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DIGITAL READINESS AND ECONOMIC GROWTH

Analyzing the Impact of DESI Scores on GDP in European Countries

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ABSTRACT

This study investigates the relationship between digital readiness and economic growth within the European Union, employing the Digital Economy and Society Index (DESI) as a comprehensive metric to evaluate the impact of digital integration on economic indicators. Through a detailed analysis incorporating factors such as human capital, connectivity, digital technology integration, and digital public services, alongside control variables including industrial production, employment, inflation, and investment, the research offers a nuanced understanding of how digital readiness influences GDP growth across 22 European countries over a six-years period. The findings highlight the significant role of human capital and technology integration in driving economic development, suggesting that investments in digital skills and business adoption of digital technologies are crucial for enhancing productivity and fostering innovation. Contrarily, digital public services showed a marginal negative association with GDP growth, indicating the need for optimization to fully realize their economic benefits. The results underscore the importance of strategic investments in digital readiness to leverage digitalization for sustainable economic growth, urging policymakers to consider both digital and traditional economic factors in their strategies. This research enriches the discourse on digital transformation's economic implications, offering insights for policymakers, economists, and business leaders to foster economic resilience and prosperity in the digital age. Nevertheless, it acknowledges limitations due to the recent inception of DESI scores since 2017, and the potential for delayed effects of digital public services investments on economic growth, highlighting the need for future studies with more extensive data to fully understand the long-term implications of digital readiness on economic development.

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1 INTRODUCTION

In the contemporary digital era, the capacity of nations to harness and integrate digital technologies plays a pivotal role in determining their economic trajectory. This interplay between digital readiness and economic growth has garnered substantial interest among scholars and policymakers, prompting a nuanced exploration of the factors contributing to a country's digital landscape. Central to this discourse is the Digital Economy and Society Index (DESI), a composite metric developed by the European Commission (2021). DESI assesses the level of digital competencies and the evolution of digital infrastructure within the European Union, serving as a crucial barometer for gauging digital readiness across member states. The index's multifaceted nature underscores the complexity of digital integration, encompassing aspects such as broadband connectivity, digital skills among the populace, digital technology adoption by businesses, and supportive regulatory environments.

The relationship between digital readiness and economic growth is underpinned by theoretical frameworks that emphasize the significance of human capital, innovation, and knowledge in driving economic development. According to endogenous growth theory, as expounded by scholars like Lucas (1988) and Romer (1990), investments in digital infrastructure and education to enhance digital skills represent critical forms of human capital and innovation investment. These investments are instrumental in fostering an environment conducive to economic growth.

Empirical studies further elucidate the positive impact of digital readiness on economic performance. For instance, research by Koutroumpis (2009) highlighted a positive correlation between broadband penetration—a key component of digital readiness—and economic growth in OECD countries. Similarly, Qiang et al. (2009) demonstrated that investments in ICT infrastructure significantly contribute to economic growth in developing countries, indicating that digital readiness can serve as a vital lever for development.

The intricate relationship between economic growth and digital readiness, particularly as measured by DESI scores, necessitates a comprehensive investigation. This exploration is paramount for providing insights into how digital preparedness interacts with economic development, offering invaluable guidance for policymakers aiming to harness digital technologies for economic advancement. To enhance the robustness of this exploration, the study incorporates control variables such as Industrial Production, Employment, Inflation, and Investment. These variables are integral to understanding the multifaceted impact of digital readiness on economic indicators. Industrial production reflects a nation's manufacturing capabilities, serving as a mirror to how traditional industries adapt to the digital age. Employment rates offer a lens through which to view the labor market's response to digitalization, revealing shifts towards more technology-oriented jobs. Inflation rates are considered to gauge the economic stability that influences investments in digital infrastructure, while investment in technology and digital assets is pivotal for spurring digital growth.

By accounting for these variables, the analysis aims to dissect the nuanced mechanisms through which digital readiness, as encapsulated by DESI scores, influences economic performance within the European Union. This comprehensive approach underscores the importance of a conducive digital environment, marked by advanced infrastructure, proficient digital skills, strategic technology adoption, and supportive regulatory policies, as essential for fostering economic growth.

As digital technologies continue to evolve, understanding the dynamics between digital readiness and economic growth becomes increasingly critical. The insights derived from analyzing DESI scores and their correlation with economic indicators offer valuable guidance for crafting policies that leverage digitalization as a catalyst for economic development. This exploration not only enriches our understanding of the digital economy's impact on economic growth but also highlights the importance of inclusive and forward-looking policies to bridge digital divides and ensure that the benefits of digitalization are widely shared across societies.

2 LITERATURE REVIEW

Recent studies have increasingly focused on the correlation between digital transformation and economic performance, particularly in the context of European economies. Vu (2021) highlights the critical role of digitalization in enhancing economic growth, arguing that digital infrastructure significantly contributes to GDP across various sectors. Similarly, the McKinsey Global Institute's (2022) analysis on AI suggests a significant potential for AI to boost global economic activity, with an estimated additional $13 trillion in global economic activity by 2030. This growth is contingent on overcoming adoption barriers and ensuring that AI's benefits are broadly shared across different sectors and geographies. The study also highlights the importance of digital skills and infrastructure in maximizing AI's economic impact, noting the risk of widening gaps among countries, companies, and workers without proactive policy and skill development efforts.

Several other studies have also established a strong correlation between digital skills and economic performance. For instance, Buccirossi et al. (2013) find that investments in digital human capital significantly contribute to GDP growth in EU countries, underlining the importance of digital literacy and ICT specialists. Furthermore, Falck et al. (2016) demonstrate that regions with higher levels of digital skills exhibit stronger economic resilience and growth, highlighting the role of education and training in digital transformation strategies.

The relationship between digital connectivity and GDP is well supported by empirical research. Pradhan and Arvin (2015) analyze data across multiple countries and find that broadband penetration is positively associated with GDP growth, emphasizing the importance of high-speed internet for economic activities. Similarly, Gruber et al. (2013) show that the deployment of 4G technology has a significant positive impact on economic development, illustrating the economic value of advanced telecommunications infrastructure.

The integration of digital technologies in businesses, particularly SMEs, is a key driver of economic performance. A study by Cardona et al. (2013) finds that the adoption of digital technologies like cloud computing, big data analytics, and online sales platforms significantly enhances firm productivity and market expansion, leading to GDP growth. This is echoed by Pietrobelli et al. (2019), who provide evidence of a positive correlation between the adoption of advanced digital production (ADP) technologies and increased firm productivity, across various industries and firm sizes, confirming as well that technological capabilities and, to a lesser extent, firm age and foreign ownership, are significantly linked to higher labor productivity. This suggests that digitalization plays a crucial role in enhancing firm performance.

The impact of digital public services on economic growth presents a complex picture. While OECD (2019) posits that e-government services can lead to efficiency gains, cost savings, and improved business competitiveness, thereby contributing to GDP growth, other studies caution about the challenges in realizing these benefits. Gil-Garcia et al. (2018) highlight the difficulties in measuring the direct economic impact of digital public services due to the indirect nature of their benefits and the need for substantial upfront investments.

In their 2022 research, Olczyk and Czarnecka critically examined the Digital Economy and Society Index (DESI), aspiring to refine its methodology to better reflect the digital transformation within EU economies. Their analysis, employing sensitivity-based methods, explored the potential for optimizing DESI's component weights and evaluated the index's efficacy in elucidating GDP per capita changes across the EU. The study's pivotal findings suggested that the DESI, especially when streamlined by excluding internet services and digital public services components, maintained its predictive power regarding digital transformation and GDP per capita variations. Connectivity was identified as the most influential factor in digital transformation. The research also proposed a reduced set of key indicators for more focused digital transformation analysis and emphasized the significance of broadband access, digital skills, and enterprise-level digital activities as critical areas for policy and investment. This investigation highlighted DESI's utility in guiding economic policy, particularly for enhancing digital infrastructure and skills to bridge the economic divide within the EU, while acknowledging methodological challenges and the dynamic nature of digital transformation metrics.

Imran et al. (2022) investigated the direct impact of Digital Economy and Society Index (DESI) dimensions on the Sustainable Development Goals Index (SDGI) in the European Union countries, including the United Kingdom. Utilizing panel regression modeling, the study found that connectivity, human capital, and the use of internet services significantly influence SDGI, while the integration of digital technology and digital public services have a limited impact. Contrary to much of the existing literature, their results suggest that the digital economy does not always positively impact sustainable development. Notably, some aspects, such as the negative effects of online courses, banking, and shopping on socialization, highlight the complex relationship between digital economy factors and sustainable development. The research underscores the importance of careful consideration by policymakers in leveraging digital economy dimensions for sustainable development, suggesting that standard views on the digital economy's benefits for sustainability may need reevaluation. The study is unique in its direct examination of DESI's impact on SDGI, offering insights for future research and policy formulation within the EU context.

The above-mentioned literature and existing research in the area, however, although very detailed and impactful, mainly use individual parameters in their assessments and do not analyze the combined impact of all four DESI Index parameters and their ability to contribute together to economic growth. Thus, this is how this study aims to contribute to the currently existing knowledge on this topic.

3 COMPOSITION OF DIGITAL ECONOMY AND SOCIETY INDEX

3.1 Human Capital

Digital transformation is significantly shaping every facet of life, emphasizing the crucial role of digital skills. These skills are foundational for navigating interactions and executing modern work tasks, making them indispensable for numerous professions. As the digital landscape evolves, the demand for advanced digital competencies is becoming a standard expectation from employers across both public and private sectors. Keeping pace with these skill requirements is vital for fostering innovation and maintaining a competitive edge. Similarly, the general public needs digital skills for various professional and personal applications.

Recognizing the importance of digital proficiency, the EU and its Member States have prioritized the digital transition, aiming to develop a digitally skilled workforce and public. The „Path to the Digital Decade" initiative sets forth ambitious goals for 2030, including equipping 80% of the population with basic digital skills and significantly increasing the number of ICT specialists to 20 million, while also aiming for gender balance in this field.

Despite these aspirations, current statistics reveal a significant gap, with only 54% of Europeans possessing basic digital skills as of now, and disparities in digital proficiency across Member States. While countries like the Netherlands and Finland are near the target, others, including Romania, Bulgaria, Poland, and Italy, lag considerably behind. Furthermore, the number of ICT specialists is also below the desired threshold, indicating a challenging path ahead to meet the 2030 objectives (European Commission, 2022a).

The Digital Skills Indicator serves as a monitoring tool to evaluate Member States' progress toward these digital skill targets. It provides insights into online behaviors, digital competences, and the distribution of skills across various digital domains, encompassing:

- The Digital Skills Composite Indicator
- Internet Usage
- Levels of Digital Skills and Online Information and Communication
- Possession of Basic Digital Skills
- Content Creation Skills
- Advanced Digital Skills
- Awareness and Identification of Online Disinformation
- ICT Specialists in the Workforce
- Participation in EU Code Week 2021
- Inclusion of Digital Skills in Recovery and Resilience Plans
- Structured Dialogue on Digital Education and Skills

3.2 Connectivity

To ensure digital inclusivity and maintain prosperity, the European Union is committed to establishing a state-of-the-art digital connectivity infrastructure. This infrastructure is envisioned to be secure, sustainable, and optimized for the latest in optical fiber and innovative wireless technologies like 5G and 6G. The need for such an infrastructure is driven by increasing consumer demands for gigabit connections, essential for advanced digital applications ranging from high-definition video to AI and automated systems, which require robust upload and download capacities and minimal latency.

Moreover, the EU places a strong emphasis on developing semiconductor technologies critical for supporting emerging data processing needs, AI applications, and the transition towards edge computing. This is part of a broader strategy to decentralize data processing, aiming to deploy thousands of climate-neutral edge nodes across the EU, including in rural areas, by 2030. The upcoming decade also anticipates significant advancements in quantum technologies, expected to revolutionize various fields by integrating quantum acceleration with classical computing.

The focus areas include enhancing broadband connectivity—covering its coverage, uptake, and affordability—and advancing semiconductor technology. These efforts are essential for achieving a secure and sustainable digital transition, aligning with the EU's Digital Decade goals (European Commission, 2022b).

The below mentioned bullet points are contributing to the connectivity scores:

- Broadband connectivity
- Broadband coverage
- Fixed broadband take-up
- Mobile broadband take-up
- Broadband prices
- Semiconductors

3.3 Integration of Digital Technology

The Digital Economy and Society Index (DESI) evaluates the progression of digital technology use within EU businesses and the e-commerce sector. It measures how extensively businesses incorporate a spectrum of digital technologies, ranging from basic practices like sharing information electronically and utilizing social media, to employing advanced tools such as big data, cloud computing, and artificial intelligence (AI). The Index also places a strong focus on the digital commerce activities of small and medium-sized enterprises (SMEs), tracking their online sales both domestically and across the EU, along with the resulting revenue. This data is primarily sourced from an EU survey examining ICT usage and e-commerce among businesses.

Furthermore, the DESI looks at how businesses use ICT to enhance their environmental sustainability efforts. The European Commission's ambitions for the Digital Decade include achieving widespread digital proficiency among SMEs, the adoption of cloud computing, AI, and big data across EU businesses, and increasing the number of high-value startups, known as Unicorns, within the region. The components of the Index—digital technology use, cloud services, big data, AI, the emergence of Unicorns, and e-commerce—are vital for reinforcing the EU's autonomy in the digital domain and its economic strength (European Commission, 2022c),

As mentioned above, the segment of the Index dedicated to the Integration of Digital Technology encapsulates various essential elements that determine the extent of digital technology integration within businesses. These elements encompass:

- Digital Intensity Index: An indicator of the general level of digital technology adoption by companies.
- Adoption of Digital Technologies: This evaluates the breadth of digital technology integration across company operations.
- Cloud Computing: The deployment of cloud-based services for data storage, processing, and business functionalities.
- Big Data: The strategic application of big data analytics to enhance decision-making and operational effectiveness.
- Artificial Intelligence (AI): The adoption of AI to streamline processes, improve decision-making, and foster innovation.
- Unicorns: The tracking of highly valued startups, which signifies a dynamic and innovative digital sector.
- e-Commerce: This measures the degree to which companies are engaging in online sales activities, both locally and across the EU.

3.4 Digital Public Services

The digital era introduces significant challenges and opportunities for the public sector, aiming to fully utilize digital technologies for better governance. The transition to e-government promises enhanced operational efficiency, cost reduction, and greater transparency. The COVID-19 pandemic accelerated the shift towards online public services, with a strategic goal to digitalize all essential services by 2030. However, the pace of digitalization varies, with citizen services often trailing behind those offered to businesses, and more sophisticated services requiring increased investment.

Supporting this digital shift, the European Interoperability Framework outlines strategies for developing interoperable digital services, integral to the Recovery and Resilience Plans (RRP). These plans earmark approximately EUR 46 billion for digital transformation across vital sectors, aiming to make public administration more user-friendly and efficient. Key initiatives include adopting eID solutions and the ‚Once Only Principle' to improve service accessibility and data governance, reflecting a concerted effort to modernize public services and enhance digital governance across the EU (European Commission, 2022d).

The components contributing to the digital technologies score, which reflects the progress and commitment of the EU towards digital innovation in public services, include:

- e-Government users
- Pre-filled forms
- Digital public services for citizens
- Digital public services for businesses
- Open data
- The use of eIDs
- eGovernment Benchmark, which encompasses:
  - User centricity
  - Transparency
  - Key enablers
  - Cross-border services

4 METHODOLOGY AND DATASET

This investigation employs a comprehensive dataset covering the period from 2017 to 2022, which includes the Digital Economy and Society Index (DESI) scores for 22 European countries: Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, and Sweden.

The dataset incorporates nine pivotal variables: Human Capital, Connectivity, Integration of Technology, Digital Public Services, Industrial Production, Employment, Inflation, Investment, and GDP growth, culminating in a total of 1,452 data points. To collate the DESI scores, the official European Union website served as the primary source, while the OECD database was utilized for the economic data. While the DESI Indicators were selected to analyze and assess their individual contributions, the control variables were chosen in line with Bassanini`s and Scarpetta`s (2001) OECD Study on economic growth, where they also utilized panel data to discuss the links between policy settings, institutions and economic growth in OECD countries. In the situation where the same variables used in the mentioned study could not be retrieved, they have been replaced with similar indicators in the present study.

Additionally, a log10 transformation was applied to standardize the dataset, facilitating a uniform analytical framework. This extensive dataset provides a solid foundation for a detailed examination of the interplay between digital readiness and key economic indicators across these European nations, enabling a nuanced understanding of their evolution over the analyzed period.

The dataset was subjected to panel regression analysis, using GDP growth as the dependent variable and the other indicators as independent variables, to explore their relationship with the GDPs of the selected countries. Subsequently, a diagnostic Hausman test was conducted to determine which model – random effect or fixed effect – was more appropriate to be used. Additionally, the White and Breusch-Pagan tests revealed the presence of heteroskedasticity. Durbin-Watson test results also indicated positive autocorrelation within the data. To address the issues of heteroskedasticity and autocorrelation, a standard clustered errors model was applied to the dataset, in conjunction with the random effects panel regression analysis. This approach is supported by academic consensus, which suggests that in the presence of both heteroskedasticity and autocorrelation, the implementation of a standard clustered errors methodology is necessary, and the results obtained should be accepted as they are.

4.1 Theoretical framework of the performed statistical analysis

4.1.1 Log10 Transformation

The log10 transformation is a valuable statistical tool that addresses several challenges in data analysis, enhancing the suitability of data for linear regression and other statistical models. By mitigating skewness, the transformation normalizes data distributions, aligning them closer to the normal distribution assumed by many statistical models and thereby improving the accuracy of model estimates (Osborne, 2010).

It also stabilizes variance across data values, addressing issues of heteroscedasticity that can obscure the interpretation of regression analysis, ensuring the data meets the homoscedasticity assumption required for reliable statistical testing (Tabachnick & Fidell, 2013). Additionally, the log10 transformation facilitates the linearization of inherently nonlinear relationships between variables, making them amenable to analysis using linear regression models, which are notably easier to interpret (Draper & Smith, 1998).

This transformative process is not just about making data fit model assumptions; it also converts multiplicative relationships between variables into additive ones, proving particularly advantageous in econometric analyses focused on understanding elasticity—the percentage change in one variable in response to a 1% change in another—thereby broadening the interpretative power of econometric models (Wooldridge, 2012). Together, these benefits underscore the log10 transformation's critical role in preparing data for analysis, ensuring that researchers can draw accurate, interpretable insights from their statistical models.

4.1.2 Regression Analysis

Regression analysis constitutes a fundamental statistical approach for modeling the association between a dependent variable and one or more explanatory variables. This analytical method aims to discern the way the expected value of the dependent variable shifts in response to changes in the explanatory variables. Linear regression, the most rudimentary form of regression, posits this relationship as a linear function. The origins of regression analysis can be traced back to the seminal work of Sir Francis Galton during the late 19th century, from which it has developed into a cornerstone technique within the realms of statistical inference and econometrics (Stigler, 1986).

4.1.3 Evolution to Panel Regression

While traditional regression analysis provides insights, its scope is limited to cross-sectional or time-series data. Cross-sectional regression analyzes data collected at a single point in time across various subjects, whereas time-series regression deals with data collected over time for a single entity.

Panel regression, or longitudinal data analysis, emerges as a hybrid approach combining elements of both cross-sectional and time-series data. This methodology allows researchers to analyze data that vary across entities (e.g., individuals, companies, countries) and over time, providing a more nuanced understanding of dynamic relationships.

4.1.4 Theoretical Foundations of Panel Regression

Panel regression models can be divided into two primary types: fixed effects models and random effects models. The choice between these models depends on the nature of the unobserved heterogeneity across entities.

1) **Fixed Effects Models**: These models assume that individual-specific effects are unique and correlate with independent variables. They control time-invariant characteristics, isolating the net effect of predictors on the response variable. This approach was notably advanced by Mundlak (1978), who emphasized its importance in the presence of unobserved individual heterogeneity.

2) **Random Effects Models**: Proposed by Wallace and Hussain (1969), these models treat individual-specific effects as random and uncorrelated with the regressors. This assumption allows for more generalizability and efficiency under certain conditions.
3) **Clustered standard errors:** Essential technique in panel data econometrics for addressing issues of heteroskedasticity and autocorrelation. Pioneered by Arellano (1987), this approach provides robust standard error calculations that are critical for data with intragroup correlations. Froot (1989) expanded upon this to encompass cross-sectional dependence, a vital concern in financial econometrics. Rogers (1993) further refined the methodology, highlighting its importance across various applications where sample clustering occurs. These methods are crucial when data violate standard econometric assumptions, often detected by diagnostic tests like those developed by Breusch and Pagan (1979), and Durbin and Watson (1950).

5 DESCRIPTIVES AND RESULTS

5.1. Table summaries

Table 1
Descriptives and Results

Variable	Count	Mean	Std. Dev.	Min	25%	50%	75%	Max
Human Capital	132	1.06	0.08	0.91	1.00	1.05	1.13	1.25
Connectivity	132	0.96	0.15	0.50	0.86	0.96	1.06	1.28
Integration T.	132	0.86	0.14	0.50	0.77	0.88	0.95	1.17
Digital Public S.	132	1.16	0.11	0.78	1.10	1.18	1.24	1.36
Industrial Prod.	132	2.05	0.05	1.95	2.02	2.04	2.07	2.26
Employment	132	1.84	0.04	1.73	1.83	1.85	1.87	1.91
Inflation	132	2.03	0.03	2.00	2.01	2.02	2.05	2.14
Investment	132	5.05	0.56	4.06	4.61	5.09	5.39	6.07
GDP	132	5.64	0.55	4.65	5.26	5.62	6.02	6.73

The dataset's summary statistics, based on 132 observations for each variable, show average values ranging from 0.86 to 5.64, with standard deviations from 0.03 to 0.56, reflecting varying degrees of dispersion among the variables. The data spans across a spectrum of minimum and maximum values indicative of each variable's scale, with the least spread observed in Inflation and the greatest in Investment. This variability suggests a diverse set of characteristics within the measured indicators of economic performance and digital integration.

Table 2
Diagnostics of the Dataset

Test	LM-Stat	LM p-value	F-Stat	F p-value	Durbin-Watson
White Test	115.5846	< 0.0000001	13.9224	< 0.0000001	N/A
Breusch-Pagan	57.7610	< 0.0000001	11.9624	< 0.0000001	N/A
Durbin-Watson	N/A	N/A	N/A	N/A	0.4761

Interpretation of Results:

- The White test indicates the presence of heteroskedasticity, as suggested by a highly significant LM statistic and p-value. The F-statistic and its associated p-value further confirm this result, with both indicating strong evidence against the null hypothesis of homoskedasticity.
- Similarly, the Breusch-Pagan test provides evidence of heteroskedasticity with a significant LM statistic and p-value. The F-statistic and its corresponding p-value also reject the null hypothesis of homoscedastic errors.
- The Durbin-Watson statistic of 0.4761 suggests positive autocorrelation in the residuals of the regression model. This is below the commonly used threshold of approximately 2, which indicates no autocorrelation.

These results would suggest that the appropriate econometric approach would involve correcting for heteroskedasticity and possibly addressing autocorrelation within the model.

Therefore, Random Effect Model with Clustered standard errors were employed to treat heteroskedasticity and autocorrelation issues in the model.

Table 3
Panel Regression Results

Parameter Estimates	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI
const	1.9304	0.4570	4.2236	0.0000	1.0257	2.8350
Human Cap	0.3164	0.1390	2.2759	0.0246	0.0412	0.5916
Connectivity	0.0194	0.0319	0.6065	0.5453	−0.0439	0.0826
Integration Tech	0.2250	0.0751	2.9969	0.0033	0.0764	0.3735
Digital Public S	−0.1678	0.0838	−2.0019	0.0475	−0.3338	−0.0019
Industrial Prod	0.4257	0.0781	5.4503	0.0000	0.2711	0.5804
Employment	0.6514	0.2427	2.6838	0.0083	0.1709	1.1318
Inflation	0.2671	0.0963	2.7727	0.0064	0.0764	0.4577
Investment	0.1463	0.0777	1.8840	0.0619	−0.0074	0.3001

- **Constant (1.9304):** This constant term indicates the expected level of GDP when all the independent variables are held at zero. It provides a baseline for comparisons when assessing the impact of the variables.
- **Human Capital (0.3164):** A 1% increase in Human Capital is associated with a 0.3164% increase in GDP. This suggests that investments in human capital are positively correlated with economic growth, which could be due to the enhanced productivity and innovation that better educated, or more skilled workers bring to the economy.
- **Connectivity (0.0194):** The Connectivity variable, while positive, is not statistically significant, implying that within this model, increases in connectivity measures do not have a discernible impact on GDP. This might indicate that other factors not captured by this variable are more influential in GDP outcomes.
- **Integration of Digital Technology (0.2250):** A 1% increase in Integration Technology corresponds to a 0.2250% increase in GDP. This positive relationship suggests that technology integration within industries or services positively affects economic output, possibly by increasing efficiency and competitiveness.
- **Digital Public Services (-0.1678):** An increase in Digital Public Services is associated with a decrease in GDP of 0.1678%. This counterintuitive result could suggest that investments in digital public services may not immediately translate into economic growth or might be reflecting short-term costs without immediate economic benefits.

- **Industrial Production (0.4257):** The Industrial Production variable shows a strong positive impact on GDP, with a 1% increase in industrial production associated with a 0.4257% increase in GDP. This underlines the traditional role of industrial production as a driver of economic growth.
- **Employment (0.6514):** A 1% increase in Employment is associated with a 0.6514% increase in GDP, indicating a strong positive relationship. This could be due to the direct impact of higher employment on consumption and production within the economy.
- **Inflation (0.2671):** The positive coefficient for Inflation suggests that a 1% increase in inflation is associated with a 0.2671% increase in GDP. This could reflect the short-term boost that inflation sometimes gives to economic activity before any central bank countermeasures.
- **Investment* (0.1463):** The coefficient for Investment is positive, suggesting that a 1% increase in investment is associated with a 0.1463% increase in GDP. While this is not statistically significant at the 5% level, it does indicate a trend where investment is likely to be beneficial for economic growth. (* Gross fixed capital formation.)

5.2 R-Squared Values Interpretation

Overall R-squared (0.9039): The high overall R-squared value suggests that the model explains a substantial portion of the variation in GDP across both entities and time. However, since the ‚Between' R-squared is much lower, it indicates that the model is more effective at explaining the variation within entities over time rather than differences between them.

The overall R-squared value of 0.9039 in this context is indicative of the model's strong explanatory power regarding the variation in GDP. It tells us that the model, taking into account all the data from both time series within entities and cross-sectional differences between entities, can explain approximately 90.39% of the variation in GDP. This high value suggests that the predictors included in the model are significantly related to GDP, making the model reliable for understanding how changes in the predictors are associated with changes in GDP.

However, the lower ‚Between' R-squared highlights a nuanced aspect of the model's explanatory power. Specifically, the ‚Between' R-squared measures how well the model explains variation in the average values of the dependent variable (GDP in this case) across different entities. A lower ‚Between' R-squared, in contrast to the high overall R-squared, signals that while the model is highly effective at accounting for the fluctuations within each entity over time (i.e., capturing the time-series dynamics of GDP for each entity), it is less proficient in explaining the differences in GDP levels across different entities.

6 CONCLUSION

This comprehensive analysis, intertwining the intricate dynamics of digital readiness and economic growth within the European context, leverages the Digital Economy and Society Index (DESI) as a pivotal framework for assessing digital integration's impact on key economic indicators. Through meticulous examination, the study elucidates the multifaceted relationship between various dimensions of digital readiness—including human capital, connectivity, integration of digital technology, and digital public services—and their consequential influence on GDP growth, underpinned by the inclusion of control variables such as industrial production, employment, inflation, and investment.

The empirical findings from the panel regression analysis reveal a nuanced landscape of digital readiness's economic implications. Notably, human capital and the integration of digital technology emerge as significant catalysts for economic development, underscoring the paramount importance of investing in digital skills and technology adoption within businesses. These elements are instrumental in enhancing productivity, fostering innovation, and driving competitive advantage, thereby contributing to GDP growth. Conversely, the analysis presents an intriguing counterpoint regarding digital public services, which, contrary to expectations, are associated with a slight decrease in GDP. This suggests that while digital public services are critical for streamlining government operations and enhancing citizen engagement, their direct economic benefits may unfold over a longer horizon or require further optimization to realize their full potential for economic impact.

Moreover, the research highlights the enduring significance of traditional economic drivers, such as industrial production and employment, in concert with digital readiness factors, in shaping economic outcomes.

These findings reinforce the notion that digital transformation, while a powerful engine for growth, operates within a broader economic ecosystem where various factors interplay to influence overall economic performance.

The study's methodological rigor, employing log10 transformation and panel regression analysis with clustered standard errors, addresses potential heteroskedasticity and autocorrelation, ensuring the robustness of the results. The comprehensive dataset, spanning 22 European countries over a six-year period, provides a solid empirical foundation for the analysis, enabling a nuanced understanding of the dynamics at play.

In conclusion, this research contributes significantly to the discourse on digital readiness and economic growth, offering valuable insights for policymakers, economists, and business leaders. The findings emphasize the critical role of digital skills and technology integration in propelling economic development, while also highlighting the complex interdependencies between digital and traditional economic factors. As digital technologies continue to evolve and permeate every facet of society and the economy, the insights derived from this study underscore the imperative for strategic investment in digital readiness as a cornerstone for sustainable economic growth. Policymakers are thus urged to craft forward-looking policies that not only enhance digital infrastructure and competencies but also address the broader economic context in which digital transformation occurs. By doing so, they can ensure that the benefits of digitalization are fully harnessed to foster economic resilience, innovation, and prosperity across the European Union and beyond.

However, as with most data driven studies, this study also bears limitations on the data point of view. The DESI Scores availability is limited, with a starting point from 2017, making it a challenge to go back in time for a more in-depth study. Furthermore, as described in the results section, investments in digital public services, for example, may not immediately translate into economic growth or might be reflecting short-term costs without immediate economic benefits. Hence, its impact might only be seen more clearly in the future and even, maybe, towards an opposite direction. We can make the same consideration for the other implemented variables as well, where more data input and more transparency might change future results.

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