НАУЧНИ ТРУДОВЕ НА УНСС (1) 2025, АКАДЕМИЧНО ИЗДАТЕЛСТВО – УНСС
ISSN (online): 2534-8957; ISSN (print): 0861-9344; http://unwe-research-papers.org/
DOI: https://doi.org/10.37075/RP.2025.1.15

LEVEL OF DIGITALIZATION AND GROSS DOMESTIC PRODUCT BY REGIONS: MEASUREMENT AND DEPENDENCIES

Konstantin Kolev[1], Maya Tsoklinova[2]
e-mail: konstantinklv@yahoo.com, e-mail: maya.koleva@unwe.bg

Abstract

A number of studies have identified significant differences in the level of digital knowledge, skills and competences between regions in Bulgaria, as well as the country lagging behind the DESI index values compared to the average for the European Union (EU). In this regard, to stimulate the digital transition, the European Commission has allocated a budget of a total of 1.6 billion euros, which represents 26% of all funds under the Recovery and Resilience Plan of Bulgaria. The latter testifies to Europe's efforts to create conditions for the development of digital technologies in the economy and society and their contribution to economic development. The purpose of this paper is based on system of indicators and the application of factor analysis, to construct a digitalization index by region in Bulgaria as well as to verify the strength and direction of the relationship between the established level of digitalization and GDP by regions.

Keywords: digitalization, GDP, factor analysis, Pearson coefficient, regions

JEL: E25, C38

Introduction

Over the past few decades, the entry of new technologies into the economy and society has largely changed the nature and scope of a number of activities, including: consumption, production, communication, education, payment, etc. The extent of the spread of the digitalization process has become even greater after the Covid-19 pandemic. After this period of social and economic distance, technologies have become the main tool for communication and creating goods and benefits for society. They have been integrated into the production, work, communication and trade processes and have created a number of changes in life. The latter requires profound study and analysis of their impact on the economic conjuncture at national and regional levels. In modern realities, the differences in

[1] Assoc. Prof., PhD, Department of Forest Management, Faculty of Forestry, University of Forestry, ORCID: 0000-0002-7060-9087
[2] Chief Assist. Prof., PhD, Department of Economics, Faculty of General Economics, University of National and World Economy, ORCID: 0000-0001-5388-8056

the economic development of countries are largely based on the degree of penetration of digitalization into the economy and society and its added value on the growth, standard and quality of life of the population. In addition, recognizing the significant role of technology for the individual, the collective and society, European policies are aimed at stimulating the digital transition. For this purpose, the European Commission is allocating 1.6 billion euro from the Recovery and Resilience Plan, representing approximately 26% of all funds (Indeks za navlizaneto na tsifrovite tehnologii v ikonomikata i obshtestvoto (DESI), 2022, Bulgaria, s. 5). It is worth clarifying here that the measures that must be taken through the financial stimulation of the digital transition in Bulgaria are aimed at digital connectivity and the digitalization of the public sector (Evropeyska Komisia, 2022). In addition to the above, in the National Development Program (NDP) Bulgaria 2030, half of the set national priorities are related to the opportunities for increasing the level of digitalization (Ministersi suvet, 2022). The latter shows the great importance of the digitalization process in modern realities, in which society develops and creates value for the economy. In addition, Bulgaria significantly lags behind in terms of DESI index values, ranking 26th among the member states of the European Union, with only Romania having lower values. This fact, as well as the existing regional differences in terms of the level of digital knowledge, skills and competences between the regions in Bulgaria, make it necessary to implement the goal of this research: based on a system of indicators, to derive a quantitative assessment of the level of digitalization by regions in Bulgaria and to verify the strength and direction of dependence between the established level of digitalization and GDP by regions.

Theoretical and methodological foundations of the study

Level of digitalization and economic growth: a literature review

In the specialized literature, it is important to clarify the categorical apparatus related to the process of digitalization. The definition of the essential characteristics of digitalization was made by the authors G. Faucher and S. Houle, who define digitalization as a process through which the use of data, digital platforms and artificial intelligence completely transform the production process and interactions with other market entities (Faucher, Houle, 2023, p. 2). In addition, the authors emphasize two important features in this definition of digitalization: first, the drivers that contribute to the acceleration of the digitalization process and second, the impact of digitalization on the efficiency of the economic system (Faucher, Houle, 2023, p. 2). Also, authors G. Faucher and S. Houle define that the process of digitalization goes beyond the boundaries of the digital economy,

including all processes improved through the use of digital technologies (Faucher, Houle, 2023, p. 3). Special attention in the authors' publication needs to be paid to ways of measuring digitalization, which is essential, considering the significant role of digital technologies in stimulating the productivity of the economy (Faucher, Houle, 2023, p. 4). In this regard, authors G. Faucher and S. Houle propose three methods for measuring the impact of digitalization on the Canadian economy, aimed at extracting information on the value of products produced as a result of the action of new technologies; assessing the value of capital used in production activities and extracting quantitative information on the transformation of the labour market in terms of employment and labour productivity (Faucher, Houle, 2023, p. 5).

According to P. Hellsten and A. Paunu (2020), digitalization is primarily associated with improving the business processes of an organization, as a result of which greater added value is created from decisions already made related to business development (Hellsten, Paunu, 2020, pp. 226-233). A widely used definition of digitalization associates it with a process of transformation of analog signals into digital ones, as a result of which digital technologies enter all spheres of publiclife, including the economy (Bloomberg, 2018; Brennen, Kreiss, 2016, pp. 1-11). The authors K. Sabbagh, R. Friedrich, Bahjat El-Darwiche, M. Singh and A. Koster (2013) define digitalization as the process of mass use of connected digital devices by consumers, manufacturers and state-owned enterprises, which in recent years has been a factor of growth through an easier way of creating new jobs (Sabbaghet al., 2013, pp. 35-42).

It is evident from the definition of the aforementioned authors that the process of digitalization is associated with generating economic growth by stimulating employment. In addition, for several years now, various European strategies have been continuously promoting the thesis that technological innovation and the achieved level of digitalization are significant factors stimulating productivity and growth (ECB, 2021). This argument is also widely supported in M. Draghi's report, which indicates that the difference between the economic growth of the USA and the EU is based on lower productivity in European countries. The reason for the lower productivity of the European economy is the weaker development of new technologies and the lower level of technological progress (Draghi, 2024a; Draghi, 2024b). The positive impact of digitalization on productivity is also confirmed by the authors M. Gebs and M. S. Nabi (2021), who defend the thesis that total factor productivity is improved by the implementation of technologies in the production process, and hence on growth and employment (Gebs, Nabi, 2021, p. 2).

In the last few years, research interest has focused on studying the impact of technological progress on economic growth. In this context, the study of the

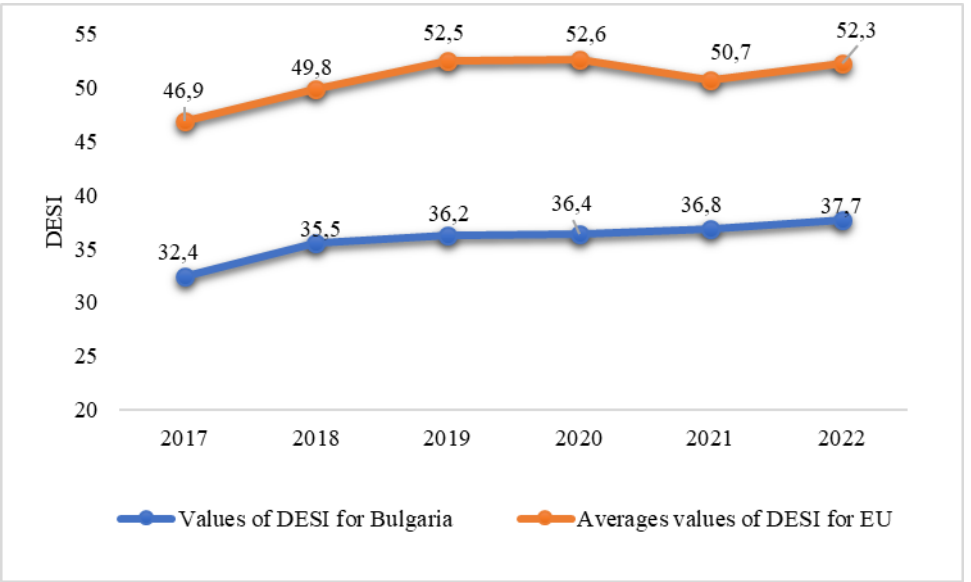
authors I. Szabóa, K. Ternaia, A. Prosserb and T. Kovácsa (2024) examines the contribution of digital technologies to GDP (Szabóa, et al., 2024, pp. 1807-1814). The study included 1045 small Hungarian enterprises for the period 2010 – 2018, with the level of digitalization measured using the DESI index. The results show that another significant factor, besides financial ones, that has a positive impact on the good economic performance of enterprises, and hence on economic growth, is the level of digitalization respectively the software products used by the companies (Szabóa et al., 2024, p. 1807). In this context is the study of R. Ya. Moskalyk and V. A. Balashova (2024), in which they build an econometric model with the participation of the DESI index as an indicator of the penetration of digital technologies into the economy and society for the EU member states for the period 2017 – 2022 (Moskalyk, Balashova, 2024, p. 55). The results of this study show a significant causal relationship between the level of digitalization and the aggregate production created, as a measure of economic growth. The authors empirically prove that a 1% increase in the DESI index leads to a GDP growth of almost 0.2% (Moskalyk, Balashova, 2024, p. 55). Such studies are evidence of the important role of digital technologies in generating economic growth and stimulating policies that promote the use of technological progress in new business models. The relationship between the level of digitalization, assessed using various indices, and the achieved economic growth in Russia is the subject of research by A. Aleksandrova, Y. Truntsevsky and M. Polutova (2022), who conclude that globally digital technologies have already created a solid foundation for generating economic growth and are perceived as one of the main endogenous growth factors, stimulating productivity, quality of services and creating greater utility for market entities (Aleksandrova, Truntsevsky, Polutova, 2022, pp. 424-441).

The introduction of new technologies into the economy and their role in terms of economic growth, as an example of an endogenous growth factor, is the subject of research by R. Rangelova (1999), where the author clearly defines new theories of growth, based on technological progress, contributing to the creation of increasing returns in the long-term perspective (Rangelova, 1999, s. 3-27). The latter is evidence that technologies are an indispensable production factor and their presence in growth theories implies continuous research and analysis of the economic system, of which they are an element. The degree of impact of the achieved level of digitalization on the gross value added in Russia is the subject of research by the authors I. L. Rozanova, V. M. Moroshkina and V. G. Gienko (2020) (Rozanova, Moroshkina, Gienko, 2020, pp. 235-239). The authors conclude that even a lower level of digitalization in the economy is associated with a large positive impact on aggregate production in terms of improving total factor productivity, stimulating a highly skilled workforce, and stimulating

the creation of new markets and innovative production (Rozanova, Moroshkina, Gienko, 2020, p. 235). The latter is related to a real process of transformation in the specifics of the production function, in which special emphasis is placed on the impact of technological progress in improving the productivity of the production factors used, and hence on the efficiency of the economic system.

The review of existing literature allows us to conclude that the entry and implementation of digital technologies in the economy and society provide an opportunity to transform old business models into new ones, with an emphasis on improving efficiency. In most studies, the emphasis is placed on the correlation between the generation of economic growth and the use of the achievements of technological progress. But there are also enough studies in which the research interest is focused on the possibility of increasing the level of digitalization to stimulate employment and reduce inequality in the distribution of resources between individual countries worldwide. This idea was scientifically developed by the authors M. Olczyk and M. Kuc-Czarnecka (2022), who, using the DESI index, study the possibility of improving the level of digitalization to reduce inequality in the distribution of wealth between individual countries, with an emphasis on studying the methodological basis for constructing the DESI index and its correlation with GDP (Olczyk, Kuc-Czarnecka, 2022, pp. 775-803).

In this regard, Bulgaria significantly lags behind the DESI index values compared to the EU average. Figure 1 presents information on the DESI index values for Bulgaria and the average DESI index values for the EU for the period 2017 – 2022. As can be seen from the figure, there is a trend towards an increase in the index both for Bulgaria and on average for the EU, with the exception of 2021, when a slight decrease of nearly 2% in the index values for the EU was observed. During the analyzed period, the DESI index values for Bulgaria significantly lag behind the EU average, as in 2022 it was equal to 37.7% for Bulgaria compared to 52.3% for the EU, for 2021 –36.6% for Bulgaria and 50.7% for the EU, for 2020 –36.4% for Bulgaria and 52.6% for the EU. In this regard, despite the increase in the DESI index values for Bulgaria, our country has to considerit in order to catch up with the other EU countries. In terms of the digitalization of the economy, Bulgaria faces serious challenges, requiring continious efforts and serious investments in the field of communication infrastructure, digital technologies and professional knowledge and skills of the employed. Therefore, it is essential to study the relationship between the level of digitalization and labor productivity.



Source: European Commision (2019, p. 14), European Commision (2020, p. 13), European Commision (2021, p. 13), European Commision (2022, p. 18).

Figure 1: Dynamics of DESI values for Bulgaria and the EU during the period 2017 – 2022

The impact of the achieved level of digitalization on labor productivity and hence on economic growth is a subject of great research interest. In this regard, the work of M. Bykova, S. Grachev and O. Donichev (2021), in which they examine the impact of new technologies on qualitative improvements in the production factor labor, as a result of which intensive economic growth is generated (Bykova, Grachev, Donichev, 2021,pp. 1-8). In the context of the fifth industrial revolution based on artificial intelligence, the authors reach results that show the importance of digitalization for improving personnel qualifications, which in turn is related to the restructuring of the labor market towards the demand for a more expensive and more productive workforce (Bykova, Grachev, Donichev, 2021, p. 6). In conclusion, the emphasis is placed on the contribution of digital technologies to the production process and their correlation with the generated economic growth.

Technological progress is a factor that influences the restructuring of the economy, which implies significant efforts to study it in detail and its impact on economic processes. In addition, the changes resulting from the use of digital technologies have an impact not only at the national level, but also at the regional level. In large part of the publications, the authors' attention is focused on build-

ing a special toolkit with which each country can collect quantitative and qualitative knowledge about how to manage change as a result of the implementation of digital technologies in economic processes, as well as assessing the results of this change on economic development. In this context, a significant part of the developments in recent years are related to assessement the impact of the digitalization process on economic growth. For example, L. Török (2024) examines the impact of digitalization on the economic growth of European Union member states using data from the International Digital Economy and Society Index (I-DESI) over a period of six years, using the Pearson coefficient to prove the existence of a positive relationship between the level of digitalization and the total production generated (Török, 2024, p. 375). The author proves a positive correlation between the digital transition and the gross domestic product of the EU member states, but with the clarification that there are differences in the achieved economic growth, expressed in the fact that the level of digitalization and the growth of aggregate production grow at a faster pace in developed countries and at a slower pace in developing ones (Török, 2024, p. 375). L. Török (2024) makes an important conclusion, namely that the development and use of digital technologies in the economy and society do not contribute to reduction the differences in economic development between individual countries in the EU (Török, 2024, p. 375).

The study of the level of digitalization on economic growth is an important topic that needs to be developed not only at the national but also at the regional level. This thesis is supported by the authors P. Angelov and S. Zarkova (2021), who place the emphasize on the benefits of economic digitalization on the development of local government in the context of the electronicization of the public sector and the challenges that stand out between individual municipalities in terms of the achieved degree of digitalization (Angelov, Zarkova, 2021, s. 24-37). The existence of regional differences in Bulgaria regarding the level of digitalization has also been established by the authors V. Boshnakov and M. Kazakova (2022), who found that in a number of regions, access to the Internet by the local population is extremely difficult, which in turn is a factor discouraging the municipal administration from directing efforts towards digitalization of the public services supplied (Boshnakov, Kazakova, 2022, s. 42-54).

The innovative development of regions in the Russian Federation and their relationship with digitalization is the subject of research of the authors S. Demin, A. Mikhaylova and S. Pyankova (2022), who, based on an analysis of a significant volume of statistical information, identify the main factors contributing to the growth of the innovation potential of regions (Demin, Mikhaylova, Pyankova, 2022, pp. 377-390). The results reached by the authors are related to the fact that regions that are characterized as more innovative and have a larger population emphasize improving digital communication between regional authorities and

society, as part of the concept of digitalization of the economy (Demin, Mikhaylova, Pyankova, 2022, p. 387). In addition to the above, as a main conclusion of the study, the authors S. Demin, A. Mikhaylova, S. Pyankova, (2022) summarize that the most economically developed regions of the Russian Federation are also distinguished by the highest level of digitalization, supported by a number of programs stimulating the digital transition in specific regions (Demin, Mikhaylova, Pyankova, 2022, p. 387). In this regard, the study by N. V. Novikova and E. V. Strogonova is an exemple that the digitalization is an endogenous factor of economic growth of the national and regional economy (Novikova, Strogonova, 2020, pp. 76-93). The authors proceed from the thesis that regional growth depends on the achieved level of digitalization and, using information on available indices measuring the level of digitalization in the economy, construct their own index consisting of 12 indicators characterizing the penetration of digital technologies into the economy and society for the Ural region, although the study focuses on the first measuring stage of the level of digitalization – the construction of and access to the available communication infrastructure (Novikova, Strogonova, 2020, p. 76). In conclusion, the authors summarize that technological progress is the new production factor and without it, greater aggregate production cannot be achieved (Novikova, Strogonova, 2020, p. 88).

The impact of digitalization on regional economic growth is the subject of research by authors Z. Mawang and L. W. Sieng (2024), who highlight the role of digitalization in improving the structure of the economy at the regional level of Asian countries for the period 2011 – 2019 (Mawang, Sieng, 2024, p. 1). Such studies demonstrate the strong impact of digital technologies on all aspects of public life, take into account the transformations that have occurred in factor markets, and outline the risks facing economies. In addition, authors Z. Mawang and L. W. Sieng (2024) find that Asian countries take advantageof the high level of digitalization of the economy, which in turn creates additional benefits for regional economies in terms of their structural improvement in respect to achieve sustainable growth (Mawang, Sieng, 2024, p. 1). In this context, the question arises whether digitalization can really be considered a factor that helpsregional economic disparities to reduce. As a continuation of the above, the study by the authors H. Liua, X. Wangc, Zh. Wange and Y. Chengc (2024) emphasizes the possibility of reducing the established regional inequality in a number of parts of China through the use and implementation of new technologies in the economy and society (Liua et al., 2024, p. 52). In addition, the authors take a creative approach by directing their research in two directions, complementing the classical production function: one part of the work is related to measuring economic inequality in different parts of China, while the other part focuses on measuring inequality as digitalization enters Chinese regions (Liua et al., 2024, p. 52). The

results achieved from the study conducted by the aforementioned authors prove the existence of both digital and economic regional imbalances and inequalities, with their degree of depth varying in different parts of China (Liua et al., 2024, p. 61). In this context, the authors focus their research interest on the government's commitment to create a comprehensive strategy for the development of digitalization, with an accent on investing in communication infrastructure and professional competencies of the population, especially in the less economically developed parts of the country (Liua et al., 2024, p. 52).

Such studies aim to study the short-term and long-term effects on the economic system that cause the penetration of digital technologies into social and economic life. In fact, the transformations under the influence of digitalization have a different aspect – they affect production, consumption, trade, distribution, but are particularly pronounced in relation to labor markets. The latter is related to the need for thorough study of the impact of digitalization on job positions and the specific requirements for their occupation, as well as the emergence of a discrepancy in the skills of the workforce. In this context, the work of P. Hetmańczyk (2024) is relevant, in which the author emphasizes the need to focus the efforts of countries on improving the existing system of knowledge and skills of workers, in order to adequately address the challenges facing professional realization in the conditions of intensive penetration of digital technologies into the economy and society (Hetmańczyk, 2024, p. 11110). The latter is primarily related to the process of accumulating appropriate knowledge and skills in line with the new realities of the labor market, as a result of which the higher level of digitalization will stimulate economic growth and raise the standard of living of the population. In addition to the above, it is necessary to mention the significant role of the state in stimulating the digitalization process in terms of investing in specialized communication infrastructure, facilitating access to Internet services and, last but not least, digitalization of public services.

The study by authors K. Zhao, H. Li, H. and Y. Luo (2024) deserves attention, who examine the direct and indirect effects of the digitalization process on the qualitative characteristics of regional employment, using data for 31 provinces in China (Zhao, Li, Luo, 2024, p. 1). The authors reach extremely interesting results related to the fact that initially digitalization has a negative impact on the qualitative characteristics of the workforce, in contrast to the long-term impact, which is positive in terms of improving the skills and professional realization of employees (Zhao, Li, Luo, 2024, p. 1). Based on such studies, it can be concluded that the positive impact of the achieved higher level of digitalization on regional economic growth depends on several factors: firstly, government incentives towards improving the communication and information infrastructure (of particular importance for economically less developed regions); secondly,

investing in specific knowledge and skills of the workforce, corresponding to the digital structure of the economy; thirdly, flexible public policies related to the new challenges of professional transformation and new forms of employment, in order to adapt human capital to the changing requirements of the labor market. In this context, everything mentioned so far is related to investments in various assets and a serious time period, which implies analyzing the positive impact of digitalization on increasing total factor productivity (including labor productivity) in a long-term perspective.

Globally, a number of economies are facing a serious problem related to the continuous growth of regional disparities, including: increasing inequality in the distribution of wealth, living standards, purchasing power of the population, as well as innovative business opportunities. In this regard, as a mandatory stage in the development of regional development strategies, emphasis is placed on the structure and dynamics of the labor market under the influence of demographic and technological changes that characterize the 21st century. In order to prevent a number of unfavorable trends in the development of regional labor markets, expressed in an increase in the rate of structural unemployment, it is necessary to take action to formulate policies regarding professional transformation, which appears as a lasting effect of the action of the digitalization of the economy.

The available research related to the role of digitalization on economic growth at the national or regional level shows the importance of this issue. All national economies are faced with the challenges of the new era, where artificial intelligence and virtual reality are already basic elements of production and trade. The new reality in which the international economy is developing requires economic growth to be based on the development of technologies, which in turn places emphasis on the search for appropriate tools for measuring the relationship and impact between the level of digitalization and the generated economic growth, both at the national and regional levels. This will be useful for the formation of policies to stimulate technological progress in those economies that are technologically lagging behind, as well as for additional stimulation of economies showing good results through the implementation of digital technologies in economic processes. The penetration of digital technologies into the production and public infrastructure has a dual role. On the one hand, digitalization creates new jobs, transforms others and places additional demands on workers. With the emergence of the digital economy, various forms of employment were created, which had a positive impact on the labor market, expanding it. At the micro level, the implementation of digital technologies allows companies to reorganize their business processes and minimize production costs in order to generate economies of scale. In addition, the use of technological progress in the production activities of enterprises allows to increase the productivity of used production factors and to

create prerequisites for increasing the efficiency of economic units. The latter is associated with an increase in aggregate production, and hence economic growth. Therefore, the digitalization of the economy is associated with the generation of economic benefits, both at the national and regional levels. The use of digital technologies in the production process and in the construction of business models is associated with the search for highly qualified labor, which in turn is an additional challenge for the labor market and the educational system of each country. The latter implies expanding economic knowledge in the main areas of scope of economic science, creating new knowledge about business processes, acquiring appropriate and adequate skills to reality, as well as sharing global competencies for the economy that human capital needs to possess in order to meet the new challenges facing the global economy.

In addition to the above, in most countries around the world, including Bulgaria, there are significant regional differences that affect the entire economic vision of the country. Compared to EU countries, Bulgaria has ranked last in terms of GDP per capita in the last few years, and some of the regions in the country are ranked first in terms of poverty and low living standards. The latter is related to the pursuit for opportunities to neutralize the negative trend that has emerged. In this context, the utility of this work is related to the possibility of measuring the level of digitalization in the regions of Bulgaria through factor analysis and using the Pearson coefficient to establish the presence of a positive relationship between the level of digitalization and gross domestic product (GDP) by region. The results obtained will allow to derive guidelines for improving the level of digitalization of lagging areas, to identify the factors that influence the increase in the level of digitalization, as well as to build regional policies for regional economic development, in the context of the digital economy and artificial intelligence. The above is also related to the use of appropriate methodological tools, with the help of which to measure the level of digitalization and to establish the dependence between it and regional economic development. This element of the paper is discussed in the next point.

Research methodology

Digitization Index

Factor analysis is used to construct a digitalization index. Based on what is presented in the paragraph above, as well as on previous studies with the participation of the authors (see Beev et al., 2024, s. 374-384), the following variables are adopted as indicators characterizing the level of digitalization by regions in Bulgaria, for which the National Statistical Institute (NSI) provides current data: relative share of persons using the Internet for interaction with

administrative authorities and public institutions; relative share of persons using the Internet for educational materials, but not a full online course; relative share of households with access to the Internet; relative share of persons aged between 16 and 74 years using the Internet regularly (every day or at least once a week). The values of the indicated indicators for 2022 are for 26 regions of Bulgaria. They are presented in Table 1. Vidin and Smolyan regions were excluded from the study because according to the NSI, the data for them are not sufficiently reliable.

Table 1: Indicators characterizing the level of digitalization by region in Bulgaria in 2022

Regions	Relative share of individuals using the Internet to interact with administrative authoritites and public institutions by region, %	Relative share of individuals using the Internet for learning materials but not a full online course, %	Relative share of households with internet access, %	Relative share of people aged 16 to 74 using the Internet regularly (every day or at least once a week), %
1	2	3	4	5
Blagoevgrad	31.1	11.6	85	77
Burgas	21.7	8.7	91	83
Varna	30.7	15.0	88	83
Veliko Tarnovo	27.3	3.8	87	81
Vratsa	62.6	23.6	89	77
Gabrovo	24.0	5.2	80	69
Dobrich	19.1	6.3	89	75
Kardzhali	24.0	3.2	75	61
Kyustendil	19.9	5.7	86	83
Lovech	29.5	12.9	87	61
Montana	11.4	8.2	88	79
Pazardzhik	7.5	3.9	84	73
Pernik	12.7	2.4	85	65
Pleven	26.4	9.3	85	87

Continued

1	2	3	4	5
Plovdiv	21.5	5.5	81	75
Razgrad	23.9	6.2	89	78
Ruse	15.9	3.3	86	80
Silistra	11,6	10.8	89	85
Sliven	3.9	0.5	71	64
Sofia	15.5	2.5	68	61
Sofia (capital)	26.1	7.7	90	82
Stara Zagora	13.9	7.2	75	72
Targovishte	43.3	8.9	95	91
Haskovo	18.9	5.0	87	69
Shumen	29.9	4.7	89	81
Yambol	22.2	3.6	92	72

Source: NSI

By applying factor analysis to the indicators presented in Table 1, a digitalization index can be constructed, reflecting its level by regions of Bulgaria. The essence of factor analysis is expressed in the possibility of transforming a set of correlated data into a set of uncorrelated factors that explain as much of the total variation of the initial data as possible (Ilieva-Gocheva, 2013, s. 339). It should be emphasized here that the essence of factor analysis has been discussed in detail in a previous study by the authors (Kolev, Tsoklinova, Delkov, 2020, pp. 143-164.). Therefore, in order not to complicate the presentation unnecessarily, we proceed directly to the formulas by which the digitalization index is calculated. In this regard, a factor score (result) is determined for each factor by formula (1) (Manov, 2002, s. 247).

$$\begin{aligned}
&\hat{F}_{i(1)} = f_{1(1)}z_{i1} + f_{1(2)}z_{12} + ... + f_{1(p)}z_{ip},\ i = 1...n \\
&\hat{F}_{i(2)} = f_{2(1)}z_{i1} + f_{2(2)}z_{12} + ... + f_{2(p)}z_{ip},\ i = 1...n \\
&... \\
&\hat{F}_{i(m)} = f_{m(1)}z_{i1} + f_{m(2)}z_{12} + ... + f_{m(p)}z_{ip},\ i = 1...n
\end{aligned} \tag{1}$$

where $\hat{F}_{i(q)}$ are factor scores;

$z_{i(j)}$ are the standardized values of the initial variables characterizing the digitalization of the i-th area of the studied population. They are determined by the formula for the classical z-transformation and are presented in table 2.

$f_{q(j)}$ – coefficients of factor scores;

m – common factors, number;

p – initial variables, number;

n – observations in the sample, number.

Table 2: Standardized values of indicators characterizing the level of digitalization by region in Bulgaria in 2022

Regions	Relative share of individuals using the internet to interact with administrative authorities and public institutions by area	Relative share of individuals using the internet for learning materials but not a full online course	Relative share of households with internet access	Relative share of people aged 16 to 74 using the Internet regularly (every day or at least once a week)
1	2	3	4	5
Blagoevgrad	1.1692	1.4476	0.0117	0.1798
Burgas	0.0490	0.6492	0.9731	0.9266
Varna	1.1216	2.3838	0.4764	0.9025
Veliko Tarnovo	0.7164	-0.7000	0.4123	0.6254
Vratsa	0.3231	-0.3145	-0.8215	-0.8080
Gabrovo	-0.2608	-0.0116	0.6527	-0.0612
Dobrich	0.3231	-0.8652	-1.4945	-1.7716
Kardzhali	-0.1655	-0.1769	0.2521	0.8302
Kyustendil	0.9786	1.8056	0.4283	-1.7235
Lovech	-1.1784	0.5115	0.4443	0.3604
Montana	-1.6432	-0.6725	-0.1325	-0.3021
Pazardzhik	-1.0235	-1.0855	0.0598	-1.2898
Pernik	0.6091	0.8144	0.0277	1.3602
Pleven	0.0252	-0.2319	-0.6292	-0.0612
Plovdiv	0.3112	-0.0392	0.7007	0.3364
Razgrad	-0.6421	-0.8377	0.2200	0.4809

Continued

1	2	3	4	5
Ruse	-1.1546	1.2274	0.6527	1.1193
Silistra	-2.0722	-1.6086	-2.2636	-1.3741
Sliven	-0.6898	-1.0579	-2.7123	-1.7596
Sofia	-0.8805	0.2362	-1.5586	-0.4587
Sofia (capital)	2.6231	0.7042	1.5980	1.8421
Stara Zagora	-0.2846	-0.3696	0.2841	-0.8080
Targovishte	1.0262	-0.4522	0.7007	0.6616
Haskovo	0.1086	-0.7551	1.1334	-0.4587
Shumen	0.7998	0.9245	0.3322	1.0952
Yambol	-0.1893	-1.5260	0.2521	0.1557

Source: Own calculations

After determining the factor scores using formula (2), the digitalization index of the respective area (I_d) is calculated (Organisation for Economic Co-operation and Development, Joint Research Centre in Ispra, 2008, p. 158; Jelili, 2019, p. 270).

$$I_{d_j} = \sum_{q=1}^{m} \hat{F}_q w_q, \quad (2)$$

where I_d is the digitalization index of a given area;

w_q – the weight of the q_{th} factor. It is defined as the eigenvalue of the qth factor divided by the sum of all eigenvalues.

Results and Discussion

Table 3 presents the correlation coefficients between the indicators characterizing the level of digitalization of the regions in Bulgaria, as well as their significance levels. From Table 2 it is obvious that the correlation coefficients measuring the degree of dependence between the variables are statistically significant ($\alpha < 0.05$). This gives reason to assume that the application of factor analysis is permissible. The assumption is verified by the Kaiser-Mayer-Olkin sampling adequacy coefficient and the Bartlett sphericity test. The value of the former is 0.728, while the significance level of the Bartlett test is 0.000 at $\lambda^2 = 28.175$ and 6 degrees of freedom.

Table 3: Correlation matrix and significance levels

	Indicators	Relative share of individuals using the Internet to interact with administrative authorities and public institutions	Relative share of individuals using the Internet for learning activities	Relative share of households with internet access	Relative share of people aged 16 to 74 who regularly use the Internet
Correlation coefficients	Relative share of individuals using the Internet to interact with administrative authorities and public institutions	1.000	0.728	0.430	0.323
	Relative share of individuals using the Internet for learning activities	0.728	1.000	0.393	0.338
	Relative share of households with internet access	0.430	0.393	1.000	0.672
	Relative share of people aged 16 to 74 who regularly use the Internet	0.323	0.338	0.672	1.000
Levels of significance	Relative share of individuals using the internet to interact with administrative bodies and public institutions by area		0.000	0.011	0.047
	Relative share of individuals using the Internet for learning activities	0.000		0.019	0.039
	Relative share of households with internet access	0.011	0.019		0.000
	Relative share of people aged 16 to 74 who regularly use the Internet	0.047	0.039	0.000	

Source: Own calculations

The extraction of factors is carried out by the principal components analysis (PCA) method, using the Kaiser unit criterion. According to it, only those principal components that have an eigenvalue greater than one can be extracted as factors. In the present study, one common factor was formed, whose eigenvalues (2.449) is greater than one. It explains 61.23% of the variance in the data (see Table 4).

Table 4: Results of factor extraction using the principal components method

Main components	Eigenvalues	Relative shares of variance explained by principal components, %	Cumulative relative shares, %
1	2.449	61.234	61.234
2	0.712	17.796	79.030
3	0.514	12.846	91.875
4	0.325	8.125	100.000

Source: Own calculations

Table 5 contains significant results from the application of factor analysis, namely the communalities, factor coefficients and factor score coefficients. The communalities reflects the contribution of the respective indicator to the identification of a given factor (in the specific study, there is only one). It (the communalities) is calculated as the sum of the squares of the factor coefficients, which are considered as correlation coefficients between the initial indicator and the respective factor. As for the factor score coefficients, it should be noted that by their nature they are regression coefficients in the factor scheme, represented by formula (1). From Table 4 it is clear that the indicators "relative share of households with Internet access" (0.689) and "relative share of persons aged 16 to 74 using the Internet regularly" (0.659) have a more significant contribution to the extraction of a common factor. The contribution of the other two indicators is not so significant.

Table 5: Communalities and factor score coefficients

Indicators	Communalities	Factor coefficients	Factor score coefficients
Relative share of individuals using the Internet to interact with administrative bodies and public institutions	0.561	0.749	0.306
Relative share of individuals using the Internet for learning activities	0.540	0.735	0.300
Relative share of households with internet access	0.689	0.830	0.339
Relative share of people aged 16 to 74 who regularly use the Internet	0.659	0.812	0.331

Source: Own calculations

The factor score coefficients and the standardized values of the initial indicators from Table 1, presented in Table 2 are used to calculate the factor scores. By means of them the digitalization index of the districts in Bulgaria for 2022 is calculated. Table 6 shows that the first three places in terms of the level of digitalization are occupied by the regions of Sofia (capital), Varna and Shumen. The first place of the region of Sofia-capital city in terms of the level of digitalization is a consequence of the first places of the region in the indicators "relative share of households with Internet access" (82%) and "relative share of persons aged 16 to 74 years who regularly use the Internet" (91%) (see Table 1).At the same time, the second place of Varna region in terms of the level of digitalization is explained by the second place in the district in terms of the indicator "relative share of persons using the Internet for educational materials, but not a full online course" (15.0%) and fourth in terms of the indicator "relative share of persons using the Internet for interaction with administrative authorities and public institutions" (30.7%) (see Table 1). The third place in terms of the level of digitalization of Shumen region is surprising, but it also has its logical explanation, namely the sixth place in the district in terms of the indicator "relative share of persons aged between 16 and 74 who regularly use the Internet" (81%) and fourth place in terms of the indicator "relative share of persons using the Internet for interaction with administrative authorities and public institutions" (29.0%), approaching in value to that of Sofia-capital (see Table 1). It should be noted that at the bottom of the ranking in terms of digitalization index values are the region of Dobrich, Sliven and Silistra. The unsatisfactory performance of the three regions is mainly due to the low values of the indicators "relative share of persons using the Internet for

educational materials, but not a full online course" and "relative share of persons aged 16 to 74 using the Internet regularly". For the three regions, the values for the first indicator are 6.3%, 0.5% and 10.8%, respectively, and for the second they are 75%, 64% and 85%, respectively (see Table 1).

Table 6: Digitalization indices by region in Bulgaria as of 2022

№	Regions	Digitalization Index
1	Sofia (capital)	2.1654
2	Varna	1.5186
3	Shumen	0.9972
4	Pernik	0.8903
5	Blagoevgrad	0.8555
6	Burgas	0.8463
7	Targovishte	0.6349
8	Ruse	0.6067
9	Plovdiv	0.4324
10	Kyustendil	0.4159
11	Veliko Tarnovo	0.3560
12	Kardzhali	0.2566
13	Gabrovo	0.1177
14	Lovech	0.0628
15	Haskovo	0.0391
16	Razgrad	-0.2140
17	Pleven	-0.2954
18	Stara Zagora	-0.3691
19	Yambol	-0.3787
20	Vratsa	-0.5414
21	Montana	-0.8495
22	Sofia	-0.8788
23	Pazardzhik	-1.0455
24	Dobrich	-1.2537
25	Sliven	-2.0304
26	Silistra	-2.3389

Source: Own calculations

After the constructed index for 2022 has established the level of digitalization by region in Bulgaria, the dependence between the level of digitalization and GDP is subject to verification. The positive relationship between the two variables has been established in numerous studies (see Dedrick, Gurbaxani, Kraemer, 2003,

pp. 1-28; Mićić, 2017, pp. 135-147; Schreyer, 2000), but has not been studied for Bulgaria so far due to the lack of a quantitative assessment of the level of digitalization by region. In this regard, the Pearson correlation coefficient for 2022 shows that the degree of dependence between the two variables (digitalization index and GDP by region) is moderate ($r = 0.486$ and significance level $\alpha = 0.012$). The obtained result confirms the validity of the positive relationship established by the above-mentioned studies for Bulgaria as well.

Conclusion

Based on the literature review, the calculated factor and correlation analyses, the following conclusions can be drawn:

- For the extraction of a common factor, the indicators "relative share of households with Internet access" and "relative share of people aged 16 to 74 using the Internet regularly" have the greatest contribution. Their inclusion coefficients are 0.689 and 0.659, respectively.
- The constructed digitalization index is reliable and logically justified. Through its application in 2022, significant differences between the level of digitalization of the regions in Bulgaria are found. The systematic assessment of the level of digitalization of the regions in Bulgaria will allow making relevant decisions for its increase and reduction of regional differences.
- The thesis of a positive relationship between the level of digitalization and GDP has been verified. The Pearson correlation coefficient established a moderate relationship ($r = 0.486$) between the digitalization index and GDP by region in Bulgaria in 2022.
- Measuring the degree of digitalization and its impact on regional economic growth would help to highlight existing regional inequalities in digitalization and the resulting structural changes in commodity, resource and financial markets, including the emergence of a discrepancy in the professional skills of the workforce.

References

Ангелов, П., Заркова, С. (2021). Финансова прозрачност на общините в България в контекста на европейската икономическа дигитализация: влияние на инвестиционните и макроикономическите нагласи, Народностопански архив, (4), с. 24-37. (Angelov, P., Zarkova, S., 2021, Finansova prozrachnost na obshtinite v Balgariya v konteksta na evropeyskata ikonomicheska digitalizatsiya: vliyanie na investitsionnite i makroikonomicheskite naglasi. Narodnostopanski arhiv, (4), s. 24-37).

Беев, Ив., Колев, К., Цоклинова, М., Петкова, А. (2024). Количествена оценка на равнището на дигитализация в България: регионални аспекти, Международна научна конференция „Съвременният свят – постижения, рискове, иновации", 23-25 април, Русе, Регионална библиотека „Любен Каравелов" – Русе, с. 374-384. (Beev, Iv., Kolev, K., Tsoklinova, M., Petkova, A., 2024, Kolichestvena otsenka na ravnishteto na digitalizatsiya v Balgariya: regionalni aspekti, Mezhdunarodna nauchna konferentsiya "Savremenniyat svyat – postizheniya, riskove, inovatsii", 23-25 april, 2024, Ruse, Regionalna biblioteka "Luben Karavelov - Ruse, s. 374-384).

Бошнаков, В., Казакова, М. (2022). Използване на дигитални услуги от населението в България: основни предпоставки, тенденции и регионални измерения. Народностопански архив, (2), с. 42-54. (Boshnakov, V., Kazakova, M., 2022, Izpolzvane na digitalni uslugi ot naselenieto v Balgariya: osnovni predpostavki, tendentsii i regionalni izmereniya. Narodnostopanski arhiv, (2), s. 42-54).

Илиева-Гочева, С. (2013). Приложна математика, Пловдив. (Ilieva-Gocheva, S., 2013, Prilozhna matrmatika, Plovdov).

Европейска комисия. (2022). Индекс за навлизането на цифровите технологии в икономиката и обществото (DESI), България. [Evropeyska Komisia, 2022, Indeks za navlizaneto na tsifrovite tehnologii v ikonomikata i obshtestvoto (DESI), Bulgaria).

Манов, А. (2002). Многомерни статистически методи с SPSS,Университетско издателство „Стопанство", София. (Manov, A., 2002, Mnogomerni statisticheski metodi s SPSS. Universitetsko izdatelstvo "Stopanstvo", Sofia).

Национален статистически институт. (2024). Регионална статистика и показатели за мониторинг, Основни показатели, характеризиращи демографското, социалното и икономическото развитие на областите,(Natsionalen statisticheski institute,2024, Regionalna statistika i pokazateli za monitoring, Osnovni pokazateli, harakterizirashti demografskoto, sotsialnoto i ikonomicheskoto razvitie na oblastite),available at:https://infostat.nsi.bg/infostat/pages/reports/query.jsf?x_2=754

Министерски съвет. (2022). Национална програма за развитие България 2030, Детайлизирана стратегия, 2020. (Ministersi suvet, 2022, Natsionalna programa za razvitie Balgariya 2030, Detaylizirana strategiya, 2020).

Рангелова, Р. (1999). Теорията на ендогенния икономически растеж: възникване и развитие, Икономически институт на БАН, Стопанска академия „Д. А. Ценов", Година VIII, Книга 3, с. 3-27.(Rangelova, R.,1999, Teoriyata na endogenniya ikonomicheski rastezh: vaznikvane i razvitie, Ikonomicheski institute na BAN, Stopanska akademiya "D. A. Tsenov", Godina VIII, Kniga 3, s. 3-27).

Aleksandrova, A., Truntsevsky, Y., Polutova, M. (2022). Digitalization and its impact on economic growth, Brazilian Journal of Political Economy, vol. 42, n 2, pp. 424-441, http://dx.doi.org/10.1590/0101-31572022-3306

Bykova, M., Grachev, S. Donichev, O. (2021). Assessment of the impact of digitalization on the socio-economic development of the country, SHS Web of Conferences 128, 04013 IFSDR 2021, pp. 1-8, https://doi.org/10.1051/shsconf/202112804013

Bloomberg, J. (2018). Digitization, digitalization, and digital transformation: confuse them at your peril, Forbes.

Brennen, J. S., Kreiss, D. (2016). Digitalization, Int. Encycl. Commun. Theory Philos., pp. 1-11.

Demin, S., Mikhaylova, A., Pyankova, S. (2022). Digitalization and its impact on regional economy transformation mechanisms, International Journal of System Assurance Engineering and Management, 14(1), pp. 377-390,https://doi.org/10.1007/s13198-022-01806-y

Dedrick, J., Gurbaxani, V. Kraemer, K. (2003). Information technology and economic performance: A critical review of the empirical evidence, ACM Computing Surveys, 35, pp. 1-28.

Draghi, M. (2024a). The future of European competitiveness Part A, A competitiveness strategy for Europe.

Draghi, M. (2024b). The future of European competitiveness Part B, In-depth analysis and recommendations.

European Commision. (2019). Digital Economy and Society Index (Desi) 2019 Country Report Bulgaria.

European Commision. (2020). Digital Economy and Society Index (Desi) 2020 Bulgaria.

European Commision. (2021). Digital Economy and Society Index (Desi) 2021 Bulgaria.

European Commision. (2022). Digital Economy and Society Index (Desi) 2022 Bulgaria.

ECB. (2021). Occasional Paper Series, Key factors behind productivity trends in EU countries, Work stream on productivity, innovation and technological progress.

Faucher, G., Houle, S. (2023). Digitalization: Definition and Measurement, Canadian Economic Analysis Department, Bank of Canada, ISSN 1914-0568, p. 2, DOI: https://doi.org/10.34989/sdp-2023-20.

Gebs, M., Nabi, S. M. (2021). The economic impacts of digitalization through an extended input-output model: theory and application to Tunisia, MPRA Paper No. 113299.

Jelili, R. (2019). A Global Foreign Direct Investment Attractiveness Index. Dhaman.

Kolev, K., Tsoklinova, M.,Delkov,Al. (2020). Factor analysis of forestry competitiveness, Forest Science No 2, pp. 143-164.

Liua, H., Wangc, X., Wange, Zh., Chengc, Y. (2024). Does digitalization mitigate regional inequalities? Evidence from China, Geography and Sustainability, Volume 5, Issue, pp. 52-63,https://doi.org/10.1016/j.geosus.2023.09.007

Mawang, Z., Sieng. W., L. (2024). Digital Economy's Transformative Impact on Regional Growth: Evidence from ASEAN Countries, Jurnal Ekonomi Malaysia 58(2), p. 11, http://dx.doi.org/10.17576/JEM-2024-5802-1.

Mićić, L. (2017). Digital Transformation and its influence on GDP, Economics, Vol. 5, №2, pp. 135-147.

Moskalyk, Ya. R., Balashova, A. V. (2024). Economic Growth Model: the Role of Digitalization, Academy Review, № 2 (61), p. 55, https://doi.org/10.32342/2074-5354-2024-2-61-4

Novikova, N. V., Strogonova, E. V. (2020). Regional aspects of studying the digital economy in the system of economic growth drivers, Journal of New Economy, vol. 21, no. 2, pp. 76-93, DOI: 10.29141/2658-5081-2020-21-2-5

Organisation for Economic Co-operation and Development, Joint Research Centre in Ispra. (2008). Handbook on Constructing Composite Indicators, Methodology and User Guide, France, 158.

Olczyk, M., Kuc-Czarnecka, M. (2022). Digital transformation and economic growth – DESI improvement and implementation, Technological and Economic Development of Economy, Volume 28, Issue 3, pp. 775-803.

Rozanova, L. I., Moroshkina, M. V., Gienko G. V. (2020). Assessing the Role of the Digital Economy in Gross Value Addition, Advances in Economics, Business and Management Research, volume 138, 2nd International Scientific and Practical Conference "Modern Management Trends and the Digital Economy: from Regional Development to Global Economic Growth" (MTDE 2020), pp. 235-239.

Sabbagh, K., Friedrich, R., Bahjat El-Darwiche, Singh, M., Koster, A. (2013). Digitization for Economic Growth and Job Creation: Regional and Industry Perspectives, The Global Information Technology Report 2013, World Economic Forum, pp. 35-42.

Szabóa, I., Ternaia, K., Prosserb, A., Kovácsa, T. (2024). The impact of digitalization on SMEs GDP contribution, Procedia Computer Science 239, pp. 1807-1814.

Schreyer, P. (2000). The Contribution of Information and Communication Technology to Output Growth: A Study of the G7 Countries, OECD Sci-

ence, Technology and Industry Working Papers, 2000/2, OECD Publishing, doi:10.1787/151634666253

Török, L. (2024). The relationship between digital development and economic growth in the European Union, International Review of Applied Sciences and Engineering, Volume 15, Issue 3, p. 375, DOI: https://doi.org/10.1556/1848.2024.00797

Hellsten, P., Paunu, A. (2020). Digitalization: A Concept Easier to Talk about than to Understand, Proceedings of the 12th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2020) – Volume 3, KMIS, pp. 226-233, DOI: 10.5220/0010145302260233

Hetmańczyk, P. (2024). Digitalization and its impact on labour market and education, Selected aspects, Education and Information Technologies 29, pp. 11119-11134, https://doi.org/10.1007/s10639-023-12203-8

Zhao, K., Li, H. & Luo, Y. (2024). Mechanism analysis of the impact of regional digital transformation on the employment quality in the perspective of labor force structure, Sci Rep 14, 25229, p. 13,https://doi.org/10.1038/s41598-024-77096-0