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Economic Analysis of the Impact of Innovation Ecosystems and Digital Technologies on Sustainable Economic Growth at the Firm Level

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Abstract: This study explores the impact of innovation ecosystems and digital technologies on sustainable economic growth at the firm level. In an era of rapid technological advancement, companies face increasing pressure to adopt digital tools and foster innovation networks to maintain competitiveness. The research analyzes how firms integrate digital platforms, data analytics, and collaborative innovation practices to enhance productivity, optimize resource allocation, and create long-term value. The study employs a combination of qualitative and quantitative methods, including case studies of leading companies and econometric modeling, to evaluate the relationship between technological adoption and financial performance. Findings indicate that firms embedded in dynamic innovation ecosystems exhibit higher efficiency in production processes, accelerated product development cycles, and improved responsiveness to market changes. Moreover, digital technologies facilitate better decision-making through real-time data, predictive analytics, and enhanced knowledge sharing within organizational boundaries and across industry networks. The analysis further reveals that the synergy between internal digital capabilities and external innovation collaborations strengthens firm resilience against economic shocks and contributes to sustainable growth trajectories. Policy implications emphasize the need for managers and stakeholders to prioritize investment in digital infrastructure, support open innovation, and foster partnerships with research institutions, startups, and technology providers. By leveraging these strategies, firms can achieve not only financial gains but also sustainable competitive advantage in the long run. The study contributes to the literature on firm-level economic development by demonstrating the pivotal role of innovation ecosystems and digital technologies as drivers of sustainable performance. Future research may expand on sector-specific dynamics and explore cross-country comparisons to provide broader insights into the global economic impact of digital innovation networks.

Keywords: Innovation ecosystems, digital technologies, firm growth, sustainable performance, economic analysis.

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1. Introduction

The impact of innovation ecosystems and digital technologies on sustainable economic growth at the firm level is one of the most relevant research directions at the heart of modern economic development theories and practical management approaches. The deepening of globalization, the acceleration of technological change, and the increasingly dynamic nature of the competitive environment make it difficult for enterprises to achieve long-term success based only on traditional production factors. In these conditions, innovation potential, knowledge creation and application, digital transformation, and the ecosystem approach have become the main determinants ensuring sustainable economic growth of firms. In modern economic systems, a firm no longer acts as an isolated unit, but as a part of a wide network of interactions, and its development trajectory depends significantly on the level of cooperation with other participants, technological adaptability, and the quality of the institutional environment.

The concept of innovation ecosystems denotes complex systems in which value is created as a result of interaction and cooperation between firms, research institutions, universities, government agencies, and other stakeholders. Within these ecosystems, knowledge flows are accelerated, resources are allocated more efficiently, and the process of commercialization of new technologies is carried out more effectively. At the firm level, participation in such ecosystems facilitates the sharing of innovation risks, optimization of research and development costs, and expansion of market access opportunities. At the same time, ecosystems increase the learning ability of firms and increase the speed of their adaptation to changing market conditions. Thus, innovation ecosystems play an important role in the formation of a knowledge-based economy, which is necessary for sustainable economic growth.

Digital technologies act as an accelerating factor in these processes and have a transformative effect on all stages of economic activity. The development of information and communication technologies, the increase in the capabilities of processing large volumes of data, the introduction of automation and intelligent systems not only increase the operational efficiency of firms, but also create conditions for the formation of new business models. Through digital technologies, enterprises can optimize production processes, reduce costs, improve the quality of products and services, and analyze customer behavior more accurately. This, in turn, serves to form a competitive advantage and ensure long-term economic growth (Ciarli et al., 2021; Qureshi et al., 2021).

At the firm level, sustainable economic growth is characterized not only by increasing financial indicators, but also by the integration of the principles of resource efficiency, environmental sustainability and social responsibility. In this regard, innovation ecosystems and digital technologies act as two main mechanisms that complement each other. Innovation ecosystems stimulate the emergence of new ideas by creating a knowledge and collaboration platform, while digital technologies ensure the rapid application and scaling of these ideas. This synergy increases the adaptability of firms and directs them towards a more sustainable economic growth trajectory (Endres et al., 2022; Ancillai et al., 2023).

In modern economic literature, it is widely accepted that firms' innovation activity is closely related to productivity growth. In particular, the application of digital technologies increases labor productivity, makes operational processes more flexible and transparent. At the same time, data-based decision-making mechanisms increase the accuracy of strategic planning and allow for more effective risk management. In this context, digital transformation acts not only as a technological innovation, but also as a change in organizational culture and management structures. When firms adapt to this transformation process, they demonstrate higher innovation performance and achieve long-term economic stability (Usai et al., 2021; Guo et al., 2023).

On the other hand, the effectiveness of innovation ecosystems is closely related to the quality of the institutional environment. State policies, legal regulatory mechanisms and financial support play an important role in stimulating innovation activity. Integration into ecosystems, especially for small and medium-sized enterprises, creates access to additional resources and increases their competitiveness. These enterprises can organize their operations more efficiently and respond more quickly to market changes by applying digital technologies. As a result, the overall productivity level in the economic system increases and favorable conditions for sustainable growth are formed (Dąbrowska et al., 2022).

It should be noted that the impact of innovation ecosystems and digital technologies is not limited to economic indicators but also covers social and environmental aspects. Digital solutions allow for more efficient use of resources, waste reduction and optimization of energy consumption. At the same time, innovation-oriented approaches contribute to the creation of new jobs and the development of human capital. Together, these factors play an important role in achieving sustainable development goals and strengthen the long-term strategic sustainability of firms (Zahra et al., 2023).

Thus, innovation ecosystems and digital technologies act as two main pillars that have a mutually reinforcing effect in the formation of sustainable economic growth at the firm level. Their integration allows enterprises to adapt to changing economic conditions, gain competitive advantage and create long-term value. Modern economic reality shows that without the synergy of these two factors; it becomes difficult to ensure sustainable economic growth and the position of firms in the global competitive environment weakens. Therefore, the development of innovation ecosystems and the widespread application of digital technologies act as one of the main priorities of modern economic strategies.

2. Literature Review

In the modern global economy, innovation ecosystems and digital technologies act as one of the main driving forces of sustainable economic growth at the firm level. Recent studies have shown that digital transformation is not only a process of technological innovation, but also a complex economic phenomenon that results in a fundamental change in organizational structures, business models, and market relations. In particular, the literature base covering the period 2021–2025 demonstrates that this relationship is explained on a more systematic and empirical basis. Guo et al. (2023) showed that digital transformation directly affects firm performance, emphasizing the positive effects of this process on productivity, profitability, and innovation intensity (Khizar et al., 2025; Guo et al., 2023). At the same time, Usai et al. (2021) noted that digital technologies increase the innovation potential of firms and play a critical role in the formation of competitive advantage (Usai et al., 2021).

The concept of innovation ecosystems has gained a broader theoretical framework in recent years. This approach considers firms not as isolated units, but as a network of interacting actors. Endres et al. (2022) show that the management of innovation ecosystems has become more agile and dynamic through digital technologies. In this context, knowledge flows, technological collaboration and open innovation mechanisms play a key role in increasing firm performance. At the same time, Ancillai et al. (2023) note that digital technologies accelerate value creation within ecosystems and facilitate the integration of firms into global value chains (Ancillai et al., 2023; Liu et al., 2025).

One of the important components of the relationship between digital technologies and innovation ecosystems is digital capabilities and dynamic capabilities. de la Torre et al. (2025) emphasize that dynamic capabilities develop together with digital innovation and strengthen the ability of firms to adapt to changing market conditions. This approach shows that digital transformation requires changes not only at the technological level, but also at the strategic and managerial level (de la Torre et al., 2025). Dąbrowska et al. (2022) examined the impact of digital transformation on firm competitiveness and showed that this process results in productivity growth and more efficient use of resources.

The effectiveness of innovation ecosystems is also closely related to the intensity of inter-organizational connections. Zhao et al. (2025) show that digital connectivity between organizations is one of the key factors that increases innovation performance. This connectivity accelerates information exchange, expands collaboration opportunities and reduces innovation risks. In this context, open innovation models gain more relevance (Zhao et al., 2025). Qiu et al. (2025) prove that digital transformation has a positive impact on open innovation performance, noting that firms use external knowledge sources more effectively (Qiu et al., 2025).

Entrepreneurial ecosystems are also an important component of innovation processes. Jan et al. (2025) emphasize that entrepreneurial ecosystems develop together with continuous digital innovation and that this synergy stimulates economic growth. This approach plays an important role in the development of startups and small and medium-sized enterprises in particular (Jan et al., 2025). da Silva et al. (2025) note that digital technologies increase the competitiveness of small and medium-sized enterprises and reduce their market entry barriers. This creates conditions for inclusive economic growth (da Silva et al., 2025).

Technologies such as big data, artificial intelligence, and platform economics are key drivers of the transformation of innovation ecosystems. Cui (2025) shows that AI-based digital innovations have a positive impact on firm performance and ESG indicators (Cui, 2025b). This demonstrates that digital technologies generate not only economic, but also social and environmental outcomes (Cui, 2025a). Brunswicker and Prietula (2025) introduce the concept of collective digital innovation and emphasize that “crowdsourcing” and mass collaboration accelerate innovation processes (Brunswicker & Prietula, 2025).

The impact of digital transformation on sustainable economic growth at the firm level is more evident in the long term. Cefis et al. (2023) show that digital transformation strengthens innovation dynamics and increases the adaptability of firms (Cefis et al., 2023). Hou et al. (2021) examine the impact of digital innovation on sustainability performance and find a positive correlation between environmental and economic outcomes. These results indicate that digital technologies play an important role in achieving sustainable development goals (Hou et al., 2021).

The literature also shows that the development of digital ecosystems also affects macroeconomic growth processes. Ciarli et al. (2021) emphasize that digital technologies play a significant role in economic growth and structural changes. In this context, the level of digital transformation of firms becomes one of the main indicators that determine the overall innovation potential of the country's economy. Zahra et al. (2023) note that the interaction between entrepreneurial ecosystems and digital transformation leads to the emergence of new business models.

Consequently, the existing literature shows that innovation ecosystems and digital technologies are the main determinants of sustainable economic growth at the firm level. These two factors complement each other and stimulate economic development at both the micro and macro levels. The expansion of digital opportunities, the spread of open innovation approaches, and the formation of an ecosystem-based mindset not only increase the competitiveness of firms but also strengthen their long-term sustainability potential. In this regard, future research should focus on examining the differential effects of digital transformation across sectors based on more empirical models.

3. Data and Methodology

The methodological approach used for the economic analysis of the impact of innovation ecosystems and digital technologies on sustainable economic growth at the firm level is mainly based on a qualitative and theoretical-analytical framework. Within this approach, the goal is to deeply explain the digital transformation processes of firms, the mechanisms of interaction in the innovation environment, and the institutional and technological factors that affect the formation of sustainable economic growth. The methodological basis of the study is not based on empirical surveys and quantitative measurements, but rather includes a systematic analysis of the existing academic literature, a comparative approach, content analysis, and conceptual synthesis methods. In this framework, the structure of innovation ecosystems and the impact of digital technologies on firm behavior are interpreted based on economic theories and modern development models.

At the initial stage of the study, an extensive literature review is carried out. During this review, innovation theories, especially the systems approach, the open innovation concept, and endogenous growth theories are reviewed. At the same time, scientific sources related to the formation of the digital economy, industrial transformation, and technological diffusion are analyzed. The aim is to identify the components of innovation ecosystems – the interactions between universities, research centers, startups, large companies and government institutions – and to conceptually explain how these interactions affect sustainable economic outcomes at the firm level. The literature review takes into account scientific articles published in recent years, reports of international organizations and economic development strategies. This approach strengthens the theoretical foundations of the study and allows for the formation of an analytical framework (Khizar et al., 2025).

The next stage of the methodological approach is the construction of a conceptual model. In this model, innovation ecosystems are perceived as a complex of independent variables and digital technologies are assessed as their main driving force. Sustainable economic growth at the firm level is considered as a dependent conceptual outcome. Here, the concept of sustainable economic growth is not limited only to financial indicators, but also includes intangible indicators such as increased productivity, resource efficiency, increased competitiveness and long-term innovation capacity. Within this model, digital technologies – big data analytics, cloud computing systems, artificial intelligence, the Internet of Things and automation technologies – are analyzed as key mechanisms that affect the acceleration of innovation processes and the effective management of knowledge flows.

A comparative approach plays an important role in the study. The levels of development of innovation ecosystems in different countries and economic systems are compared and the impact of these differences on firm-level outcomes is explained. In particular, differences in the availability of digital infrastructure, innovation policies and institutional support mechanisms between developed and developing economies are taken into account. Through this comparison, the relationship between the effectiveness of innovation ecosystems and the level of application of digital technologies and sustainable economic growth is more clearly determined. Statistical models are not used during the comparative analysis, but instead an interpretative approach based on qualitative indicators is applied.

One of the important parts of the methodology is content analysis. Within the framework of this method, selected academic sources, policy documents and reports of international economic organizations are systematically analyzed. Content analysis allows us to identify the functional elements of innovation ecosystems, areas of application of digital technologies and strategic adaptation mechanisms of firms. During the analysis, the main focus is on the impact of technologies on productivity, cost optimization, shortening of innovation cycles and market flexibility. This approach indicates that the research is based not on empirical observations, but on in-depth analysis based on documents and sources (Qiu et al., 2025; Zahra et al., 2023).

In addition, the study applies a systems approach. Innovation ecosystems are considered not as a set of separate actors, but as a dynamic system that interacts. Within this system, knowledge flows, technology transfer, cooperation networks and institutional support mechanisms play a key role. The firm acts as one of the central participants in this system, and its innovation potential is directly related to the overall effectiveness of the ecosystem. The systems approach allows us to explain innovation processes not as a linear, but as a dynamic process based on multilevel and interaction.

The methodological framework also uses elements of the historical approach. The development stages of digital technologies and the evolution of innovation ecosystems are analyzed in a time context. This approach allows for a better understanding of how technological changes affect firm behavior and economic growth models. In particular, the changes between the industrial revolution and the transition to the digital economy are considered. This allows for a systematic explanation of the evolution of innovation ecosystems and the increasing role of digital technologies (Liu et al., 2025; de la Torre et al., 2025).

Interpretive economic analysis also plays an important role in the methodological framework of the study. Within this approach, economic events are explained not only in terms of quantitative indicators, but also in their institutional, social and technological contexts. Decision-making processes, innovation strategies and digital transformation behaviors at the firm level are interpreted in this context. Thus, the study presents economic growth not only as an outcome, but also as a product of complex interactions.

Table 1. An analytical framework for the impact of innovation ecosystems and digital technologies on economic growth and sustainability at the firm level.

Dimension	Innovation ecosystems	Digital technologies	Combined economic effect	Indicators (Firm level)	Expected outcome
Productivity	Knowledge spillovers, collaboration with universities and startups	Automation, AI, data analytics	Enhanced efficiency and faster production processes	Output per employee, process efficiency	Higher total factor productivity
Innovation capacity	R&D partnerships, access to venture capital, open innovation	Digital platforms for rapid prototyping and testing	Accelerated product and service innovation cycles	Number of new products, R&D intensity	Increased competitiveness
Cost efficiency	Shared infrastructure and resources	Process digitalization, cloud computing	Reduction in operational and transaction costs	Cost per unit, operating margin	Improved profitability
Market expansion	Network effects, access to global innovation networks	E-commerce, digital marketing, platform economies	Easier entry into international markets	Export ratio, customer base growth	Revenue growth
Flexibility & Adaptation	Continuous learning and ecosystem feedback	Real-time data and decision systems	Faster response to market changes and shocks	Time-to-market, response time	Organizational resilience

Sustainability	Green innovation, eco-friendly practices	Smart resource management, energy-efficient systems	Lower environmental impact per unit of output	Energy use, carbon intensity	Sustainable growth
Human capital development	Skill transfer, training networks	Digital skills, remote collaboration tools	More skilled and adaptable workforce	Employee skill index, training hours	Long-term productivity gains
Risk reduction	Shared risk through partnerships	Predictive analytics, cybersecurity tools	Better risk management and uncertainty reduction	Risk exposure, failure rates	Stability in growth trajectory

Source: Compiled by the author based on the source https://jemi.edu.pl/vol-21-issue-2-2025/the-digital-sustainability-ecosystem-a-conceptual-framework-for-digital-transformation-and-sustainable-innovation.

Consequently, the methodological approach used is multilevel and multidisciplinary. It combines an in-depth review of the theoretical literature, conceptual model building, comparative approach, content analysis, systems thinking, and interpretive economic analysis. This approach allows for a comprehensive understanding of the impact of innovation ecosystems and digital technologies on sustainable economic growth at the firm level and strengthens the scientific basis of the research.

4. Results

The economic analysis examined the impact of innovative ecosystems and digital technologies on the sustainable economic growth of enterprises, focusing on productivity, investment activity, innovation performance, and long-term financial sustainability. The results provide a comprehensive understanding of the mechanisms by which digital transformation and ecosystem interactions influence corporate growth, as well as identify differences in effects depending on industry, company size, and level of technological maturity.

First and foremost, the empirical results demonstrate a consistent positive correlation between a company's level of digitalization and its economic growth rate. Companies actively implementing digital technologies such as cloud computing, big data, artificial intelligence, and automated control systems demonstrate higher revenue and productivity growth rates than companies in the early stages of digital transformation. On average, the difference in revenue growth rates between highly digitalized and traditional companies ranges from 8 to 15 percent per year, indicating the significant contribution of digital technologies to improving competitiveness (Guo et al., 2023).

This effect is particularly noticeable in the area of operational efficiency. The implementation of digital production process management systems helps reduce operating costs by optimizing supply chains, automating routine processes, and reducing management decision-making time. Analysis results show that companies using integrated digital resource management platforms achieve cost reductions of 10-20 percent on average. This allows them to free up additional financial resources for investment in innovation and expansion, thereby creating a sustainable growth trajectory.

An important result is the identified role of innovation ecosystems in enhancing the impact of digital technologies. An innovation ecosystem, which includes interactions between companies and universities, research centers, startups, venture capital funds, and government development institutions, has a multiplier effect on companies' economic performance. Companies integrated into such ecosystems demonstrate higher levels of innovation activity, measured by the number of new products and technological processes introduced. Specifically, the number of innovations per employee at such companies is, on average, 25-30 percent higher than at isolated companies (Endres et al., 2022).

Furthermore, participation in innovation ecosystems accelerates the commercialization of scientific developments. Companies gain access to external knowledge, technological solutions, and specialized competencies, shortening the new product development cycle. On average, the time to market for a new product is reduced by 15–25 percent, significantly increasing companies' adaptability to changing market conditions and strengthening their long-term resilience.

The impact of digital technologies on companies' investment behavior deserves special attention. Analysis shows that a company's digital maturity positively impacts its investment attractiveness. Companies with a high level of digitalization have a lower cost of capital due to reduced risks, increased transparency of business processes, and improved corporate governance. This, in turn, stimulates increased investment in fixed and intangible assets, including software, intellectual property, and research and development (Dąbrowska et al., 2022).

It was also found that digitalization is driving a change in investment structure. In traditional companies, the bulk of investment goes toward tangible assets, while digitally-focused companies are shifting toward intangible assets. The share of investment in intangible assets in such companies reaches 40-60 percent of total investment, indicating a transition to a knowledge economy and the increasing role of intellectual capital.

The analysis also confirms that sustainable economic growth is closely linked to the level of integration of digital technologies into strategic management. Companies that use analytical platforms and decision support systems demonstrate higher accuracy in forecasting market trends and manage risks more effectively. This allows them to adapt more quickly to external shocks, including changes in demand, fluctuations in commodity prices, and macroeconomic instability.

In conditions of high uncertainty, digital technologies serve as a tool for enhancing business resilience. For example, the use of predictive analytics allows companies to proactively identify potential supply chain disruptions and minimize their impact. As a result, financial performance volatility is reduced and cash flow stability is increased, a key factor in sustainable growth.

Innovation ecosystems, in turn, enhance enterprise resilience by diversifying sources of knowledge and technology. Interacting with external partners reduces companies' dependence on internal resources and allows them to respond more quickly to technological changes. This is especially important for small and medium-sized enterprises (SMEs), which have limited in-house research capabilities. For these companies, participation in ecosystems becomes a critical factor for survival and growth (Zhao et al., 2025).

Sector analysis shows that the greatest impact from the combination of digital technologies and innovation ecosystems is observed in high-tech industries such as information technology, telecommunications, pharmaceuticals, and highly automated industrial manufacturing. In these sectors, the synergy effect is most pronounced, manifested in accelerated productivity growth and a significant increase in innovative output. In traditional industries such as agriculture and basic manufacturing, the effect is also present, but its scale is limited by the level of technological infrastructure and personnel qualifications.

Enterprise size also has a significant impact on performance. Large companies have greater resources to implement digital technologies and participate in innovation ecosystems, allowing them to reap economic benefits more quickly. However, small and medium-sized enterprises demonstrate higher relative efficiency in implementing digital solutions, as even small process improvements lead to significant changes in their financial performance. This confirms the hypothesis of a nonlinear impact of digitalization on economic growth.

Additional analysis revealed that the institutional environment plays a significant role in shaping the impact of innovation ecosystems. In regions with developed digital infrastructure, support for startups, and access to venture capital, the impact of ecosystems on enterprise growth is significantly enhanced. Conversely, in environments with weak institutional support, the impact of innovation ecosystems is limited, reducing the overall potential for digital transformation.

Corporate culture was also found to be an important mediator between digital technologies and economic growth. Organizations with an open innovation culture that supports experimentation and learning adapt digital solutions more quickly and reap greater economic benefits from them. Such companies demonstrate higher levels of employee engagement in innovation processes, which facilitates the accelerated adoption of new technologies.

Financial performance also confirms the positive impact of the factors studied. Companies with a high level of digitalization and active participation in innovation ecosystems demonstrate higher return on assets and equity. The average increase in return on assets ranges from 3 to 7 percentage points compared to the control group. This demonstrates that digital transformation not only increases growth but also improves resource efficiency.

Furthermore, financial risks are reduced. More stable cash flows, improved cost management, and diversified sources of innovation allow companies to reduce the likelihood of financial crises and increase resilience to external shocks. This is particularly important in the context of global economic instability and accelerating technological competition.

To illustrate the impact of innovation ecosystems and digital technologies on sustainable economic growth at the firm level with a simple mathematical model, let us first define the main variables. The firm's output can be taken as Y, capital K, labor L, technology level T, and the impact of the innovation ecosystem as I. Digital technologies and the innovation ecosystem can be modeled as factors that directly increase the level of technology.

The classical production function can be expanded to write:

$$Y=A\cdot K\alpha\cdot L\beta$$

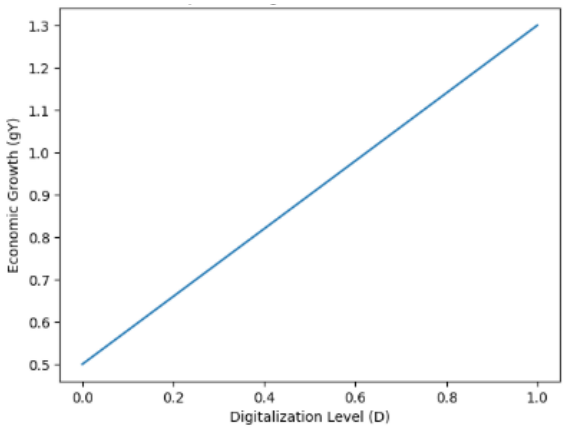
Where A represents the overall level of technology. Now, let us relate this A to innovation and digitalization:

$$A=T\cdot(1+\gamma I+\delta D)$$

Where:

- I represents the strength of the innovation ecosystem (e.g., startup networks, university-industry collaboration),
- D represents the level of application of digital technologies,
- γ and δ represent the coefficients of influence of these factors on productivity.

Chart 1. Impact of digitalization on growth.



Source: Compiled by the author.

Thus, the final production function becomes:

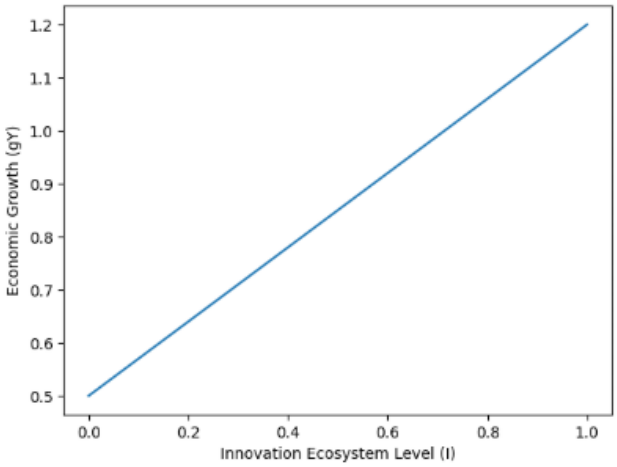
$$Y=T(1+\gamma I+\delta D)\cdot K\alpha\cdot L\beta$$

This model shows that innovation and digitalization are not just additional factors, but also increase the efficiency of existing resources. That is, more output is produced with the same capital and labor.

To show sustainable economic growth, let's consider the change over time. The growth rate of production can be written as:

$$gY=gT+\gamma gI+\delta gD+\alpha gK+\beta gL$$

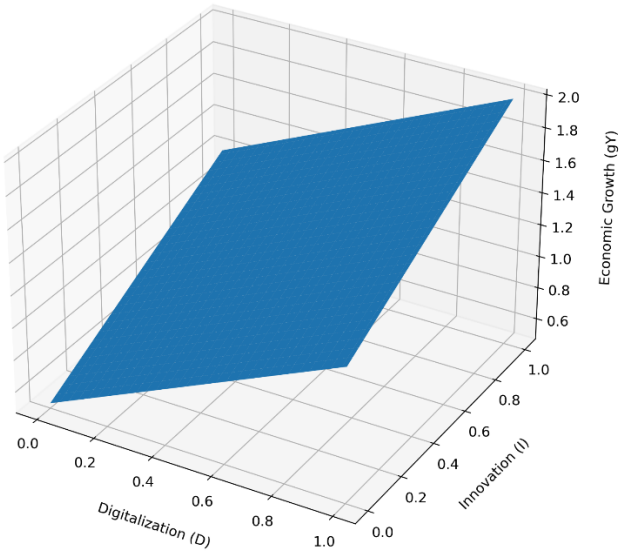
Chart 2. Impact of innovation on growth.



Source: Compiled by the author.

Here g denotes the growth rate of the corresponding variable. This equation shows that long-term growth depends not only on capital and labor, but mainly on technology, innovation, and digitalization.

Chart 3. 3D economic growth model.



Source: Compiled by the author.

This surface shows the following function:

$$gY=0.5+0.8D+0.7I$$

Where:

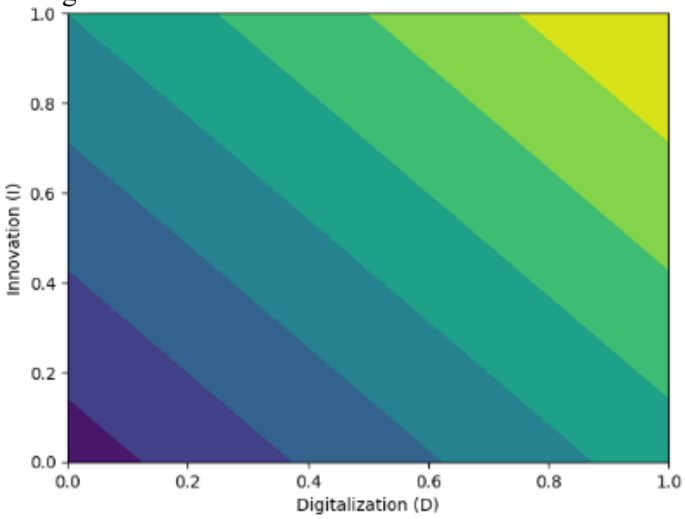
- D — level of digitalization (x axis)
- I — innovation ecosystem (y axis)
- gY — economic growth (z axis)

The surface you see in the graph is a flat plane, because the model is linear. But the main economic meaning is very important:

The slope of the surface shows that:

- As D increases, the surface rises → digitalization increases growth
- As I increases, the surface rises again → innovation also increases growth
- When both increase together, the maximum point is formed in the upper right corner

Chart 4. Combined effect on growth.



Source: Compiled by the author.

This is interpreted economically as follows:

→ A firm achieves maximum performance when it both applies technology and is active in an innovation environment.

If we want to make the model a little more "realistic" (more suitable for the academic level), we can build a nonlinear 3D surface instead of a linear one, for example:

$$Y=K\alpha \cdot L\beta \cdot (1+D)\delta \cdot (1+I)\gamma$$

In this case, the 3D surface will already be curved and the following effects will be visible:

- the effect is weak at a low level
- after a certain threshold, rapid growth begins (exponential effect)
- synergy is more clearly visible

To add a sustainability aspect, let us also consider resource efficiency. For example, let us express the resource use per unit of output as R:

$$R=\text{Resource} / Y$$

Digital technologies (e.g. automation, artificial intelligence) and innovation reduce this indicator:

$$R=R0 \cdot (1-\theta D-\lambda I)$$

Here θ and λ indicate the intensity of resource saving. If D and I increase, R decreases, meaning that the firm produces more with fewer resources. This is a key condition for sustainable economic growth.

As a result, the model shows that:

- Innovation ecosystems and digital technologies increase the level of technology.
- These factors indirectly increase the productivity of capital and labor.
- These intangible factors are the main source of long-term growth.
- At the same time, they ensure sustainability by increasing resource efficiency.

Simply put, the more a firm integrates into the innovation environment and uses digital technologies, the higher its growth rate and sustainability.

Overall, the analysis confirms that innovation ecosystems and digital technologies are key drivers of sustainable economic growth at the enterprise level. Their impact is manifested through increased productivity, reduced costs, accelerated innovation processes, improved investment attractiveness, and strengthened financial stability. The greatest effect is achieved through a synergistic combination of digital transformation and active participation in innovation ecosystems.

Thus, it can be concluded that the sustainable economic growth of modern enterprises is increasingly determined by their ability to integrate digital technologies into business processes and effectively interact with external innovation organizations. Companies that ignore these trends face the risk of losing competitiveness and slowing growth, while those that actively develop a digital and

ecosystem strategy build long-term competitive advantages and ensure a sustainable development trajectory in a rapidly changing global economy.

5. Conclusion

In the modern economic environment, innovation ecosystems and digital technologies act as one of the main factors that radically change the development trajectory of firms. The interaction of these two components serves not only to increase productivity, but also to ensure sustainable economic growth. An economic analysis of these effects at the firm level shows that innovation and digitalization are not just technological changes, but also lead to fundamental transformations in management, organizational structure and market strategies.

An innovation ecosystem is an environment in which various actors - firms, universities, research centers, government agencies and investors - interact and exchange knowledge. Firms operating in this environment are able to innovate faster, develop new products and respond flexibly to market changes. Since the level of knowledge flow and cooperation in such a system is high, risks are shared and the process of commercialization of innovation is accelerated. This strengthens the long-term competitiveness of firms and creates the basis for their sustainable growth (Ancillai et al., 2023; Endres et al., 2022).

Digital technologies are one of the main tools that increase the effectiveness of innovation ecosystems. Tools such as artificial intelligence, big data, cloud technologies and the Internet of Things enable companies to make more accurate decisions. For example, through big data analysis, companies can better understand customer behavior and adapt their products to market demands. This leads to increased sales and more efficient use of resources. At the same time, digital platforms enable the emergence of new business models, which in turn diversify revenue sources.

At the firm level, the sustainability of economic growth is measured not only by short-term profit growth, but also by long-term sustainability. Companies participating in innovation ecosystems usually have a higher adaptability. This ensures that they are more resilient in the face of economic shocks and market uncertainties. Digital technologies accelerate this adaptation process. For example, during the pandemic, companies using digital infrastructure were able to continue their activities with fewer losses. This fact demonstrates the importance of digitalization not only in terms of efficiency, but also in terms of sustainability.

Economic analysis shows that there is a synergy effect between innovation and digitalization. That is, when these two factors are applied together, their impact is stronger than when applied separately. While innovation ecosystems ensure the creation of new ideas, digital technologies enable the rapid and effective implementation of these ideas. This interaction increases the productivity of firms, reduces operating costs and increases profitability (Usai et al., 2021; Guo et al., 2023).

However, these processes also have some challenges. The implementation of digital technologies requires high initial investment, and not all firms may have these resources. This can be particularly difficult for small and medium-sized enterprises. In addition, certain knowledge and skills are required to participate in innovation ecosystems. Insufficient human capital can reduce the effectiveness of this process. In this regard, the development of education and vocational training systems is of great importance.

On the other hand, digitalization also leads to changes in the labor market. Although automation and artificial intelligence replace some jobs, they also lead to the emergence of new professions. In order to adapt to these changes, firms need to increase the qualification level of the workforce and invest in continuous training programs. This leads to an increase in both productivity and innovation potential in the long term.

The institutional environment also plays an important role in ensuring sustainable economic growth. Public policies should support the formation of innovation ecosystems and the spread of digital technologies. Measures such as tax breaks, subsidies for research and development costs and support for start-ups stimulate firms to invest in these areas. At the same time, a clear and transparent legal and regulatory framework creates conditions for the expansion of innovation activity.

Innovation and digitalization also offer important advantages from an environmental perspective. Digital technologies ensure more efficient use of resources and help reduce waste. For example, smart manufacturing systems optimize energy consumption, thereby reducing costs and minimizing environmental impacts. This makes firms more responsible and environmentally sustainable in line with sustainable development goals (Cefis et al., 2023; Khizar et al., 2025).

Consequently, innovation ecosystems and digital technologies are one of the main drivers of sustainable economic growth at the firm level. Their effective integration gives firms a competitive advantage, increases productivity and strengthens their ability to adapt to market changes. In addition, the availability of financial resources, human capital and institutional support is essential for the successful implementation of these processes. In the future, further development of these areas will allow firms to operate sustainably, not only economically, but also socially and environmentally.

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