

# ЕКОНОМІКА ТА УПРАВЛІННЯ НАЦІОНАЛЬНИМ ГОСПОДАРСТВОМ / ECONOMICS AND MANAGEMENT OF THE NATIONAL ECONOMY

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## IMPACT OF INFORMATION AND COMMUNICATION TECHNOLOGY ON THE DIGITAL ECONOMY

**Purpose.** The article explores the impact of Information and Communication Technologies (ICT) and their role and place in the dynamics of the digital economy. The aim of this research is to assess the impact of the digital economy on GDP per capita in EU countries. **Methodology.** Analysis of ICT as a key factor in enhancing economic growth through the implementation of digital technology opportunities. Panel data from Eurostat and the World Bank covering EU countries from 2014 to 2021 were used for analysis. A correlation analysis was then conducted between variables, and the model was relevant for forecasting. **Results.** The number of studies on the impact of Information and Communication Technologies on the economic growth of countries has increased in recent years. However, there is still no assessment of the real GDP impact on the level of household Internet access in the EU area. Studying this gap in the literature allows us to draw conclusions about the implications for stakeholders regarding more effective implementation of the digital agenda. **Scientific novelty.** The digital economy, measured by Internet, mobile phone, and fixed broadband access, influences the economic growth of a country. This, in turn, depends on the level of technology measures covering the digital economy. ICT positively influence the development of countries' economies and can be used as tools by stakeholders. These agents should generate policies that enhance ICT technological infrastructure, digital empowerment of the population, and greater access to ICT. The GDP level model is presented as a function of Internet access for households in the EU area along with a short-term forecast for this index. It is shown that investments in ICT infrastructure are indispensable for the development of a strong knowledge- and digital technology-based economy. **Practical significance.** The research results will help in identifying opportunities and levers of influence for governmental institutions and other socio-economic systems on the impact of digital economy development processes on GDP per capita in EU countries.

*Ключові слова:* Internet, mobile phone, fixed broadband access, digital economy, economic growth.

### Problem statement

The modern economy is on the way to a new technological order based on knowledge-intensive industries relying on digital technologies [1]. Now the digital economy figures in diverse economic activities that use digital knowledge and information as critical factors of production, information, and communication technology, along with modern information networks as a virtual space of activities to develop productivity growth [2]. Every country is looking for ways to create gradual and sustainable growth. The growth of the gross domestic product (GDP) per capita depends strongly on the technological progress that the country has. Countries that are more innovative and technological often manage to be more competitive and have better economic performances [3], [4]. From the analysis of the influence of

information and communications technology (ICT) on innovation, several studies have shown that the use of ICTs, in particular the internet, allows the dissemination of tacit knowledge, favors technological diffusion, the development of new products, processes, business, and cooperation between companies [5]. Thus, ICTs stimulate and favor innovation opportunities by favoring information networks that allow the creation of knowledge spillovers [6]. The digital economy is a challenge that countries have been working on to develop and accelerate the digital single market [7]. To ensure the country competitiveness is one of the main tasks of each and every nation economy. Countries' wealth is directly related to their capacity to produce. There is no universal and practically applicable solution to the problem; however there are certain sectors that can become a significant driver to increase efficiency and productivity of the economy by implementing the digital economy opportunities [8]. The growth of the gross domestic product (GDP) per capita depends on the technological progress that the country has, and vice versa. Countries that are more innovative and technological often manage to be more competitive and have better economic performances [4], [9], [10].

Innovation and the use of information and communication technologies (ICT) are key areas for the European Cohesion Policy [5]. Studies available at the regional level explore innovation and ICT use incorporating different variables, while those investigating ICT use mainly focus on that of households. The importance of promoting specialization strategies based on the knowledge economy that may contribute to creating synergies between innovation and ICT use in different environments [5].

From the analysis of the influence of information and communications technology (ICT) on innovation, several studies have shown that the use of ICTs, in particular the internet, allows the dissemination of tacit and codified knowledge, favors technological diffusion, the development of new products, processes, business, and cooperation between companies [5]. Thus, ICTs stimulate and favor innovation opportunities by favoring information networks that allow the creation of knowledge spillovers [6]. The paper explores the possibilities of ICT infrastructure and the impact of the level of use of broadband and the Internet for consumers on economic growth.

### **Analysis of recent research and publications**

#### **THE CURRENT MEANING OF THE DIGITAL ECONOMY**

The digital economy recently has gained the attention of researchers, consultants, journalists, policymakers, and business managers as an area of high potential [2], [11], [33]. Innovation is a factor that directly influences the production and socio-economic development of countries and their regions [9], [12]. Every country is looking for ways to create gradual and sustainable growth. It is proper to evaluate the impact of the level of digital economy development and the infrastructure of information and communication technologies on economic growth. Recent empirical studies show that some countries may have a positive relationship between ICT and economic growth. Still, there is evidence of a negative relationship, indicating that its impact depends on the level of economic development in the countries under analysis [13] since more significant investments in ICT lead to more significant economic benefits in developed countries to the detriment of developing countries [14], [15]. Nowadays widespread use of the Internet and mobile telecommunications, information and communication technology (ICT) infrastructure plays a significant role in accelerating economic growth. Competitiveness of the industries is to a large extent based on availability and quality of ICT sector solutions. In the era of global changes ICT infrastructure became one of the key sectors for future economy growth. The development of information technologies is a foundation of growth for economy and society. The significance of the ICT as a key factor development in global economies continues to dynamically increase [8], [16]. Undoubtedly, the ICT sector, as a significant factor in the development of the digital economy, is important for improving the country's competitiveness, developing production and state-of-the-art business processes, and contributing to a synergy effect in terms of the competitive advantage of small businesses. Information and communication technology infrastructure is a key driver of economic growth in countries that have realized its importance [16].

Therefore, many developing countries are working hard to internalize ICT, balancing the distribution of limited revenues in their quest to quickly catch up with developed countries [17]. Actually, today one of the main tasks of the governments of most developing countries is to adopt policies aimed at ICT development [18]. The information and communication technologies infrastructure currently covers the

digital telephone network, mobile phones, Internet capabilities, Internet servers, and fixed broadband, and other technologies. Aside from basic network coverage challenges, the quality of network connections also needs to be enhanced, to ensure that the ICT infrastructure base is robust enough to support a digital first world. Strengthening ICT, in order to develop the digital economy, is now a commonly held priority for countries. Compulsory action is therefore required, in order to prepare for the digital economy. The possibilities of ICT infrastructure have had a significant impact on communication and interaction between decision-makers in business and management as key factors of economic prosperity.

### **Formulation of the article's objectives (task setting)**

The purpose of this research is to assess the impact of the digital economy on GDP per capita in EU countries. Analysis of ICT as a key factor in enhancing economic growth through the implementation of digital technology opportunities. Panel data from Eurostat and the World Bank covering EU countries from 2014 to 2021 were used for analysis. A correlation analysis was then conducted between variables, and the model was relevant for forecasting.

### **The presentation of the main material**

#### **THE ROLE AND PLACE INFORMATION AND COMMUNICATION TECHNOLOGIES TO FORCE ECONOMIC GROWTH**

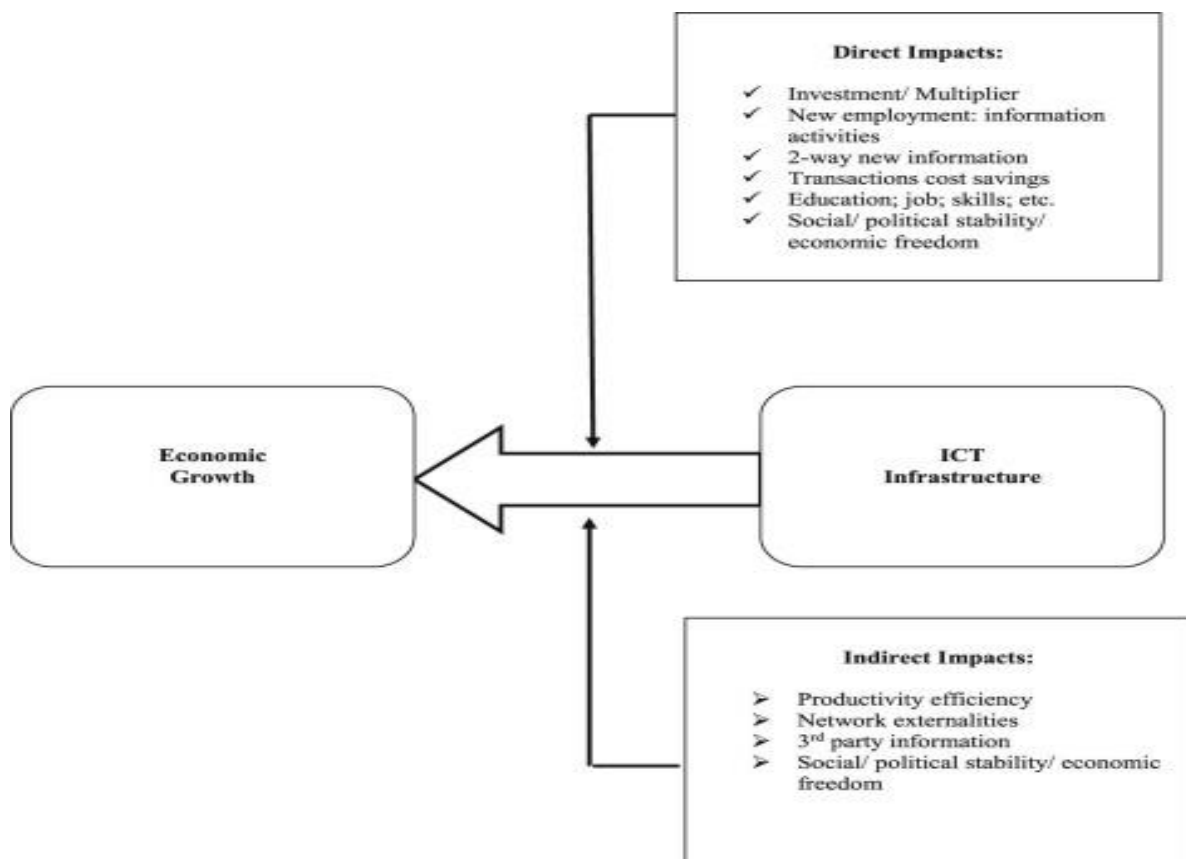
The current globalization stage is marked by the IT revolution. The novel method of digital recording of data introduced a new dimension and unprecedented quality to storing and processing information [19]. In the past few decades, the digital economy has gained the attention of researchers, consultants, journalists, policymakers, and business managers as an area of high potential [2], [11]. Digital Infrastructure is the main engine of Future Economic Growth from connectivity to cloud computing. Despite the increase in studies on the influence of ICTs on countries' economic growth in recent years, no study has yet used ICTs as a proxy for the three measures used in this study (internet, mobile phone, and fixed broadband). Information and Communications Technology (ICT) infrastructure is the foundation of the Digital First Economy (DFE). However, its development is uneven around the world [20]. It is generally accepted that information and computer technologies are becoming a driver of economic growth in the modern world. Most countries have embarked on the digital economy, but they are at different stages. Huawei has published a report on the results of the study "Huawei Global Connectivity Index - 2017" (GCI) [21]. The study reflects the progress of the world largest countries in the transition to digital technologies. The 50 countries assessed in 2017 account for 90% of global GDP and 78% of the World's population. Huawei's research showed that the growth rate of the global movement towards the digital economy increased in 2017, and the Global Network Interaction Index (GCI) grew by an average of 4 points over the period 2015-2017 [21]. The GCI Index is based on 40 indicators that reflect the degree of development of countries and the influence of 5 main technological growth factors. Countries accelerate the digital transformation of their economies by investing in the following areas and key technologies: deployment of broadband networks; operation of data centers; the use of cloud services; working with big data, and development of the Internet of things (IoT) [21].

Broadband defined as permanent online Internet access with data rates equal to or greater than 256 Kbit/s for downlink connections and 64 Kbit/s for uplink connections (Organization for Economic Cooperation and Development, OECD, 2001), is currently the most commonly used method of Internet access [22]. Both types of broadband for Internet users have become a vital component of the new market infrastructure, even leading to economic restructuring. The introduction of broadband has had a broad impact on the economy, especially on economic growth, employment, and national competitiveness [23]. It should be noted the particular importance of information and communication technologies (ICT) as a factor to increase competitiveness and digital economy development, exploring ICT use in the nation economy to highlight the benefits of the development and adoption of new solutions in ICT which will contribute to the improvement of the business environment in the ICT sector, and the digital economy in overall.

The importance of ICT infrastructure, otherwise called information highways, is undeniable in the areas functioning of modern business such as supply chain management, B2C and B2B transactions, and instant transfer of funds. One of the important features of broadband infrastructure that other types of infrastructure do not have is the presence of network externalities: the larger the number of users, the more value other

users get. For example, these characteristics are not found in other types of public infrastructure, such as transport, drainage, and sewer systems. Thus, the return on investment (ROI) in terms of higher economic growth rates, in broadband infrastructure is likely to be higher than in other types of infrastructure. In addition, revenue may not accumulate as a linear function of the cost of infrastructure investments. Thus, one can expect a positive relationship between broadband infrastructure and economic development in all countries [24]. Although broadband infrastructure can contribute to economic development in many ways [25], broadband infrastructure may have the greatest impact on information dissemination and organizational effectiveness [26]. First, the total number of businesses does not reflect the number of firms entering and exiting the market. If the increase in broadband usage leads to an overall sector shift, there may be no change in the total number of businesses. Second, the related issue is that increased use of broadband leads to growth self-employment, extension of telecommunications, and / or easier import of goods and services outside the country.

Third, businesses can take advantage of economies of scale by using physical capital, such as broadband. These factors usually lead to a reduction in the actual number of commercial enterprises, although they cause an increase in productivity [27], [28]. Hypothetically possible links between broadband infrastructure and economic growth illustrates Fig. 1 [29].



**Figure 1. The impact infrastructure of information and communication technologies on economic growth.**

*Source [29]*

Many economists argue that broadband infrastructure directly or indirectly affects economic growth. Others argue that the development of broadband infrastructure is a prerequisite for using other infrastructure advances (such as transport, education, and remote sensing) that are necessary for economic growth [27]. These examples imply that a positive relationship between broadband infrastructure and economic growth (often measured by the total number of businesses) would be natural. However, there are reasons why it is not always possible to observe a positive relationship between them. Currently, broadband infrastructure is emerging and growing globally. This trend has increased the debate about the benefits of broadband Internet and generated a lot of interest in broadband infrastructure, as well as the attention of governments and

industry [30]. However, experts increasingly agree that broadband infrastructure should be compared with other types of infrastructure, so it is necessary to be aware of the diverse role of broadband infrastructure and to know its limits. The relationship between broadband and economic growth is expected to be complex, as well as mutually reinforcing. Broadband infrastructure can contribute to economic development by reducing transaction costs (for example, by providing faster financial services), creating new opportunities for innovations to reach new markets (for example, through e-Commerce and improved information exchange), reducing the cost of capital (based on increased efficiency of financial markets), closing regional differences in income and productivity, and providing access to human capital (through tele-networks), and generating positive external effects. As noted, in developed countries, a strong broadband infrastructure is a key condition for accelerating economic development by supporting industry and production, marketing and sales, improving agriculture, education, health, social services, and transport, as well as contributing to macroeconomic stability [31], [32].

The investigation for the existence of some stationary linear combination of several time series, based on statistical data, shows that these two statistics are significant at the level of 1% [33]. Thus, the null hypothesis about the absence of cointegration can be rejected. The results of investigation strongly confirm the existence of long-term equilibrium relationships between economic growth, ICT infrastructure, gross domestic fixed capital accumulation, labor force participation, and the consumer price index [34]. Research confirms the existence of a long-term causal relationship between ICT infrastructure, the consumer price index, the labor force participation rate, and gross domestic fixed capital formation and economic growth per capita. In the short term, all coefficients are significant and indicate that the ICT infrastructure (broadband/Internet users) affects economic growth indicators [34].

The empirical results of the study show that there are significant causal relationships between economic growth per capita, ICT infrastructure (broadband adoption/Internet users), consumer price index, labor force participation, and gross domestic fixed capital formation. This will be important for policy makers in developing countries. The results show that ICT infrastructure (broadband adoption/Internet users), along with the consumer price index, labor force participation, and gross domestic fixed capital formation, increase the level of economic growth in the G20 countries. Therefore, effective use/implementation of information and communication technology infrastructure is an important condition for obtaining economic growth results [35, 36]. Further studies of the nature and direction of the causal relationship between the selected broadband/Internet user variables, the consumer price index, the labor force participation rate, and gross domestic fixed capital formation would be an important contribution for policy makers in countries seeking to take appropriate measures to ensure economic growth per capita [17], [37]. In the study the researchers used to analyze characteristics such as influence on the development of ICT infrastructure (broadband adoption/Internet users), the consumer price index and participation rate in the labor force; second, the impact of ICT infrastructure (broadband adoption/Internet users), consumer price index, the share of participation in the labor force, and gross domestic investment in fixed capital [17]. The results of empirical research show that all variables (ICT infrastructure-broadband and Internet users, consumer price index, labor force participation rate, gross domestic fixed capital accumulation, and economic growth) are co-integrated, which is confirmed by panel baseline tests [17]. When integrated, these variables do not diverge in the long run. The same conclusion is made for the integration of economic growth, ICT infrastructure (both broadband and Internet users), consumer price index, labor force participation rate, and gross domestic fixed capital formation (GDCF).

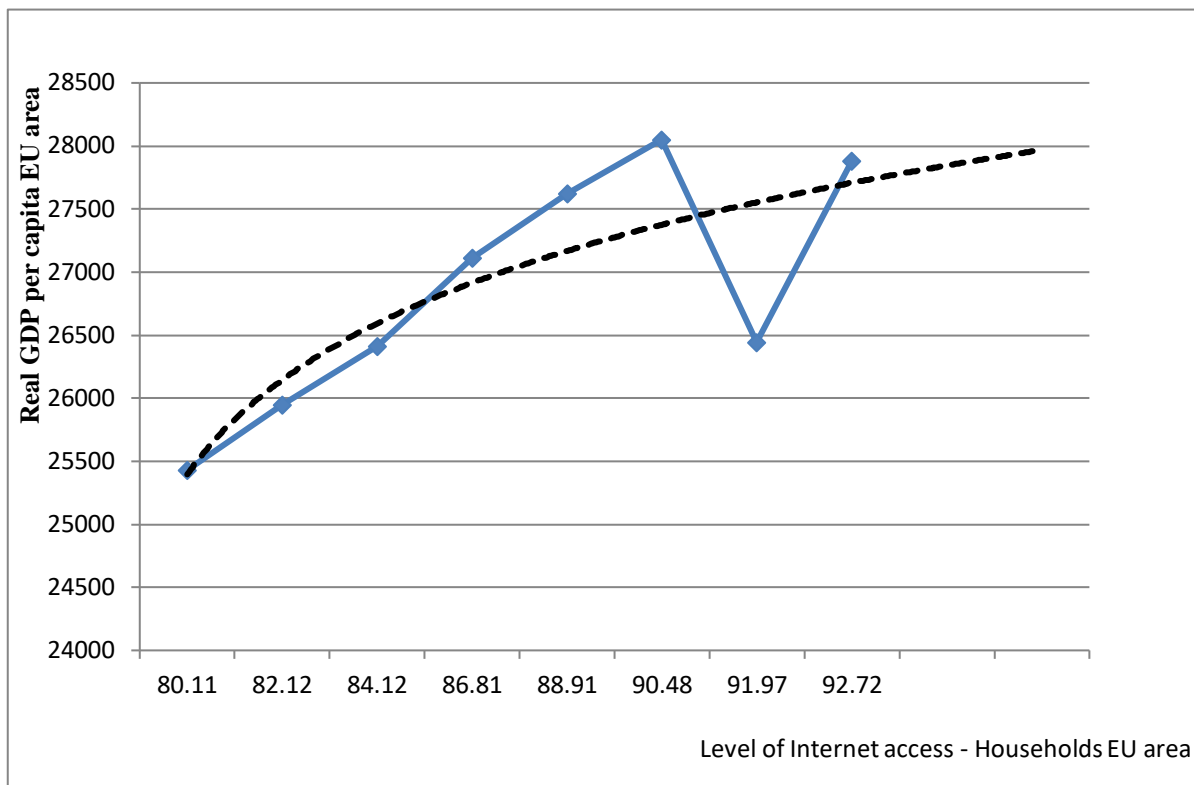
According to the methodology of assessing the impact of the digital economy on countries' economic growth, a set of indicators was collected for the period 2014-2021 for EU zone countries. An indicator that measured economic growth under the digital economy is measured by the level of GDP per capita at constant 2010 prices as the dependent variable, while the level of Internet access for households in the EU area was chosen as the independent variable.

To evaluate the impact of the degree of using the Internet on economic growth, in the paper the model was built of Real GDP per capita as a function of the Level of Internet access of Households in the EU area. Real GDP per capita is presented as a function of the level of Internet access of households in the EU area as the next:

$$Y = 25395 x 0,0419$$

The chosen form of dependency has value of the accuracy of the approximation  $R^2 = 0,69$ , which is appropriate for the short-time trend forecast (see Fig. 2).

An important policy consequence, based on the overall results of the study, is that in order to accelerate economic growth, it is necessary to modernize and expand the ICT infrastructure and pay special attention to the introduction of broadband and Internet users. This is not surprising; given the way ICT catalyzes the implementation of business communication and decision-making today. Thus, governments should stabilize the economic environment by regulating GDCF in order to promote high economic growth. In addition, governments should prioritize the allocation of resources for the development of ICT infrastructure and ensure that fixed broadband systems and Internet users are updated as necessary [32].



**Figure 2. Real GDP per capita as a function of the Level of Internet access of Households in the EU area.**

*Source: authors' elaboration on the base EUROSTAT data (2014-2021).*

ICT make it possible to identify new sources of innovation, develop the capacity for exploration and creativity and reduce the time to market [38]. Results consistent with the view that broadband access does enhance economic growth and performance and that the assumed (and oft-touted) economic impacts of broadband are real and measurable ICTs enable strategic innovation by identifying new customer needs, new production and logistics methods, and new customer segments [39].

Investment in information and communication technologies (ICTs) is increasing in highly developed countries that rely on digital technologies, so investment in the development and application of ICTs is becoming an important growth factor [40]. Late adopters, where digital technology development is just beginning, are looking to accelerate their growth. They invest in promising areas of ICT, which will allow them to quickly get into the global digital community [38]. But despite this, the digital gap between developed and developing countries continues to grow. In order for the economy of any country taking the first steps towards digital transformation to remain competitive, priority must be given to the development of ICT infrastructure, especially broadband networks, as well as the use of cloud services. At the same time, countries that have already made significant progress and want to take full advantage of the benefits they have received should rely on cloud technologies to launch a chain reaction of transformations in areas such

as big data and the Internet of things. The Lisbon strategy, as one of the most important strategic documents for improving the competitiveness of EU countries, also indicates that the strengthening of the EU's competitiveness is based, in particular, on the effective use of new information technologies and the creation of a zone for innovation and the digital economy.

The positive impact of ICT on economic growth has been seen through the increase in business outputs, namely due to the reduction of transaction costs of companies with the use of digital technologies [41] and/or the modernization of production techniques in the productive units [42], in greater productivity [43] in the indirect growth caused in the non-ICT sectors, in the improvement of the market processes, the creation of employment opportunities, the creation of knowledge, and the reduction of price fluctuations, among others [24]; [44]; [45]; [46]; [47]; [48]; [49]. On the other hand, there is a consensus by international organizations, namely the United Nations and the European Commission, that in countries where ICT is used in different sectors ranging from industry, commerce, health, education, and transport, in the public and private sector's supply of goods and services, a better quality of life for the population and economic development is promoted.

## Conclusion

The development of ICT is a necessary condition for an economy based on the introduction of new technologies, while the relatively low level of ICT development in the country should not be considered as a limitation, but rather an opportunity to further improve the level of ICT. Improving the foundations for the Digital First Economy will help countries speed up their economic growth. The digital transition is transforming the way we live and work, but not everyone has the same opportunities to develop the competencies which are needed to thrive. It is important to ensure that every citizen, regardless of their background or circumstances, has access to digital skills. As digital use increases across sectors, there may be a growing need for national policies, technical standards, and global guidelines that enable consumers to transport, access, and use data in multiple settings without encountering significant barriers or compromising their privacy and security. The difficulties are complex, but the potential value - to consumers and industry alike - is impossible to overestimate. The end vision should be based on an interoperable digital world in which the universal use of digital assets encounters the least possible amount of contradictions under appropriate conditions for consumers. The European Training Foundation now devotes its efforts to improving digital skills and learning. Meaningful efforts by the European Training Foundation provide digital skills training through all levels of education and training. That's why it's essential making digital skills a priority in EU neighboring countries as well [50]. The impact of the digital economy measured by the technology proxy – internet, mobile phone, and fixed broadband – on the economic growth of OECD countries depends on their level of development and the technologies that capture the digital economy. A positive impact of the internet on the GDP per capita was found for all OECD countries. It was noted the mobile phone's positive impact on the economic growth of OECD countries. Thus, one can conclude that ICTs positively influence the development of the economies of the European Union. In addition, it is important to introduce appropriate educational policies, to increase the quotas for enrolling students in electrical, mechanical, technological and other specialties related to the development of ICT in the country. The levels of ICT investment and talent development must be enhanced, to build up capabilities to drive digital transformation. The shortage of digital skills and talent, and a lack of ICT investment, will impose significant constraints on the digital transformation of industries, which, in turn, impacts the digital transformation of the entire economy. Only significant investments in the ICT structure and its development can contribute to the creation of a strong economy based on knowledge and information technology.

There are some limitations during this study. The data collected is secondary and covers only EU zone countries. When these data were collected, the available data were from 2014 to 2021. As future lines of investigation, the database can be updated in the coming years, and the forecasting results can be compared with this study. It would still be essential to use more measures of the digital economy, allowing a more comprehensive analysis of the impact of information communication technologies on countries' economic growth.

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## ВПЛИВ ІНФОРМАЦІЙНИХ ТА КОМУНІКАЦІЙНИХ ТЕХНОЛОГІЙ НА ЦИФРОВУ ЕКОНОМІКУ

**Мета.** У статті досліджується вплив інформаційних та комунікаційних технологій (ІКТ) та їх роль і місце у динаміці цифрової економіки. Метою цього дослідження є оцінка впливу цифрової економіки на ВВП на душу населення в країнах ЄС. **Методика.** Аналіз ІКТ як ключового фактору для підвищення зростання економіки шляхом впровадження можливостей цифрових технологій. Для аналізу було використано вибірку панельних даних з Eurostat та Світового банку, що охоплює країни ЄС з 2014 по 2021 рік. Потім було проведено кореляційний аналіз між змінними, і модель була релевантною для прогнозування. **Результати.** Кількість досліджень щодо впливу інформаційних та комунікаційних технологій на економічне зростання країн зросла за останні кілька років. Однак, все ще не існує оцінки впливу реального ВВП на рівень доступу до Інтернету домогосподарств у зоні ЄС. Вивчення цього пробілу в літературі дозволяє нам зробити висновки про наслідки для зацікавлених сторін щодо більш ефективного впровадження цифрової порядку денної. **Наукова новизна.** Цифрова економіка, вимірювана інтернетом, мобільним телефоном та стаціонарним ширококутовим доступом, впливає на економічне зростання країни. Це, в свою чергу, залежить від рівня заходів технологій, що охоплюють цифрову економіку. ІКТ позитивно впливають на розвиток економік країн і можуть використовуватися як інструменти зацікавленими сторонами. Ці агенти повинні генерувати політики, які покращують технологічну інфраструктуру ІКТ, цифрове зміцнення можливостей населення та більший доступ до ІКТ. Модель рівня ВВП подається як функція рівня доступу до Інтернету для домогосподарств у зоні ЄС разом з короткостроковим прогнозом для цього індексу. Показано, що інвестиції в структуру ІКТ є невід'ємними для розвитку міцної економіки, заснованої на знаннях та цифрових технологіях. **Практична значущість.** Результати дослідження сприятиме допомогти в визначенні для державних інституцій та інших соціально-економічних систем можливостей і важелів впливу процесів розвитку цифрової економіки на ВВП на душу населення в країнах ЄС

*Ключові слова:* інтернет, мобільний телефон, фіксований ширококутовий доступ, цифрова економіка, економічне зростання

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