Assessing the Correlation Between Digitalization and Economic Performance: An Empirical Analysis for European Countries

Ensem Mourou iD University of Miskolc, e-mail: ensemmourou13@gmail.com

SUMMARY

The rapid growth of information and communication technology (ICT) has profoundly impacted how societies and economies function, making digitalization a key factor in progress. This study explores how digitalization influences economic growth in European Union (EU) countries between 2017 and 2022, using the Digital Economy and Society Index (DESI) from the European Commission as a measure of digital readiness. By applying a panel data analysis within the Cobb-Douglas production framework, we uncover a strong link between digitalization and economic performance. Our findings show that a 1% increase in digitalization, as measured by DESI, leads to a 0.3838% rise in GDP growth. This highlights the transformative power of digital technologies and the need for governments and policymakers to embrace digital innovation. By leveraging these advancements, countries can drive sustainable economic growth and build resilience in an increasingly digital world.

HOW TO CITE:

1. INTRODUCTION

Economic growth has long been a central topic in academic research due to its significant impact on a nation's social, political, and economic stability. Countries with strong economies often demonstrate balanced development across these sectors, laying the groundwork for overall prosperity (Hanushek & Woessmann, 2020).

The importance of economic growth extends beyond mere statistics; it enhances a nation's global standing, strengthens its influence, and fosters resilience amid global challenges (Gründler & Potrafke, 2019). In recent decades, the rapid advancement of information and communication technologies (ICT) has transformed the global economy, introducing new drivers of growth and productivity. Emerging technologies such as the Internet of Things (IoT) and artificial intelligence (AI) have accelerated digitalization, leading to significant changes in economic and social structures (Audretsch & Fritsch, 2002; van Stel et al., 2005).

As we advance further into the digital era, digitalization has emerged as a significant force driving economic transformation. It is redefining traditional economic models of production, consumption, and trade by fostering innovation, enhancing productivity, and boosting competitiveness. Consequently, digital transformation has become a foundational element of economic modernization, recognized by governments and businesses around the world as crucial for sustainable growth. Major economies have responded by making substantial investments in digital infrastructure and technologies contributing to a global digital economy that now represents approximately 15 % of world GDP about $16 trillion. Furthermore, reaching universal broadband access alone is expected to require more than $400 billion in investment by 2030 underscoring the scale of digital infrastructure spending worldwide according to the World Bank's Digital Progress and Trends Report 2025 (World Bank, 2025).

Developing countries also stand to gain significantly from this shift, as digitalization can improve capital and labor productivity, provide access to global markets, and accelerate economic development (Arendt, 2015).

1.1. Novelty and Contribution of This Study

This study contributes to the existing literature by examining the impact of digitalization on economic growth within the European Union, specifically focusing on the EU-27 countries from 2017 to 2022. A unique aspect of this research is its utilization of the Digital Economy and Society Index (DESI), developed by the European Commission as a comprehensive measure of digitalization. Unlike traditional ICT metrics, DESI offers a multi-dimensional assessment that includes indicators such as digital infrastructure, digital skills, technology adoption, and digital public services. By employing DESI, this study provides a more comprehensive understanding of how digital transformation influences GDP growth, offering insights that extend beyond conventional ICT measurements.

This paper presents a novel approach to measuring digitalization as a multi-faceted driver of economic growth. Specifically, the research aims to answer two key questions:
1. How did digitalization progress among EU-27 countries from 2017 to 2022?
2. Is there a significant relationship between digitalization, as measured by the Digital Economy and Society Index (DESI), and GDP growth within these countries?

By addressing these questions, this study seeks to enhance the understanding of digitalization's role in economic growth within the EU. The findings are particularly relevant for EU policymakers who aim to nurture a resilient digital economy and strengthen the region's global competitiveness. By emphasizing the importance of digital infrastructure, digital skills, and technology adoption, this research provides a data-driven foundation for strategic decision-making in the EU. Additionally, it offers insights into the EU's progress in achieving its Digital Agenda, an initiative designed to build a robust and inclusive digital economy.

This paper is organized into five main sections, each exploring different aspects of how digitalization impacts economic growth within the EU-27. The introduction section establishes the context for the study, highlighting the transformative role of digitalization in driving economic growth. It outlines the study's objectives and research questions and introduces the Digital Economy and Society Index (DESI) as a key metric for analyzing the relationship between digitalization and GDP growth in the EU. The Literature Review section provides an overview of both foundational and recent studies regarding the role of digitalization in economic growth. It focuses on areas such as ICT infrastructure, digital skills, and technology adoption. By situating the study within broader academic discourse, this section supports the use of DESI as a relevant and comprehensive measure of digitalization. The Methodology part describes the empirical approach. This involves using the Cobb-Douglas production function to model the relationship between economic growth and inputs such as capital, labor, and digitalization. The section explains how DESI is utilized as a proxy for digitalization and details the fixed-effects panel data model used for analysis, including descriptions of the data sources and the reliability of the results. And finally, in the Results and Discussion section we highlight the findings that reveal a positive correlation between DESI and GDP growth, indicating that digitalization significantly drives economic growth in the EU. The results are discussed in relation to existing research, highlighting the policy implications of investing in digital infrastructure and human capital. The Conclusion section summarizes the study's key contributions, emphasizing the impact of digitalization on GDP growth and the EU's advancements in achieving its digital transformation goals. It also addresses the study's limitations and suggests potential avenues for future research, such as examining individual components of DESI to gain a more nuanced understanding of the economic impact of digitalization. In summary, this study examines the impact of digitalization, as measured by the Digital Economy and Society Index (DESI), on economic growth in the EU-27. By analyzing data from 2017 to 2022 using a fixed-effects panel model, the research provides empirical evidence that digital infrastructure, digital skills, and technology adoption are vital for economic growth. These findings are consistent with the work of Brodny and Tutak, (2022); Mura and Donath (2023); Toader et al. (2018) and others who highlight the essential role of digitalization in enhancing economic performance.

The insights from this study emphasize the significance of digitalization as a driver of sustainable growth, competitiveness, and resilience within the EU. As digitalization continues to influence global economies, it is crucial to understand its effect on economic growth to develop policies that foster inclusive and sustainable development. By utilizing DESI as a comprehensive measure of digitalization, this study contributes to a deeper understanding of its role in contemporary economic systems, making it a valuable resource for both academics and policymakers who are navigating the complexities of digital transformation.

2. LITERATURE REVIEWS

This literature review examines how digitalization influences economic growth across the EU-27, with a focus on two primary questions: (1) How has digitalization progressed among EU countries? and (2) What is the relationship between digitalization, as measured by the Digital Economy and Society Index (DESI), and GDP growth? This review synthesizes core theories, concepts, and recent empirical findings to offer insights into how digitalization impacts economic performance

within EU member states. Additionally, it identifies notable gaps in existing literature and highlights emerging research trends that underscore the need for further, targeted study.

2.1. Defining Key Concepts: Digitization, Digitalization, and Digital Transformation

To understand digitalization's economic impact, it is essential to distinguish between digitization, digitalization, and digital transformation. Savić (2019) delineates these as stages in the digital integration process: digitization (converting physical information into digital formats), digitalization (using digital tools to improve processes), and digital transformation (a comprehensive restructuring of business models and public services).

Recent literature focuses on the transformative potential of advanced digital technologies, such as artificial intelligence (AI), the Internet of Things (IoT), and cloud computing. Bharadwaj et al. (2013) highlighted how digital transformation enables governments and businesses to respond to evolving demands more efficiently, thereby improving service delivery and citizen engagement. Ghobakhloo and Iranmanesh (2021) further argued that digital transformation is critical for economies to adapt to rapidly changing environments, fostering both short-term resilience and sustained economic growth.

These distinctions are relevant to the DESI framework, which captures various stages of digital integration across dimensions like human capital, connectivity, and digital public services. However, few studies systematically examine how each stage of digitalization, especially digital transformation, affects economic growth within the EU-27. This gap underlines the need for research that explores digital transformation's specific contributions to economic resilience and competitiveness within the EU, an area this study aims to address.

2.2. Digitalization as a Catalyst for Economic Growth:

The positive relationship between digitalization and economic growth has been extensively studied, particularly regarding ICT infrastructure and connectivity. In the EU context, Toader et al. (2018) highlighted that ICT investments are linked to increased GDP per capita, positioning digitalization as a driver of productivity and competitiveness in global markets. Furthermore Fernández-Portillo et al. (2020) support this idea highlighting that progress in the deployment and use of ICT drives the economic growth of countries that are within the framework of developed European economies.

Recent research has expanded the digitalization–growth literature by shifting attention from productivity gains toward economic resilience, particularly in the face of systemic shocks such as the COVID-19 pandemic. Papaioannou (2023) provides compelling macroeconomic evidence from European countries, showing that economies with higher ICT intensity experienced significantly lower cyclical GDP losses during the pandemic. Using a difference-in-differences approach, the study demonstrates that the economic impact of COVID-19 was uneven across Europe and closely linked to national levels of ICT adoption. These findings suggest that digital infrastructure plays a stabilizing role during crises by enabling economic continuity, facilitating remote work, and supporting digital service delivery. At the firm level, Furceri et al. (2022) reach similar conclusions, showing that firms operating in more digitalized industries suffered smaller revenue declines during economic downturns, with the resilience effect becoming even stronger during the COVID-19 recession. Their results remain robust across a wide range of digitalization measures, including ICT inputs, digital skills, online sales, automation, and intangible assets. Taken together, these studies indicate a clear evolution in the role of digitalization from a driver of efficiency and innovation in normal times to a critical mechanism for absorbing shocks and enhancing adaptive capacity, particularly in digitally advanced economies such as those of the European Union.

Despite extensive literature on the link between digitalization and growth, limited empirical work focuses specifically on the EU-27, particularly studies that utilize the DESI framework. This gap suggests a need for region-specific analyses that consider the EU's unique economic, policy, and social contexts. Much of the existing research centers around ICT infrastructure alone, often neglecting other digitalization dimensions, such as digital skills and public services, which are critical for a comprehensive understanding of digital transformation. Addressing these gaps can provide a more holistic view of how digitalization drives growth across the EU.

Empirical studies consistently demonstrate that digitalization positively influences economic growth, especially when coupled with strong ICT infrastructure, broadband access, and digital public services. Toader et al. (2018) found that ICT investments within the EU significantly contribute to GDP growth, affirming digitalization's role in economic performance. Mura and Donath (2023) also emphasized that digitalization enhances productivity in sectors such as education, healthcare, and public administration.

Large-scale cross-country evidence from the Katz and Callorda (2020) global study confirms that broadband expansion and digitalization play a significant role in driving economic performance, with effects that vary by income level. Using a structural econometric model for 139 countries, the study finds that a 10 percent increase in fixed broadband penetration raises GDP per capita by 0.8 percent globally, with stronger effects in high-income economies, where the same increase leads to a 1.4 percent rise in GDP. In contrast, mobile broadband exerts a larger impact in less developed economies, reflecting its role as a substitute for fixed infrastructure where broadband access remains limited. Beyond connectivity, the study shows that broader digitalization measured through the CAF Digital Ecosystem Development Index significantly

enhances economic outcomes. A 10 percent increase in the digitalization index is associated with a 1.3 percent increase in GDP per capita globally and a 1.4 percent increase in OECD countries, alongside notable gains in labor and total factor productivity. Overall, these findings highlight digitalization as a structural driver of growth, particularly in digitally advanced economies such as those of the European Union.

2.3. Measuring Digitalization in the EU: The Digital Economy and Society Index (DESI)

The EU utilizes the DESI as its primary metric for measuring digitalization, which evaluates digital progress across four dimensions: human capital, connectivity, integration of digital technology and digital public services. While other indices like the ICT Development Index (IDI) and the Global Connectivity Index (GCI) provide global perspectives, they do not consider EU-specific policy frameworks and socioeconomic conditions Thus, DESI provides a comprehensive measure that aligns with the EU's goal of fostering digital innovation and resilience (Almeida de Figueiredo, 2024).

This study builds on DESI by analyzing data from 2017 to 2022, addressing digitalization's role on economic growth within the EU-27. By focusing on DESI, this study contributes to the literature by linking digital dimensions to economic growth metrics, offering insights that are highly relevant for EU policymakers aiming to bridge digital divides across member states.

2.4. The State of Digitalization in the EU-27: Insights from DESI Data

DESI data offers a detailed overview of digitalization trends within the EU, tracking progress in areas such as human capital, connectivity, digital technology integration, and public services. According to European Commission DESI Reports (2017–2024) (European Commission, 2023), EU countries have shown steady improvement in DESI scores, reflecting significant strides toward digital transformation. However, a study by Hunady et al. (2022) points to ongoing disparities, with Northern European countries generally leading in digital readiness while Southern and Eastern European countries lag, particularly in connectivity and digital skills.

These disparities suggest a "dual speed" digital economy within the EU, where some countries reap greater benefits from digitalization than others. Such uneven progress underscores the importance of targeted policies to ensure balanced digital transformation across member states. By analyzing recent DESI data, this study assesses digitalization's progression within the EU-27 and its influence on economic growth, directly addressing the research question on digitalization's trajectory.

In fact, increasing digitalization across all significant facets of modern society and the economy has become more than just a topic for academic study; instead, it is the underlying reality that motivates the creation of various laws and regulations. Digitalization is currently the focus of most global economic ambitions. As a result, one of the primary courses of action for achieving a national goal is frequently to increase digitalization; thus, significant efforts are being made to foster digital development. In fact, DESI is a well-known metric for measuring digital progress among EU member states, and it has been used for monitoring purposes since 2014.

Since it is a composite index, the four primary directions that the DESI now focuses on human capital, connectivity, integration of digital technology, and digital public services are seen as indicative of the digital world's progress.

2.4.1. Human capital

This component underlines the relevance of the population's digital capabilities, which are critical for capitalizing on the benefits provided by digital technologies. Human capital refers to the extent to which European individuals use the Internet and other digital tools and services. The measure of internet usage represents people's efficiency in accessing digital resources.

2.4.2. Connectivity

Connectivity is a dimension that measures the extent of fixed broadband coverage, reflecting the proportion of homes that use different broadband technologies such as DSL, cable, MiMAx, and FTTP. It also measures mobile broadband usage, which is expressed as the number of persons that use mobile data per 100 people. Internet access is also evaluated based on speed, regarded as adequate if it exceeds 30 Mbps. Affordability is another connectivity component, with fixed broadband prices ranging from 12 to 30 Mbps. It is critical to increase access to digital services and boost communication and collaboration.

2.4.3. Integration of digital technology

Integration of digital technology includes variables like corporate digitization and e-commerce. Business digitalization consists of numerous components. It involves electronic information sharing, in which firms use software for duties such as resource planning and information exchange between departments. Second, it involves the use of Radio Frequency Identification technology to transport or identify items. Additionally, businesses use social media platforms such as networks, websites, and blogs to improve their digital presence.

2.4.4. Digital public services

Digital public services, often called eGovernment, aim to modernize public administration and improve citizen services. The connectivity component refers to the extensive infrastructure and its quality.

    The DESI Index publications provide a comprehensive overview of EU member states' digital progress, which is an excellent place to start, as they are more relevant to the intended goal than analyzing the index's methodology.
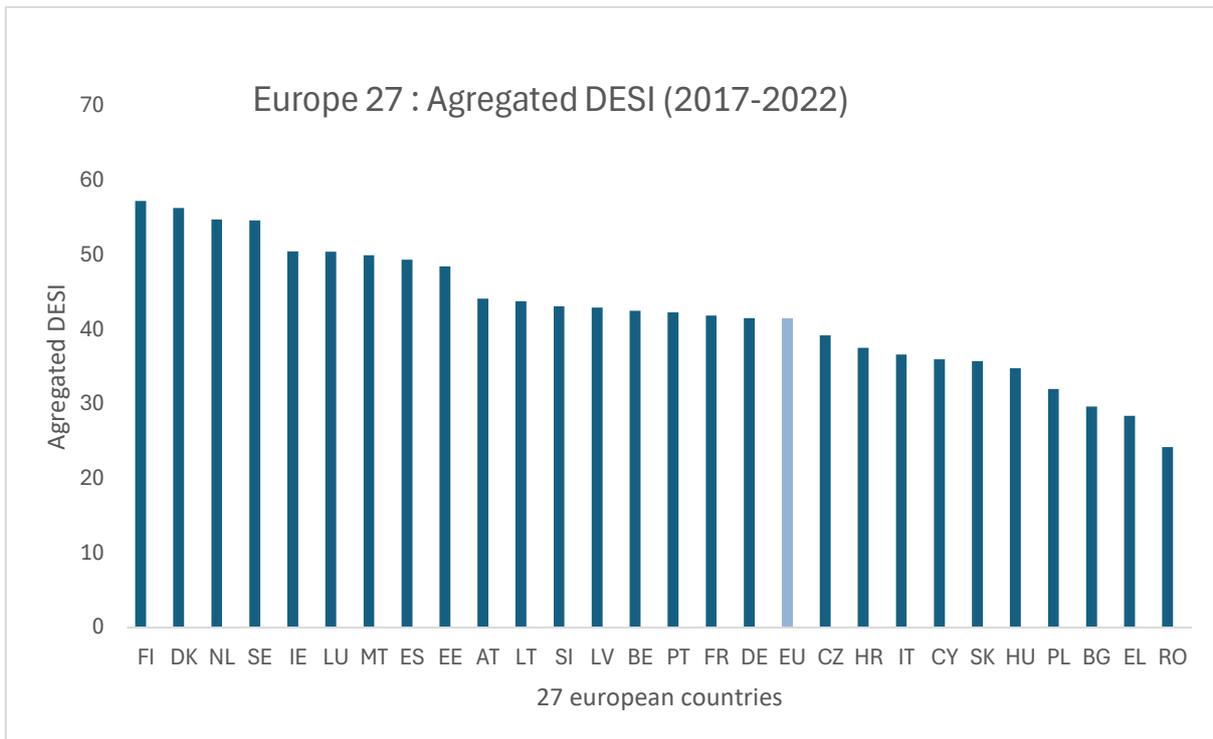
Source: Author's compilation based on (European Commission, 2023)

Figure 1: Europe 27-Aggregated DESI (2017-2022)

    The Figure 1 reveals an additional obstacle to the future of the European digital agenda. Even though the combined rating for the 27 European countries is higher (41.48) as per the lighter blue bar, one-third of the nations are still in the transitional stage of digitization. Furthermore, the level of DESI evolution in EU countries has an overall upward trend, as Figure 2 illustrates.
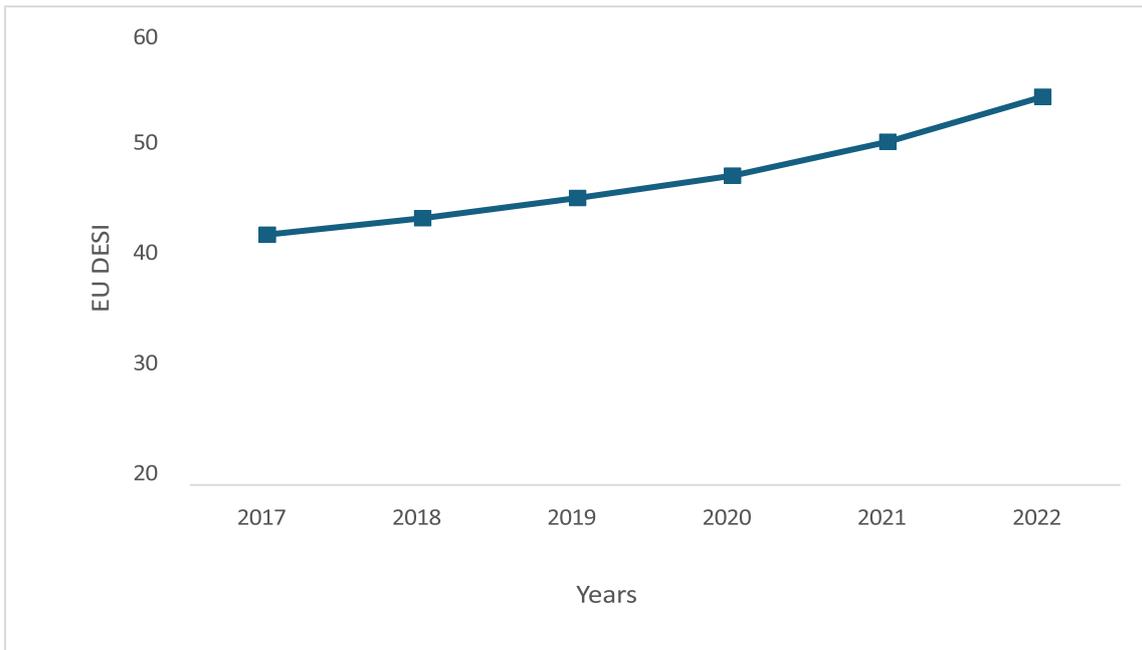
Source: Author's compilation based on (European Commission, 2023)

Figure 2: Evolution of EU average DESI (2017-2022)

The reviewed literature underscores digitalization as a vital economic growth driver, primarily through ICT infrastructure and digital skills. DESI's multidimensional structure captures these elements, offering a robust framework for assessing digitalization's impact within the EU-27.

By analyzing DESI data from 2017 to 2022, this study seeks to bridge the gap, providing a nuanced understanding of digitalization's economic influence within the EU. In doing so, it offers new insights into the EU's progress toward the Digital Agenda which can guide policies that foster inclusive digitalization. Ultimately, this study contributes to the broader literature on digital transformation and economic growth, emphasizing the importance of targeted interventions that ensure all EU member states can benefit from the economic advantages of digital transformation.

3. METHODOLOGY

3.1. Theoretical Framework

This study aims to analyze the impact of digitalization on economic growth within EU-27 countries by using a production function model that incorporates traditional inputs (capital and labor) along with a digitalization index (DESI). After adjusting for labor and capital, we assess how digitalization influences GDP. This assessment is achieved by employing a panel data approach, which allows us to consider both time series and cross-sectional dimensions.

Panel data regression is particularly suitable for this type of research as it reduces biases caused by unobserved heterogeneity, those unique characteristics specific to each country but not explicitly measured in the model (Baltagi, 2021).

This methodological approach addresses both heterogeneity and endogeneity issues, where heterogeneity refers to differences in characteristics across countries, and endogeneity reflects correlations between independent variables and unobserved factors that may influence economic growth (Gujarati, 2003).

The Cobb-Douglas production function is widely recognized in economic research for capturing the non-linear relationship between inputs (capital and labor) and outputs (GDP growth).

In traditional economic growth models, GDP is a function of capital and labor, with each factor contributing to the output in a multiplicative manner .The Cobb-Douglas model has been validated in empirical economic studies for its robustness in analyzing production dynamics and growth factors across various economies (Cobb & Douglas, 1928). This model's flexibility allows for the inclusion of additional variables, which in this study is digitalization as measured by DESI.

One of the model's advantages is its ability to allow for elasticity calculations, which quantify how responsive GDP growth is to each input. This feature is particularly useful here as it enables us to measure the unique contribution of digitalization (proxied by DESI) alongside traditional factors like labor and capital. Previous studies, such as those by Mankiw et al. (1992) and Tripathi and Inani (2020) have successfully employed the Cobb-Douglas model to explore the roles of traditional

inputs in growth, demonstrating its validity in similar contexts. Their evidence that the Cobb-Douglas model is effective in studying production dynamics across various economies further validates its use here. In this study, we introduce DESI as a third variable to capture digitalization's potential impact on growth, exploring whether it serves as an additional driver alongside capital and labor. By incorporating DESI as an additional input, the Cobb-Douglas model provides a robust framework for examining the role of digitalization alongside capital and labor in driving GDP growth. Specifically, DESI serves as a proxy for digital infrastructure and digital readiness, capturing various dimensions of a country's digital environment, including human capital, connectivity, integration of digital technology, and digital public services (European Commission, 2023).

This inclusion aligns with recent studies that integrate digitalization metrics into growth models, emphasizing the importance of digital infrastructure in modern economic systems (Brodny & Tutak, 2022; Mura & Donath, 2023)

In this context, my study seeks to determine if DESI acts as a complementary input to capital and labor in influencing GDP growth. Study of Habibi and Zabardast (2020) also used digitalization indices to model the economic effects of ICT infrastructure, further supporting the use of a Cobb-Douglas framework with digitalization as an added factor.

The Cobb-Douglas function is be expressed in log-linear form as follows:

$$\log(GDP_{it}) = a_1\log(Capital_{it}) + a_2\log(Labor_{it}) + a_3\log(DESI_{it}) + \varepsilon_{it}$$

where

- GDP: Gross Domestic Product (current USD)
- Capital (GFCF): Gross fixed capital formation (current USD)
- Labor refers to the whole labor force
- DESI serves as a proxy for digitalization
- i indicates the sample countries
- t refers to the time period
- the regression coefficients (a_1, a_2, and a_3) are estimated using panel data regression
- ε is a random residual term.

The variables included in the empirical model are defined as follows:

1. Gross Domestic Product (GDP): Our dependent variable, GDP, represents the economic output of each country and is measured in current US dollars. GDP is a widely accepted measure of a country's economic performance and is often used in studies of economic growth (World Bank, 2023)
2. Capital (Gross Fixed Capital Formation - GFCF): Capital input is measured through GFCF, representing investments in physical assets such as infrastructure, machinery, and equipment. This measure captures the role of physical capital in driving productivity and is expressed in current US dollars. GFCF is a standard proxy for capital in economic research, as seen in foundational studies like (Solow, 1956; World Bank, 2023)
3. Labor Force: The labor input is captured by the total labor force in each country, which includes individuals employed or actively seeking employment. Labor is a crucial factor in economic models, reflecting the human resources available to drive production. This measure aligns with previous economic growth study, such as
4. Digitalization (Digital Economy and Society Index - DESI): developed by the European Commission, serves as a proxy for digitalization in this study. DESI aggregates multiple dimensions of digitalization, including connectivity, human capital, use of internet services, integration of digital technology, and digital public services. This index provides a holistic view of digital readiness and infrastructure in each EU country, making it an ideal measure for understanding digitalization's economic impact (European Commission, 2023)

The inclusion of capital and labor is based on established economic theory, specifically the Cobb- Douglas production function, which identifies these factors as fundamental drivers of economic output. Adding DESI as a measure of digitalization reflects recent shifts in economic growth theory, acknowledging that technological infrastructure and digital skills have become essential components of modern economic systems. The use of DESI aligns with the growing body of literature that highlights digitalization's critical role in enhancing productivity and growth.

The data for GDP, capital (GFCF), and labor force were obtained from the World Bank's World Development Indicators database (World Bank, 2023), ensuring consistency and reliability across countries and years. DESI data were sourced from the European Commission database, providing insights into the digitalization progress across EU member states.

This study uses annual data from 2017 to 2022, covering 27 EU countries, to analyze the impact of digitalization on economic growth. The data, sourced from Eurostat and the World Bank, ensures a comprehensive and reliable foundation for examining how digital advancements interact with traditional economic factors like capital and labor.

3.2. Empirical Analysis: Panel Data Regression and Model Selection

3.2.1. Panel Data and Choice of Regression Models

In this study, we employ panel data analysis to capture both country-specific and time-specific variations in the EU-27, which allows for a more nuanced understanding of how digitalization influences economic growth. Panel data combines time-series and cross-sectional dimensions, enabling us to observe changes within each country over time while also accounting for differences across countries. When analyzing panel data, there are three commonly used regression models: Pooled Ordinary Least Squares (OLS), Fixed Effects (FE), and Random Effects (RE).

Pooled OLS treats all observations as part of a single dataset, ignoring unique country-specific characteristics. While straightforward, it assumes that there are no correlations between independent variables and unobserved factors, which is often unrealistic for panel data. Due to its limitations in accounting for individual country differences or changes over time, Pooled OLS is not suitable for this study.

The Fixed Effects (FE) and Random Effects (RE) models address the limitations of Pooled OLS by allowing for unobserved heterogeneity. These models account for country-specific factors that might influence GDP growth but are not explicitly measured in the model.

- **Fixed Effects (FE) Model**: The FE model is particularly effective when unobserved characteristics vary across countries but remain constant over time. This model introduces a unique intercept for each country, enabling us to capture country-specific effects. The FE model is especially useful for our study as it helps control endogeneity the correlation between independent variables (such as digitalization) and unobserved individual effects that might simultaneously affect GDP growth.
- **Random Effects (RE) Model**: The RE model assumes that unobserved country-specific effects are random and uncorrelated with the independent variables. This model is typically used when observations (countries) are randomly drawn from a larger population. However, this assumption does not hold in our case, as we focus on a specific set of EU countries rather than a random sample.

To determine the most appropriate model, we employ the Hausman test, which examines the correlation between regressors and unobserved effects. If this test reveals a correlation, this suggests that the FE model is more suitable, as it provides unbiased estimates in the presence of endogeneity. In this analysis, the Hausman test favors the FE model, indicating that fixed effects capture the country-specific factors better than random effects. To further refine our model, we apply robust standard errors to address potential issues related to heteroskedasticity and autocorrelation.

The FE model is selected due to its ability to control for unobserved country-specific factors that are constant over time, which is particularly important given the diversity in digitalization and economic structures among EU countries. According to Gujarati (2003) the FE model is suitable for datasets with relatively few time periods and numerous cross-sectional units that are not randomly selected, as is the case in our study. Other research, including studies by Mura and Donath (2023); Toader et al. (2018) has also demonstrated the value of the FE model in examining economic growth across countries with significant heterogeneity and potential endogeneity.

3.2.2. Model Estimation and Addressing Econometric Issues

We use the Least Squares Dummy Variable (LSDV) method to estimate the coefficients of the FE model. This technique includes dummy variables for each country, allowing for country-specific intercepts that account for unobserved heterogeneity across countries. The LSDV approach is appropriate for our dataset, as we are working with the complete set of EU-27 countries rather than a random sample (Gujarati, 2003).

In panel data analysis, issues like heteroskedasticity (unequal variance of errors) and autocorrelation (correlated errors across time) can affect the accuracy of our results.

- **Heteroskedasticity**: This occurs when error variances differ across countries, potentially leading to inefficient estimates. To mitigate this, we use robust standard errors, which adjust for non-constant variance in the residuals, thus improving the reliability of our results (Cobb & Douglas, 1928; Solow, 1956)

- **Autocorrelation**: Autocorrelation can arise when errors are correlated over time within the same country, which may introduce biases. We test for autocorrelation and confirm that residuals are not correlated across time, ensuring the accuracy of our regression results.

To ensure the robustness of our findings, we conduct diagnostic tests to check for normality, autocorrelation, and heteroskedasticity in the residuals. The model achieves an R-squared value of 0.9983, indicating that it explains 99.83% of the variation in GDP based on the independent variables (capital, labor, and digitalization). This high R-squared value demonstrates the model's strong fit, suggesting that our chosen variables effectively capture the key drivers of GDP growth across the EU.

The Fixed Effects model, validated by the Hausman test and complemented by robust standard errors, allows us to accurately account for country-specific differences within the EU, reduce biases, and measure the influence of digitalization on economic growth. By addressing potential econometric issues and rigorously testing the model, we have strengthened the reliability of our findings. This methodology not only aligns with best practices in econometric analysis but also enables a deeper understanding of how digitalization, alongside traditional economic factors, contributes to GDP growth across the EU. This approach is consistent with prior research and enhances the validity of our conclusions regarding the role of digitalization in shaping modern economic performance.

4. RESULTS AND DISCUSSION

In this section we're going to highlight the empirical regression results for our Model.

The analysis represented in Table 1 provides a comprehensive examination of the relationship between GDP growth and three key variables: capital, labor, and digitalization (captured through the Digital Economy and Society Index, or DESI) across the EU-27 from 2017 to 2022. Utilizing a Cobb-Douglas production function within a fixed-effects model, this study quantifies the distinct contributions of each variable to economic growth while controlling for country-specific, time-invariant characteristics. This approach enables a nuanced understanding of how digitalization interacts with traditional economic inputs, such as capital and labor, to drive growth within the European Union.

In this model, the dependent variable is the natural logarithm of GDP, while capital, labor, and DESI serve as independent variables, also in logarithmic form. To improve the robustness and representativeness of our findings, we excluded significant outliers, including Germany, Italy, and France. These economies exhibit unique characteristics and more advanced digital infrastructures, which could distort the model's results. By focusing on a more homogenous subset of EU countries, we aim to capture the broader impact of digitalization on economic growth without the disproportionate influence of the largest and most digitally advanced states.

Diagnostic tests confirmed the model's reliability. The acceptance of the null hypothesis in normality and autocorrelation tests indicated that residuals are normally distributed and uncorrelated over time, meeting essential assumptions for regression analysis. However, the heteroskedasticity test suggested inconsistent variances across observations, prompting the use of robust standard errors to mitigate any potential bias. This rigorous approach enhances the credibility of our findings and ensures that the coefficient estimates are both reliable and statistically significant.

Our regression analysis reveals a strong positive association between GDP growth and the three primary independent variables: capital, labor, and DESI. With an R-squared value of 0.9983, the model demonstrates an exceptional fit, explaining 99.83% of the variation in GDP across the EU-27. This high explanatory power underscores the effectiveness of our model in capturing the dynamics of economic growth within the European Union.

A particularly noteworthy finding is the significance of the DESI coefficient, which is both positive and statistically significant at the 1% level (coefficient = 0.3838, p-value = 0.0057). This implies that a 1% increase in digitalization, as measured by DESI, corresponds to a 0.3838% increase in GDP growth. This result highlights the pivotal role of digital infrastructure and digital capabilities in fostering economic expansion. It suggests that digitalization has moved beyond being a complementary element to traditional economic inputs such as capital and labor to become a core driver of productivity gains and competitiveness across various sectors.

The elasticity indicated by the DESI coefficient also points to the transformative impact of digitalization on economic structures. Digital infrastructure not only enhances efficiency within existing frameworks but also reshapes production processes, enabling innovation and greater productivity. This aligns with endogenous growth theories, which posit that knowledge and technological advancements are central to sustainable economic growth. By complementing traditional inputs, digitalization amplifies the productivity of both capital and labor, unlocking new avenues for economic development that conventional resources alone cannot achieve.

Table1: LSDV model through Fixed effects

Fixed-effects, using 144 observations Included 24 cross-sectional units Time-series length = 6 Dependent variable: l_GDP Robust (HAC) standard errors				
Variable	Coefficient	Std. Error	t-Ratio	p-value
constant	15.8926	3.22487	4.928	8.30E-07
l_capital	0.220726	0.173834	1.27	0.2042
l_labortotal	0.211515	0.294064	0.7193	0.472
l_DESI	0.383838	0.138756	2.766	0.0057
Effects Specification				
Mean dependent var		25.82187	S.D. dependent var	1.19997
Sum squared resid		0.344705	S.E. of regression	0.05428
LSDV R-squared		0.998326	Within R-squared	0.71262
Log-likelihood		230.1841	Akaike criterion	−406.3683
Schwarz criterion		−326.1833	Hannan-Quinn	−373.7856
rho		0.139397	Durbin-Watson	1.36345
Joint test on named regressors Statistic test: F(3, 23) = 102.279 with p-value = P(F(3, 23) > 102.279) = 1.91256e-13				
Distribution free Wald test for heteroskedasticity Null hypothesis: the units have a common error variance Asymptotic test statistic: Chi-square(24) = 324.794				
Residual normality test Null hypothesis: error is normally distributed Test statistic: Chi-square(2) = 4.33508				
Wooldridge test for autocorrelation in panel data Null hypothesis: No first-order autocorrelation (rho = -0.5) Test statistic: F(1, 23) = 4.10634				
Correlation Coefficients, Two-tailed critical values for n = 144: 5% 0.1637, 1% 0.2140				
	l_GDP	l_capital	l_labortotal	l_DES
l_GDP	1.0000	0.9862	0.8704	0.1489
l_capital		1.0000	0.8413	0.1992
l_labor			1.0000	-0.2018
l_DESI				1.0000

Source: Author's compilation based on (European Commission, 2023) and (World Bank, 2023)

Our findings are consistent with and extend previous research on the relationship between digitalization and economic growth. For instance, Toader et al. (2018) found that ICT investments significantly boost GDP within the EU, a result corroborated by our study, which highlights DESI's continued relevance as an economic growth driver post-2017. Similarly, Mura and Donath (2023) demonstrated a positive link between DESI and economic performance, further supporting our assertion that DESI is a reliable metric for evaluating the economic impact of digitalization in the EU.

Beyond the European Union context, international evidence further underscores the importance of digitalization for economic growth. Habibi and Zabardast (2020) report similar positive effects of ICT development in both OECD and Middle Eastern countries, highlighting the broad and universal role of digital infrastructure as a key driver of productivity. Using fixed-effects OLS and GMM estimation techniques, the authors find that ICT is positively associated with economic growth in both groups.

These findings highlight the universal relevance of digital infrastructure as a productivity driver. Our study contributes to this body of literature by providing an EU-specific analysis that links DESI dimensions with economic growth, offering actionable insights for policymakers within the EU.

5. CONCLUSION

This study has shown that digitalization, represented by the Digital Economy and Society Index (DESI), is a key driver of economic growth in the EU-27. By incorporating DESI into a Cobb- Douglas production function within a fixed-effects panel model, we were able to quantify the impact of digital infrastructure on GDP growth. The findings reveal that a 1% increase in digitalization corresponds to a 0.3838% rise in GDP, underscoring the transformative power of digitalization. These results demonstrate that digital infrastructure and capabilities are not just complementary to traditional inputs like capital and labor, they are essential drivers of innovation, productivity, and economic resilience.

5.1. Validation of EU Policy Frameworks

These findings strongly validate the European Union's current digitalization policy framework, particularly its Digital Decade objectives, which aim to foster economic resilience in Europe through digitalization. The positive correlation between DESI and GDP growth underscores the rationale behind the EU's push for widespread digital adoption and infrastructural enhancements across member states.

For EU policymakers, our findings provide empirical support for digitalization as a central component of economic growth strategies. The results emphasize that countries with lower DESI scores – indicating lagging digital infrastructure, digital skills, and digital public services – stand to benefit significantly from targeted investments in these areas. By bridging digital divides across the EU, particularly in less digitally advanced regions, these policies can contribute to economic convergence within the bloc, fostering a more balanced and inclusive digital economy. For member states that already score highly on DESI, further investments in advanced technologies such as artificial intelligence, cloud computing, and automation, drive continued productivity gains and secure their leadership in emerging technology sectors. These insights suggest that the EU's digital policy framework should not only focus on broad-based infrastructure and skills development but also encourage innovation-driven digital investments in digitally mature economies.

5.2. Broader Implications for Economic Theory and Growth Models

From an economic theory perspective, our study contributes to the evolving understanding of growth models in an increasingly digitalized economy. Traditional growth models, which focus on physical capital and labor as primary inputs, fall short of explaining the full impact of intangible, technology-driven factors like digital infrastructure. By incorporating DESI into the Cobb- Douglas production function, this study extends growth modeling to reflect the pivotal role of digital skills and infrastructure as essential productivity drivers in modern economies.

This finding aligns with endogenous growth theories proposed by scholars like Solow (1956) who argue that knowledge and technology are vital for sustained economic growth. The strong positive relationship between DESI and GDP growth suggests that digital infrastructure should be regarded as a core economic input, alongside capital and labor, in contemporary growth models. These results imply that digitalization not only complements traditional inputs but fundamentally transforms production capabilities, enhancing productivity and fostering resilience in ways that were previously unachievable.

5.3. Future Research Directions and Study Limitations

While our study provides valuable insights, several limitations warrant further exploration. First, by excluding the largest EU economies (Germany, Italy, and France), we may have limited the model's applicability to the entire EU-27. Future studies could explore methods to account for economic size and digital maturity, enabling a more comprehensive view of digitalization's impact across the full spectrum of EU countries.

Additionally, examining the sector-specific impacts of digitalization could reveal more granular insights, as the effects of digital infrastructure may vary across industries. Further research could also dissect the individual dimensions of DESI to determine which components are most influential in driving growth. Expanding this analysis to include non-EU regions would provide a comparative perspective, shedding light on the global relevance of the EU's digitalization policies.

Finally, extending the timeframe of the analysis would allow future studies to examine the long- term effects of digitalization on economic growth. As new digital technologies and policy frameworks emerge, continually updating digitalization metrics will be essential for capturing the evolving impact of digital transformation on economic resilience and productivity.

In conclusion, as digitalization continues to shape economies worldwide, understanding its role in economic   growth will be crucial for crafting policies that foster inclusive, sustainable development. The EU's commitment to digital transformation, as reflected in the DESI index, presents a model for building resilient, forward-looking economies, a strategy that other regions might consider as they navigate the challenges and opportunities of the digital age.

Disclosure statement

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Data availability statement

The data that support the findings of this study are available from the author, **Ensem Mourou** iD ensemmourou13@gmail.com, upon reasonable request.

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