2022).

In the second, competency-digitalization model, variables related to the level of digitalization, managerial readiness to implement AI and innovation orientation were included. Recent studies confirm that managerial competencies and digital maturity are key predictors of successful AI implementation (Sousa and Rocha, 2019; Tarafdar *et al.,* 2019; Jonathan and Kuika Watat, 2020).

Including both groups of variables in the logistic regression models made it possible to assess the extent to which technological, organizational, managerial and network-related factors increase the likelihood of achieving high competitiveness in the SME sector.

3.4 Data Analysis Methods

Logistic regression was applied to analyse the data, as it is recommended for modelling the probability of an event occurring based on multiple predictors and does not require assumptions of normality, homoscedasticity or linearity (Hosmer *et al.,* 2013; Menard, 2010). Logistic regression enables modelling the nonlinear relationship between predictors and the log-odds (logit), allowing for precise estimation of the influence of individual factors on the likelihood of achieving high competitiveness (Peng, Lee and Ingersoll, 2002).

Recent methodological studies confirm that logistic regression remains one of the most effective analytical methods in research on digital transformation and AI implementation, especially when variables are of mixed types (continuous and categorical) (Kraus *et al.,* 2022; Jonathan and Kuika Watat, 2020). The method is also widely used in studies on technology adoption, organizational performance and competitive advantage (Dwivedi *et al.,* 2023; Shrestha *et al.,* 2019).

A two-stage analytical approach was applied. First, a model including all countries combined was estimated to identify general determinants of competitiveness in the context of AI implementation. Subsequently, separate analyses were conducted for each of the five countries, allowing the identification of specific institutional and cultural conditions influencing the results (as discussed in Lee and Trimi, 2022; Bogers *et al.,* 2022).

Two logistic regression models were estimated, corresponding to the two key research areas. The first model (implementation model) included technological variables and collaboration-related factors associated with AI adoption. The second model (competency-digitalization model) included managerial and organizational variables reflecting digital maturity and managerial readiness.

4. Data Analysis and Results

4.1 AI Implementation Model

To identify the factors determining enterprise competitiveness, a logistic regression analysis was conducted, incorporating a set of variables related to the implementation of artificial intelligence (AI) technologies. The model proved to be statistically valid and well fitted to the empirical data. The value of the −2 log-likelihood statistic was 134.553, while the Cox and Snell and Nagelkerke pseudo-R^2 values reached 0.294 and 0.473, respectively. This indicates that the model explains approximately 47% of the variance in the dependent variable, which in the context of logistic regression can be considered a satisfactory result, demonstrating moderate to high explanatory power.

Additionally, the Hosmer-Lemeshow test ($\chi^2 = 7.254$; df = 8; p = 0.509) did not reveal significant differences between the observed and predicted values, confirming the model's good fit and the absence of systematic prediction errors.

In the overall model including all analysed countries, the only variable that reached statistical significance was international collaboration in the implementation of AI technologies (p = 0.007). The odds ratio Exp(B) = 7.799 indicates that enterprises engaging in international cooperation have nearly eight times higher odds of achieving greater competitiveness compared to firms that do not engage in such collaboration.

This finding is consistent with recent research on open innovation, which highlights that integration with global knowledge ecosystems significantly enhances firms' ability to absorb and implement advanced technologies, including AI (Bogers, Chesbrough and Moedas, 2022; Lee and Trimi, 2022). Cross-border cooperation provides access to cutting-edge technological solutions, experts and knowledge resources, thereby accelerating innovation processes and strengthening competitive advantage.

The remaining variables, although in some cases associated with relatively high odds ratios (e.g., the use of AI tools, collaboration with technology providers, access to financing for AI implementation), did not reach statistical significance. This means that their impact on enterprise competitiveness was not confirmed within this model.

The result suggests that merely implementing tools or possessing technological resources is not sufficient to generate competitive advantage unless accompanied by an appropriate organizational and network context. This aligns with recent studies indicating that the effectiveness of AI implementation depends on an organization's ability to integrate technology with business processes and on the quality of relationships with external partners (Shrestha *et al.,* 2019; Dwivedi *et al.,* 2023).

Table 2. *Summary of the AI Implementation Model Fit for All Countries*

Model Summary						
−2 Log-likelihood	**Cox & Snell R²**			**Nagelkerke R²**		
134,553	0,294			0,473		
Hosmer-Lemeshow Test						
χ²	**df**			**Significance**		
7,254	8			0,509		
Variables in the Model						
Variable	**B**	**SE**	**Wald**	**df**	**Sig.**	**Exp(B)**

Use of AI-based tools	0,933	0,617	2,291	1	0,130	2,543
Having a formal AI implementation strategy	-0,510	0,710	0,516	1	0,473	0,601
Having a dedicated unit for implementing new AI technologiesHaving a dedicated unit for implementing new AI technologies	0,111	0,649	0,029	1	0,864	1,118
Employees participate in AI training	-0,753	0,619	1,483	1	0,223	0,471
Having a grant or funding for AI implementation	1,379	1,089	1,605	1	0,205	3,972
Collaboration with an external AI technology provider	1,254	0,735	2,912	1	0,088	3,505
Conducting a technological readiness assessment	0,618	0,747	0,684	1	0,408	1,855
Collaboration with international partners in AI implementation	2,054	0,761	7,293	1	**0,007**	**7,799**
Applying for financial support for AI implementation	-1,425	1,019	1,956	1	0,162	0,241
Receiving financial support for AI implementation	0,112	0,953	0,014	1	0,906	1,119
Use of ERP systems	0,451	0,577	0,611	1	0,434	1,569
Use of CRM systems	-0,238	0,597	0,159	1	0,690	0,788
Use of analytical tools (e.g., Big Data)	0,409	0,549	0,555	1	0,456	1,505
Use of artificial intelligence tools	0,796	0,579	1,892	1	0,169	2,217
Use of communication platforms (Teams, WhatsApp, Zoom, etc.)	-0,529	0,574	0,852	1	0,356	0,589
Constant	-0,019	0,591	0,001	1	0,974	0,981

Source: *Own study.*

Although international collaboration emerged as the only statistically significant predictor in the AI implementation model, it is important to consider the direction and magnitude of the effects of the remaining variables. Even though they did not reach statistical significance, most of them displayed positive odds ratios, indicating that their presence increased the likelihood of achieving higher competitiveness.

In particular, the use of AI tools, collaboration with technology providers, and access to funding for AI implementation were associated with relatively high Exp(B) values. This suggests that enterprises engaging in AI-related implementation activities tend to achieve better competitive outcomes, even if the effect is not yet strong enough to reach statistical significance in the overall model.

Analysis conducted separately for individual countries revealed significant variation in the determinants of competitiveness. In Poland, the key factor was the use of artificial intelligence tools ($p = 0.046$; $Exp(B) = 17.659$). This indicates that, in Polish enterprises, the practical application of AI constitutes an important element in building competitive advantage.

Table 3. *Significant Logistic Regression Coefficients in the AI Implementation Model Across Countries*

Country	X_i	Significance	Exp(B)
Poland	Use of artificial intelligence (ChatGPT, Gemini, Copilot, DeepSeek, etc.)	0,046	17,659
Slovakia	Use of AI-based tools	0,028	7,348
	International collaboration in AI implementation	0,032	5,129
Spain	Collaboration with an external AI technology provider	0,029	38,254
Italy	International collaboration in AI implementation	0,051	13,678
	Collaboration with an external AI technology provider	0,050	6,782
Germany	International collaboration in AI implementation	0,029	14,051

Source: *Own study.*

In Slovakia, two factors proved significant: the use of AI tools ($p = 0.028$; $Exp(B) = 7.348$) and international collaboration ($p = 0.032$; $Exp(B) = 5.129$). These results suggest that Slovak enterprises achieve higher competitiveness through the synergy between practical technology adoption and active participation in international cooperation networks.

In Spain, the strongest predictor was collaboration with an external AI technology provider ($p = 0.029$; $Exp(B) = 38.254$), which represents the highest odds ratio in the entire set of analyses. This finding indicates that Spanish enterprises particularly benefit from outsourcing technological competencies and partnering with specialized providers.

In Italy, international collaboration again emerged as a significant (borderline) factor ($p = 0.051$; $Exp(B) = 13.678$). In Germany, two predictors were significant: collaboration with an AI technology provider ($p = 0.050$; $Exp(B) = 6.782$) and international collaboration ($p = 0.029$; $Exp(B) = 14.051$). These results confirm that in countries with more developed technological ecosystems, integration with external partners and access to global knowledge resources play a crucial role.

4.2 Competency-Digitalization Model

To identify the factors determining enterprise competitiveness, a logistic regression analysis was conducted using a set of variables describing managerial readiness, managerial competencies and the technological advancement of the organization. The model was well fitted to the empirical data, as confirmed by both pseudo-R^2 indicators and the Hosmer-Lemeshow test. The Cox and Snell R^2 reached 0.301, while the Nagelkerke R^2 was 0.462, indicating that the model explains approximately 46% of the variance in the dependent variable. This is a relatively high value for logistic regression models, demonstrating solid explanatory power. Additionally, the Hosmer–Lemeshow test ($\chi^2 = 7.085$; df = 8; p = 0.527) did not reveal significant differences between observed and predicted values, confirming good model fit and the absence of systematic prediction errors.

Table 4. *Summary of the Competency–Digitalization Logistic Regression Model for All Countries*

Model Summary						
−2 Log-likelihood	**Cox & Snell R^2**			**Nagelkerke R^2**		
485,834[a]	0,301			0,462		
Hosmer-Lemeshow Test						
χ^2	**df**			**Significance**		
7,085	8			0,527		
Variables in the Model						
Variable	**B**	**SE**	**Wald**	**df**	**Sig.**	**Exp(B)**
Management knows the potential of AI	0,091	0,151	0,363	1	0,547	1,096
Management seeks AI-based solutions	-0,074	0,153	0,234	1	0,628	0,929
Management is open to AI technologies	0,051	0,151	0,114	1	0,735	1,053
Top management actively supports AI use	0,051	0,157	0,105	1	0,746	1,052
The company has a high level of digitalization	0,950	0,126	56,469	1	**<0,001**	**2,586**
Management is ready to implement AI	0,332	0,139	5,713	1	**0,017**	**1,394**
The company should implement the latest AI-based solutions	0,483	0,123	15,463	1	**<0,001**	**1,622**
Constant	-5,157	0,539	91,580	1	<0,001	0,006

Source: *Own study.*

In the overall model, three variables emerged as statistically significant predictors of enterprise competitiveness. The strongest predictor was the company's level of digitalization (B = 0.950; p < 0.001; Exp(B) = 2.586). This indicates that enterprises with a high level of digitalization are more than twice as likely to achieve higher competitiveness than firms with lower technological advancement. This underscores the fundamental role of digital infrastructure as a prerequisite for effective AI implementation.

The second significant predictor was managerial readiness to implement AI (B = 0.332; p = 0.017; Exp(B) = 1.394). This means that organizations whose managers demonstrate strong preparedness and competencies in AI implementation have significantly higher chances of achieving competitive advantage. This finding confirms the importance of leadership competencies and adaptive managerial capabilities in digital transformation processes.

The third significant factor was the belief that the company should implement the latest AI-based solutions ($B = 0.483$; $p < 0.001$; $Exp(B) = 1.622$). This indicates that organizations with a high innovation orientation, understood as readiness to adopt cutting-edge technologies, have a 62% higher likelihood of achieving greater competitiveness. This highlights the importance of a proactive strategic stance toward technological innovation.

The remaining variables related to managerial attitudes and behaviours (e.g., knowledge of AI potential, openness to technology, active support for AI adoption) did not reach statistical significance.

This suggests that declarative managerial attitudes do not directly translate into enterprise competitiveness unless accompanied by real implementation readiness and an adequate level of organizational digitalization.

4.3 Country-Level Analysis

Analysis conducted separately for each country revealed important contextual differences. In all analysed countries, the company's level of digitalization emerged as the key predictor of competitiveness: Poland: $p = 0.001$; $Exp(B) = 2.694$; Slovakia: $p < 0.001$; $Exp(B) = 2.411$; Spain: $p < 0.001$; $Exp(B) = 2.741$; Italy: $p = 0.001$; $Exp(B) = 2.792$; Germany: $p < 0.001$; $Exp(B) = 3.124$.

This indicates that, regardless of national context, digitalization constitutes a universal foundation enabling effective use of AI technologies.

Table 5. *Significant Logistic Regression Coefficients in the Competency–Digitalization Model Across Countries*

Country	X_i	Significance	Exp(B)
Poland	High level of digitalization	0,001	2,694
	Managerial readiness to implement AI	0,005	2,213
Slovakia	High level of digitalization	<0,001	2,411
	The company should implement the latest AI solutions	0,002	2,316
Spain	High level of digitalization	<0,001	2,741
	The company should implement the latest AI solutions	0,039	1,733
Italy	High level of digitalization	0,001	2,792
Germany	High level of digitalization	<0,001	3,124

Source: *Own study.*

In Poland, an additional significant predictor of competitiveness was managerial readiness to implement AI ($p = 0.005$; Exp(B) = 2.213), confirming the importance of managerial competencies in digital transformation processes.

In Slovakia and Spain, innovation orientation, expressed as the belief that the company should implement the latest AI-based solutions, also played an important role ($p = 0.002$; Exp(B) = 2.316 and $p = 0.039$; Exp(B) = 1.733, respectively). These findings suggest that in these countries, a pro-innovation organizational culture supporting AI adoption is a key factor enhancing competitiveness.

5. Discussion

The results of the logistic regression analyses provide important insights into the role of artificial intelligence (AI), managerial competencies and the level of digitalization in shaping enterprise competitiveness. The findings align with the growing body of research indicating that AI is becoming one of the key drivers of competitive advantage in the digital economy (Brynjolfsson and McAfee, 2017; Cockburn, Henderson and Stern, 2018; Shrestha *et al.,* 2019).

At the same time, the results highlight that the effectiveness of AI implementation depends not only on the technology itself but also on the organization's ability to absorb, integrate and strategically leverage it, as confirmed by recent studies on generative AI and its impact on business models (Dwivedi *et al.,* 2023; Huang and Rust, 2023).

The first model, which included variables related to AI implementation, showed that the only significant predictor of competitiveness was international collaboration. This result is consistent with the literature on open innovation, which argues that enterprises participating in global collaboration networks gain access to advanced technologies, knowledge and competencies that would be difficult to develop internally (Chesbrough, 2020; Bogers, Chesbrough and Moedas, 2022).

Research indicates that in the area of AI, international collaboration accelerates organizational learning, enhances absorptive capacity and enables access to cutting-edge technological solutions, all of which directly contribute to competitive advantage (Zhang, Zhao and Kumar, 2021; Lee and Trimi, 2022). The findings of this study therefore confirm that AI is a highly network-dependent technology, and its effective implementation requires integration with the global innovation ecosystem.

At the same time, the lack of significance for variables such as having an AI strategy, employee training or the use of analytical tools suggests that these actions, although important, are not sufficient conditions for achieving competitive advantage. This result is consistent with Davenport and Ronanki (2018), who argue that many organizations implement AI in a fragmented manner, without adequate organizational preparation, which limits business outcomes.

Recent studies confirm that AI implementations often fail to deliver expected results if they are not embedded within a broader organizational and strategic context (Shrestha *et al.,* 2019; Dwivedi *et al.,* 2023). Similarly, Raisch and Krakowski (2021) emphasize that AI implementation requires not only technology but also structural, cultural and competency-related changes that enable its full utilization.

The results of the implementation model indicate that the only significant predictor of competitiveness at the aggregate level is international collaboration. This suggests that at the current, still early stage of AI adoption in the SME sector, external sources of knowledge and integration with global innovation networks play a more important role than the technological implementations themselves.

Other technological variables may not show significance because many firms remain at the pilot stage, and the effects of AI implementation often materialize only in the longer term, as confirmed by recent analyses of digital transformation (Jonathan and Kuika Watat, 2020).

The second model, which included competency- and digitalization-related variables, identified three significant predictors of competitiveness: the level of digitalization, managerial readiness to implement AI and innovation orientation expressed through the belief that the company should adopt the latest AI-based solutions.

These findings align with the literature on digital transformation, which emphasizes that digital infrastructure constitutes the foundation enabling effective implementation of advanced technologies, including AI (Verhoef *et al.,* 2021; Kraus *et al.,* 2022). A high level of digitalization increases organizational flexibility, enables data integration and supports process automation, which translates into higher operational efficiency and improved market performance (Jonathan and Kuika Watat, 2020).

The significance of managerial readiness confirms the importance of leadership competencies in technological transformation processes. Research shows that managers play a key role in initiating, supporting and overseeing technological implementations, and their competencies, attitudes and adaptive capabilities determine the success of digital projects (Tarafdar *et al.,* 2019; Sousa and Rocha, 2019).

Recent studies emphasize that managers act as "technology translators," converting the potential of AI into concrete organizational actions, which significantly increases implementation effectiveness (Shrestha *et al.,* 2019).

The significance of innovation orientation indicates that enterprises actively seeking and adopting the latest AI solutions achieve higher competitiveness. This finding aligns with theories of dynamic capabilities, which argue that the ability to rapidly adapt to technological change is one of the most important drivers of competitive advantage in the digital economy (Teece, 2018). Recent studies confirm that technologically proactive organizations identify AI opportunities more quickly, integrate them more effectively with business processes and achieve greater economic benefits (Huang and Rust, 2023; Dwivedi *et al.,* 2023).

Country-level analysis revealed that although digitalization and managerial readiness constitute universal predictors of competitiveness across the entire sample, other factors vary depending on national context. In Poland, the practical use of AI tools played a particularly important role, whereas in other countries international collaboration or relationships with technology providers were more influential.

This finding aligns with literature indicating that digital transformation processes are strongly shaped by institutional, cultural and structural factors (Hinings, Gegenhuber and Greenwood, 2018). Recent studies confirm that AI adoption differs across countries depending on digital maturity, institutional context and local regulations (Kraus *et al.,* 2022; Jonathan and Kuika Watat, 2020).

Enterprise competitiveness in the context of digital transformation is therefore determined by a combination of technological, organizational and competency-related factors. The key determinants include a high level of digitalization, managerial readiness and integration with global innovation networks.

These findings align with the current research stream on artificial intelligence and digital transformation, emphasizing that competitive advantage in the digital economy arises not only from technology adoption but primarily from the ability to use technology strategically (Shrestha *et al.,* 2019; Dwivedi *et al.,* 2023).

6. Conclusions and Implications

The conducted research clearly demonstrates that artificial intelligence constitutes an important factor in building the competitive advantage of enterprises; however, its effectiveness depends on a set of organizational, managerial, and network-related conditions.

The findings show that the mere implementation of AI tools or the possession of technological resources does not guarantee market success. What proves crucial is the context in which these technologies are implemented, particularly the degree of digitalization within the organization, the readiness of managers to support transformation, and the extent of integration with global innovation networks.

Across all analysed countries, the most important predictor of competitiveness in the AI implementation model was international collaboration, highlighting the importance of cross-border knowledge and technology flows. At the same time, it is important to note that the remaining variables included in the model, although not statistically significant, displayed positive odds ratios. This means that their presence increased the likelihood of achieving higher competitiveness.

In particular, the use of AI tools, collaboration with technology providers, and access to funding for AI implementation showed a positive direction of influence. This suggests that AI-related implementation activities may gradually strengthen the market position of enterprises, with their full impact emerging over a longer time horizon as technological and organizational processes mature.

The comparative analysis revealed an interesting distinction between Poland and the other countries included in the study. In Poland, the key factor driving competitiveness was the direct use of artificial intelligence tools such as ChatGPT, Copilot, or Gemini. This suggests that Polish enterprises tend to focus on independently implementing and practically using AI technologies, relying on their own resources and competencies.

In the other countries, international collaboration played a more significant role, indicating a stronger openness to external sources of knowledge and integration with global innovation ecosystems.

It is worth noting that in Slovakia both factors, the use of AI tools and international collaboration, were statistically significant. This indicates that Slovak enterprises combine practical technological adoption with active participation in international cooperation networks, which may enhance their ability to absorb and implement innovations.

This differentiation can be explained by several factors. Cultural and historical conditions have shaped the development of Polish SMEs in an environment with limited access to international networks, fostering the development of internal competencies. Economic factors suggest that Polish firms more often choose ready-to-use solutions that can be implemented independently rather than engaging in costly international projects.

Organizational factors indicate that managers in Poland may place greater trust in their own resources and tools, whereas in Western European countries greater emphasis is placed on collaboration and technology transfer. It can therefore be concluded that Polish enterprises rely more heavily on internal technological implementation, while firms in other countries build their competitive advantage through network-based collaboration and international integration.

This means that pathways to competitiveness in the digital economy are diverse, some more autonomous and others more network-oriented, and their effectiveness depends on institutional and cultural context.

These findings have direct implications for managerial practice and policy. In Poland, managers should focus on developing internal competencies and the practical implementation of AI tools, which aligns with national studies indicating that Polish SMEs remain at an earlier stage of digital transformation and rely more on internal resources than on international collaboration.

At the same time, the literature emphasizes that as innovation ecosystems mature, the importance of cross-border collaboration increases, becoming the next stage in the development of firms' innovation capabilities. In the remaining countries, greater emphasis should be placed on supporting international collaboration and integration with global innovation networks.

Managers should actively seek cross-border partnerships, while public institutions should develop programmes facilitating technology transfer, access to international research and development projects, and the development of open innovation. In Germany, in particular, strengthening synergies between local innovation ecosystems and international cooperation is essential, requiring platforms that connect enterprises, research institutions, and foreign partners.

In the competency-digitalization model, three factors proved significant: the level of digitalization, managerial readiness to implement AI, and innovation orientation. These results indicate that competitive advantage in the digital economy does not stem solely from possessing technology but from the complementarity of technological, organizational, and managerial resources.

Importantly, in this model, cross-country differences were less pronounced than in the implementation model. This suggests that managerial competencies and digital maturity constitute more universal determinants of competitiveness, regardless of institutional context.

With respect to the research questions, the findings confirmed that factors related to AI implementation influence enterprise competitiveness to a limited extent, with international collaboration being the key determinant (RQ1). At the same time, organizational factors such as digitalization level, managerial readiness, and innovation orientation proved to be significant predictors of high competitiveness, confirming the importance of complementary resources for effective AI use (RQ2).

Cross-country analyses revealed differences in competitiveness determinants, highlighting the role of institutional context and digital maturity (RQ3). The study also confirmed that international collaboration strengthens the competitiveness of enterprises implementing AI, although its importance varies across countries (RQ4).

6.1 Theoretical Implications

The results of the conducted analyses provide important theoretical implications for the literature on artificial intelligence, digital transformation and enterprise competitiveness. First, the study confirms that AI is not an autonomous determinant of competitiveness; rather, its impact is strongly conditioned by organizational and network contexts. This finding aligns with the growing body of research indicating that the effectiveness of AI implementation depends on an organization's ability to integrate technology with business processes, decision-making structures and organizational culture (Raisch and Krakowski, 2021; Verhoef *et al.,* 2021).

Second, the significance of international collaboration as a key predictor of competitiveness expands the theoretical understanding of AI's role in organizations by demonstrating that these technologies are inherently network-based. This result supports the concept of open innovation (Chesbrough, 2020) and the theory of absorptive capacity, which posits that competitive advantage arises from the ability to acquire, process and utilize external knowledge (Zhang, Zhao and Kumar, 2021).

Third, the significance of digitalization, managerial readiness and innovation orientation confirms the importance of dynamic organizational capabilities (Teece, 2018). The findings indicate that enterprises achieve higher competitiveness not only through the adoption of AI technologies but, above all, through their ability to use them strategically.

The study thus contributes to the literature by highlighting the complementarity of technological and competency-based resources as the foundation of competitive advantage in the digital economy.

6.2 Practical Implications

The findings also have important implications for managerial practice. First, enterprises should view AI implementation not as a one-off technological project but as a process requiring a high level of digitalization, data integration and appropriate technical infrastructure. Organizations with low levels of digitalization may be unable to fully leverage the potential of AI, as confirmed by the strong and consistent impact of digitalization on competitiveness across all analysed countries.

Second, managerial readiness plays a crucial role. Managers should develop competencies related to AI technologies, understand their potential and actively support implementation processes. The results suggest that even technologically advanced organizations may fail to achieve competitive advantage if technological leadership is lacking.

Third, enterprises should develop international collaboration networks that provide access to the latest AI solutions, expert knowledge and global technological resources. Collaboration with foreign partners can significantly enhance the effectiveness of AI implementation, as confirmed by its role as the strongest predictor of competitiveness in the implementation model.

Fourth, organizations should promote innovation orientation, including readiness to experiment, test new technologies and adopt the latest AI solutions. The findings indicate that a proactive approach to innovation increases the likelihood of achieving competitive advantage.

6.3 Limitations and Directions for Future Research

Despite the study's cognitive value, several limitations should be acknowledged. The applied method relies on self-assessment by enterprises, which may involve perceptual biases; therefore, future research should also incorporate objective indicators such as levels of automation or investments in digital technologies.

The models include selected technological and organizational variables but omit institutional, cultural and sector-specific factors that may also shape implementation effectiveness.

The study is limited to five European countries, which restricts the generalizability of the findings to other regions. Moreover, the analysis does not account for differences in types of AI applications, such as generative artificial intelligence or machine learning, which may influence competitiveness in distinct ways.

References:

Bieńkowska, A., Szymańska, K. 2020. Innowacyjność polskich przedsiębiorstw w warunkach gospodarki cyfrowej. Warszawa: Wydawnictwo Naukowe PWN.

Bogers, M., Chesbrough, H., Moedas, C. 2022. Open innovation: Research, practices, and policies. California Management Review, 64(2), 5-23.

Brock, V., von Wangenheim, F. 2019. Demystifying AI: What digital transformation leaders need to know. Business Horizons, 62(6), 761-772.

Brynjolfsson, E., McAfee, A. 2017. Machine, platform, crowd: Harnessing our digital future. W.W. Norton.

Chesbrough, H. 2020. To recover faster from Covid-19, open up: Managerial implications from an open innovation perspective. Industrial Marketing Management, 88, 410-413.

Cockburn, I., Henderson, R., Stern, S. 2018. The impact of artificial intelligence on innovation. In: The economics of artificial intelligence. University of Chicago Press.

Davenport, T.H., Ronanki, R. 2018. Artificial intelligence for the real world. Harvard Business Review, 96(1), 108-116.

Dwivedi, Y.K., et al. 2023. So what if ChatGPT wrote it? Multidisciplinary perspectives on opportunities, challenges and implications of generative AI for research, practice and policy. International Journal of Information Management, 71, 102642.

Gupta, M., George, J.F. 2016. Toward the development of a big data analytics capability. Information & Management, 53(8), 1049-1064.

GUS. 2022. Społeczeństwo informacyjne w Polsce w 2022 roku. Główny Urząd Statystyczny.

Hinings, B., Gegenhuber, T., Greenwood, R. 2018. Digital innovation and transformation: An institutional perspective. Information and Organization, 28(1), 52-61.

Hosmer, D.W., Lemeshow, S., Sturdivant, R.X. 2013. Applied logistic regression (3rd ed.). Wiley.

Huang, M.H., Rust, R. 2023. Artificial intelligence in service. Journal of Service Research, 26(1), 3-20.

Jonathan, G., Kuika Watat, J. 2020. Digital transformation in business: A systematic literature review. Journal of Business Research, 116, 237-251.

Kozminski, A., Mroczkowski, T. 2021. Zarządzanie w warunkach cyfrowej transformacji. Warszawa: Wydawnictwo Akademii Leona Koźmińskiego.

Kraus, S., et al. 2022. Digital transformation in business and management research: An overview of the current status quo. International Journal of Information Management, 63, 102466.

Lee, S.M., Trimi, S. 2022. Innovation for creating a smart future. Journal of Innovation & Knowledge, 7(2), 100-120.

Li, L., Su, F., Zhang, W., Mao, J.Y. 2018. Digital transformation by SME entrepreneurs: A capability perspective. Information Systems Journal, 28(6), 1129-1157. https://doi.org/10.1111/isj.12179.

Menard, S. 2010. Logistic regression: From introductory to advanced concepts and applications. SAGE.

OECD. 2019. OECD SME and Entrepreneurship Outlook 2019. OECD Publishing. https://doi.org/10.1787/34907e9c-en.

PARP. 2023. Monitoring transformacji cyfrowej przedsiębiorstw w Polsce. Raport PARP 2023. Polska Agencja Rozwoju Przedsiębiorczości.

Peng, C.Y.J., Lee, K.L., Ingersoll, G.M. 2002. An introduction to logistic regression analysis and reporting. The Journal of Educational Research, 96(1), 3-14.

Raisch, S., Krakowski, S. 2021. Artificial intelligence and management: The automation–augmentation paradox. Academy of Management Review, 46(1), 192-210.

Richard, P.J., Devinney, T.M., Yip, G.S., Johnson, G. 2009. Measuring organizational performance: Towards methodological best practice. Journal of Management, 35(3), 718-804.

Shrestha, Y.R., Ben-Menahem, S.M., von Krogh, G. 2019. Organizational decision-making structures in the age of artificial intelligence. California Management Review, 61(4), 66-83.

Sousa, M.J., Rocha, Á. 2019. Skills for disruptive digital business. Journal of Business Research, 94, 257-263.

Tarafdar, M., Beath, C., Ross, J. 2019. Using AI to enhance business operations. MIT Sloan Management Review, 60(4), 37-44.

Teece, D.J. 2018. Business models and dynamic capabilities. Long Range Planning, 51(1), 40-49.

Verhoef, P.C., et al. 2021. Digital transformation: A multidisciplinary reflection and research agenda. Journal of Business Research, 122, 889-901.

Zhang, X., Zhao, K., Kumar, V. 2021. Digital transformation and firm performance: The role of digital platforms. Technological Forecasting & Social Change, 166, 120-636.