ISSN: 2029-4913 / eISSN: 2029-4921

TECHNOLOGICAL and ECONOMIC DEVELOPMENT of ECONOMY

2025
Volume 31
Issue 4
Pages 980–1007
https://doi.org/10.3846/tede.2025.22576

SETTLING THE DEBATE: DOES DIGITALISATION IMPACT THE ECONOMIC GROWTH IN THE EUROPEAN UNION MEMBER STATES?

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Article History:
- received 06 March 2024
- accepted 01 October 2024
- first publihed online 02 July 2025

Abstract. This research analyses the influence of digitalisation (Digitalisation Composite Indicator (ITC)) on economic growth (GDP per capita) by scrutinising the progression of digitalisation intensity and its impact. Digital technology has the potential to exert a substantial influence on various facets of the national economy, significantly impacting economic growth, innovation, and overall quality of life. Given the disparities among European Union Member States concerning governance quality, the imperative of digitalisation becomes evident in advancing economic prosperity, irrespective of a country's development status. Specifically, our study aims to evaluate the effects of the implementation of digital tools on economic growth in the Member States of the European Union (EU-27) from 2017 to 2021. Two advanced methods, Principal Component Analysis (PCA) and the Ordinary Least Square model (OLS), were employed to conduct the empirical research. The findings indicate that before the pandemic, the level of digitalisation was subpar, marked by limited technological advancement. Nations exhibiting a heightened degree of digitalisation also demonstrate elevated levels of economic development. These results underscore countries' need to realign and reconfigure their digital transformation strategies, emphasising incorporating digital technologies and cultivating ongoing innovation to bolster long-term economic growth.

Keywords: digitalisation, economic growth, bibliometric analysis, principal component analysis, Ordinary Least Square model.

JEL Classification: B22, O33, O43.

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1. Introduction

This study examines the extent and influence of digitalisation on economic growth among the European Union's 27 member states. Effectively, our research aims to present in detail the digitisation process and its effects on economic growth within the European Union (EU), while, at the same time, shedding light on the best practices used by some EU governments and how they can be transposed and implemented as policy at EU level. The significance of the digital sector's development for the national economy is confirmed by several member states of the European Union, which are currently implementing complex and comprehensive programs for developing their economies' digital sectors.

Given the disparities between the European Union's member states in terms of governmental quality, the presence of sound public governance, the proper and fair allotment of public resources, and sensible public spending, as well as targeted initiatives to improve the well-being and economic growth (Houngbo et al., 2017), in both less developed and developed countries, digital transformation is an essential factor for reaching economic prosperity (Myovella et al., 2020). The digitalisation of the economy is a current topic that affects almost all areas, including individuals and society. It is essential to understand that digitalisation in the economic process goes beyond simply adopting digital technologies. It involves creating initiatives and plans for the digital economy and simulating the risks and consequences of implementing innovations and ICT. Through digital media, platforms and technology, digitalisation has affected the reconfiguration of the economy, society and culture (Karimi & Walter, 2021). Furthermore, Costea et al. (2022) stated that effective public policies and quality public administration can trigger technological progress and economic development. Globalisation and improved technology have made digitalisation necessary; it is therefore essential to look at it from many angles, including politics, society and economics.

The contemporary challenges generated by digitisation processes in the context of modern globalisation, supported at the same time by the period of the COVID-19 pandemic, have generated multiple and significant changes regarding the development of economic systems at different levels (Melnychuk et al., 2023). Notably, in the context of globalisation, digital technology has become the main solution to help countries develop economically. In this context, Nguyen (2021) identifies a series of public policies with a crucial role, which tend to highlight and promote the stability of appropriate conditions and actions by the governments of their developing countries that lead to the promotion of digital technology and which to allow the contribution of citizens' opinions regarding government policies and regulations, in the context of increasing the degree of digitisation, respectively economic growth of the countries. According to Novikova et al. (2022), the increased development of digitalisation generates the transformation of the entire socioeconomic system, thus determining the growth of new economic opportunities and the high degree of digitalisation of a country, leading to sustainable economic growth. On the other hand, in a global context, in order to promote economic growth and sustainability, Asian countries have focused on the expansion of ecological markets, they have placed particular emphasis on the entire process of digital transformation, the use of artificial intelligence, along with the promotion of energy production ecological in urban areas. Moreover, there is a significant heterogeneity of the countries in the EU compared to major economies such as the United States or Canada in the sphere of adoption of digital technologies, highlighting the fact that a multitude of EU member countries lag behind the most important competitors, especially the United States, identifying the key ways in which EU countries can benefit and gain significantly from digitalisation, including the uniform adoption of structural policies. Gastrow and Adams (2022) investigate the trajectory through which the European Union is aligning itself with South Africa in identifying international changes regarding the regulation of data and digital technology, emphasising privacy and data protection regulations, thus facilitating the development of new knowledge and partnerships, which emphasise digitisation. The results reveal that

South Africa needs rapid regulation of the digital environment; otherwise, it risks remaining underdeveloped in the sphere of technological and digital changes.

The current situation, nuanced by the pre-COVID 19 and post-COVID 19 periods, has demonstrated the importance of digital resources for a country's economy. As stated by Eusebio et al. (2021), the COVID-19 pandemic has accelerated the digital transformation of both public and private enterprises and the need to implement digital tools to ensure business continuity and sustainability. The introduction of digital tools for working in the economy (distribution, exchange, production, use of basic products and services) can generate benefits for enterprises that are small and medium-size (SMEs), as well as for EU countries as a whole (Magomedov et al., 2020).

The research results contribute to the existing specialised literature by shedding light on the progression of digitalisation intensity and its impact on economic growth, which explains the results registered within the EU-27 Member States, thus filling a gap as regards the impact of digitalisation on economic growth, since the vast majority of the literature pointed out the relevance of digital transformation processes, country-specific stances, or limited assignments to its impact on economic growth. It also highlights the similarities and differences between the EU-27 countries by embedding a hierarchy regarding the level of digitalisation and its important performance and effects on economic growth. Another notable element of the research's novelty lies in the innovative way in which digitalisation effects on economic growth are captured and analysed through constructs such as composite indicators, which allow the gathering of the cumulative effects of many variables alongside complex and comprehensive methods of reviewing specialised literature, namely bibliometric, systematic and content analysis of the current state of knowledge. Furthermore, another significant contribution reveals that the level and direction of the impact of digitalisation on economic growth require assessment and determination of national differences among the 27 European Union states by revealing the particularities of both national and international experiences of determining the impact of digitalisation on economic growth.

The study considers all the EU-27 member states for five years, from 2017 until 2021. For this paper, a novel way of tackling the issue of digitalisation was employed by utilising advanced econometrics models such as the principal component analysis (PCA) and regressions (Ordinary Least Square, Fixed Effects and Random Effects model). To better showcase the necessity and importance of the digitalisation process for the European Union's member states, a composite indicator was created – the Digitalisation Composite Indicator (ICT).

The research paper is structured in the following way: Section 1 briefly establishes the link between digitalisation and its effects on the national economy. Section 2 is dedicated to a thorough analysis of the body of research on the connection between digitalisation and economic development, complemented by data mapping to highlight the working hypotheses and determine the level that each analysed indicator holds in each of the EU countries. Section 3 includes a description of the variables relevant to our research and the presentation of the research methodology. The main results, discussions, and concluding remarks are presented in Sections 4 and 5, respectively.

2. Literature review

We employed a bibliometric analysis to identify the most significant contributors to our research field. Thus, the VOSviewer program allowed the organisation of articles related to our area of interest. Therefore, the application of the analysis allowed the observation of the multiple keywords utilised by the most influential authors and the highlighting of links and top collaborations from certain countries. VOSviewer is programmed in English, which determines the retention of terms in this language in the analysis.

We chose keywords such as "digitalisation", "economic growth" and "European Union" based on their relevance to current search trends," would provide clarity.

With the help of the Web of Science (WoS) database, the following two terms were utilised: "digitalisation" and "economic growth" as they mirror the current research trends for the domain of digitalisation, and as type, the selected documents were considered: "article" and "book chapter". The analysis period between 2017 and 2021 was supposed to highlight the actuality of the scientific research carried out and to capture the period before and after the COVID-19 pandemic. Therefore, 185 documents were produced by the WoS Core Collection, and the findings were downloaded as a.txt file, which was subsequently opened in the VOSviewer program for examination.

The first type of analysis focuses on keyword analysis, highlighting the authors' most utilised keywords in all 185 final articles taken into analysis. Referring to the frequency of their appearance in the selected articles, this analysis aims to determine the most frequently utilised keywords by the authors who address our research field. Thus, following the analysis, it was demonstrated that in addition to the keywords initially applied, according to Figure 1. ("digitalisation" and "economic growth"), the scientific network provided by the VOSviewer program also presents other words that are the subject of the analysed articles, such as: "digital-economy" (with 33 appearances), "innovation" (with 31 appearances), "ICT" (with 21 appearances), "information" (with 22 appearances), "digital transformation" (with 11 appearances) and "internet" (with 15 appearances). Analysing the terms that have been revealed during our findings, we can clearly state that "digitalisation" has a strong link with terms like "economic growth", "innovation", and "digital economy" those findings showcase the importance and the validity that it gives to our research. Furthermore, in the green cluster, the key term of "economic growth" has a strong link with terms such as "financial development" and "internet".

The exploration of "scientific co-authorship" concerning the amount of citations and documents reported to the "countries" measurement unit was considered for the second analysis. In the last section of the analysis, we used a sample of 185 publications and a minimum of five citations per document to analyse the scientific co-authorship based on the nations most prominently highlighted in the authors' affiliations identified in the examined papers. The map allows us to visualise the connections and cooperation among participating writers from many nations. As a result, this map illustrates the level of scientific exchange among the participating countries and those with the most influential roles in digitalisation and its impact on economic growth. Figure 2 encompasses clusters of distinct colour shades with notable connections. Moreover, our findings indicate that the most influential nations are Greece, England, China, Russia, Pakistan, and Ukraine, possessing the most prominent nodes in our study and the largest nodes.

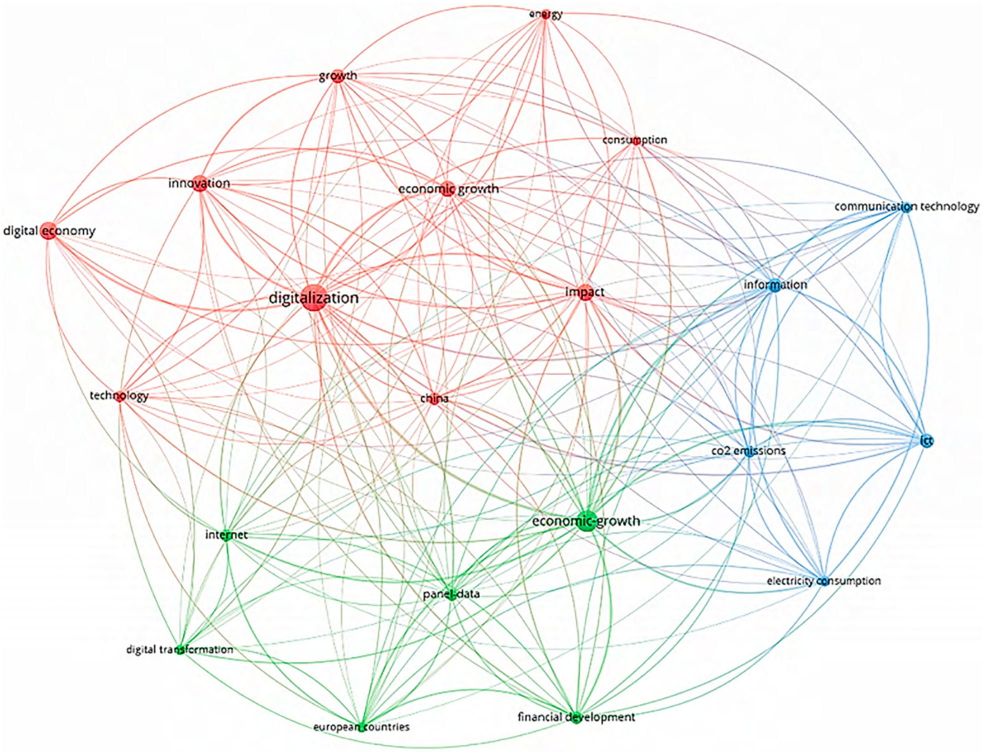

Figure 1. Keywords network on the relationship between digitalisation and economic growth

Figure 2. Network of the most prominent countries researching the relationship between digitalisation and economic growth

However, when we look at the analysis of "scientific co-authorship" and the quantity of publications and citations reported to the "countries" unit of measurement, we can observe that the most robust connections are also found between the most significant nations. Simultaneously, based on the line thickness, we can keep strong connections among the countries in the red, green, and blue groups; most of these crucial connections include nations within our field of study and analysis (Poland and Romania).

As observed in the findings from the bibliometric analysis, we observe the increased interest in this subject both in the EU area and within it. Thus, China, Russia, Pakistan, Ukraine, England, Italy, Germany, Poland, and Romania reflect a high interest in the subject addressed in the current paper regarding the link between economic growth and digitalisation. Concurrently, relevant phenomena are identified in the research, such as how the services and the system adapt to society's needs, vulnerabilities in reaching the performance objective and how society feels the impact of specific public policies.

Additionally, the question of whether digitalisation impacts the economic growth in the European Union member states has attracted attention over the years. Yoo and Yi (2022) imply that the use of digital technologies is altering the economic and social framework by impacting economic growth and the well-being of society. The digital economy has brought about significant changes in various aspects of society, including economic development (Koesharijadi et al., 2022). Lane et al. (2021) suggest that technology can be viewed as a primary factor that affects economic growth. Dahlman et al. (2016) demonstrated that, in developing countries, digitisation has been a significant driver of economic growth, sustained by increasing capital and labour productivity, lowering transaction costs, and facilitating access to global markets. Nguyen (2021) showed that digital technology can reduce transaction costs in economic activities and improve the skills and knowledge of workers, which are considered sources of economic growth promotion in developing economies. Evidence from Europe is highlighted by the research of Evangelista et al. (2014), who find that digital empowerment, especially ICT, has a significant impact on the economy regarding employment and favours the inclusion of "disadvantaged" groups in the workforce. Nipo and Bujang (2014) reveal that TIC is among the most critical factors among the determinants of digitalisation. Li and Zhao (2023) emphasised the role of the digital economy as a driver of economic growth, attributing the rapid development of information technology to its growing importance. At the same time, Ding et al. (2021) further supported this notion, highlighting the function of the digital economy in promoting high-quality economic development in different regions. Bondarskaya et al. (2023) investigated the multiple impacts of digitalisation on individuals in society, sustaining that problems and challenges exist generated by introducing digital technologies into human life. Spath et al. (2022) also discussed the impact of digitalisation on society, highlighting that nowadays, digital transformation also covers changes in individuals' lives, offering multiple possibilities and potentials for innovation and the well-being of society. Vasilescu et al. (2020) investigate the way in which individuals are impacted in different ways by digitalisation, the main results affirming the fact that the positive perceptions of digitalisation on society are perceived by individuals who possess the necessary level of digital skills, they being able to benefit from all the advantages offered by the digital process.

Furthermore, Stremousova and Buchinskaia (2019) identify the variables, such as per capita Gross Domestic Product (GDP), to evaluate the extent of digitalisation in economies. In assessing the influence of digitalisation on GDP, the specific authors proposed three indicators: mobile subscribers, internet subscribers, and broadband subscribers (Waqar, 2015; Habibi & Zabardast, 2020), while others advocate for the inclusion of a fourth variable: fixed phone subscriptions (Bahrini & Qaffas, 2019).

However, adverse effects and the many benefits of digital growth must also be considered. Kacprowska (2022) argues that this process also presents challenges, including social impact, security risks and different levels of preparedness in various sectors. These negative effects include rising income inequality and the digital divide. The impact of digitalisation on income inequality and the digital divide is of significant concern. Jandrić and Ranđelović (2018) claim that the workforce's low adaptability levels can pose an essential obstacle to future growth and development in some countries. Mwanaumo et al. (2023) highlight that the digitalisation of industries can lead to environmental degradation because digitalisation relies on information and communication technologies, which require energy and resources to manufacture, operate, and dispose of. Vinuesa et al. (2020) reveal that automation and artificial intelligence replace specific job roles, and there is a risk of widespread unemployment for workers who are not able to adapt or acquire new skills in digital technologies. Moreover, considering the security issues, which may increase risks and create new threats to economic security (Susanto et al., 2018; Popov & Semyachkov, 2018), leading to profound economic and societal issues, including digital inequality, insufficient infrastructure, shifts in the job market, and manipulation of personal data (Stewart et al., 2022; Ageeva et al., 2022).

In summary, we can conclude that research in the field of the digital economy has made significant progress, but most studies are limited to theoretical surveys, with few empirical aspects explored. In addition, the selection process for the index system of the digital economy is devoid of depth and encompasses a limited scope. Moreover, the serious problem is the construction of the system of evaluation indices, in which selection criteria, the absence of diverse expert consultation and horizontal comparison have not been adequately addressed.

Additionally, the bibliometric analysis that complements the classical literature review highlights that the major research interest regarding the relationship between digitalisation and economic growth comes both from the countries of the European Union as well as the non-EU ones, the degree of communication between them being considerable. Even according to the analysis of the "scientific co-authorship" in terms of the number of documents and citations reported to the countries, the non-EU countries have a more numerous research base, and the EU countries register a developing concern regarding this subject. In addition, the desire to satisfy citizens in the use of digital services was identified, as well as the continuous concern of public decision-makers to improve the results regarding the increase in the degree of digitisation but and the desire to act directly in terms of the implementation process of digital technologies and technological innovation that would lead to sustainable economic growth at the level of the European Union.

Furthermore, the main points discussed in the specialised literature highlight that political factors consider the progress of digital technology as a suitable solution for promoting economic growth. Moreover, in short, from the literature perspective, although there is a series of controversies regarding the effects of digitalisation on economic growth in the specialised literature, the authors tend to focus on both the negative and positive aspects of digitalisation on economic growth. According to Ishida (2015), Bakari and Tiba (2020), ICT investments do not confirm their contribution to increasing GDP. Conversely, information and communication technology (ICT) has helped improve economic growth (Yousefi, 2011).

In summary, the conclusions are diverse and depend on the interest given to one or another of the digitalisation indicators. The direct link between digitalisation and economic growth is explicitly evidenced by different impacts within the research studies presented. The researched subject remains topical, while the continuous interest in analysing digital transformation to enhance economic growth is significantly growing, even more so in these challenging times.

Future research directions will also consider additional variables for digitalisation credentials (ICT – Digitalisation Composite Index) oriented to other dimensions of digital transformation, such as technological development and innovation. The study can also be extended by comparing EU-27 member countries with other countries worldwide and a considerable period for the empirical analysis when examining the statistical connection between digitalisation and economic growth.

3. Methodology and data

3.1. Methodology

In this paper, various econometric methods examine the statistical connection between digitalisation and economic growth. Therefore, we thought of the research methods employed by Vătavu et al. (2022) and Crăciun et al. (2023) in their papers. These methods include regression analysis, correlations, and principal component analysis (PCA). PCA is applied to simplify the digitalisation dimension, and regression analysis is applied to evaluate the influence of this dimension on economic growth. The regression models tested include ordinary least squares (OLS), fixed effects (FE), and random effects (RE).

Following Popescu's (2021) methodology, we developed a composite ICT digitalisation index to provide a more comprehensive understanding of the EU's degree of digitalisation and its effects on economic growth. A composite indicator offers a complex and multidimensional analysis of the situation, easing the elaboration processes by reducing the number of indicators and deepening the data analysis (Gagauz & Pahomii, 2016). To build the ICT, several predetermined steps are required to be followed as the recommendations of the OECD Manual: theoretical framework, data selection, insertion of missing data, normalisation, weighting and visualisation of the results (Davidescu et al., 2018). As a result, we performed the PCA to combine many indicators into fewer principal components. These principal components can recover a substantial amount of the variance in the original, uncorrelated variables since they are linear combinations of those variables. The first stage consisted of identifying the dimension of digitalisation. The ICT construction methodology follows the preliminary stages: normalisation, computing the covariance matrix, weighting, selecting principal components, and visualising the results onto principal components. Using principal components, the PCA approach reduces the high number of linked primary variables (12 indicators) to a small number of uncorrelated items. By reducing the dimensionality of the data, PCA not only simplifies the analysis process but also improves efficiency and accuracy in clustering and classification tasks. It makes it possible to transfer high-dimensional data into a lower-dimensional space while maintaining the most essential details intact. Thus, principal component analysis is a powerful technique for dimension reduction in multivariate data analysis (Benidis et al., 2016). It provides a way to capture the most crucial information from a dataset while reducing its complexity. This allows for a more straightforward interpretation of the data and visualisation of the data points in a lower-dimensional space.

Since Nardo et al. (2005) highlighted the significance of data normalisation when dealing with diverse measurement units, our study standardised the indicators.

Another essential step consisted of normalising the values of the sub-indicators. Normalisation was performed for all the analysed sub-indicators using Equation (1):

$$I = \frac{x - x_{\min}}{x_{\max} - x_{\min}}. \tag{1}$$

Data normalisation involved assigning a value of 0 or minimum to the lowest value and 1, respectively, to the one that recorded the best score. All intermediate values were calculated according to Equation (2):

$$y = \frac{x - \mathrm{MIN}}{\mathrm{MAX} - \mathrm{MIN}}. \tag{2}$$

Thus, values within the interval [0, 1] were obtained after the normalisation of the data. The composite indicator was constructed as a weighted average of all individual indicators, assigning the same weight to each indicator. The minimum level of digital intensity, connectivity, level of digital skills and the degree of digitalisation of public services is illustrated by employing the minimum values of the range. In contrast, the maximum level is determined by the value approaching the upper limit of the range. During the process of gathering data, the problem of missing data points was showcased; where needed, an imputation method of selecting the mean between two variables was employed.

Another step in the PCA algorithm involves the establishment of the covariance matrix of standardised samples.

Moreover, we combined the principal components into a single composite index by utilising the proportion of variation recovered by each component in the overall variance retrieved by all principal components (Davidescu & Strat, 2014). The primary variables hold much information about the studied phenomena, which is retained via these major components. The input observable variables are converted into linear combinations of the primary variables or new unobservable variables known as principal components. The variations of the primary components are progressively reduced by how they are arranged. The sum of the variances of the new components and the old variables is identical since they are uncorrelated. Therefore, information about the phenomena under study is not lost due to the variable modification. Typically, the first two or three principal components contain most information from the original collection of input variables (PC1, PC2, PC3).

Moreover, we test the influence of digitalisation dimensions on economic growth through regression analysis. OLS (Ordinary Least Squares) is a widely employed statistical method for regression analysis. It is beneficial in estimating the relationships between variables and making predictions. Ordinary Least Squares is a statistical method commonly applied in regression analysis. The general OLS model:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_n X_n, \tag{3}$$

where: Y represents the dependent variable, β_0 is the intercept, β_1 to β_n represents the coefficients of the independent variables X_0 to and X_1 to X_n represent the independent variables.

The OLS approach is widely used in regression analysis to estimate and analyse the relationship between variables. OLS regression is a versatile and commonly applied statistical method that allows for analysing relationships between variables.

We have identified previous studies from relevant scholarly sources (Iddrisu & Chen, 2022; Fajar et al., 2021; Imran & Rashid, 2022) that have conducted empirical analyses utilising fixed effects models to examine the effects of the variables studied. These methods help to control for unobserved time-invariant characteristics and address potential endogeneity issues. Fixed and random effects are two commonly employed methods in panel data analysis (Ali et al., 2019). They both allow for the analysis of panel data, which contains data on multiple entities observed over multiple time periods. The fixed effects method is suitable when time-invariant variables vary across individuals, allowing us to control for individual-specific heterogeneity. However, the random effects technique is better appropriate when there is no association between the regressors and individual-specific effects since it assumes that the latter are uncorrelated. The utilisation of fixed effects models is particularly relevant (4) when the countries being analysed possess unique characteristics correlated with the independent variables, as the fixed effects approach helps to remove the influence of these attributes. The general form of this model can be expressed through the following Equation:

$$Y_{it} = \beta_1 X_{it} + \alpha_i + \varepsilon_{it}, \tag{4}$$

where: i represent the country, t represents the year, Y_{it} dependent variable, X_{it} independent variable, β_1 coefficient of the independent variable, α_i is the constant of each country, ε_{it} standard error.

Nevertheless, it cannot be assumed that the fixed effects model suits our dataset. As a result, it is advised to apply a random effects model for dataset analysis. Variations that may be attributed to certain features of the independent variables are considered by the random effects model (5), but they happen randomly. The random effects model aids in removing these random fluctuations from this kind of research so that the link between the examined variables may be found. This model's general Equation may be written as follows:

$$Y_{it} = \beta X_{it} + \alpha + U_{it} + \varepsilon_{it}, \tag{5}$$

where i represent the country (I = 1……n), t represents the year, Y_{it} dependent variable, X_{it} independent variable, β_1 coefficient of the independent variable, α is constant, U_{it} is the error between countries, ε_{it} standard error.

Furthermore, we test the influence of the *ICT* on *GDP* per capita through the regression analysis. We intend to examine the robustness of our results by testing various regression models, including ordinary least squares (OLS), fixed effects (FE), and random effects (RE) models. The basic form of the regression Equations tested (6) is outlined as follows:

$$GDP_{capit} = \alpha_i + \beta 1 * ICT_{it} + \varepsilon_{it}. \tag{6}$$

In this context, α represents the intercept specific to each country (i = 1…27), with the observed period from t = 2017 to 2021. The β_s represent the regression coefficients corresponding to the explanatory variables, and ε_{it} stands for the error term.

3.2. Data

All the multiple dimensions have been decomposed into variables; only the most relevant and those presenting a range of data availability were retained as indicators. To collect the annual data utilised to construct the composite indicator, a series of databases, such as Eurostat, European Commission, and The World Bank, covers the 2017–2021 interval relevant to the 12 variables for European countries, respectively EU27. The GDP per capita indicator represents the specific dimension of the economic growth indicator. The time sample was selected based on the available data.

Furthermore, to simplify the comparative analysis of the annual situation, the Digitalisation Composite Index (ICT) was built based on the digitalisation dimension. Data analysis was performed using EViews software.

The proposed framework aims to determine the ranking of top-performing countries across four distinct digitalisation domains: Workforce, Digital Technologies, Infrastructure, and Digital Education. Based on these areas, a Composite Digitalisation Indicator was developed to assess the overall ICT performance of the 27 EU Member States. Consequently, this study's complex and innovative methodology involves analysing the determinants of the four digitalisation-related domains, which collectively represent the level of digitalisation. Furthermore, the findings have highlighted the considerable disparities among the diverse Member States, the multiple contemporary challenges countries encounter in implementing the digitalisation process, and their relative performance levels. The structure of each domain included in the formation of the composite digitalisation indicator is as follows:

1. Workforce and exports: (i) Advanced Skills and Development by ICT Specialists; (ii) ICT goods exports;
2. Digital Technologies: (i) Individuals using the internet for interacting with public authorities; (ii) Digital Public Services- by e-government; (iii) e-Government Users;
3. Digital infrastructure: (i) Level of internet access – households, (ii) Individuals using the Internet; (iii) Connectivity – by Mobile broadband; (iv) Integration of Digital Technology- by Digital Intensity; (v) Digital intensity;
4. Digital Education: (i) Human capital – by Internet User Skills; (ii) Internet User Skills, by At least Basic Digital Skills.

The proposed analysis, based on a standardised data architecture and leveraging the robust capabilities of the PCA method in managing multiple variables, along with its high predictive accuracy, offers a series of robust dimensions in both the level and the score of the Digitalisation Composite Indicator. The methodology is presented in Figure 3.

Table 1 encompasses the description of dataset indicators to provide a complete overview of the indicators employed.

Further, we analysed descriptive statistics for all variables employed in the analysis, Tables 2 and 3.

Moreover, we applied the data mapping process through the STATA18 software to graphically represent the main dimensions of digitalisation for the 27 countries included in the analysis for the year 2021, the results are presented in Figures 4a and 4b.

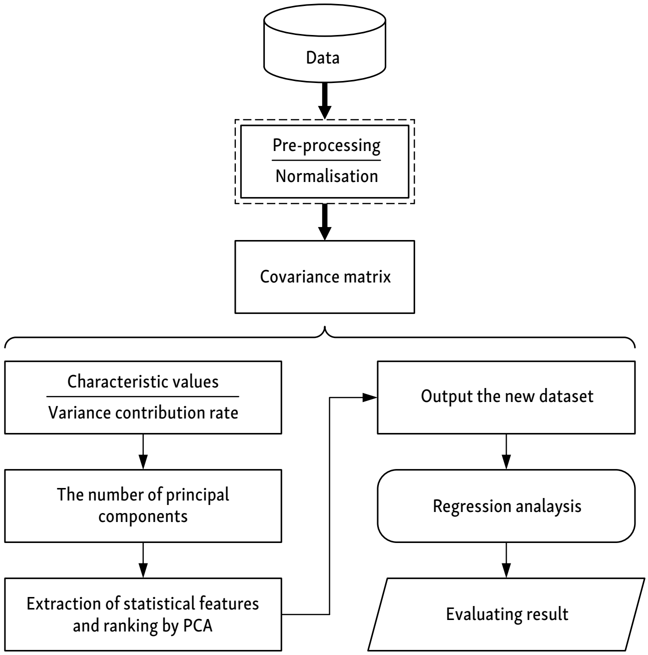

Figure 3. The methodology pathway

Table 1. The description of dataset indicators

Acronym	Description	Unit of measure	Source
IA	"Level of internet access – the percentage of households who have internet access at home"	% of households	Eurostat (2023a)
IUINT	"Individuals using the Internet – people who have used the Internet (from any location) in the last three months"	% of population	The World Bank (2023a)
IUIPA	"Individuals using the internet for interacting with public authorities – Within the last 12 months before the survey for private purposes" "Derived variable on use of eGovernment services. Individuals used at least one of the following services: for obtaining information from public authorities websites, for downloading official forms, for submitting completed forms."	% of population	Eurostat (2023b)
ITCEX	"Information and communications technologies (ICT) exports – Information and communication technology goods exports include computers and peripheral equipment, communication equipment, consumer electronic equipment, electronic components, and other information and technology goods (miscellaneous)"	% of total goods exports	The World Bank (2023b)
CMB	"Connectivity by mobile broadband"	weighted score (0 to 100)	European Commission (2022a)

End of Table 1

Acronym	Description	Unit of measure	Source
IDT	"Integration of digital technology"	weighted score (0 to 100)	European Commission (2022b)
DPS	"Digital public services"	weighted score (0 to 100)	European Commission (2022c)
HC	"Human capital"	weighted score (0 to 100)	European Commission (2022d)
INTS	"Internet user skills"	weighted score (0 to 100)	European Commission (2022e)
ADVS	"Advanced skills and development"	weighted score (0 to 100)	European Commission (2022f)
DIGINT	"Digital intensity"	weighted score (0 to 100)	European Commission (2022g)
EGOV	"e-Government users"	% of individuals who used the internet within the last 12 months	European Commission (2022h)
GDPCAP	"Gross Domestic Product (GDP) per capita"	Current USD	The World Bank (2023c)

Table 2. Descriptive statistics

	IUINT	IUIIPA	ITCEX	INTS	IDT	IA
Mean	84.39	49.95	5.82	27.81	6.14	87.86
Median	85.77	48.63	3.71	27.39	6.14	89.00
Maximum	98.86	90.60	19.65	39.74	12.68	99.00
Minimum	63.07	7.00	1.45	13.12	0.40	67.00
Std. Dev	8.16	19.47	4.38	6.15	2.78	6.43

Table 3. Descriptive statistics continuation

	HC	EGOV	DPS	DIGINT	CMB	ADVS
Mean	25.12	63.90	59.43	14.77	14.82	13.61
Median	24.5	63.63	61.26	9.50	13.70	12.66
Maximum	38.31	94.08	91.76	58.57	35.69	25.33
Minimum	10.46	12.09	10.27	–7.15	8.05	6.33
Std. Dev	6.18	18.69	16.34	16.48	4.00	4.28

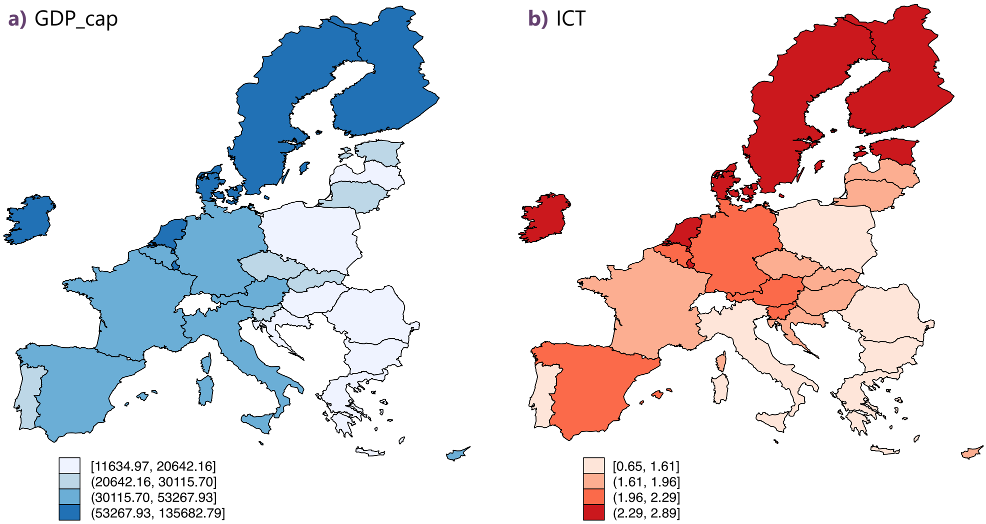

Figure 4. Mapping of the level of the analysed indicators

To emphasise and rank the variables in our study model at the EU member state level in 2021, following the method used by Lobonţ et al. (2023), the data mapping technique was utilised for the two dimensions, namely the economic dimension (GDP per capita) and the digitalisation one with the composite indicator (ICT) for the data collected in 2021 GDP per capita (GDP_cap) (a), and the composite indicator of digitalisation (ICT) (b) for the year 2021 for all EU-27 member states, Figure 4. The most intensive level of digitalisation (ICT) was recorded in Finland at 2.89, Denmark at 2.83, Sweden at 2.63, Netherlands at 2.79, Estonia at 2.33, Ireland at 2.30, Luxembourg at 2.29, Austria at 2.28, while 16 states recorded values within the range 1, 3 and 2, thus presenting an average intensity of digitalisation. At the opposite pole, we find countries such as Romania, with 0.65 and Bulgaria, with 0.81, registering the lowest level of digitalisation in the EU-27. The GDP per capita (a) registers the lowest level in Bulgaria, Romania, and Poland, and the highest values were recorded in countries such as Luxembourg, Ireland, Denmark, and Sweden.

4. The results of the empirical analysis

During the initial phase of the principal component analysis (PCA) analysis, which constitutes fundamental research, an examination was conducted to ascertain the correlation and interrelation among the digital indicators employed in the study. Furthermore, we generated a correlation matrix between indicators to explore the interrelationships between variables. Correlation coefficients between 0.3 and 0.7 provide compelling evidence that the variables are correlated with one another. This involved scrutinising Tables 4 and 5 to determine the extent and nature of correlations and assessing whether the correlation matrix demonstrated unity.

Table 4. Correlations matrix between digital indicators

	IA	IUINT	IUIIPA	ITCEX	CMB	IDT
IA	1					
IUINT	0.86416	1.0000				
IUIIPA	0.62299	0.7145	1.0000			
ITCEX	0.04104	0.0757	0.1826	1		
CMB	0.61427	0.5299	0.4777	–0.0213	1	
IDT	0.71547	0.6642	0.6723	–0.0134	0.51767	1
DPS	0.64055	0.7127	0.6700	0.0679	0.50382	0.72897
HC	0.63528	0.6619	0.7051	0.11246	0.42251	0.75941
INTS	0.69141	0.7208	0.8114	0.10755	0.40567	0.78661
ADVS	0.71453	0.6847	0.6511	0.06419	0.43184	0.8332
DIGINT	0.15303	0.1892	0.2498	–0.0424	–0.2311	0.29865
EGOV	0.56052	0.7156	0.9107	0.13570	0.3905	0.60731

Table 5. Correlations matrix between digital indicators continuation

	DPS	HC	INTS	ADVS	DIGINT	EGOV
DPS	1					
HC	0.67922	1				
INTS	0.6140	0.81232	1			
ADVS	0.72262	0.71471	0.74339	1		
DIGINT	0.1374	0.34706	0.40394	0.27863	1	
EGOV	0.73398	0.73315	0.78130	0.64799	0.24973	1

The examination of correlation coefficients among the selected study indicators revealed the absence of a unitary correlation matrix, validating the application of the PCA method. Conversely, a statistically significant correlation was found between the majority of the employed indicators.

The eigenvalues of the principal components (PCs) offer the proportion of variance attributed to each component. The percentage of a PC's eigenvalue to the sum of its eigenvalues determines the part of the overall variation that the component represents. Meanwhile, the cumulative proportion shows the overall variation explained by each component.

Based on our result, the proportions of the variability of the first principal component (PC1) constitute 59.4% of the variance, the second component 11%, and the third 8%. Furthermore, using the rule-of-thumb, which suggests retaining a sufficient number of principal components such that the cumulative proportion of variance is at least 80% of the total variance of the original data, it is determined that the first three principal components collectively account for 78.4% of the total variability. This signifies that these three components effectively capture a substantial portion of the original data's variance, aligning with the recommendation.

The ICT composite indicator, close to the value 0, illustrates a low level of digital intensity. In contrast, a value as close as possible to 2 suggests a high level of digital intensity within the period of conducting the research, respectively, 2017–2022. The values of the composite indicator are presented in Table 6.

Figure 5 evidences the correlation between GDP per capita and the ICT composite indicator from 2017–2021 for the EU-27 member states. Thus, we can identify the link between the two indicators. We have determined the shape and significance of the dependence connections and the dependency relationship between the two variables via the Scatter-Plot diagram. The Ox axis is the independent variable of the model, namely ICT, and the Oy axis is the dependent variable of the GDP per capita research. Figure 5 illustrates the pairs through a cloud of points located in the (X, Y) plane.

Table 6. Values for the digitalisation composite indicator (ICT) by country and year

Country	Digitalisation Composite Indicator (ICT)				
	Year				
	2017	2018	2019	2020	2021
Austria	1.121995842	1.182631094	1.25177372	1.196989043	1.315288259
Belgium	1.020413992	1.084588122	1.149702037	1.106398178	1.172518161
Bulgaria	0.186340464	0.270133921	0.337234617	0.383014781	0.457246686
Croatia	0.69417975	0.796740374	0.836795485	0.809027297	0.92648918
Cyprus	0.70132948	0.824290012	0.895151353	0.856559881	0.92072893
Czechia	0.851350074	0.983003399	1.064155646	1.061235433	1.111018844
Denmark	1.545247787	1.553860125	1.615857017	1.526839339	1.615499626
Estonia	1.247859462	1.315995384	1.349285454	1.332226044	1.400167755
Finland	1.519829393	1.583334782	1.648852317	1.609326612	1.67764659
France	0.948923072	1.019545917	1.077481373	1.092927773	1.145277099
Germany	1.012458319	1.07240622	1.13205245	1.141007286	1.155729462
Greece	0.566861786	0.633229946	0.701282382	0.729946432	0.779739361
Hungary	0.753734593	0.783399791	0.876716453	0.918983479	1.026855595
Ireland	1.049472741	1.130648577	1.181960534	1.172932055	1.349828188
Italy	0.565438348	0.666117196	0.679058831	0.653937547	0.730811852
Latvia	0.906967412	0.904595615	0.952811622	1.024648017	1.078559956
Lithuania	0.758761267	0.838518399	0.908141843	0.916873267	0.997708715
Luxembourg	1.242256565	1.223349635	1.236041335	1.199957255	1.309325948
Malta	1.026939769	1.121958928	1.192602491	1.179847126	1.214137081
Netherlands	1.499269658	1.553246595	1.610388047	1.546011721	1.639238763
Poland	0.567250808	0.630130476	0.704120862	0.740081227	0.794297613
Portugal	0.742435814	0.770356142	0.796129356	0.822629399	0.901963084
Romania	0.067015887	0.153063227	0.203890885	0.28437571	0.346741795
Slovakia	0.8564881	0.876094211	0.940286554	1.00862683	1.051813243
Slovenia	0.840266699	0.927524009	0.993479294	0.998737792	1.129047707
Spain	0.951546656	1.022238623	1.121237097	1.128155649	1.190579049
Sweden	1.468221571	1.53858999	1.644379073	1.526456408	1.551679297

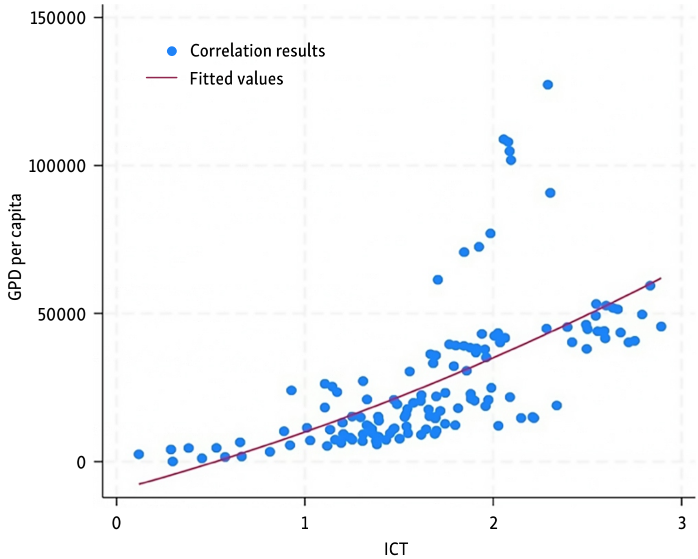

Figure 5. Correlation results between GDP per capita and the ICT

The effect of the digitalisation level on a country's economic growth through GDP per capita was possible by applying and using panel data and linear regression and OLS regression models, respectively random effect and fixed effect, for a set of 135 observations. All EU-27 Member States were included in the analysis.

Principal component analysis (PCA) was employed to reduce the dimensionality of the data and extract the core components of digitalisation. Subsequently, regression models were utilised to establish a statistical relationship between these key components and digitalisation. This methodological approach ensures the accuracy and consistency of the results while also offering a comprehensive understanding of the relationships between the studied variables.

To determine the level of significance of the impact of digitalisation on economic growth, three OLS, fixed effect and random effect regression models were further applied. The first step consists of applying the OLS model. The results of the OLS regression are presented in Table 7. According to our findings, increasing digitalisation places significant pressure on economies. The implementation of digitalisation will directly result in increased application of technology across multiple sectors of the economy. This dependence on technology leads to greater efficiency, productivity, and innovation, ultimately driving economic growth. Aleksandrova et al. (2022) offers a more cautious perspective, eliminating the uncertainty and risks associated with digitalisation; in addition, macroeconomics and the willingness of the population to use digital technologies can limit the impact of digitalisation on economic growth. Moreover, the existing literature on the impacts of digitalisation presents a complex and often contradictory landscape (Amankwah-Amoah et al., 2021). On the one hand, studies have highlighted the potential for digital transformation to drive economic and productivity benefits (Yun, 2022). However, growing evidence shows that digitalisation can have negative consequences, such as job displacement, rising youth unemployment, and increasing inequality (Fischer et al., 2021).

Table 7. Ordinary Least Square results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	–14789.99	5113.128	–2.892552	0.0046
ICT	41649.13	4758.643	8.752312	0.0000
R-squared	0.365467	Mean dependent var		27547.43
Adjusted R-squared	0.360696	Akaike info criterion		22.58306
S.E. of regression	19249.46	Schwarz criterion		22.58275
F-statistic	76.60296	Hanna-Quinn criteria.		22.62610
Prob(F-statistic)	0.00000	Durbin-Watson stat		0.026145

Based on our methodology, we applied multiple regression models with cross-sectional and time series aspects to panel data. We employed random effects (RE) through the least squares method. At the same time, we validated our developed models via the fixed effects (FE) method. Table 8 encompasses the findings from the fixed effect regression analysis

According to our results, EU countries have improved their infrastructure and policies to enable seamless integration of digital technologies into their economies. The success of EU nations in promoting economic growth has been aided, among other factors, by the growth of technological innovation. Digital technologies have transformed the economic landscape of European Union (EU) member states. Digital transformation has benefited EU economies through productivity growth, societal change, and economic development. Moreover, the relationship between digitalisation and economic growth has been the subject of extensive research, with mixed findings reported in the literature (Timilsina et al., 2021; Sahoo & Dash, 2012). Variations in economic context, government policies, industrial sectors, and other factors can influence the stability of this relationship, as evidenced by the work of researchers such as Wen et al. (2021) and Gagea (2014). While some studies have documented a strong positive association, others have found only a mildly positive or insignificant relationship. The differing findings can be attributed to various factors, including variations in research methodologies, the measurement of infrastructure progress, and the developmental stages of the nations examined. Additionally, the European Union comprises countries with diverse economic structures, which necessitates an analysis of the impact of digitalisation on economic development and broader societal outcomes. However, developing countries tend to experience wider income disparities and larger digital technological access gaps than developed countries. The digital economy has brought significant societal changes, including economic development (Koesharijadi et al., 2022). As a result, digital transformation has substantially benefited the EU's economies through increased economic growth. These results are similar to the findings of (Mićić, 2017; Vyshnevskyi et al., 2020; Wysokińska, 2021; Mura & Donath, 2023)

The level of digitalisation has a significantly positive impact on economic growth. The variables obtained in the regression with fixed effects significantly impact the degree of significance of the model. It can be stated that 98% of the variation in GDP per capita can be clarified by the indicators included in the model. Moreover, we applied the random effects model presented in Table 9. Based on our findings, digitalisation boosts economic growth in the European Union, which aligns with the findings of other studies. Investing in information technology has grown across all EU states, especially in industrialised countries. This highlights the significance of adopting digital technologies as a part of business strategies and policies to enhance economic growth (Qu et al., 2017; Gruber, 2019).

The linear regression model with random effects was applied to analyse the changes in GDP per capita for five years. The model assumes individual random effects. Furthermore, we resorted to the application of a series of statistical tests. Therefore, we applied the Hausman test. The results from the Hausman Test are listed in Table 10.

To determine which of the two models, random effect and fixed effect, is more suitable for the study, we applied the Hausman test. Therefore, if: H0: $p > 0.05$, we will select the RE model, H1: $p < 0.05$, and we will select FE. In performing the Hausman test, the null hypothesis is appropriate, and the random effect type model lends itself to our study. To simplify the interpretation of the Panel Data regression analysis, the results will be arranged in Table 11.

Table 8. Fixed effect

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ICT	23691.88	3499.350	6.770366	0.0000
C	3464.019	3566.152	0.971361	0.3336
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.988114	Mean dependent var		27547.43
Adjusted R-squared	0.985115	S.D. dependent var		24074.92
S.E. of regression	2937.262	Akaike info criterion		18.99071
Sum squared resid	9.23E+08	Schwarz criterion		19.59329
Log-likelihood	–1253.873	Hanna-Quinn criteria		19.23558
F-statistic	329.4520	Durbin-Watson stat		1.317424
Prob(F-statistic)	0.000000			

Table 9. Random effect

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ICT	25391.87	3337.081	7.609006	0.0000
C	1735.941	5075.966	0.341992	0.7329
Weighted Statistics				
R-squared	0.300760	Mean dependent var		1844.270
Adjusted R-squared	0.295503	S.D. dependent var		3520.530
S.E. of regression	2954.933	Sum squared resid		1.16E+09
F-statistic	57.20658	Durbin-Watson stat		1.038318
Prob(F-statistic)	0.000000			

Table 10. Hausman Test

Hausman Test			
Variable	Fixed	Random	Prob.
ICT	23691.881	25391.8656	0.1065

Table 11. Unifactorial estimation

Variable	OLS	Fixed effect	Random effect
ICT	41649.13	23691.88	25391.87
C	–14789.99	3464.019	1735.941
R-squared	0.365467	0.988114	0.300760
Adjusted R-squared	0.360696	0.985115	0.295503
F-statistic	76.60296	329.4520	57.20658
Prob-F-statistic	0.000000	0.000000	0.000000
Durbin-Watson	0.026145	1.317424	1.038318

Analysis of the unifactorial model, which includes the ICT (Digitalisation Composite Indicator) as an independent research variable, statistical verification involving the utilisation of OLS, random effect, and fixed effect regression models. Using the EViews program, we determined the parameters of the econometric model that describe the relationship between the two indicators, with panel data being applied as the structure.

This study reinforced the empirical findings regarding the robustness of the previous estimate, as demonstrated through the use of FMOLS, DOLS, and Robust Least Square Regression analyses. The projected outcomes presented in Table 12 for DMOLS and FMOLS support the earlier findings of the OLS, fixed, and random effect models, suggesting that the examined factors are significant in explaining economic development in the EU 27 economies.

We conducted a robust least squares regression analysis to validate our findings. As shown in Table 13, the results demonstrate that digitalisation has a positive and statistically significant impact on economic development within the EU member states. This further corroborates that the selected factors are important in accounting for the GDP per capita variation across the EU economies.

Through the results provided by the EViews program, we can state that the constant within the three regression models has positive values and a significant influence. The slope registers positive values in all three models, a fact that demonstrates a direct, positive relationship between the two variables of the model, as well as a significant influence on GDP per capita. We can state that R-squared, the coefficient of determination, within the OLS type model, has a value of 0.365467, and we can state that only 36.5% of the variation in GDP per capita can be explained by the variation in the ICT (Digitalisation Composite Indicator). Within the random effect model, R-squared recorded a value of 0.300760; it can be stated that only 30% of the GDP per capita variation is explained by the ICT indicator. Furthermore, the fixed effect type model has a value of 0.988114 and states that 98.8% of the GDP per capita variation is explained by the ICT (Digitalisation Composite Indicator). The validity of the regression model is confirmed through the F-statistic and Prob F-statistic tests; it can be noted that only the random effect model is employed.

Moreover, the Hausman test is applied to confirm the appropriate model; the test focuses on choosing between the random and fixed effects models. The Hausman test is utilised to determine if there is a correlation between each individual random effect and the explanatory factors. The probability obtained was less than 1%, 5%, and 10%; thus, based on the results, the fixed effect model is suitable for the present research. An increase in the ICT (Digitalisation Composite Indicator) will cause an increase in GDP per capita.

Table 12. Results of DOLS and FMOLS (robustness check)

Variable	FMOLS estimators	DOLS estimators
ICT	11503.61*** (0.0000)	17326.97*** (0.0000)
R-squared	0.990443	0.345042
Adjusted R-squared	0.987217	0.345042
S.E. of regression	2772.056	19483.70
Long-run variance	6178584	9.12E+08
Mean dependent var	28251.52	27547.43
S.D. dependent var	24518.23	24074.92
Sum squared resid	6.15E+08	5.09E+10

Table 13. Robust least square regression results

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	–12128.71	2650.162	–4.576593	0.0000
ICT	20881.13	1484.075	14.07013	0.0000
Robust Statistics				
R-squared	0.447775	Adjusted R-squared		0.443623

Our research brings more information to the existing literature by employing different variables for the analysis. Thus, in terms of the positive influence of TIC on GDP growth, our results align with previous studies (Inklaar et al., 2005; Koutroumpis, 2009; Brasini & Freo, 2012), we also confirm the direct influence of digitalisation on improved economic growth, (Oliner & Sichel, 2000; Czernich et al., 2009). Furthermore, our results also highlight that EU-27 member states have specific policies and directives that influence the relationship between digitalisation and economic growth. Moreover, the influence of digitalisation on economic growth has been examined through a correlative approach (Georgescu & Kinnunen, 2021). Furthermore, the growing adoption of digital technologies has raised awareness of topics such as how the digital economy influences the creation of new business models, how new innovative technologies affect economic relations, and how to lower the primary expenditures related to digital economic activity (Akaev & Sadovnichiy, 2021). Overall, the level of digitalisation has a positive and significant influence on economic growth across various studies.

5. Conclusions

This research analysed the effects of digitalisation on economic growth and economic policy uncertainty to determine whether digitalisation can stimulate economic development. To assess the impact and implications of digitalisation on economic growth, we employed sophisticated econometrics methods, including principal component analysis (PCA) and regression analysis (ordinary least squares, fixed effects, and random effects model). Empirical results highlighted that digitalisation has positively impacted contemporary society and the global economy in the European Union. These findings significantly impact comprehending the link between digitalisation and economic development in the EU-27.

The positive effects indicate that digitalisation can cause economic growth. Moreover, digitalisation plays a crucial role in boosting economic growth. However, constructing a composite ICT indicator to measure digitalisation allows for forecasting economic growth likelihood. Thus, the composite digitalisation indicator is a potential tool in studying the growth through digitalisation. The main results show that countries with high levels of digitisation also show high economic growth.

Moreover, the bibliometric analysis allowed the review of specialised literature by identifying and mapping the most cited keywords and authors by analysing scientific co-authorship and co-citation. The results allowed the identification of the most relevant authors, an analysis based on the countries in which the works that addressed the relationship between digitalisation and economic growth were published, and the identification of the most innovative current topics associated with digitalisation and economic growth.

Comparing the results for the panel composed of the EU member countries for 2017–2021, following the regression analysis, the digitalisation composite indicator directly influenced economic growth. Following applying the OLS, fixed effect and random effect regression models, we demonstrated the statistically significant impact of digitalisation on economic growth. The application of the Hausman test demonstrated that the most suitable model for our study is the fixed effect model, which suggested that an increase in the ICT composite indicator will cause an increase in GDP per capita. Thus, we could affirm that countries with a high level of digitalisation also show a high level of economic growth, demonstrated through the results of the empirical study and the individual graphs obtained by mapping the data for each sub-indicator separately. These main results are consistent with the general model, which suggests that digitalisation can affect economic growth. Additionally, our composite indicator indicates a positive association between digitalisation and economic growth. The impact of digitalisation on economic growth is a complex and diverse problem, as other factors are driving digitalisation.

The main results attest to the fact that countries with a high level of digitalisation also show a high level of economic growth. The highest level of digitalisation intensity was recorded in Finland and Denmark. Furthermore, the COVID-19 pandemic has accelerated the pace of development of digital intensity; this phenomenon can be explained through the lens of the imposition of a series of restrictions during the pandemic period, businesses, as well as citizens, were forced to adopt new digital processes that improve their ability to make effective decisions and quickly adapt to unique circumstances. However, Romania and Bulgaria continue to present a low level of digitalisation in technological processes; this resistance to change can be explained by the fact that the digitalisation process is perceived as an expense rather than a sustainable investment.

Additionally, different factors influence the digitalisation process to boost economic growth. Culture, education, sound public policies, and industrial agglomeration influence a nation's digital intensity. Moreover, the economy can be boosted by creating new high-paying jobs, improving the efficiency of processes and boosting productivity, increasing innovation and entrepreneurship, and creating new industries.

Based on the results of the research study, several policy guidelines and recommendations can be proposed, such as: (i) the EU states present a significant need to improve and strengthen the way of allocating expenses for the public sector that considers digital transformation; (ii) the method of implementing tactics meant to boost economic performance and enhance the standard of public services must be of good quality. Thus, the results of scientific research recommend that all governments across the EU develop specific policies and tailored strategies to ensure the effective implementation of digitalisation and to reduce the uncertainty associated with national economic policies. In addition, current scientific research can be helpful to policymakers both from the perspective of identifying support solutions for the implementation of digital processes and efficient allocation of expenditure to the digitalisation sector.

The research undertaken in this paper also has some main limitations, such as the lack of multiple statistical data that accurately reveals the amplitude of the digitalisation processes in defining the composite index of digitalisation (ICT – Digitalisation Composite Index). Coping with these limitations, future research will focus on the Europe's digital performance, tracking especially the progress made by EU countries for the European Union (EU) countries. Moreover, some considerations are taken into account, as regards the impact of digitalisation on economic growth by aligning our future research directions with "The digital agenda for Europe" that sustain the continuous evolving of economic and social areas through adaptable digital technologies. However, there are some methodological limitations and other factors that could influence the results, such as the expansion of the number of observations, the introduction of new indicators in the composition of ICT – Digitalisation Composite Index, which would automatically lead to perhaps losing some information and details then when reducing the dimensionality of the data, including different results regarding the existence or not of the common characteristics of the countries applying the OLS models.

Author contributions

Each author has made an equal contribution to the creation of this research paper.

Disclosure statement

The authors have stated that they do not have any conflict of interest.

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