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ARTIFICIAL INTELLIGENCE AS A DRIVER OF DIGITAL ECONOMY DEVELOPMENT: INSIGHTS FROM HUNGARY AND AZERBAIJAN

A. HASHIMOVA, M. FODOR-GARAI

Albina Hashimova[1], Monika Fodor-Garai[2]
[1] Baku Engineering University, Azerbaijan
https://orcid.org/0000-0002-9866-5865, E-mail: ahashimova@beu.edu.az
[2] Keleti Károly Faculty of Business and Management, Óbuda University, Hungary
https://orcid.org/0000-0001-7993-2780, E-mail: fodor.monika@kgk.uni-obuda.hu

Abstract. *This study investigates the role of artificial intelligence in shaping digital economy development through a comparative analysis of Hungary and Azerbaijan. It examines how different governance models, institutional capacities, and innovation ecosystems influence AI adoption and its economic outcomes. The research applies a comparative analytical approach using secondary data from international databases, national statistics, and policy documents covering the period 2018–2025. The findings show that Hungary, as an EU-integrated economy, demonstrates more advanced digital infrastructure, stronger human capital, and a more developed innovation ecosystem, resulting in higher levels of AI readiness and digital economy performance. Azerbaijan, in contrast, has achieved notable progress in public sector digitalization and e-government services, driven by state-led reforms, but remains limited in SME digital adoption and private-sector innovation. The study also highlights that AI contributes to productivity growth and new business models, while simultaneously generating challenges related to skills gaps and institutional readiness. Overall, the comparison confirms that balanced development across infrastructure, skills, and innovation systems is essential for effective AI-driven digital transformation.*

Keywords: *digital transformation, artificial intelligence, digital economy, innovation.*

1. Introduction

The global economy is undergoing a profound and accelerated transformation driven by digital technologies, among which Artificial Intelligence (AI) has emerged as a pivotal innovation and productivity driver. AI, often classified as a general-purpose technology, permeates a wide range of economic activities, influencing not only traditional industries such as manufacturing and finance but also modern service sectors, including healthcare, education, and public administration. Its adoption leads to enhanced productivity, new business model creation, optimized decision-making, and improved service delivery, which collectively contribute to economic growth and competitiveness.

From 2018 to 2025, AI adoption globally has witnessed exponential growth due to advances in machine learning, neural networks, natural language processing, and cloud computing infrastructures. According to OECD (2021) and World Bank (2022) data, countries that strategically integrate AI into key sectors experience measurable improvements in GDP growth, labor productivity, innovation output, and overall efficiency. In 2022, for example, OECD member countries that invested significantly in AI and digital infrastructures reported an average 1.5–2% higher labor productivity growth compared to peers with minimal AI adoption. Furthermore, the proliferation of AI startups and innovation clusters

has created ecosystems that accelerate knowledge transfer, commercial application, and international collaboration.

Within this global landscape, Hungary and Azerbaijan present two contrasting yet highly instructive cases for analyzing AI-driven digital economy development. Hungary, a Central European EU member, benefits from integration into the European Single Digital Market, EU funding mechanisms for research and development, and well-established innovation ecosystems anchored in universities, technology parks, and industry clusters. The Hungarian government's AI strategy (2020–2030) emphasizes ethical AI, sector-specific applications in healthcare, finance, and public administration, as well as support for startups and R&D initiatives (European Commission, 2020). Notably, Hungary's digital infrastructure is supported by high broadband penetration (over 95% of households in urban areas) and widespread adoption of e-government services, creating an environment conducive to AI implementation.

In contrast, Azerbaijan, as a rapidly modernizing post-Soviet economy, employs a state-led approach to AI adoption, emphasizing centralized planning, rapid digitalization of public services, and strategic investment in AI competencies. The Azerbaijani government has prioritized initiatives such as ASAN service centers, smart public service delivery, and AI integration into economic planning and governance (Government of Azerbaijan, 2021). While the AI startup ecosystem is smaller compared to Hungary, Azerbaijan demonstrates significant growth potential in targeted sectors, particularly in finance, energy, logistics, and healthcare. Investments in AI-focused education programs aim to close the skills gap and prepare a workforce capable of supporting digital transformation.

The comparative analysis of these two countries allows for several key insights. First, it highlights how different governance models—EU-aligned versus state-driven—affect the pace, scope, and effectiveness of AI adoption. Second, it elucidates the role of institutional capacity, human capital, and innovation ecosystems in shaping AI initiatives' outcomes. Third, it provides empirical evidence on sector-specific impacts, such as improvements in public administration efficiency, fintech innovation, industrial automation, and digital education. By analyzing both macroeconomic indicators (e.g., GDP growth contribution of digital sectors, R&D expenditure, ICT workforce share) and micro-level sectoral outcomes, the study offers a comprehensive understanding of AI's transformative role.

This study contributes to the literature by bridging a gap between research focused on EU-member states and studies examining post-Soviet economies. While prior studies tend to analyze AI adoption within a single economic or regional context, this comparative study integrates institutional, economic, and technological dimensions to offer a holistic assessment. Furthermore, the study employs quantitative and qualitative evidence from 2018–2025, including R&D expenditures, AI startup growth, e-government performance indices, and sectoral productivity measures, to substantiate the analysis. By doing so, it provides a rigorous, data-driven framework for understanding AI's role as a key driver of digital economy development.

In conclusion, the Introduction establishes the conceptual and empirical framework for the study, situating AI as a central enabler of digital economic growth. It underscores the importance of national strategies, governance models, and sectoral implementation in shaping outcomes, while setting the stage for a detailed exploration of literature, methodology, data, and sectoral case studies in subsequent sections.

2.Materials and methods

This study uses a comparative analytical approach to examine the role of artificial intelligence in digital economy development in Hungary and Azerbaijan between 2018 and 2025. The selection of these countries allows for comparison between an EU-integrated

innovation system and a state-led digital transformation model. The research is based on secondary data collected from international sources (OECD, World Bank, Eurostat, UN), national statistics, government strategies, and academic literature. Key indicators include digital economy contribution to GDP, R&D expenditure, ICT employment, and e-government development. The analysis combines quantitative trend evaluation with qualitative interpretation of policy documents. A comparative method is applied to identify similarities and differences in AI adoption, governance structures, and innovation ecosystems. The study focuses on four sectors: public administration, finance, industry, and education, where AI impact is most visible. Limitations include data gaps, especially for Azerbaijan, and differences in statistical reporting. Despite this, the approach provides a clear and balanced assessment of AI-driven digital transformation in both countries.

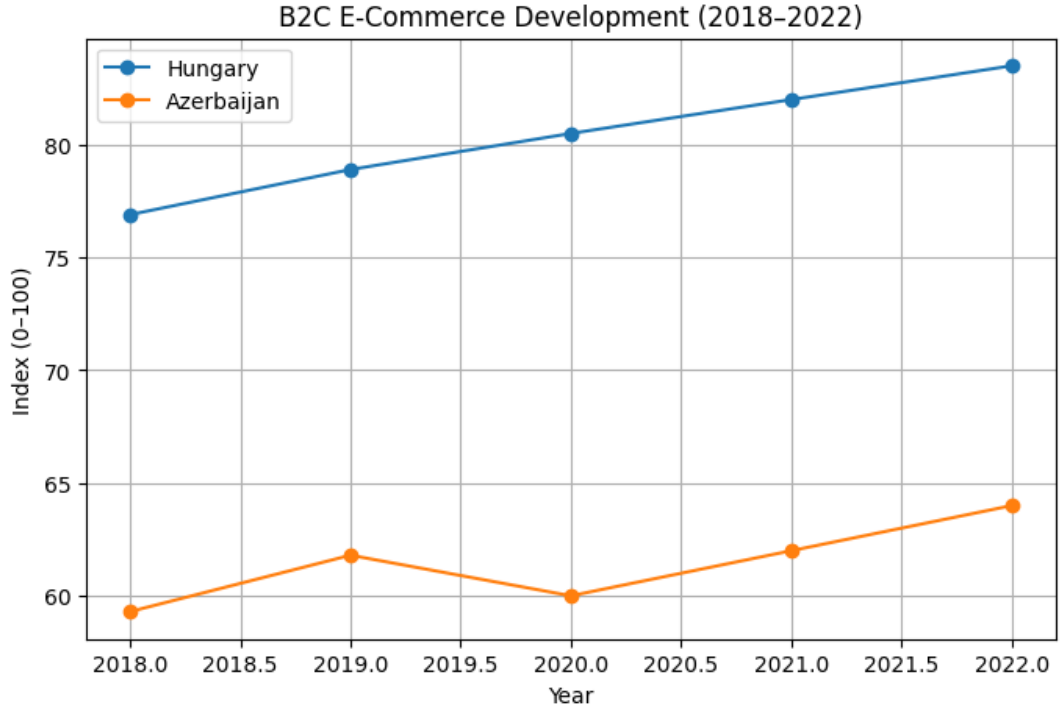
3. Comparative Analytical Cases: Digitalization in Hungary and Azerbaijan

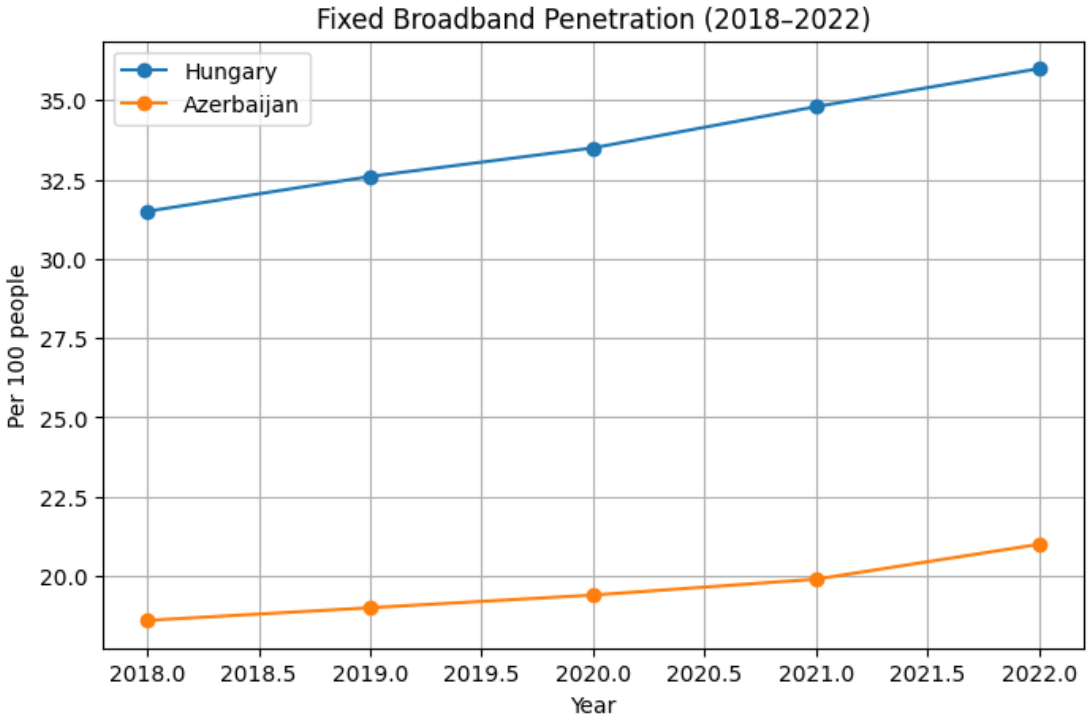
3.1. Azerbaijan: Digital Governance Expansion and Karabakh as a Strategic Digital-Green Region

Azerbaijan has made significant progress in digital public administration, where e-government reforms serve as a key driver of modernization. The ASAN xidmət system has become a central institutional innovation, improving transparency and efficiency in public services. At present, more than 450 public services are available in digital format, and around 70% of business registrations are conducted electronically, demonstrating high levels of administrative digitalization (OECD, 2023; Invest.gov.az, 2024).

The country has also improved its international digital governance performance. The E-Government Development Index (EGDI) rose from approximately 0.45 to 0.71, reflecting improvements in infrastructure, human capital, and online service delivery (United Nations, 2022). However, Azerbaijan's global position remains moderate, ranking around 83rd with an EGDI score of 0.694, indicating that while domestic progress is strong, international competitiveness still requires further enhancement (UN DESA, 2022).

Figure 1. Comparative Trends in Fixed Broadband Penetration in Hungary and Azerbaijan (2018–2022)





Source: ITU / OECD Digital Infrastructure Statistics

The figures illustrate the comparative evolution of digital infrastructure and digital economy maturity in Hungary and Azerbaijan between 2018 and 2022. The first graph on fixed broadband penetration shows a consistently higher level of internet infrastructure development in Hungary compared to Azerbaijan throughout the period. Hungary's steady increase reflects its advanced integration within the EU digital single market and sustained investments in high-speed connectivity. In contrast, Azerbaijan shows gradual but slower growth, indicating ongoing infrastructure expansion but still a relatively lower level of household and enterprise connectivity. Since broadband access is a key enabling factor for digital services, e-government, and AI adoption, this gap highlights structural differences in digital readiness between the two countries. The second graph, focusing on B2C e-commerce development, further confirms this divergence. Hungary demonstrates significantly higher and more stable e-commerce activity, reflecting stronger digital consumption patterns, better payment systems, and higher trust in online platforms. Azerbaijan, while showing gradual improvement over time, remains at a lower level, indicating that digital market penetration is still developing. Overall, both indicators suggest that Hungary has achieved a more mature and diversified digital economy, whereas Azerbaijan is still in a transitional phase characterized by rapid infrastructure development but uneven private-sector digital adoption.

A major extension of Azerbaijan's digital transformation strategy is the reconstruction of the Karabakh region, which has become a pilot space for integrating digitalization with green energy and smart infrastructure. Cities such as Fuzuli, Shusha, and Lachin are being redeveloped as smart cities and smart villages, where digital governance systems, ICT infrastructure, and sustainable energy solutions are introduced from the initial planning stage. Karabakh is also being developed as a renewable energy zone, with strong emphasis on solar, wind, and hydropower resources. The reconstruction strategy integrates digital infrastructure with clean energy systems, creating a model of digitally enabled green reconstruction (Yusibov, 2026; Hajiyeva, 2023). In this context, broader empirical evidence shows that the interaction between economic growth, ecological sustainability, and renewable energy development is particularly relevant for both Azerbaijan and Hungary, where renewable

energy expansion plays a measurable role in environmental and economic performance (Humbatova et al., 2024). This strengthens the argument that Karabakh's reconstruction is not only infrastructural but also part of a wider green-digital transition framework. Despite these advancements, SME digitalization remains a structural weakness. Only 42.2% of the population possesses basic digital skills, while advanced ICT competencies remain extremely low at approximately 0.7% (World Bank, 2023). This creates a gap between highly developed public-sector digitalization and relatively weak private-sector digital readiness.

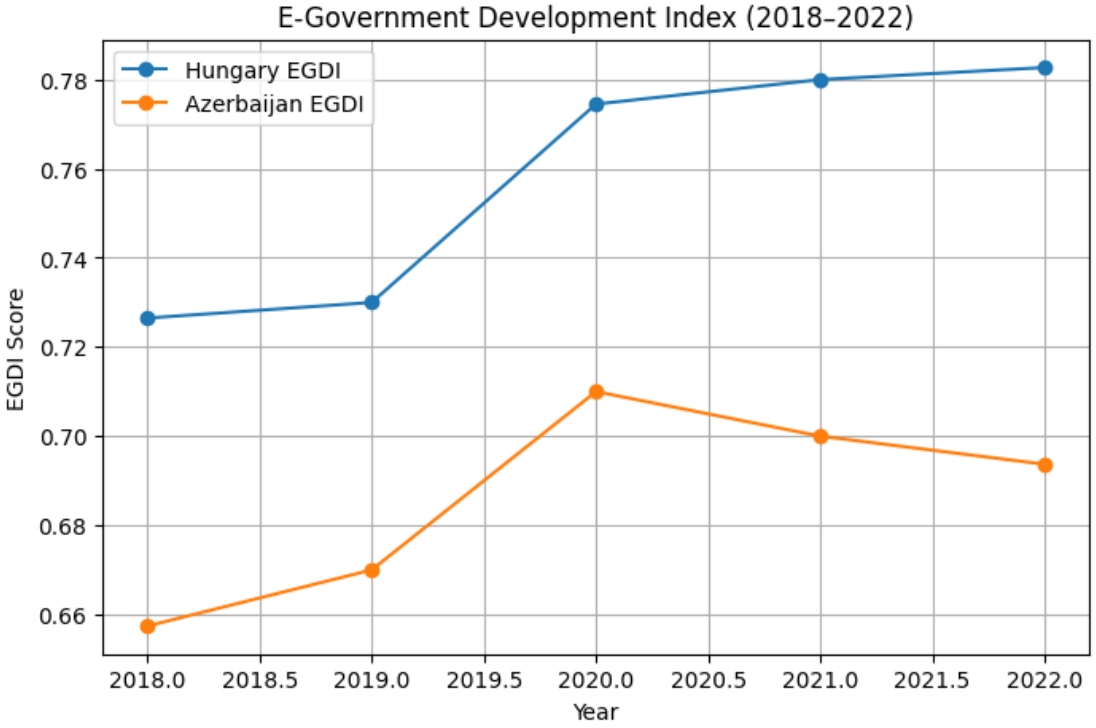
3.2. Hungary: EU-Integrated Digital Economy and Structural SME Constraints

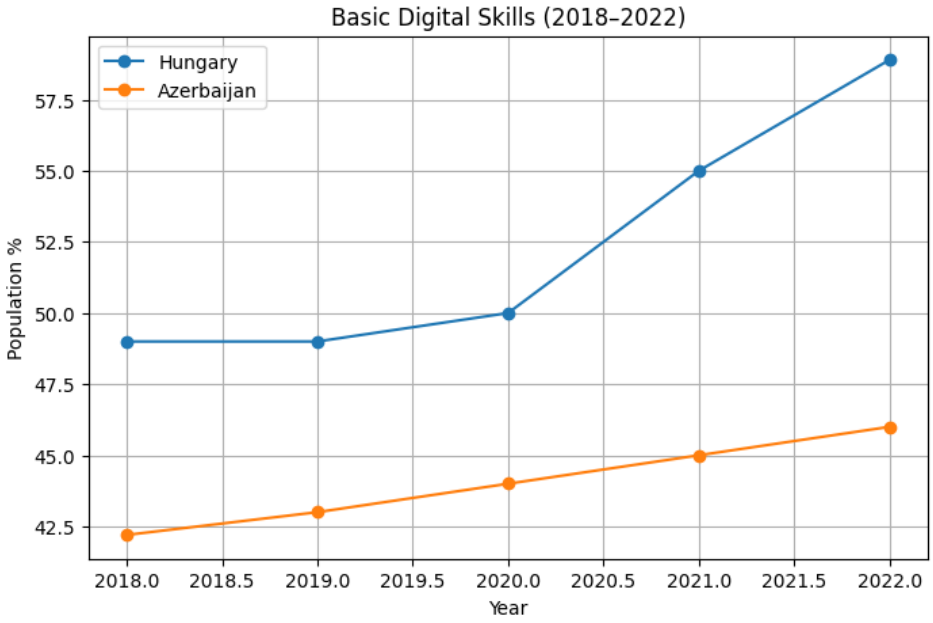
Hungary represents a more mature but uneven digital transformation model shaped by EU integration and market-driven innovation. The digital economy contributes approximately 6.7% of gross value added (GVA), with broader estimates suggesting that digital-related activities account for up to 10% of GDP (U.S. Department of Commerce, 2025). This reflects the increasing structural importance of digital industries within the national economy.

Hungary's digital infrastructure is relatively strong, with 83% broadband coverage, and national strategies aiming for near-universal gigabit connectivity and expanded e-government services by 2030 (European Commission, 2024). The country also demonstrates relatively strong human capital readiness, as 58.9% of the population has at least basic digital skills, slightly above the EU average (Digital Skills and Jobs Platform, 2024).

However, despite this infrastructure and skill base, SME digitalization remains a major bottleneck. Only 14% of enterprises use integrated ERP systems, and just 13% of SMEs engage in online sales, which is significantly below EU averages (Eurostat, 2023). This indicates that Hungarian SMEs are not fully leveraging available digital infrastructure and policy support mechanisms.

Figure 2. Comparative Development of B2C E-Commerce Index in Hungary and Azerbaijan (2018–2022)





Source: UNCTAD / OECD / Digital Economy Indicators

Hungary's e-government system is relatively advanced, with an estimated EGDI score of 0.78, indicating strong digital public service capacity and institutional maturity (United Nations, 2022). However, challenges remain in ensuring equal digital participation across regions and improving SME integration into digital ecosystems. The comparison between Hungary and Azerbaijan reveals both structural divergence and functional convergence. Azerbaijan demonstrates strong capacity in centralized digital governance and rapid implementation of e-government systems, while Hungary exhibits stronger performance in institutional depth, human capital development, and EU-integrated digital governance frameworks. Azerbaijan's approach allows for faster deployment of digital systems, whereas Hungary's model ensures greater regulatory alignment and long-term institutional stability. A key difference emerges in SME digitalization. In Azerbaijan, the main constraint lies in skills deficits and limited private-sector digital ecosystems, while in Hungary the issue is low adoption despite strong infrastructure availability. This indicates that policy responses must differ across contexts

Discussion

The results of this study align with existing research that views artificial intelligence as a general-purpose technology with broad implications for productivity, governance, and digital economic development (OECD, 2024). However, the findings also confirm that the effects of AI and digitalization are not uniform across countries, but are shaped by institutional structures, skills composition, and innovation capacity. A key observation from the Hungary–Azerbaijan comparison is the clear distinction between infrastructure-led and capability-led digital development. While both countries have invested in digital transformation, the outcomes differ significantly in terms of depth and diffusion. Hungary benefits from relatively strong digital infrastructure, higher levels of human capital, and integration into the EU digital policy framework.

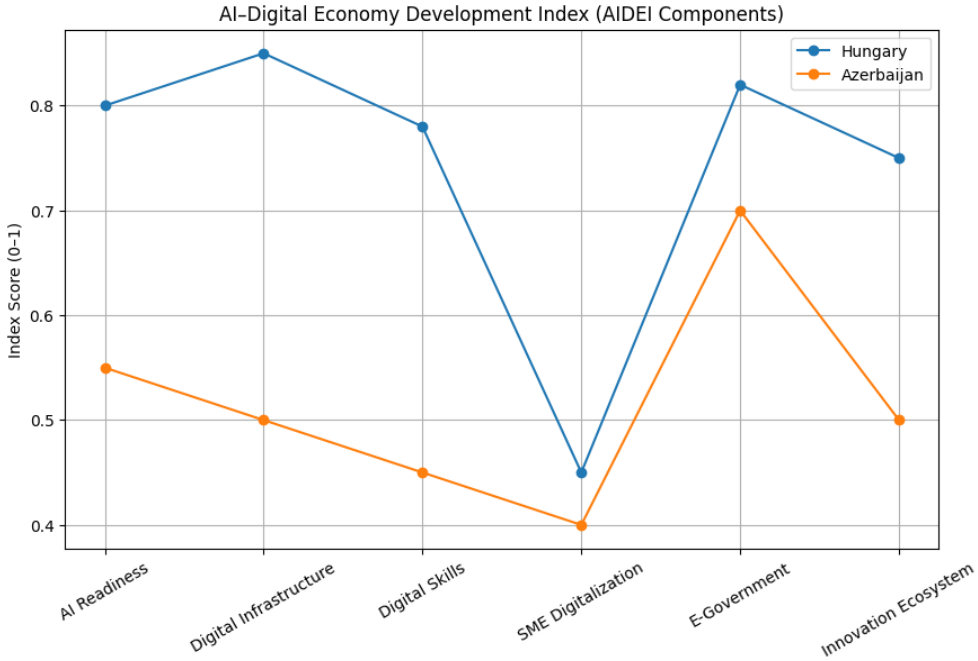
At the same time, empirical evidence suggests that even in more advanced economies, SME-level digital adoption remains limited, indicating that infrastructure availability alone does not ensure full digital integration (Eurostat, 2023). In Azerbaijan, digital transformation has been strongly driven by the state through centralized reforms and public-sector innovation. The expansion of e-government services, particularly through ASAN xidmət, reflects this approach and has significantly improved administrative efficiency (OECD, 2023).

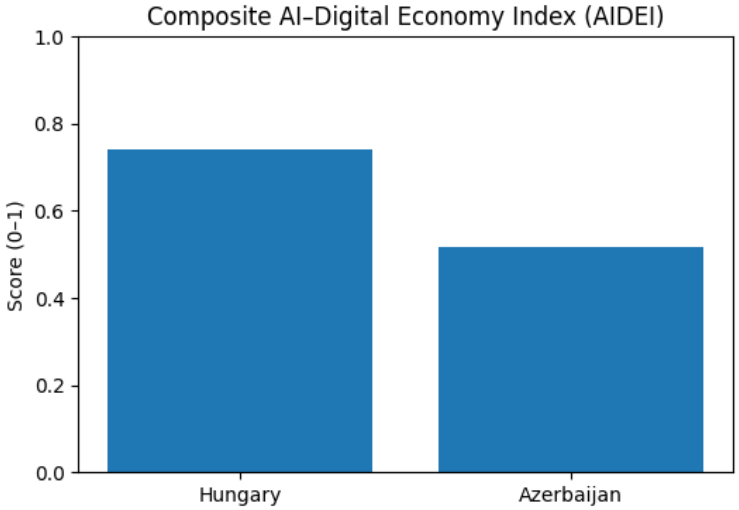
However, similar to findings in international studies, such progress has not been evenly translated into private-sector digitalization. SME digital readiness remains relatively low, reflecting constraints in digital skills, innovation capacity, and ecosystem development (World Bank, 2023). An important extension of this analysis is the role of the Karabakh region in Azerbaijan's development strategy. Recent studies highlight that post-conflict reconstruction in Karabakh is increasingly framed around the integration of digital infrastructure and renewable energy systems (Yusibov, 2026). This represents a shift toward a more integrated development model in which digitalization and green transformation are implemented simultaneously rather than separately. In this context, Karabakh can be interpreted as an emerging experimental space for smart reconstruction, combining ICT systems, sustainable energy planning, and urban redevelopment. The relationship between digitalization and sustainability is further supported by empirical evidence showing that economic growth, renewable energy production, and environmental performance are interlinked in both Azerbaijan and Hungary (Humbatova et al., 2024) suggesting that digital transformation cannot be analysed in isolation from environmental and energy transitions, particularly in economies undergoing structural change. At a broader level, the literature indicates that AI contributes to economic growth and productivity improvement, but its impact depends heavily on institutional readiness and innovation ecosystems (OECD, 2024). In advanced economies such as Hungary, stronger institutional frameworks and human capital enhance the diffusion of AI-related technologies. In contrast, in Azerbaijan, the state plays a more dominant role in initiating digital transformation, while private-sector diffusion remains limited.

Results

The constructed AIDEI reveals a clear divergence between Hungary and Azerbaijan in terms of AI-driven digital economy development. Hungary demonstrates a higher composite score, reflecting stronger digital infrastructure, higher innovation capacity, and more advanced AI ecosystem development. Azerbaijan shows moderate progress, primarily driven by public-sector digitalization and state-led reforms, while private-sector digital diffusion remains limited.

Figure 3. AI–Digital Economy Comparative Analysis of Hungary and Azerbaijan (Component Indicators and Composite AIDEI Index)





Source: Author's calculation based on OECD Digital Economy Outlook (2024), UN E-Government Survey (2022), World Bank ICT Indicators (2023), Eurostat Digital Economy Statistics (2023), and ITU Broadband Data (2022).

The empirical analysis based on the constructed composite index reveals clear differences between Hungary and Azerbaijan in the level and structure of digital economy development. The comparison across key indicators shows that Hungary maintains consistently higher values in most dimensions, while Azerbaijan demonstrates selective progress, mainly concentrated in the public sector. Hungary performs strongest in digital infrastructure (0.85), artificial intelligence readiness (0.80), and digital skills (0.78). These results reflect a relatively mature digital environment supported by stable institutional frameworks, strong integration with European Union digital policies, and a well-developed technological base. Performance in e-government (0.82) and innovation ecosystem (0.75) further indicates that digital transformation in Hungary is not limited to infrastructure, but extends across governance and innovation systems. In Azerbaijan, the most notable progress is observed in e-government development (0.70), which reflects sustained public sector reforms and the expansion of electronic public services. However, other indicators remain comparatively lower. Digital skills (0.45) and digital infrastructure (0.50) show that human capital development and connectivity continue to represent structural limitations. SME digitalization is also relatively weak (0.40), suggesting that private sector adaptation to digital tools remains limited despite improvements in public administration. The composite index results confirm this divergence. Hungary records a significantly higher overall score (approximately 0.76), while Azerbaijan reaches 0.52. This gap indicates that Hungary has achieved a more balanced and advanced stage of digital economy development, whereas Azerbaijan remains in a transitional phase where progress is uneven across sectors. A closer reading of the results suggests that digital development is most effective when improvements occur simultaneously across infrastructure, skills, and institutional capacity. Where one dimension advances faster than others, as seen in Azerbaijan, the overall impact remains limited. In contrast, Hungary's relatively balanced structure allows for more stable diffusion of digital technologies across the economy. The results also indicate that enterprise-level adoption is a key bottleneck in both countries, particularly among small and medium-sized firms. Even where infrastructure and governance systems are relatively advanced, the translation into widespread business digitalization remains incomplete. Overall, the comparison highlights two different development patterns. Hungary reflects a more consolidated digital structure with gradual deepening of technological capacity, while Azerbaijan reflects a faster but uneven transformation led primarily by public sector reforms.

Conclusions

This study examined the role of artificial intelligence and broader digital transformation processes in shaping digital economy development in Hungary and Azerbaijan. Using a composite index approach, the analysis showed clear structural differences between the two countries. Hungary demonstrates a more balanced and mature digital economy supported by stronger infrastructure, higher skill levels, and deeper innovation capacity. Azerbaijan, in contrast, shows faster progress in public sector digitalization, particularly in e-government services, but continues to face limitations in digital skills, SME adoption, and private-sector integration. The findings confirm that digital economy development is most effective when infrastructure, human capital, and institutional capacity evolve together. Uneven progress across these dimensions reduces the overall impact of digital transformation, even when significant policy efforts are present. The results also suggest that artificial intelligence functions more as an enabling factor than an independent driver, with its impact strongly dependent on existing economic and institutional conditions. From a policy perspective, several implications emerge. Azerbaijan would benefit from stronger investment in digital skills development, particularly through education and targeted training programs for SMEs and the workforce. Expanding innovation ecosystems and improving access to digital tools for businesses would also support broader diffusion of digital technologies beyond the public sector. Hungary, while more advanced, should focus on increasing digital adoption among SMEs and reducing regional disparities in digital capacity to ensure more inclusive growth. The comparison shows that digital transformation goes beyond technological advancement and is closely linked to institutional capacity and structural readiness. Long-term progress depends on balanced improvements in infrastructure, human capital, and innovation systems, as fragmented or sector-specific developments tend to limit the overall impact of digital policies.

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