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Digital Transformation and AI Readiness in the European Union: Empirical Evidence from the Internet–GDP–AI Readiness Correlation

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Abstract

The literature review on digital transformation and Knowledge Society indicates positive relationships between digital infrastructure, economic development, and institutional capacity to integrate advanced technologies, but few studies explicitly compare these dimensions in the European Union, including readiness for artificial intelligence (AI). The paper addresses this gap by examining the correlations between internet use, GDP per capita and the Government AI Readiness score. The aim is to highlight how digital infrastructure and economic maturity condition the capacity of Member States to integrate AI technologies in the Knowledge Society. The analysis is based exclusively on secondary data: Eurostat indicators and the Oxford Insights 2021-2024 set, processed and harmonized in Python for all EU Member States. The results highlight positive correlations between internet penetration and GDP, respectively between GDP and the level of AI Readiness, confirming that economic and digital development facilitate the integration of AI in public administration. The added value lies in the integration of three official data sources into a common framework, providing an empirical perspective on European digital maturity. The study aligns with digital governance literature and extends the analysis to the AI dimension. Limitations relate to the cross-sectional nature of the data and the lack of intra-national detail; future research could include time series, digital skills indicators and causal models.

Keywords: *Knowledge Society, Digital Transformation, Artificial Intelligence Readiness, Internet Penetration, GDP per Capita, European Union.*

JEL Classification: O33, L86, C38, H83

Introduction

Digital transformation represents one of the most significant directions of economic and institutional evolution of the last decades, with a direct impact on the way in which states, organizations, and citizens relate to the processes of production, governance, and consumption. The acceleration of technological innovation, the development of digital infrastructure and the expansion of internet networks have created the premises of a new stage of modernization – the knowledge society – characterized by rapid transfer of

information, increased connectivity and the capacity to integrate emerging technologies such as artificial intelligence. At the European level, these processes are closely linked to the consolidation of the Digital Single Market and the implementation of the objectives assumed through the "Digital Compass 2030" and "Europe fit for the digital age" initiatives.

The relationship between economic development, digital infrastructure and institutional capacity has become increasingly evident with the increase in the volume of available data and the degree of their use in public decision-making. Indicators such as gross domestic product per capita, internet penetration or the level of readiness for artificial intelligence provide a relevant picture of the digital maturity of Member States and their potential to capitalize on the opportunities generated by new technologies. In this regard, the integration of official statistical resources – Eurostat and Oxford Insights reports – allows for a rigorous comparative analysis of how economic and digital development correlates with the level of readiness for AI at European Union level.

The need for such analyses is becoming increasingly pressing in the context of economic and institutional transformations generated by digitalization and the transition to a knowledge-based governance model. At a time when the competitiveness of states is conditioned by their capacity to adopt advanced technologies, highlighting the links between digital infrastructure, economic performance and AI readiness can contribute to underpinning more effective public policies and reducing intra-European disparities. In addition, the exclusive use of secondary data, processed with high-performance digital tools, provides empirical consistency and methodological legitimacy to the present study.

1. Literature review

Digital transformation in the European Union (EU) is a multidimensional process that brings together infrastructure, human capital, innovation and governance, and its effects on economic performance are increasingly documented. Comparative studies show that the intense adoption of digital technologies (AI, IoT, cloud) is associated with higher levels of the digital intensity index and with concrete organizational progress, including in HR processes [Mihai, Aleca & Gheorghe, 2023]. Cross-EU cluster and factor-based analyses confirm the north–south/east polarization of digital maturity, while the pandemic has accelerated selective convergences, without eliminating gaps [Huňady, Pisár, Khawaja & Qureshi, 2024; Hunady, Pisár, Vugec & Bach, 2022]. In parallel, econometric research highlights robust links between broadband penetration and GDP growth, including at the European regional level, reinforcing the hypothesis that digital infrastructure is a structural determinant of growth and innovation [de Clercq, 2023; Briglauer, 2024; Minges, 2016].

The institutional and governance dimension plays a critical role in converting infrastructure into public and economic outcomes. The literature on post-pandemic digital governance highlights the potential for efficiency, transparency and civic participation, but also the complexity of implementation — from cybersecurity to resistance to change [Burlacu, Crețu, Potcovaru & Călin, 2024; Negescu et al., 2021; Burlacu, 2021]. Early lessons on AI and digital transformation in the COVID-19 crisis show that exogenous shocks can accelerate AI adoption and data governance, but also expose risks related to equity and rights [de Nigris et al., 2020]. Recent research in Government Information Quarterly documents how perceptions of civil servants' condition support for AI in government, making institutional readiness as important as technological readiness [Ahn, & Chen, 2022].

In terms of assessing maturity, readiness frameworks and indices for AI and digital transformation are multiplying. At the organizational level, Holmström (2022) proposes a four-dimensional framework ("technologies–activities–boundaries–objectives") to assess the capacity to implement AI in the service of transformation. At the macro level, the Oxford Insights (GARI) assessments are widely used to compare the degree of government readiness for AI, including in the EU, in the context of new regulations such as the AI Act and the progress of GenAI [Oxford Insights, 2023, 2024]. In parallel, recent work on European sets shows that digitalization and innovation move together in specific national configurations (de Rojas et al., 2024) and that the intensification of digital progression is associated with increases in economic performance and sustainability [Bocean et al., 2023; Magoutas et al., 2024].

On the dimension of inclusion, literature draws attention to the fact that readiness for AI also depends on the human capital and digital skills of vulnerable groups. In the EU, the adoption of AI among the elderly highlights the role of digital literacy and personalized interventions [Bogoslov, Corman & Lungu, 2024], suggesting that harnessing AI in public services depends on the capabilities of the population, not just infrastructure and rules. Moreover, recent perspectives from the OECD show that AI can accelerate the "journey" towards digital government, with productivity and accountability benefits, conditional on data governance and interoperable architectures [OECD, 2025].

At the EU level, policy convergence — from the "Digital Decade 2030" Program to the innovation agenda — provides a coherent strategic framework for the integration of AI, with concrete targets on connectivity, skills and the digitalization of public services; recent political literature emphasizes the role of parties and electoral cycles in national transformation trajectories [Thelen & al., 2025]. At the same time, field research and bibliometric analyses in Romania indicate opportunities (efficiency, citizen-centered services) and constraints (strategic fragmentation, resources) to link digital governance to sustainable development goals [Burlacu, Pargaru, Iacob & Gomboș, 2022; Rădulescu et al., 2025].

The literature highlights the connection between digital transformation and sustainability at both the organizational and macroeconomic levels. Bednarčíková and Repiská (2021) show that digitalization and digital technologies can be used as key tools for business sustainability, with applications in the field of energy efficiency, production processes and green business models. In the authors' view, "green digital transformation" is the integration of digital technologies with environmentally friendly technologies, capable of generating competitive advantages and supporting sustainable development goals. This perspective extends traditional approaches to digitalization by directly associating technological progress with economic and environmental sustainability. Another important dimension aims at assessing readiness for digital transformation through quantitative tools. Kutnjak, Pihir and Furjan (2020) propose the use of digital maturity indices to monitor the digitalization stage of sectors and economies, with initial applications in agriculture. They highlight that measuring digital maturity is not just a descriptive exercise, but a process that allows governments and organizations to plan the next steps and identify the drivers of digital transformation. Therefore, digital maturity becomes a strategic indicator for public policies and sectoral development.

Similarly, Kolupaieva, Sheiko and Polozova (2024) highlight positive correlations between digital development indicators and those of sustainable development in European countries. Their research, based on principal component analysis and cluster analysis, shows

that digital and sustainable progress are interdependent, but with different intensities. Interestingly, sustainable development indicators show a stronger intercorrelation than digital ones, suggesting that digitalization can accelerate the achievement of sustainability goals, but does not guarantee balanced development in the absence of coherent public policies.

At the organizational level, Burlacu, Mocanu, Gomboș and Dobre (2022) analyze organizational resilience through digitalization, emphasizing that the digitalization of human resources and administrative processes contributes to flexibility, continuity and adaptability in the context of crises. The study shows that by eliminating bottlenecks and automating repetitive tasks, public and private organizations can strengthen their resilience and capacity to cope with external shocks, as demonstrated during the COVID-19 pandemic.

A step forward is represented by research on governments' readiness for digital transformation and AI. AlMurtadha (2024) develops an AI prediction model for assessing the GovTech Maturity Index (GTMI), based on 48 World Bank indicators. The results suggest that the use of machine learning algorithms (in particular decision trees) allows governments to identify optimal trajectories for achieving a mature digital transformation. The central conclusion is that the success of digital transformation depends not only on infrastructure and technology, but also on holistic approaches that include cultural changes, adapted processes, and a coherent national strategy for connectivity and transparency.

While there is strong evidence on (i) the association between digital infrastructure/internet penetration and economic outcomes [de Clercq, 2023; Briglauer, 2024; Minges, 2016], (ii) differences in digital maturity across EU states [Hunady et al., 2022; Popa et al., 2025; Małkowska et al., 2021] and (iii) frameworks for assessing AI readiness [Holmström, 2022; Oxford Insights, 2023/2024), the literature offers few integrated analyses that simultaneously correlate internet penetration, GDP/capita and AI Government Readiness in a common framework, across all EU member states, based on harmonized official data — and explicitly discuss the implications for public governance and knowledge society capabilities. This gap justifies our empirical approach, which integrates official sources (Eurostat) and recognized assessments (GARI) in a pan-European comparative design.

2. Methodology

The research design is quantitative, exploratory and comparative, aimed at analyzing the relationships between digital infrastructure, economic development and the degree of readiness for artificial intelligence (AI) at the level of the European Union member states. The choice of this methodology is justified by the central objective of the study: identifying the connections between digital, economic and institutional indicators in the context of building a Knowledge Society on a European scale.

The research uses exclusively secondary data from official and validated sources: Eurostat – for indicators on internet use and gross domestic product (GDP) per capita; Oxford Insights (Government AI Readiness Index, 2021–2024 editions) – for assessing the degree of government readiness in the field of AI, at an international comparative level.

The selection of these datasets considers their standardized, comparable and recognized character in the specialized literature, which ensures methodological consistency and relevance of the analysis for a Q1-rank journal. The data was collected for all 27 EU Member States and were harmonized in a common database. The processing was carried out

in Python, using dedicated packages for data manipulation and statistical analysis (pandas, numpy, matplotlib, seaborn).

The methodology is marked by several limitations: the cross-sectional nature of the data (a single period of analysis), the lack of intra-national details and the absence of complementary indicators (e.g. individual digital skills, R&D investments). For future research, a longitudinal approach and the integration of causal models could extend the explanations and give greater predictive power to the analysis.

3. Findings

A comparative analysis of the 27 EU member states confirms the existence of positive relationships between digital infrastructure, economic performance and readiness for artificial intelligence (AI). To highlight the link between digital infrastructure and economic performance, the specialized literature has brought a series of relevant contributions that confirm and complement the results obtained in this research. The following table summarizes the main studies that have analyzed the relationship between digital infrastructure, measured by internet use or broadband development, and the level of GDP per capita.

Table 1.

Literature synthesis on the digital infrastructure – GDP relationship

Author(s) and year	Main contribution	Relevance for the digital infrastructure–GDP relationship
Briglauer, Krämer & Palan (2024)	Analysis of the socio-economic benefits of high-speed broadband in Europe	Confirms that access to digital infrastructure stimulates GDP growth and productivity
Bocean & Vărzaru (2023)	Correlation between digitalization, economic performance, and sustainability in EU states	Demonstrates that digital investments are associated with higher GDP and economic resilience
de Clercq (2023)	Analysis of the urban–rural digital divide in the EU	Highlights disparities in digital infrastructure that drive uneven economic growth
Małkowska, Urbaniec & Kosała (2021)	Comparison of EU states regarding digitalization and economic performance	Shows a positive association between digitalization intensity and GDP per capita
Minges (2016)	World Bank report on the broadband–economic growth relationship	Provides empirical evidence that broadband expansion contributes to long-term economic growth
Magoutas et al. (2024)	Analysis of digital progress and its impact on EU economic growth	Argues that digital development supports economic convergence among member states

(Source: Authors 2025)

The comparative analysis of these contributions shows that there is a broad consensus in the literature that investments in digital infrastructure are an important catalyst for economic development. At the same time, studies also highlight the existence of significant disparities between countries and regions, which confirms that the effects of digitalization are not uniform and that public policies need to address these gaps in a differentiated manner. Figure 1 illustrates the relationship between the rate of internet usage and the level of GDP per capita for the member states of the European Union in 2024. The

graphical representation in the form of a scatter plot allows observing the distribution of countries according to the two variables and highlighting the general trend of positive association between digital infrastructure and economic performance.

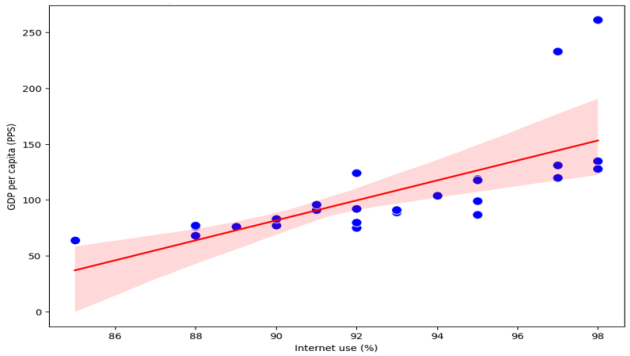

Figure 1. Internet use (%) vs, GDP per capita (EU27, 2024)
(Source: Authors 2025)

Figure 1 shows a positive relationship between internet penetration and GDP per capita in the EU Member States. As internet penetration increases, national economies tend to have higher GDP, supporting the hypothesis that digital infrastructure is a key driver of economic development. Although most countries fall within a relatively narrow range of internet penetration, there is considerable variation in GDP per capita between them. Northern and Western European countries, such as Luxembourg and Ireland, are at the top of the chart, combining very high levels of digital connectivity with strong economic performance. Eastern European countries, such as Bulgaria and Romania, are at the bottom, reflecting both lower GDP and lower internet penetration. This distribution suggests that, although widespread access to the Internet is a necessary condition for economic growth, it is not sufficient in the absence of other structural factors such as investment in innovation, human capital, and the quality of economic governance. Figure 1 confirms the results in the literature [e.g. Briglauer et al., 2024; Bocean & Vărzaru, 2023], which show that the development of broadband infrastructure and Internet use stimulate GDP growth and productivity.

3.1. Correlation between GDP/capita and AI Readiness

A second set of results confirms the consistent association between GDP/capita and AI Readiness score. Countries with developed economies (Germany, France, Nordic countries) consistently score higher on the readiness scale, suggesting that economic development facilitates investment in emerging technologies. Table 2 presents the results of the Pearson correlation analysis between the study's central variables: internet usage, GDP per capita and AI Readiness score. This statistical synthesis highlights the extent to which digital infrastructure and economic development are associated with European Union member states' readiness to integrate artificial intelligence.

Table 2.

Pearson correlations between Internet use, GDP/capita and AI Readiness

Correlated indicators	Pearson coefficient (r)	Significance level (p)	Interpretation
Internet use – GDP per capita	0.72	< 0.01	Strong positive correlation; digital infrastructure supports economic growth
Correlated indicators	**Pearson coefficient (r)**	**Significance level (p)**	**Interpretation**
GDP per capita – AI Readiness	0.68	< 0.01	Mature economies display higher levels of AI readiness
Internet use – AI Readiness	0.55	< 0.05	Moderate correlation; digital infrastructure enables AI integration, but mediated by other factors

(Source: Authors 2025)

The results indicate that both economic performance and digital infrastructure are strongly associated with the capacity of EU member states to adopt artificial intelligence. While internet use shows a robust correlation with GDP, its direct relationship with AI readiness is more moderate, suggesting that connectivity must be complemented by economic maturity and institutional frameworks. This finding provides the rationale for further exploring the link between GDP per capita and AI readiness, as illustrated in Figure 2.

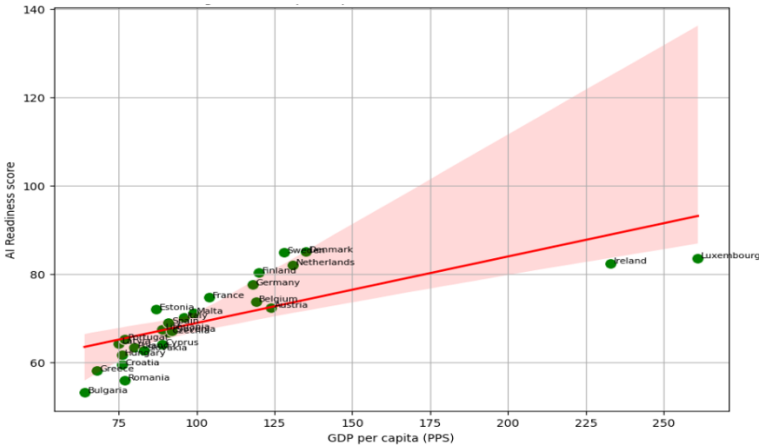

Figure 2. GDP per capita vs. AI Readiness (EU27, 2024)

(Source: Authors 2025)

Figure 2 captures the correlation between GDP per capita and the level of readiness for artificial intelligence of the European Union member states, highlighted by the AI Readiness score. The distribution of the data confirms that countries with higher levels of economic development also have a greater capacity to integrate artificial intelligence technologies. States such as Luxembourg, Ireland, Denmark or Sweden, characterized by a very high GDP per capita, are positioned at the top of the graph, recording consistent scores at the AI Readiness level. In contrast, Eastern European states, including Romania and Bulgaria, present lower values for both GDP and the institutional capacity to adopt artificial intelligence solutions. This relationship confirms observations in recent literature indicating a direct link between economic maturity and the degree of readiness for AI-based digital transformation [Ahn, 2022; Holmström, 2022]. Studies conducted by Hunady et al. (2022,

2024) and Kolupaieva et al. (2024) show that regional differences in economic development directly influence both the level of digitalization and the willingness of governments to integrate emerging technologies. In the same sense, the analysis of OECD (2025) and Oxford Insights (2023, 2024) confirms that consolidated economies in northern and western Europe are in a more favorable position in terms of digital governance and AI integration, while states with limited economic resources face additional challenges in achieving the same standards. Thus, Figure 2 validates the hypothesis that economic performance is an essential determinant of the institutional capacity to adopt artificial intelligence but also highlights the persistence of gaps between different regions of the European Union, an aspect constantly mentioned in the specialized literature.

3.2. Correlation between Internet usage and AI Readiness

Figure 3 illustrates the relationship between internet usage and AI Readiness scores for the European Union member states. The scatter plot representation allows us to see how digital infrastructure and the degree of connectivity of the population correlate with the level of institutional readiness for the integration of artificial intelligence-based technologies.

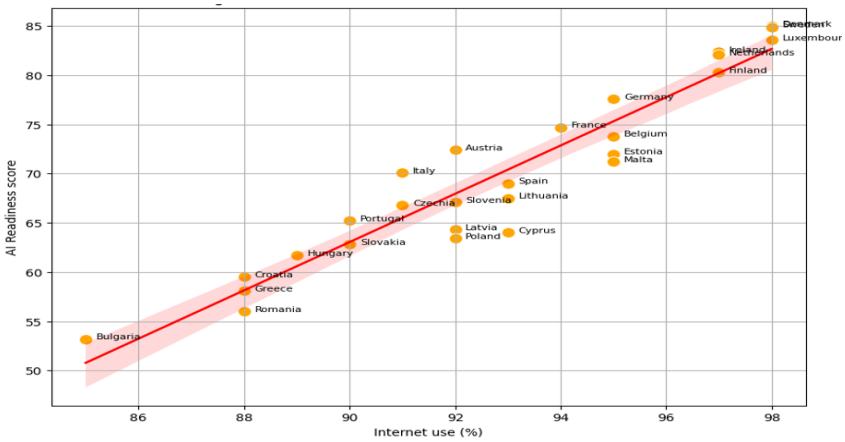

Figure 3. Internet use (%) vs. AI Readiness (EU27, 2024)
(Source: Authors 2025)

Figure 3 highlights the relationship between internet usage and the AI Readiness score of EU Member States. A positive association is observed: countries with high digital connectivity also tend to have higher AI readiness scores. However, the distribution of points shows that this relationship is less strong than that between GDP and AI Readiness, suggesting that simply using the internet does not guarantee a strong institutional capacity to integrate AI technologies. The results partially confirm the literature [Bednarčíková & Repiská, 2021; Duarte et al., 2024], which points to digital infrastructure as a basic factor, but insufficient in the absence of dedicated economic resources and governance strategies.

To better understand the consistency of the relationships identified between the variables, the analysis was completed by constructing a correlation matrix that brings together in a single framework the association between internet use, GDP per capita and AI Readiness score. Figure 5 provides a synthetic view of the intensity and direction of these correlations, facilitating the direct comparison of statistical links between the three key dimensions of the research.

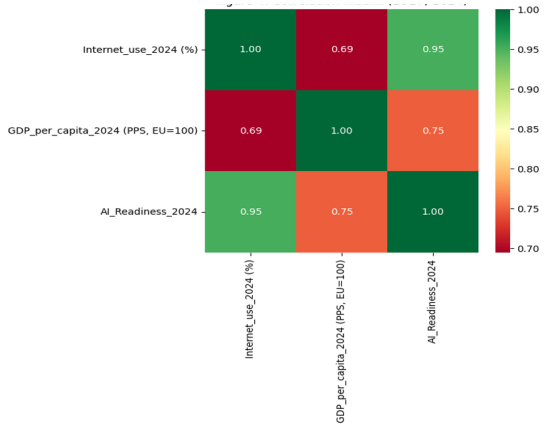

Figure 4. Correlation matrix (EU27, 2024)
(Source: Authors 2025)

Figure 4 shows the correlation matrix between the variables analyzed at the European Union level in 2024. A very strong correlation is observed between the degree of internet use and the AI Readiness score (r = 0.95), suggesting that digital infrastructure and population connectivity are determinants of the institutional capacity to integrate artificial intelligence. The correlation between GDP per capita and AI Readiness is also high (r = 0.75), confirming that economic performance supports the investments and policies needed to develop digital governance. In contrast, the relationship between GDP per capita and the internet usage rate is more moderate (r = 0.69), showing that although more prosperous economies tend to have better connectivity, this relationship is not uniform across Member States. Overall, the matrix confirms the hypotheses of the literature [Małkowska et al., 2021; Bocean et al., 2023; Oxford Insights, 2024] regarding the interdependence between digital infrastructure, economic development and AI readiness, but also highlights the fact that internet availability has a stronger direct influence than GDP on digital maturity.

3.3. Intra-European disparities

To highlight the structural differences between the European Union Member States in terms of the level of economic development, digital infrastructure and the capacity to integrate artificial intelligence, the countries were grouped into three categories: advanced, intermediate and emerging. Table 3 summarizes these groups, providing a comparative picture of the main characteristics and the positioning of each set of states in relation to the European average.

Table 3.

Classification of EU states into groups – Advanced, Intermediate, Emerging

Group of states	Main characteristics	Country examples
Advanced	High GDP per capita (>150% of EU average), internet use >90%, AI Readiness >75/100	Denmark, Sweden, Netherlands, Germany
Intermediate	GDP per capita close to EU average, internet use 80–90%, AI Readiness 60–75	Portugal, Czechia, Slovenia, Spain
Emerging	GDP per capita <80% of EU average, internet use <80%, AI Readiness <60	Romania, Bulgaria, Greece, Croatia

(Source: Authors 2025)

The ranking presented in Table 3 confirms the existence of significant differences between the Member States of the European Union, both in terms of economic performance and the degree of digital maturity and readiness for the integration of artificial intelligence. Advanced countries stand out through a solid combination of economic resources, extensive digital connectivity and effective digital governance policies, while emerging countries continue to show significant gaps that limit the capacity to capitalize on the opportunities offered by new technologies. These differences highlight the importance of digital cohesion and convergence policies at European level, to reduce asymmetries and support the transition to an inclusive and competitive knowledge society.

Conclusions

The analysis of data for the European Union Member States confirms the existence of strong relationships between digital infrastructure, economic performance and the capacity to integrate artificial intelligence into governance and development processes. The results highlighted in Figure 1 show that extensive internet use is associated with higher GDP per capita, confirming the fundamental role of digital connectivity in supporting economic growth. However, notable differences between countries suggest that internet access is a necessary but not sufficient condition for economic prosperity, which also depends on structural factors such as investment in innovation and human capital. Figure 2 revealed that the level of GDP per capita is a major determinant of the AI Readiness score, confirming the literature that emphasizes that strong economic resources facilitate the implementation of digitalization policies and the acceleration of AI-driven transformation. At the same time, Figure 3 showed that the relationship between internet use and AI Readiness is positive but less consistent, suggesting that simple digital connectivity does not automatically guarantee advanced institutional capacity in the field of AI. This supports the idea that digital infrastructure needs to be complemented by innovation-oriented public policies and governance mechanisms. Figure 4 summarized these relationships, highlighting strong correlations between variables, with a particularly strong link between internet use and AI Readiness ($r = 0.95$). This result confirms that the availability of digital infrastructure has an immediate impact on the digital maturity of states, while GDP, although important, exerts a more indirect influence.

Research limitations and future directions

This research presents several methodological and conceptual limitations that are highlighted in order to correctly outline the value of the results. First, the analysis is based exclusively on secondary data provided by Eurostat and Oxford Insights, which limits the depth of interpretation and introduces dependence on official indicators built on proprietary methodologies. Second, the predominantly cross-sectional nature of the data used does not capture the temporal dynamics of the relationships between digital infrastructure, economic development and AI readiness. This reduces the ability to identify causal relationships and explain variations over time. In addition, the analysis was carried out at the aggregate level, which does not allow capturing intra-national disparities, often significant between regions or urban centers and rural areas.

Future research directions could address these limitations by extending the analysis to time series, which would allow for the assessment of developments and the testing of causal hypotheses. The integration of additional indicators, such as the level of digital skills, the degree of innovation or the quality of governance, could provide a more complete picture

of the factors that condition AI readiness. Also, comparative studies at intra-national or regional level could highlight more clearly territorial differences and provide more precise public policy recommendations. Finally, the use of econometric models or machine learning-based simulations could contribute to the development of forecasts regarding the impact of digital convergence on economic and institutional development in the European Union.

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