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FACTORS DETERMINING DIGITALIZATION IN POLISH COMPANIES IN THE CONTEXT OF THE EUROPEAN INDUSTRIAL STRATEGY

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Purpose: The purpose of this study was to identify and analyse the key factors that shape and drive the digitalisation processes of Polish enterprises within the broader framework of the European Industrial Strategy. More specifically, the study aimed to determine the significance of individual entrepreneurial ecosystem components—particularly government policy, institutional support, relational networks, and human‑capital capacities—in influencing firms' progress toward digital transformation.
Design/methodology/approach: The starting point for the research discussed in this article was to determine the degree of identification, significance, and comparison of the elements of the ecosystem, with a particular focus on the role of higher education institutions. Higher education institutions are a significant component considered in most economic development policies, as they play a crucial role in transferring knowledge and scientific achievements to businesses and are vital in building national, sectoral, and technological ecosystems. To achieve this goal, data was collected using the CATI method in a nationwide study of enterprises (n = 302).
Findings: The research findings indicated a weak identification of the elements of the entrepreneurial ecosystem within the processes of digitalisation. Furthermore, it revealed that government policy is the best-identified element of the entrepreneurial ecosystem (27%) and is, among the others, the most positively impactful aspect concerning the integration of digital technology in business operations (63.9%).
Practical implications: Government policy influence affects the digitalisation processes and the adaptive actions taken by enterprises, regardless of their size.
Originality/value: Future research on the ecosystem and its structure should consider the role of enterprises in the functioning of this system as a whole.
Keywords: government policy, entrepreneurship, economic development, technological change, digital transformation, innovation leaders, IT Management, innovation, technological change and growth.
Category of the paper: research paper.

1. Introduction

The transformation of industrial policy since the mid-20th century has increasingly emphasised entrepreneurship, innovation, and technology as foundational drivers of economic development. While early post-war policies primarily targeted reconstruction and support for fundamental sectors of the economy, subsequent decades saw the emergence of structured measures supporting micro-, small-, and medium-sized enterprises (MSMEs) in regions such as India in the 1950s and Europe in the 1970s (Audretsch, Beckmann, 2007). This evolution ultimately shifted the focus of national economic strategies toward the cultivation of enterprise dynamism and the facilitation of innovation-based growth (Warwick, 2013; Borbas, 2015).

Against this historical backdrop, the contemporary policy environment—particularly within the European Union—places unprecedented emphasis on digitalisation as a central determinant of competitiveness and resilience. The European Industrial Strategy (2020) identifies digital transformation and ecological sustainability as its two fundamental pillars, outlining a coordinated approach to strengthening industrial ecosystems through regulatory harmonisation, increased innovation capacity, development of digital skills, and improvements in data-processing and technological infrastructure (Autio, 2016; *Prosperity, People and Planet*, 2019). These priorities have direct implications for enterprises across member states, including Poland, where digital competencies, access to enabling technologies, and institutional support mechanisms increasingly shape patterns of organisational development and market competitiveness.

Within this policy context, the digitalisation of Polish companies is not solely a technological issue but rather a multidimensional process influenced by a set of interrelated factors, including government policy, the availability of skilled labour, institutional support networks, the maturity of entrepreneurial ecosystems, and firms' internal capacities for organisational adaptation. The European Industrial Strategy underscores the need to strengthen these determinants by promoting cross-industry collaboration, investing in digital infrastructure, enhancing access to low-emission energy, and supporting the development of advanced technological solutions. Consequently, the factors influencing digitalisation in Polish enterprises must be examined through the lens of both domestic conditions and supranational strategic frameworks.

The concept of the entrepreneurial ecosystem—originating in natural sciences (Clements, Pound, 1898) and later adapted to economics and management (Blew, 1996)—provides an analytical foundation for understanding how these factors interact. Modern entrepreneurial ecosystems encompass institutional and resource configurations that shape productive entrepreneurship and drive economic development (Baumol, 1993; Stam, 2024). Their structure includes core actors such as universities, firms, public institutions, and specialised intermediaries, all of which contribute to the diffusion of knowledge and the development of digital capabilities (Iansiti, Levien, 2004; Oliveira et al., 2019).

However, empirical studies highlight persistent weaknesses in ecosystem coordination, especially in contexts where relationships between institutions, enterprises, and policy frameworks remain fragmented. This challenge is observable in Poland, where—despite substantial progress—companies demonstrate varying levels of digital maturity and uneven engagement with ecosystem actors. Understanding the determinants of digitalisation therefore requires investigating how Polish enterprises interact with governmental initiatives, access technological resources, and participate in knowledge-sharing networks shaped by both national and European policies.

Digitalisation is also a focal point of EU industrial policy due to its structural implications for labour markets, productivity, and long-term competitiveness. While digital technologies may create new economic opportunities, they can also lead to the stagnation of wages, automation of routine activities, and significant shifts in employment structures (Acemoglu, Restrepo, 2018). These dynamics highlight the importance of developing comprehensive support mechanisms that enable companies—especially SMEs—to harness digital tools while adapting effectively to evolving market conditions.

In this context, the present chapter seeks to analyse the factors determining the digitalisation of Polish companies, with particular emphasis on their alignment with the priorities and mechanisms defined within the European Industrial Strategy. Given that higher education institutions serve as critical nodes for knowledge transfer and capacity building, their role within the entrepreneurial ecosystem is of particular interest. By examining the degree to which Polish enterprises identify, value, and utilise ecosystem components, this study contributes to a deeper understanding of how institutional, organisational, and policy-driven factors jointly determine the pace and effectiveness of digital transformation in Poland.

2. The Economic Development Policy in the Digital Age

In the digital age, economic development policy undergoes profound transformation as governments confront new technological, organisational, and societal challenges. Contemporary research on economic policy and entrepreneurial ecosystems reflects a shift from traditional industrial frameworks toward models that recognise the centrality of digital technologies, knowledge flows, and innovation networks in shaping economic performance. This scholarship highlights how mechanisms of spatial business concentration, competitiveness, and development dynamics increasingly depend on institutions that support digital-enabled entrepreneurship—such as incubators, accelerators, clusters, hubs, and both traditional and digital entrepreneurship ecosystems (Ahokangas et al., 2018; Sussan, Acs, 2017). These institutions play a vital role in enabling firms to access knowledge, adopt new technologies, and integrate into digitally networked markets.

The digital age also expands the scope of development policy beyond individual enterprise support to encompass systemic strategies facilitating innovation diffusion and knowledge transfer. Universities, in particular, emerge as pivotal actors within these reconfigured policy landscapes. Their functions extend from educating graduates equipped with digital and entrepreneurial competencies (European Commission, 2005; Bedő et al., 2020; Czaja, Kafel, 2022), to collaborating with industry and public stakeholders on applied research and technology deployment (Watson, 2010; Buła, Schroeder, 2020). As centres of innovation and knowledge creation, universities significantly influence growth dynamics at both national and regional levels (Solow, 1956; Romer, 1990; Altmann, Ebersberger, 2013). Their participation in triple-helix structures—linking academia, business, and government—illustrates the increasingly interdependent nature of economic development in the digital era (Etzkowitz, Leydesdorff, 1999; Truskolaski, Waligóra, 2015). The evolution toward quadruple and quintuple helix models (Carayannis et al., 2012) further reflects how digitalisation widens the policy arena to incorporate civil society and ecological sustainability as integral dimensions of innovation-driven development.

Economic development policy in the digital age is also characterised by a strategic reorientation of competitive models. Whereas earlier industrial paradigms relied heavily on low labour costs or material efficiencies, contemporary economic advantage derives increasingly from capabilities in knowledge production, technological innovation, and digital resource integration. These conditions require strengthened collaboration and resource sharing between universities, enterprises, public administration, and social organisations—the full spectrum of actors embedded in digitally mediated entrepreneurial ecosystems (Etzkowitz, Zhou, 2018). Moreover, the escalating costs and complexity of research and development, particularly in frontier technologies, have prompted renewed recognition of the state's role as a key catalyst of innovation. Recent analyses emphasise that public institutions frequently initiate or enable the development of transformative technologies, challenging assumptions that innovation is solely the domain of private enterprise (Mazzucato, 2019).

In this context, economic development policy becomes both a regulatory framework and an active instrument for shaping digital transformation. Governments increasingly influence the pace and direction of technological change by establishing standards for digital infrastructure, environmental sustainability, and resource efficiency; by designing incentive mechanisms for technological upgrading; and by directly participating in markets where necessary. Innovation leaders—entities whose solutions become dominant within a technological regime—serve as important drivers of digital restructuring, and may emerge from either the private or public sector (Nelson, Winter, 1982). Leadership in the digital age is defined not only by technological capacity but by the ability to reimagine goods, services, and organisational processes through digital transformation, thereby making them more personalised, efficient, and accessible (Sacavém et al., 2025). Table 1 illustrates how economic development policy has evolved across successive paradigms: from traditional enterprise-oriented policies, through

growth-oriented approaches, to ecosystem-based frameworks, and finally toward an increasingly individual-centred perspective. This evolution reflects a fundamental recalibration of policy goals, instruments, and governance arrangements necessitated by digital transformation. Within the European Union, current economic policy places strong emphasis on the creation of entrepreneurial ecosystems and networks of technology centres as mechanisms for supporting digitally advanced organisational structures across industry, production, trade, and services. These frameworks align with broader European objectives related to digitalisation, decarbonisation, and cross-sector innovation.

Table 1.
Traditional, Growth-Oriented, Entrepreneurial Ecosystem and Individual-oriented policy

Policy and its components	**Traditional Enterprise Policies**	**Growth-Oriented Enterprise Policies**	**Entrepreneurial Ecosystem Policies**	**Individual-Oriented policy**
Main unit of focus	On specific actors, such as individuals, entrepreneurs, geographic clusters of firms.	On specific types of entrepreneurs, networks of entrepreneurs or 'temporary' clusters.	On leaders of innovations in the field of high and digital technologies, AI, and ecology.	On science, technology and innovation, on individual open access to the markets.
Policy objectives	Generate more entrepreneurs and grow more new ventures.	Focus on the high potential or 'blockbuster entrepreneurs' with the largest economic potential, high growth firms (HGFs).	Projects, startups, and enterprises increasing digitisation and resource reduction, strengthening "technopreneurship"	Generate more innovators and entreprenurs, grow more new projects, market, private ownership and free entrepreneurship.
Policy targets	Specific focused interventions aimed at parts of entrepreneurial systems (i.e. non-systemic).	At connecting components within ecosystems to enable the system to better function (i.e. systemic).	Growth through the use of technology, awareness, self-sufficiency, development based on recycled materials.	Limited Access Order to Open Access Order. Free access to the economic circulation.
Main forms of assistance	'Transactional' forms of suport such as grants, tax incentives, subsidies etc.	'Relational' forms of support such as network.	Hubs, accelerators, centres for startups.	Simplification of regulatory frameworks, assistance at the microeconomic, local level.
Main forms of assistance by policy makers	Generating and promoting entrepreneurial sources of finance aimed at start-ups, particularly in the form of venture capital and business angel funding.	Building, developing connections between entrepreneurial actors, institutional alignment of priorities, fostering peer-based interactions.	Technological centres (that are key actors in innovation ecosystems due to their technical expertise and their ability to bring together and steer collaboration among various types of actors in their own ecosystems and beyond).	Increasing forms of cooperation, collaboration, and subcontracting between organisations and individual entrepreneurs and innovators.

Cont. table 1.

Recognition of vital and supportive spheres	New firm-based intellectual property and innovation, R&D and the protection of intellectual property rights.	Different funding requirements such as debt finance, peer to peer, crowdfunding, etc. due to businesses growth and upscale firms require access to a 'funding escalator' and 'cocktails' of different funding sources.	Support in two areas: (1) digitalisation and industrial modernisation, (2) greening, energy and resource efficiency.	Creation of new versions of existing tasks, in which labor has a comparative advantage.
Tactical policies	Strong encouragement to technology and innovation within hightech sectors.	Focus on developing innovation systems and fostering connections with customers, end users, suppliers, universities etc. increasing recognition of unprotected and 'open' sources of innovation. Innovation is porous transcending many sectors and industries – both new and traditional.	Dedicated to technology generating industrial ecosystems.	State intervention through regulatory legal measures during periods of turmoil and economic difficulties.
Top-down policy vs bottom-up policy (direction)	The level of policy making is mostly 'top down'.	The bulk of systemic policies are enacted at the regional or local level.	The level of policy making is 'top down' along technological path and/or ecological path. The key role of state institutions and corporations in the implementation of modern technologies.	Policy of liberalising people's activities and reclaiming economic areas protected by regulations friendly to public entities and large private ones.
Economic policy centres	The implementation of policy is mostly undertaken at national level but some initiatives are devolved.	Multi-scalar policy frameworks are emerging.	Policy implementation regulations and tools are undertaken at above national level. Centralisation of planning.	Decentralisation of planning.

Source: own elaboration on: Mason, Colin, Brown, Ross (2014). Entrepreneurial Ecosystems And Growth Oriented Entrepreneurship Background paper prepared for the workshop organised by the OECD LEED Programme and the Dutch Ministry of Economic Affairs, Monitoring European industrial ecosystems, Conceptual, Monitoring and Indicator Framework (2023) & Radu G., Liviu A., Warnke P. (2022). ISIS&T&I for 2050. Science, Technology and Innovation for Ecosystem Performance – Accelerating Sustainability Transitions. Case Study: Data As Representation.

Building on empirical insights from the systemic transformation of centrally planned economies and contemporary scenario modelling of future development trajectories, the authors propose an additional paradigm: an economic development policy centred on individual agency

and digitally empowered entrepreneurship. As presented in the final column of Table 1, this perspective highlights open access to markets, decentralised participation, and regulatory environments that enable individuals to engage directly in economic activity. In the digital age—where technological tools increasingly democratise access to knowledge, data, and markets—such an approach complements ecosystem-oriented strategies by emphasising the micro-level drivers of innovation and adaptability.

3. The Digital Transformation in the European Industrial Strategy

Contemporary European Union policy continues to rely on long-standing mechanisms designed to influence social, economic, cultural, and political development through the coordination of shared strategic objectives among Member States. This approach emphasizes coherence between the economic system and the broader socio-political order, aiming to increase inclusiveness, strengthen governance efficiency, and enhance overall prosperity, cohesion, and justice within a framework grounded in political democracy and the rule of law (North et al., 2009). The transition toward a more structured and sustainable market economy is supported by an inclusive legal-economic system based on the principles of markets, private property, and free entrepreneurship (Fiedor, 2023). The expansion of inclusiveness within the European legal-economic order is embedded in the growing openness of political, social, and economic domains—an openness intended to transform the system from a limited access order into an open access order. This openness does not imply institutional laxity; rather, it signifies increased access to markets, resources, and economic opportunities, subject to clear legal and regulatory frameworks (Table 1). State intervention through regulatory and strategic measures becomes particularly important during periods of economic instability. In response to disruptions caused by the COVID-19 pandemic and the Russian–Ukrainian conflict, EU policy shifted toward economic resilience and recovery. Within this context, the European Commission introduced the European Industrial Strategy (EIS), a comprehensive framework articulating nine strategic priority areas: digital transformation, ecosystems, energy-intensive industries, clean hydrogen, skills for industry, interregional partnerships, innovation, industrial policy dialogue and expert advice, and intellectual property. These strategic domains—defined in 2020—were accompanied by timelines and implementation pathways tailored to the varying levels of advancement across Member States (Fig. 1). Among them, digital transformation and ecosystems represent two interdependent pillars: one technological, the other political-economic. Their integration marks an innovative attempt to connect digitisation with specific industrial sectors and policy-driven development processes.

Figure 1. European industrial strategy 2020.

Source: own elaboration Monitoring European industrial ecosystems, Conceptual, Monitoring and Indicator Framework (2023).

Modern EU industrial policy recognizes the emergence of interconnected sectors—FinTech, MedTech, e-banking, e-governance, and others—that did not previously exist in such codified forms. These sectors constitute new forms of economic ecosystems, creating value for both individual and institutional users (Ruohomaa, 2020). The literature on digitalisation highlights how digital technologies—automation, data mining, machine learning, and new communication tools—enhance efficiency, reduce processing times, expand service offerings, and increase transparency within production and service chains (Layne, Lee, 2001; Norris, Reddick, 2011; Matheus et al., 2018).

Within EU development strategies, sectoral ecosystems function as multidimensional constructs that combine technological–digital and ecological pathways, each representing distinct yet interrelated transformation trajectories. These ecosystems encompass coordinated activities among industry, public institutions, social partners, and other stakeholders. They collectively develop transformation pathways across both dimensions, supported by initiatives such as the Monitoring European Industrial Ecosystems (MEI) project, which tracks changes and progress (MEI, 2023).

The ambitious development trajectory envisioned by the European industrial strategy suggests that both the ecological and technological paths—rooted respectively in the Green Deal and the Fourth Industrial Revolution—will evolve through ecosystem-based approaches. Importantly, the EU's use of the term "ecosystem" narrows its traditional ecological meaning, while expanding its common economic interpretation to encompass systems of institutional support for innovation and entrepreneurship. This reconceptualization was formalized in 2022, when the EU identified 14 industrial ecosystems functioning as microeconomic environments ("smart units") and socio-economic environments ("smart markets"), operating in both urban (smart cities) and rural (smart villages) settings (Fig. 2).

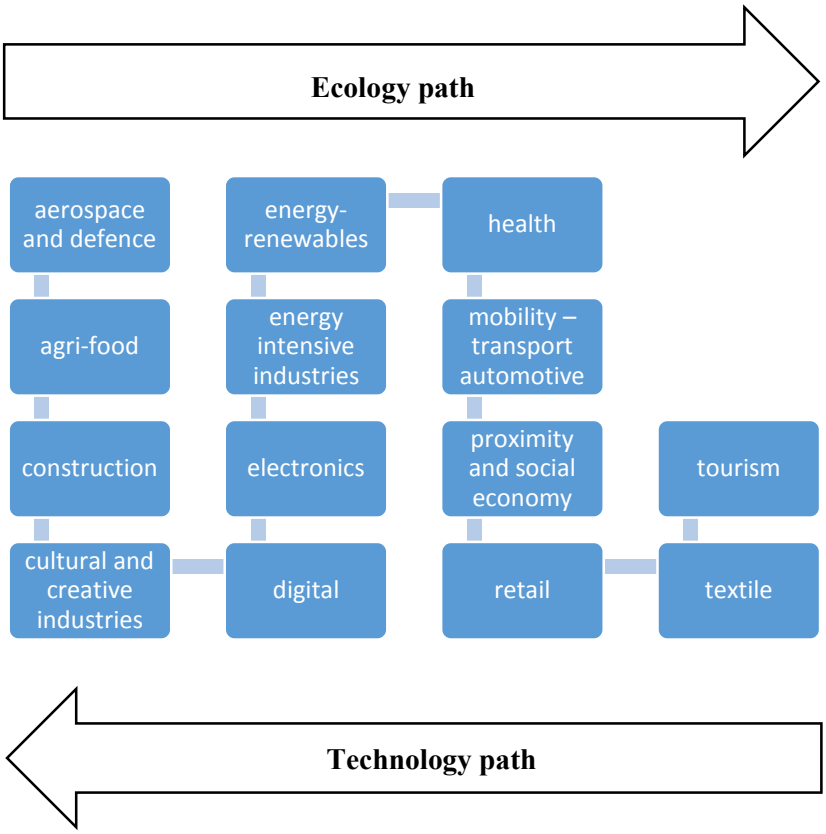


Figure 2. 14 industrial ecosystems as highlighted in the European industrial strategy in 2020.
Source: own elaboration on European industrial strategy 2020.

These ecosystems—ranging from aerospace and defence to agri-food, cultural and creative industries, digital, electronics, renewables, mobility, social economy, retail, textiles, and tourism—represent the foundation of EU industrial transformation. They demonstrate how digital technologies are not merely tools but structuring principles for industrial organization, sectoral interdependence, and value-creation processes. By accelerating the **twin transitions**—green and digital—the EU aims to transform traditional sectors into dynamic industrial ecosystems capable of meeting future economic and environmental challenges. Many actions outlined in the 2020 Industrial Strategy to support these transitions have already been initiated across Member States.

4. The Digital Transformation Gap Between Poland and the European Union

The digital transformation gap between Poland and the European Union (EU) has become increasingly evident when assessed against international benchmarks. According to the *International Benchmarking of the Digital Transformation 2024* report, the EU as a whole displays only moderate competitiveness compared with global digital leaders; however, Poland

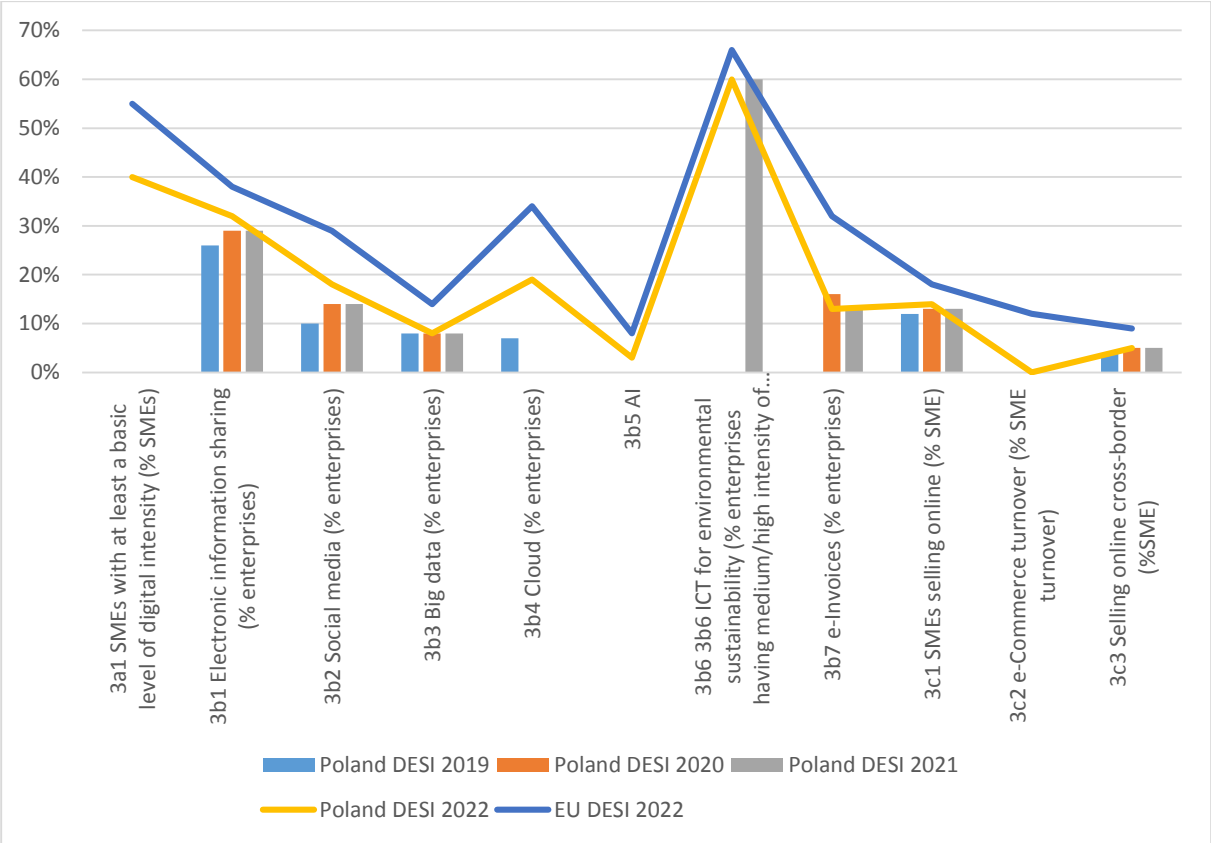
consistently performs below the EU average across most examined dimensions (Bednorz et al., 2024). This divergence underscores persistent structural, infrastructural, and organisational barriers that inhibit Poland's pace of digital advancement relative to European standards.

The EU's digital transformation is typically evaluated through multidimensional indices such as the International Index of Digital Economy and Society (IDESI), the World Digital Competitiveness Index (WDSI), the Network Readiness Index (NRI), the Digital Intelligence Index (DII), and the UN E-Government Development Index (EGDI). When benchmarked against these indicators, Poland's progress remains limited, weakening its position within the European digital ecosystem (Bednorz et al., 2024).

Since 2023, the process of identifying Key Performance Indicators (KPIs) that monitor progress toward the objectives of the Digital Decade has included DESI. KPIs were developed using the DESI exercise, which was already in existence and tracked the annual state of the digital transformation in Europe. Since that year, the strategy of digitising the economy and society has been implemented. Its implementation in EU countries has been based on the Digital Decade policy program (DDPP), and the "State of the Digital Decade 2025" reports monitor the progress and changes in digitisation. The DDPP promotes investments in digital skills, digital transformation of businesses, digitalisation of public services, and the deployment of gigabit and 5G networks that are safe and sustainable. This is driven by the governance framework, which is founded on an annual cooperation mechanism including the Commission and Member States, according to the Communication - 2030 Digital Compass: the European strategy for the Digital Decade. The objectives of the Digital Decade Program are based on the four cardinal elements of the program: a population with high levels of digital competence and experience; safe and sustainable digital infrastructures; business transformation; and digitisation of public services.

Although some EU member states demonstrate excellence in digital skills, infrastructure deployment, and enterprise transformation, Poland's slower development in these areas widens the internal EU gap. A central component of this disparity is the insufficient level of advanced digital competencies in Poland. Challenges persist in the supply of ICT graduates, the diffusion of high-speed connectivity, and the deployment of 5G networks. These gaps affect Poland more severely than the EU average, thereby constraining its ability to participate fully in the region's digital transition (Bednorz et al., 2024). Furthermore, Poland significantly underperforms in frontier areas such as semiconductor uptake, quantum-technology-related patents, and the scaling of high-growth technology enterprises. While the EU as a whole struggles with these strategic sectors, the gap between Polish and EU performance remains substantial.

The divergence is further illustrated by enterprise-level indicators. Poland ranks 24th out of 27 EU member states in the Digital Economy and Society Index (DESI), with particularly low scores in digital technology integration (Fig. 3).



X-axis label: DESI Indicator Categories.
Y-axis label: DESI Score (percentage share).

Figure 3. Integration of digital technology.

Source: Authors' own study on DESI for 2022, Poland, p.13 and DESI for 2019-2021.

Polish companies are less likely to use electronic information-sharing systems, social media, big data analytics, cloud solutions, artificial intelligence, or cross-border e-commerce compared with the EU average. For example, cloud computing adoption in 2022 was significantly lower in Poland than in the EU, and the use of AI technologies was also markedly behind European benchmarks. At the same time, disparities within the EU often exceed the distance between EU averages and global digital leaders—yet Poland typically falls near the bottom of the EU distribution (DESI 2019-2022). The difference in enterprise digital maturity is also notable. Only 6.8% of medium-sized and 22% of large Polish enterprises have reached advanced digitalisation levels, compared with 9.6% and 26.3% in the EU, respectively. Although productivity in Polish firms improved between 2021 and 2023, these gains were still smaller than improvements recorded across the EU, further intensifying the productivity gap linked to digitalisation. E-commerce participation also remains weaker in Poland (21% of SMEs) compared with the EU average (30%). These discrepancies demonstrate that Poland's business sector remains less capable of using digital tools to enhance competitiveness, efficiency, and market reach (Olszynka et al., 2024). Despite these gaps, Poland shows strengths in specific areas that may help narrow the divergence. Cloud adoption, for instance, has risen substantially: 56% of Polish companies used at least one cloud solution in 2023—a 27%

increase over two years. This acceleration outpaced the rate of change in several EU states, although overall Polish adoption levels still trail behind leading European performers. The growing interest in process automation and data analytics also suggests an emerging readiness to bridge the digital divide, as confirmed by surveys showing widespread recognition of digital transformation as a strategic necessity (Olszynka et al., 2024). Nevertheless, structural obstacles continue to widen the gap. Many Polish enterprises remain reliant on manual workflows: 38% maintain paper-based documentation and 58% use manual data entry, compared with significantly lower levels in the EU. Adoption of advanced planning systems (APS), typical of Industry 4.0 environments across Europe, has dropped to 6% in Poland. Barriers cited by Polish companies—security concerns, integration difficulties, and cost pressures—appear more acute than those reported by many EU peers, indicating national-level constraints affecting digital readiness (Olszynka et al., 2024).

Regulatory developments in the EU, such as the National e-Invoicing System (KSeF), the VAT in the Digital Age (ViDA) initiative mandating electronic invoicing by 2028, and the Corporate Sustainability Reporting Directive (CSRD), further highlight Poland's lag in aligning enterprise systems with evolving European standards. While many EU firms have already integrated advanced reporting, invoicing, and sustainability-tracking technologies, a significant share of Polish enterprises continues to adapt reactively rather than strategically. This dynamic reinforces the structural dimension of the Poland–EU digital gap (Olszynka et al., 2024). Closing this gap requires substantial strategic investment. According to estimates cited in the analysed reports, effective implementation of AI could improve operational efficiency by up to 20%, but Polish firms remain less capable of identifying and deploying viable AI use cases compared with their EU counterparts. The National Recovery and Resilience Plan (KPO), which offers over one billion euros to accelerate Industry 4.0 adoption, represents an opportunity to converge with EU digital standards—yet its success will depend on firms' capacity to overcome existing organisational and infrastructural barriers (Olszynka et al., 2024).

Overall, the digital transformation gap between Poland and the European Union is multifaceted and persistent. It stems from disparities in digital skills, infrastructural investment, enterprise digital maturity, regulatory readiness, and technological innovation. While Poland demonstrates progress in selected areas, the structural nature of the gap indicates that without coordinated public policy, stronger enterprise capabilities, and sustained investment in advanced technologies, Poland will continue to lag behind the EU average, potentially limiting its economic competitiveness and strategic resilience in the digital era.

5. The Key Factors Shaping and Driving the Processes of Polish Companies' Digitalisation (Empirical Research)

The purpose of this empirical study was to identify and analyse the key factors shaping and driving the digitalisation processes in Polish enterprises. Recognising that digital transformation is embedded within a broader entrepreneurial ecosystem (EE), the study sought to determine which ecosystem components play the most significant role in stimulating, enabling, or accelerating digital adoption at the firm level. To this end, a nationwide CATI survey of 302 enterprises—stratified by sector and employment size—was conducted using a reference population of 98,153 firms (Fig. 4).

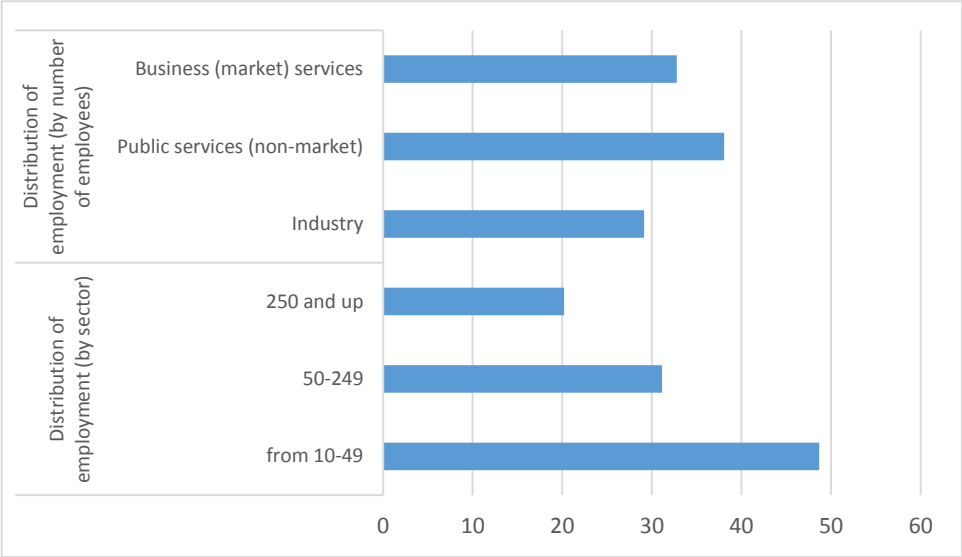


Figure 4. Structure of the research sample (percentage).

Source: own elaboration.

The inclusion of entrepreneurial ecosystem models featuring universities and knowledge generating institutions reflects the assumption that digitalisation processes develop through interactions between firms and their institutional, regulatory, educational, and technological environments.

Two research questions guided the empirical analysis:

Q1. Which elements of the entrepreneurial ecosystem exert the strongest impact on firms' digitalisation processes?

Q2. Do enterprises perceive their internal conditions and external surroundings as favourable for implementing digital transformation?

5.1. Key External Drivers of Firms' Digitalisation (Q1)

The first research question focused on identifying the **critical ecosystem elements** that shape and drive digitalisation in Polish companies. Respondents assessed the influence of ten ecosystem components using a 7-point scale. Across all sectors and enterprise sizes, the most powerful driver of digitalisation was **government policy and legal regulation (Fig. 5)**.

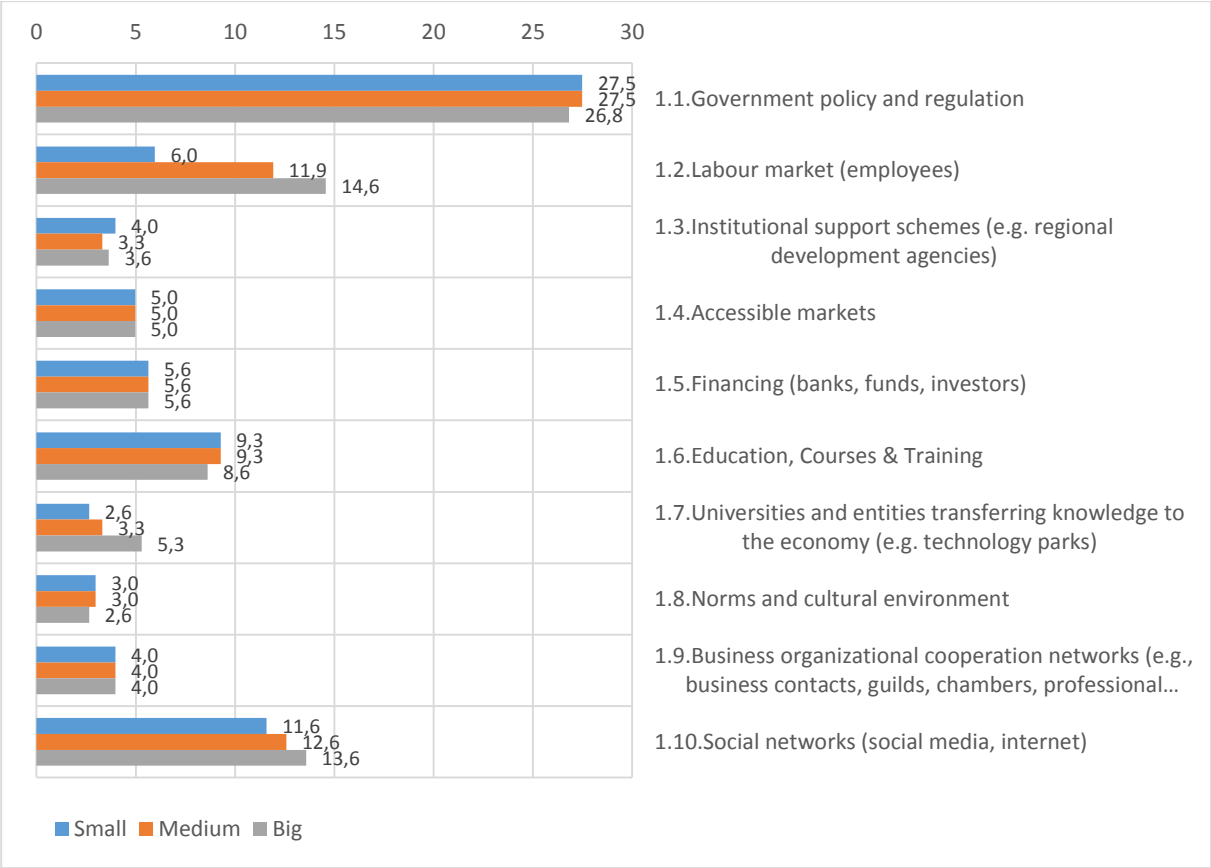


Figure 5. Significant elements of the ecosystem in digitalisation processes.

Source: Own elaboration.

With 27% of firms ranking this factor as most significant, public policy emerges as the dominant structural force directing digital transition. This reflects both regulatory pressures (e.g., obligatory digital reporting systems) and state-supported incentives encouraging the adoption of digital solutions.

Two additional ecosystem factors strongly shaping firm-level digitalisation were identified:

- Social networks (Internet and social media), highlighted by 12% of firms as a major driver due to their centrality in communication, marketing, and customer interaction.
- Education, courses, and training, pointed out by 9% of respondents, indicating that skill development constitutes a relevant—though secondary—mechanism enabling digital transformation.

Other ecosystem components—such as the labour market, external financing, and cultural norms—exert a moderate yet meaningful influence.

Importantly, firm size differentiates how these drivers are perceived:

- Small enterprises emphasise government policy, labour market characteristics, and cultural norms.
- Medium-sized enterprises recognise the role of social networks and workforce skills alongside public policy.

- Large organisations particularly stress the labour market and the availability of skilled employees as central drivers of digitalisation.

Sectoral differences also reveal divergent digitalisation drivers (Fig. 6). For instance, education and healthcare identify government policy as a decisive force, reflecting their regulatory intensity.

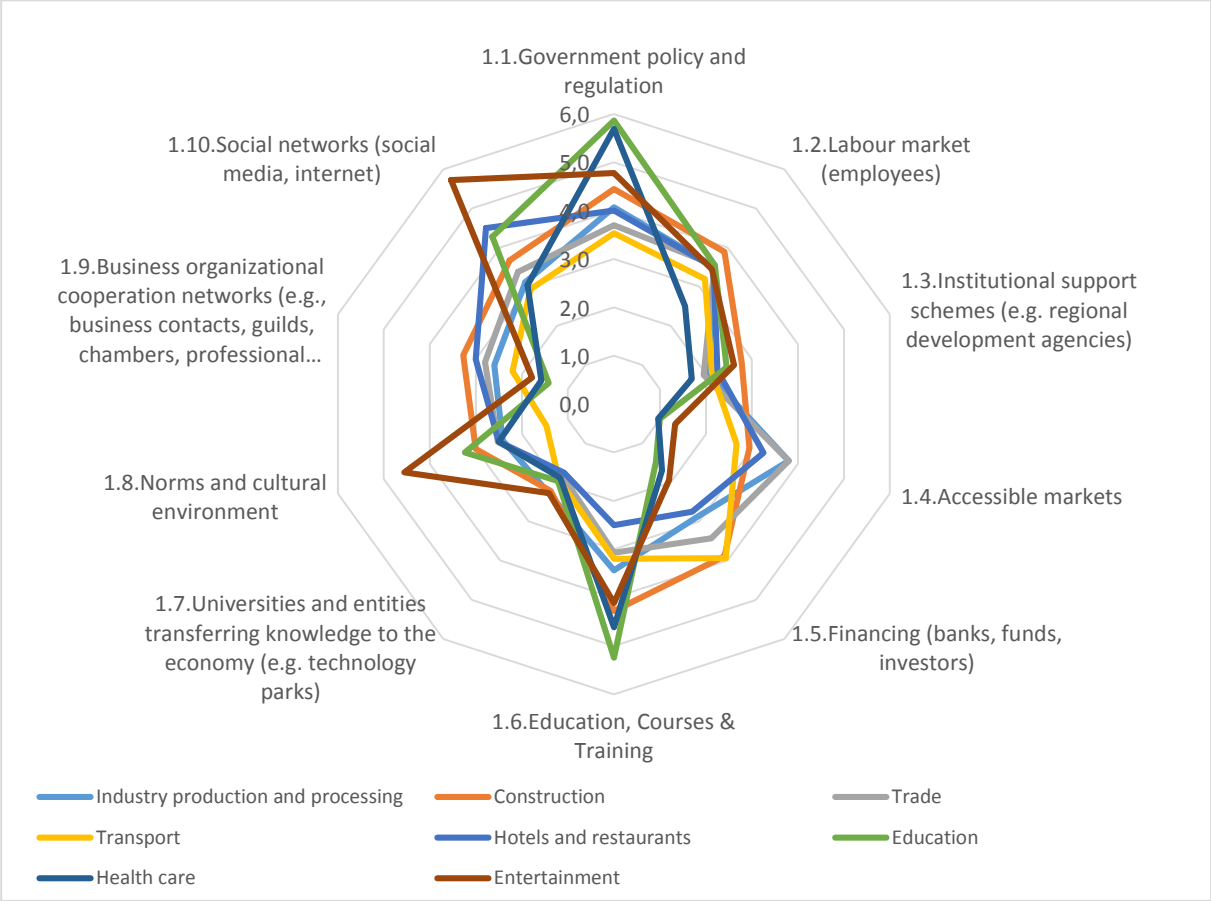


Figure 6. Assessment of the impact of ecosystem elements on the business digitalisation in a sectoral approach.

Source: Own elaboration.

Conversely, entertainment enterprises view digital social networks as their primary digitalisation driver, underscoring the sector's dependence on online channels.

Across the sample, universities, research institutions, and formal institutional support schemes were assessed as weak drivers of digitalisation, suggesting that these actors—although essential in many theoretical EE frameworks—currently play a marginal role in shaping the digital transformation of Polish firms (Fig. 7).

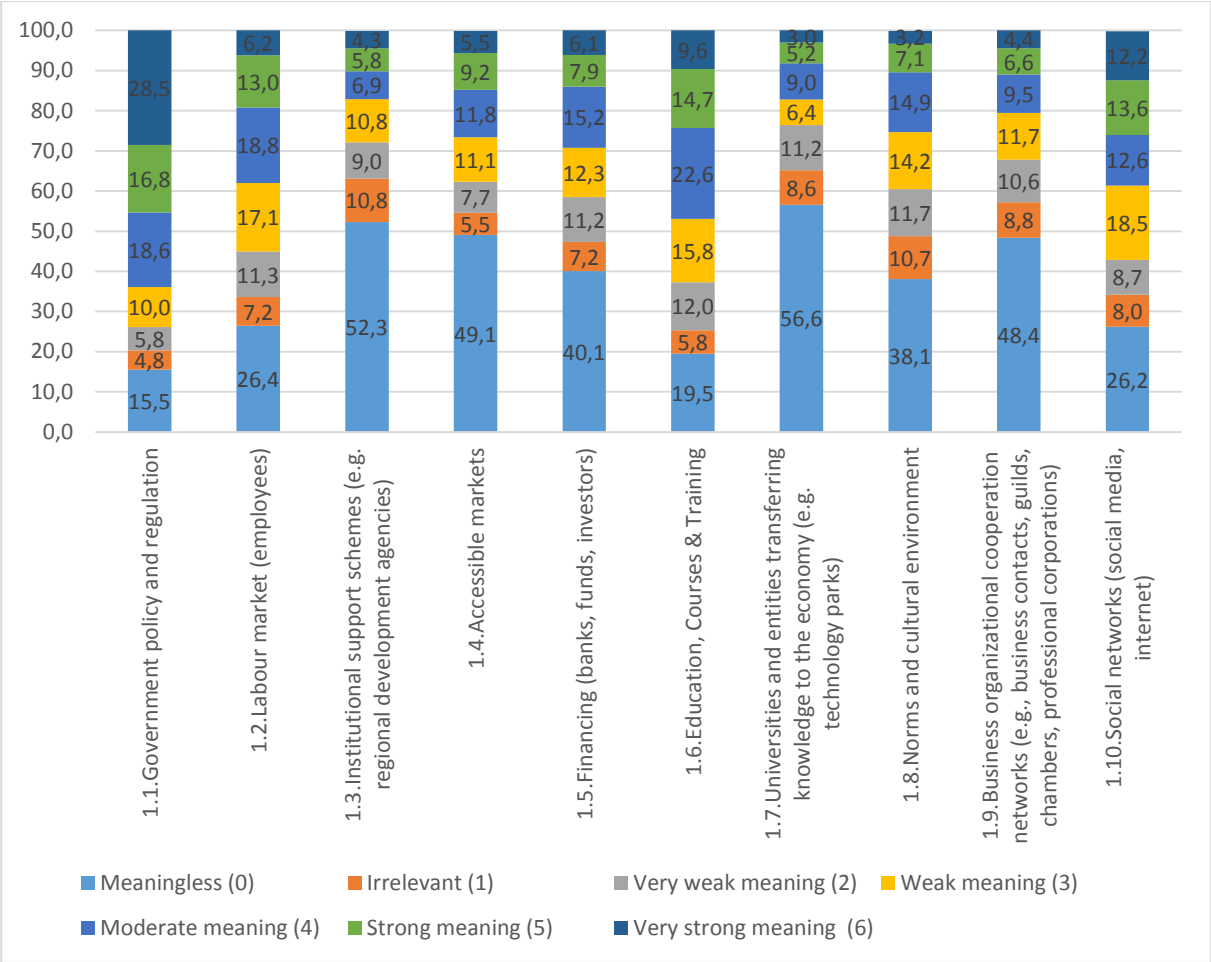


Figure 7. Assessment of the impact of ecosystem elements on the business digitalisation of enterprises.

Source: Own elaboration.

5.2. Internal and Relational Factors Driving Digital Transformation (Q2)

The second research question explored whether firms perceive their internal environment and network relationships as conducive drivers of digitalization. Respondents evaluated five statements related to human capital, partner readiness, and the use of digital platforms.

Two factors emerged (Fig. 8 and Fig. 9). as particularly strong internal or relational drivers of digitalisation processes:

1. The engagement of qualified employees who understand the need for change (Q2.3).
2. Partners (suppliers, customers) perceiving digitalisation as an opportunity for growth (Q2.2).

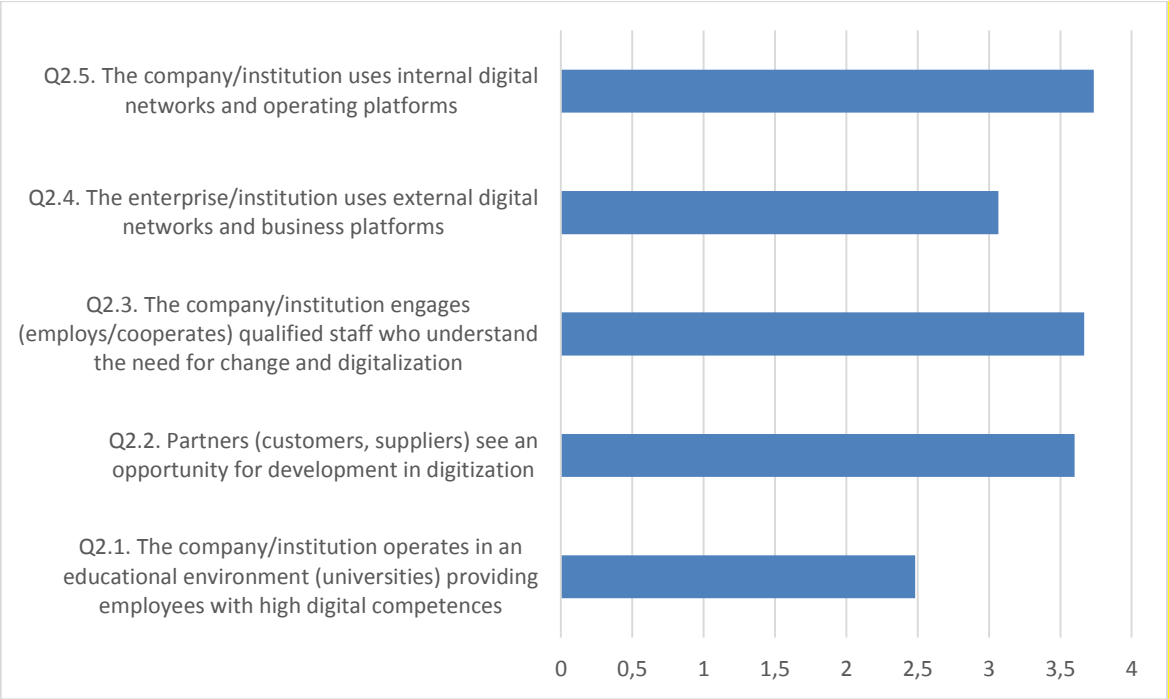


Figure 8. Assessment of the elements of the entrepreneurial ecosystem creating conditions conducive to the introduction of digital transformation in the surveyed enterprises (arithmetic mean of the responses).

Source: own study.

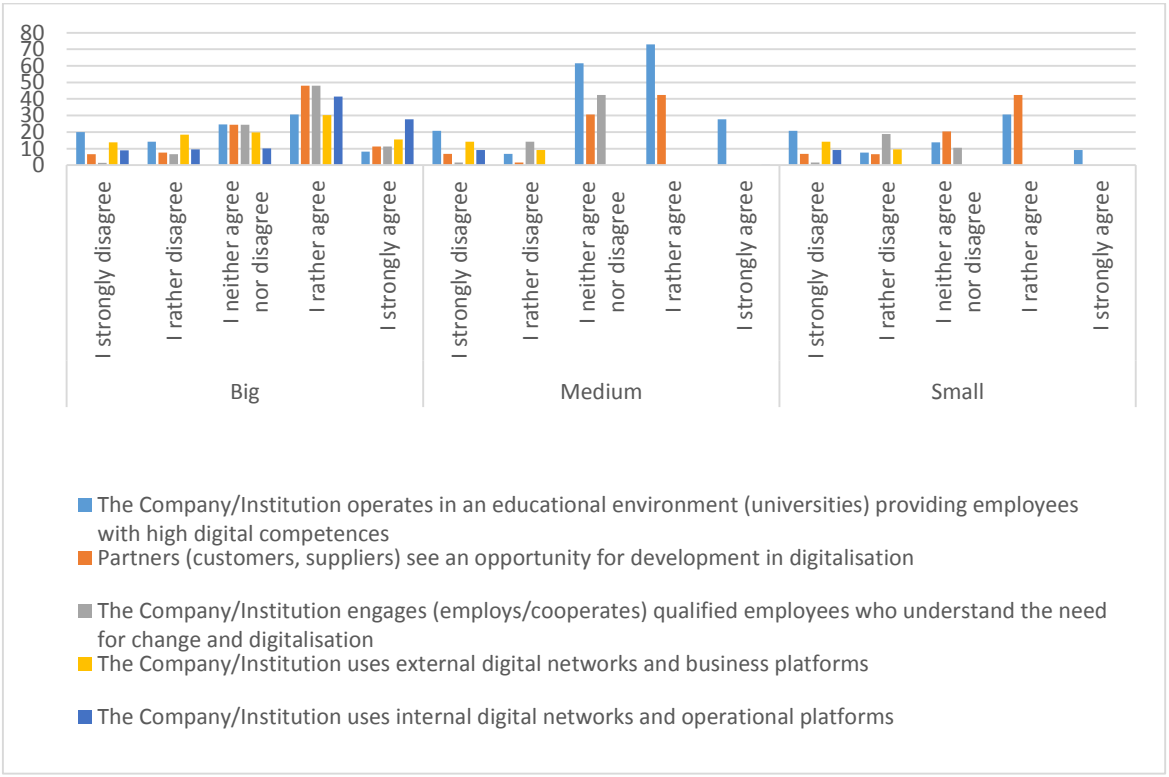


Figure 9. Assessment of the elements of the entrepreneurial ecosystem and its surroundings creating conditions conducive to the introduction of digital transformation in the surveyed enterprises by size (percentage of the responses).

Source: own study.

These findings highlight the importance of micro-level relational dynamics in driving digital transformation. Digitalisation is not isolated within the firm but co-constructed through cooperation networks, especially in supply chains and customer relationships.

The role of these internal drivers varies by firm size:

- SMEs show especially strong dependence on digitally oriented partners and employees, indicating that relational and human-capital-based drivers compensate for resource constraints.
- Large enterprises, in contrast, report extensive use of internal and external digital platforms, demonstrating more advanced digital infrastructure as a driver of ongoing transformation.

5.3. Interactions Between Drivers: Correlational Insights

Correlation analysis (Spearman's coefficient, $\alpha = 0.05$) revealed several significant interdependencies that help explain how digitalisation processes develop within firms:

- Firms with partners who see digitalisation as a development opportunity tend to place greater importance on business cooperation networks as drivers of digital transformation.
- The perceived influence of cooperation networks correlates with the strategic importance of employing qualified staff, highlighting a joint relational–human-capital mechanism driving digitalisation.
- The importance assigned to education and training corresponds with both the perceived necessity of skilled employees and the use of external digital platforms.
- The increasing relevance of cooperation networks is linked with the adoption of internal digital platforms, showing that relational factors stimulate technological investment.

These correlations indicate that digital transformation is shaped by interacting drivers, not isolated influences. Systemic relationships between partners, workforce capabilities, and digital infrastructure collectively drive the digitalisation trajectory.

5.4. Synthesis: The Key Factors Shaping and Driving Digitalisation Processes

Overall, the study identifies three categories of key drivers shaping the digitalisation processes of Polish companies:

1. Regulatory and institutional drivers
   With government policy clearly emerging as the most influential factor, regulatory frameworks shape digital adoption across all enterprise types and sectors.
2. Relational and network-based drivers
   Customer-supplier relationships and digital social networks play a central role, indicating that digitalisation is network-driven and highly dependent on interactions within the business ecosystem.
3. Human-capital and capability drivers
   The availability of digitally skilled employees and access to training significantly shape firms' ability to implement digital change.

By contrast, universities, research institutions, and formal support organisations currently do not function as major drivers of digitalisation, despite their theoretical importance in entrepreneurial ecosystem models.

The empirical evidence demonstrates that digitalisation in Polish enterprises is primarily driven by a combination of state policy, network interactions, and workforce capabilities. These forces—acting simultaneously—shape the pace, direction, and depth of digital transformation processes.

6. Conclusions

This study advances an evidence-based account of the key factors shaping and driving the digitalisation processes of Polish companies within the broader frame of the European Industrial Strategy. The results demonstrate that government policy and legal regulation constitute the dominant structural driver of enterprise digitalisation, consistently outstripping the influence of other entrepreneurial-ecosystem components across sectors and firm sizes. Regulatory mandates and incentives—covering digital communication, reporting, fiscal-administrative systems, and platform use—act as the principal levers that initiate, coordinate, and scale digital adoption at the firm level.

At the same time, the analysis reveals limited recognition of universities, research institutions, and formal support schemes as proximate drivers of firms' digitalisation. Despite their prominent place in ecosystem theory and EU policy discourse, surveyed firms ascribe comparatively weak influence to these actors, signalling a persistent translation gap between the knowledge-production subsystem and enterprise-level digital capability building. Beyond regulation, the relational and capability mechanisms of digital transformation emerge clearly in the data. Firms that employ digitally competent staff and operate with partners who see digitalisation as an opportunity report stronger progress, while correlations indicate that cooperation networks are associated with both human-capital investments and the adoption of internal and external digital platforms. This pattern supports a network-embedded view of digitalisation in which regulatory pressure, ecosystem relations, and firm capabilities jointly determine the pace and depth of transformation. Finally, firm size and sector shape how drivers are prioritised. SMEs emphasise regulatory guidance alongside labour-market and cultural factors; large firms more often combine regulation with capability-oriented drivers (training, platformisation). Sectors with high regulatory intensity (e.g., health, education) foreground policy as decisive; relationship-intensive sectors (e.g., entertainment) elevate digital social networks. Collectively, the evidence indicates that Polish companies' digitalisation trajectories are driven by an interplay of regulatory–institutional, relational–network, and human-capital forces, with knowledge-infrastructure actors currently underutilised.

This study offered a number of complementary viewpoints on the digital transformation issue. In contrast to previous studies, such as Sacavém et al. (2025), which focus on internal organisational dynamics and highlight leadership behaviour, emotional intelligence, and micro-level mechanisms of technological integration, our analysis turns its focus to the external entrepreneurial ecosystem and the macro-level factors that influence firms' digital trajectories. While Sacavém et al. see leaders as key players who use AI-enhanced decision making to strengthen adaptive capacities and align organisational goals with innovation processes, the nationwide empirical findings show that, in the Polish context, state policy and regulatory mandates constitute the predominant forces driving digital adoption, which 27% of surveyed enterprises identified as the primary catalyst for transformation. Despite the general consensus in the literature that technological advancement alone is insufficient to produce significant organisational change, there is still a clear disagreement about the basic initiating mechanism: the top-down, regulatory impetus highlighted in the authors' results versus the leadership-driven, vision-anchored perspective.

6.1. Implications for Policy and Management Policy

Given the centrality of state policy, effectiveness depends not only on what is mandated but how mandates connect to firms' absorptive capacity. Instruments that combine clear compliance pathways (standards, deadlines, templates) with capability scaffolds (targeted training, interoperable public platforms, vendor-neutral toolkits, and SME-friendly financing) are likely to accelerate adoption while reducing compliance-driven cost burdens. Strengthening university–industry interfaces (e.g., practice-oriented microcredentials; joint labs anchored in sectoral ecosystems; brokered placements of ICT talent into SMEs) can convert currently weak knowledge links into actionable capabilities.

Management. For firms—especially SMEs—the data suggest three priorities:

1. Codify partner-centric roadmaps (co-design use cases with customers/suppliers).
2. Invest in role-specific digital skills (pair training with process redesign, not just tools).
3. Platform readiness (progressive onboarding to external and internal platforms to unlock data flows and automation). These steps align with the identified synergy between partner readiness, skilled staff, and platform adoption.

6.2. Limitations and Future Research

The study relies on a cross-sectional CATI survey and perceptual measures of influence, which constrain causal inference and may under-represent fast-moving technological niches. Future research should (1) triangulate perceptions with objective digital-maturity indicators (e.g., transactional e-invoicing rates, API usage, cloud workload shares), (2) employ panel designs to track transformation pathways under evolving EU regulatory timelines, and (3) examine intervention logics that link policy instruments to firm-level capability accumulation, including the role of universities and technology intermediaries as active co-producers of enterprise outcomes.

References

1. Acemoglu, D., Restrepo, P. (2018). The Race between Machine and Man: Implications of Technology for Growth, Factor Shares and Employment. *American Economic Review*, *108(6),* pp. 1488-1524. Available at: https://doi.org/10.1257/aer.20160696
2. Ahokangas, P., Boter, H., Iivari, M. (2018). Ecosystems Perspective on Entrepreneurship. In: R. Turcan, N. Fraser (eds.), *The Palgrave Handbook of Multidisciplinary Perspectives on Entrepreneurship.* Cham: Palgrave Macmillan. Available at: https://doi.org/10.1007/978-3-319-91611-8_18
3. Audretsch, D.B., Beckmann, I.A. (2007). From small business to entrepreneurship policy. *Handbook of research on entrepreneurship policy*, pp. 36-53.
4. Audretsch, D.B., Gilbert, B.A., McDougall, P.P. (2004). The emergence of entrepreneurship policy. *Small Business Economics, No. 22*, pp. 313-323.
5. Bednorz, J., Makarevičiūtė, A., Pozzo, G., Sadauskaitė, A., Martinaitis, Ž. (2024). *International Benchmarking of the Digital Transformation 2024 CNECT/2022/LVP/0137 Final Report*. Directorate-General for Communications Networks, Content and Technology (European Commission), Visionary Analytics. Available at: https://data.europa.eu/doi/10.2759/908255
6. Bedő, Z., Erdős, K., Pittaway, L. (2020). University-centred entrepreneurial ecosystems in resource-constrained contexts. *Journal of Small Business and Enterprise Development, Vol. 27, No. 7*, pp. 1149-1166. Available at: https://doi.org/10.1108/JSBED-02-2020-0060
7. Blew, R.D. (1996). On the Definition of Ecosystem. *Bulletin of the Ecological Society of America, 77(3).* Available at: https://www.researchgate.net/publication/331464563_On_the_definition_of_ecosystem
8. Borbás, L. (2015). *The role of SMEs in the European entrepreneurship policy*.
9. Brown, R., Mason, C. (2014). *Entrepreneurial ecosystems and growth oriented entrepreneurship. Final Report to OECD*. Paris. Available at: http://lib.davender.com/wp-content/uploads/2015/03/Entrepreneurial-ecosystems-OECD.pdf
10. Brown, R., Mason, C. (2017). Looking inside the spiky bits: a critical review and conceptualisation of entrepreneurial ecosystems. *Small Bususinnes Economy*, *No, 49*, pp. 11-30. Available at: DOI 10.1007/s11187-017-9865-7
11. Buła, P., Schroeder, T. (2020). Selected aspects of the co-evolution of the Polish entrepreneurial ecosystem. *Organization Review*, *No. 10(969),* pp. 20-27, DOI: 10.33141/po.2020.10.03
12. Carayannis, E.G., Barth, T.D., Campbel, D.F. (2012). The Quintuple Helix innovation model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, Available at: http://www.innovation-entrepreneurship.com/content/1/1/2

13. Czaja, I. (2024). Elements of Entrepreneurial Ecosystem in Business Digitalization: Empirical Polish SME Study in: Empower Businesses and Create Economic Development in Digital Future: Vision 2030. In: K.S. Soliman (ed.), *Proceedings of the 44th International Business Information Management Association Conference (IBIMA)*. 27-28 November, pp. 1120-1132.
14. Czaja, I., Kafel, T., Wałęga, A. (2025). Polityka państwa jako kluczowy element ekosystemu przedsiębiorczości w procesach cyfrowej transformacji gospodarki. *Horyzonty Polityki, vol. 16, nr 55*, pp. 271-294. https://doi.org/10.35765/HP.2692
15. Czaja, I., Kafel, T. (2025). Entrepreneurial Ecosystem in Business Digitalization: A Study of Polish Enterprises' Perspective. *Journal of Eastern Europe Research in Business and Economics,* Article ID 428800, https://doi.org/10.5171/2025.428800
16. Czaja, I., Śliwa, R. (2003). *System wspierania przedsiębiorczości w Polsce.* Kraków: Wydawnictwo Akademii Ekonomicznej.
17. Eesley, Ch.E., Roberts, E.B. (2009). *Entrepreneurial Impact: The Role of MIT* (February 1, 2009). Available at SSRN: https://ssrn.com/abstract=1352633 or http://dx.doi.org/10.2139/ssrn.1352633
18. Fiedor, B. (2023). *Ewolucja kapitalizmu a idea naturalnego porządku ekonomicznego, No. 3,* pp. 315-332. DOI: 10.52335/ekon/170316
19. https://www.businesseurope.eu/wp-content/uploads/2025/02/2019-11-13-prosperity-people-planet_interactive-b2b-1.pdf
20. Iansiti, M., Levien, R. (2004). The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability. *Harvard Business School Press.* Boston.
21. Isenberg, D. (2011). *The Entrepreneurship Ecosystem Strategy as a New Paradigm for Economic Policy: Principles for Cultivating Entrepreneurship. Babson College: Babson Entrepreneurship Ecosystem Project.* Available at: http://www.innovationamerica.us/images/stories/2011/The-entrepreneurship-ecosystem-strategy-for-economic-growth-policy-20110620183915.pdf
22. Leendertse, J., Schrijvers, M., Stam, E. (2021). Measure Twice, Cut Once: Entrepreneurial Ecosystem Metrics. *Research Policy*, *no. 104336*. Available at: https://www.sciencedirect.com/science/article/pii/S0048733321001359?via%3Dihub#bib0106
23. Mazzucato, M. (2019). *The value of everything making and taking in the global economy*. London: Penguin Books.
24. *Monitoring European industrial ecosystems, Conceptual, Monitoring and Indicator Framework* (2023). Available at: https://monitor-industrial-ecosystems.ec.europa.eu/sites/default/files/2023-12/EMI%20Methodological%20Report.pdf
25. Moore, J.F. (1993). Predators and Prey: A New Ecology of Competition. *Harvard Business Review, 71, 3,* pp. 75-86.

26. Moore, J.F. (1996). *The Death of Competition: Leadership and Strategy in The Age of Business Ecosystems.* Harper Business. Available at: https://www.researchgate.net/publication/31744644_The_Death_of_Competition_Leadership_and_Strategy_in_the_Age_of_Business_Ecosystems_JF_Moore
27. Moore, J.F. (2006). Business ecosystems and the view of the firm. *The Antitrust Bulletin, March,* DOI: 10.1177/0003603X0605100103
28. Nelson, R., Winter, S. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.
29. North, D.C., Wallis, J.J., Weingast, B.R. (2009). Violence and the Rise of Open-Access Orders. *Journal of Democracy, 20(1),* 55-68.
30. OECD (2011). *Raport New Models for Entrepreneurship*. Available at: https://reports.weforum.org/new-models-for-entrepreneurship/executive-summary/
31. Oliveira, M.I.S., Barros Lima, G.d.F., Farias Lóscio, B. (2019). Investigations into Data Ecosystems: a systematic mapping study. *Knowledge and Information Systems*, *61, 2,* pp. 589-630. DOI: 10.1007/s10115-018-1323-6
32. Olszynka, P., Gryzło, K. (2024). *Raport Made in Poland 2024, Jak przebiega cyfrowa transformacja w średnich i dużych polskich Przedsiębiorstwach*. PMR Market Experts & Comarch ERP, pp. 1-91.
33. *Prosperity, People and Planet – Three pillars for the European Union agenda in 2019-2024* (2019).
34. Radu, G., Liviu, A., Warnke, P. (2022). *ISIS&T&I for 2050. Science, Technology and Innovation for Ecosystem Performance – Accelerating Sustainability Transitions. Case Study: Data As Representation.* Available at: https://www.prospectiva.ro/wp-content/uploads/2023/02/STI2050-case-study-Data-as-representation.pdf
35. Rotschild, M. (1990). *Bionomics: Economy as Ecosystem*. New York: Henry Holt and Company.
36. Sacavém, A., de Bem Machado, A., dos Santos, J.R., Palma-Moreira, A., Belchior-Rocha, H., Au-Yong-Oliveira, M. (2025). Leading in the Digital Age: The Role of Leadership in: *Organizational Digital Transformation. Administrative Sciences*, *No. 15(2),* 43. Available at: https://doi.org/10.3390/admsci15020043
37. Shwetzer, C., Maritz, A., Nguyen, Q. (2019). Entrepreneurial ecosystems: a holistic and dynamic approach. *Journal of Industry-University Collaboration, vol. 1, no. 2,* pp. 79-95. Available at: https://doi.org/10.1108/JIUC-03-2019-0007
38. Stam, E. (2015). Entrepreneurial Ecosystems and Regional Policy: A Sympathetic Critique. *European Planning Studies, 23, 9*, 1759-1769.
39. Stam, E. (2018) Measuring Entrepreneurial Ecosystems. Entrepreneurial Ecosystems. In: A. O'Connor, E. Stam, F. Sussan, D. Audretsch (eds.), *International Studies in Entrepreneurship, vol 38*. Cham: Springer. Available at: https://doi.org/10.1007/978-3-319-63531-6_9

40. Stam, E., van de Ven, A. (2021). Entrepreneurial ecosystem elements. *Small Business Economics*, *56*, pp. 809-832. Available at: https://doi.org/10.1007/s11187-019-00270-6
41. Theodoraki, C., Messeghem, K. (2017). Exploring the entrepreneurial ecosystem in the field of entrepreneurial support: a multi-level approach. *Journal of Entrepreneurship and Small Business*, *Vol. 31, No. 1,* pp. 47-66.
42. Watson, J. (2010). *SME Performance: Separating Myth from Reality*. Edward Elgar Publishing.
43. WEF (2014). *Entrepreneurial ecosystems and around the globe and early-stage company growth dynamics—an entrepreneurs perspective*. Davos: World Economic Forum. Available at: http://www3.weforum.org/docs/WEF_II_ EntrepreneurialEcosystems EarlyStageCompany_ Report_2014.pdf