The Influence of Factors on the Level of Digitalization of World Economies

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Abstract
The advanced development of the world's economies requires a detailed study of the impact of factors on the level of digitalization, to ensure economic growth and promote the use of information and communication technologies in the digital economy. Digitalization of the world's economies is ensured through the implementation of relevant regulations and policy decisions to implement public policy and strategy of the digital economy. The purpose of the study is to establish the pattern of the impact of factors on the level of digitalization of world economies by conducting a regression analysis to reflect the dependence of the impact of factors on the level of digitalization in 25 economies (by IMD digital competitiveness), to check the level of digitalization of the world's economies. It is necessary to analyze the ranking of countries in the world according to the DiGiX Index, IMD, and DESI Digital Competitiveness Rating. Research methods: information synthesis method; regression analysis; systematization, and generalization. Results. It was found that because of regression analysis, the value of the coefficient of determination indicates that the regression model by 78% explains the relationship between future readiness of countries to implement digital technologies and information and communication technologies, but there are still a small number of other factors not included in the regression model. It is determined that the greatest progress among EU member states for the period 2015-2020 according to the DESI index belongs to Ireland, the Netherlands, Malta, and Spain. It is established that Estonia, Spain, and Denmark are in the lead in the DESI rating, in terms of e-government implementation. The study found that the impact of factors on the level of digitalization of world economies contributes to solving current economic problems through further implementation of information and communication technologies and improving legislation in the digital economy, which will ensure the implementation of effective digital policy. It is established that ensuring the appropriate level of digitalization of the world's economies should solve the problems in the digital economy sector faced by governments and businesses, which requires the implementation of measures to regulate and ensure the continued operation of the digital economy.

Key words: *Digitalization, World Economy, DiGiX, IMD Digital Competitiveness Rating, DESI, Digital Technologies, Digital Economy*

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1. Introduction

At the beginning of the XXI century, humanity has been engulfed by a wave of major global change. This stage is characterized by the intensive development of digital technologies, the revolution in the information space, the acceleration of globalization, and the digitalization of the economy. Information has acquired the status of a key resource in government and business processes [1; 2; 3]. The penetration of digital technologies into life is one of the characteristic features of the future world. This is due to advances in microelectronics and telecommunications, IT technologies. The transition to digitalization today is one of the key priorities in the development of the world economy. As countries around the world intend to carry out a comprehensive digital transformation of the economy, it is necessary to develop legislation on digital technologies, modernize digital infrastructure, introduce digital practices in all key areas of economy and management and organize training in the transformation period [4].

Modern information, digital technologies, and innovations used in production, distribution, exchange, and consumption have become important in the process of increasing competitiveness [5]. The spread of innovation and digital technologies is observed not only in the real sector of the economy but also in the social sphere, i.e. in education, health care, and culture. Modern society perceives the world through the prism of the penetration of such phenomena of digitalization as the Internet, digital communications, software, information and communication technologies, etc. [6]. Changes in the socio-economic spheres around the world are exacerbated by the growing role of information and communication technologies, the development and implementation of innovations that have led to structural changes in the economies of all developed countries and countries, developing [7]. The product of these changes is a new type

of economy – "Digital economy", which is based on digitalization. In the period of post-industrial development and the formation of the "digital economy", human capital becomes one of the most important factors in the socio-economic development of regions and countries as a whole [8; 9].

The formation of a modern competitive economy and the achievement of irreversible economic growth is hardly possible without the implementation of a digitalization approach. In the 21st century, the leading role in the long-term growth of the national economy lies in innovative and revolutionary technologies capable of formulating and supporting long-term economic growth and social welfare. Innovative development and scientific growth are impossible without digital technological development and digitalization processes. In today's global economy, digital technologies are widely used in all sectors of the economy and can be incorporated into any part of public life, as result, these processes lead to a constant evolution of business models, which over time become increasingly digitalized [10].

The need to determine the impact of factors on the level of digitalization of world economies is caused by the idea of determining the course of economic development, contributing to economic and social growth to attract higher GDP, where this issue becomes particularly relevant, namely in the development of the world economy, through the application of effective innovation experience in the economy of the country. The importance of practical use of research results is to analyze further the impact of factors on the level of digitalization of world economies, to promote the implementation of digital policy, which provides a way of state development, where economic management will be based on information and communication environment.

The study aims to establish regularity on the impact of factors on the level of digitalization of world economies by conducting a regression analysis to reflect the dependence of factors on the level of digitalization in 25 economies according to IMD digital competitiveness, to check the level of digitalization of world economies DiGiX, IMD and DESI Digital Competitiveness Rating.

Research objectives of this article:

1. Analyze the progress of EU member states for the period 2015-2020 according to the DESI index.

2. Analyze the ranking of countries by DiGiX indices, IMD, and DESI digital competitiveness rating.

3. Analyze the use of advanced cloud computing and analysis of big data in the EU by company size for 2018.

4. Analyze the implementation of e-government in EU member states in 2020.

5. Conduct a regression analysis to reflect the dependence of the impact of factors on the level of digitalization in 25 economies around the world on the rating of digital competitiveness IMD between the results of future readiness of countries to implement digital technologies and information and communication technologies.

2. Literature review

The modern economy is characterized by the growing role of knowledge and human capital in the organization of modern products and services. Science and technology have expanded the limited resources of economic resources, offered consumers radically new types of goods and services, and ensured the growth of national corporations that actively innovate globally [11; 12]. Several factors contribute to these trends. Firstly, it is globalization and digitalization of economic relations. Digitalization brings the relationship between science, education, manufacturing, the market closer, and globalization blurs the boundaries of national economies [13].

Digitalization is a modern concept that attracts businesses to the business world. The transformation process into digitalization is defined as a procedure used to reorient the economy of the state, organizations, and communities to the system level [14; 15]. Companies that fail to align their business digitalization strategy with the competitive environment will face serious challenges [16]. According to the Gartner IT Glossary, "Digitalization is the use of digital technologies to change the business model, which will help attract new income and valuable creative opportunities" [17].

Digitalization is defined as an activity based on innovation, more precisely, on information technology. In today's globalization challenges, the pandemic has had a positive impact on the development of the digitalization of world economies, thereby accelerating the introduction of new innovative technologies in everyday life [18]. The scientific literature on digitalization focuses on the interpretation of this concept and the impact of digitalization on various macroeconomic indicators, such as GDP per capita, growth, productivity, etc. [19; 20].

Digitalization is formed based on three components: the sector of information and communication technologies (ICT); e-commerce market, measured as online sales of goods; out-of-network consumer spending on digital equipment. The interpretation of the concept of "digitalization" is relatively broader than just the ICT sector, but more specific than "all activities related to digital data" [21]. Rapid progress towards digitalization based on the exponential growth of technologies such as advanced robotics, artificial intelligence, the Internet, 3D printing, and nanotechnology have made digital connections an increasingly distinctive feature of the global digital economy. Also, this process is facilitated by the accelerated market penetration of key technologies such as cloud computing, the Internet, and mobile devices,

which form the basis of digitalization. At the same time, there is a huge increase in both the volume and speed of digital data flows. In connection with digitalization, the transformation of traditional production methods is already taking place, where the achievement of digital technologies is changing production opportunities and schemes of specialization within and between countries. Digitalization provides specialization of production processes in both production and services, facilitating the fragmentation of tasks and supporting the efficient process of global supply chains [22; 23].

Digitalization facilitates market integration by significantly reducing communication costs and increasing compliance efficiencies, which in turn increases the competitive advantage of those using innovative technologies. They support the reduction of barriers to entry by offering online services such as globally available cloud computing and internet marketing platforms for SMEs and startups, thanks to a significant reduction in the fixed costs of doing business in both domestic and foreign markets [10].

In recent years, the digital economy has experienced unprecedented growth as an important component of the fourth industrial revolution [24]. Although digitalization is a pervasive process, its impact is crosscutting and specific, affecting the role of governments and government agencies in the development and implementation of new regulations. Applying digitalization and digitalization effectively can accelerate economic growth, increase productivity and create jobs in countries, facilitate the access of micro, small and medium-sized enterprises to markets and business services, and help countries overcome barriers for inclusive development [25].

A key aspect of digitalization is its infrastructural nature, which has a transformational impact on the initiation and coordination of cross-border interactions, making digital assets easily accessible from anywhere, thereby radically changing both management and coordination issues in global strategy development. This adds a new level to internationalization beyond the country-specific physical level and fundamentally transforms the coordination of global activities. However, digital resources may face institutional and legal constraints on the part of states when firms use them as part of cross-border strategies. These characteristics mean that digitalization is a general-purpose technology [26].

Modern tools for studying the level of digitalization cover a variety of techniques. In particular, the main indicators that characterize digitalization include DiGiX, IMD Digital Competitiveness Rating, and DESI. Each index has different methodological approaches and contains different factors that help to investigate the impact on the level of digitalization of world economies. DiGiX index is a digitalization index that measures the factors, behavior of agents and institutions that allow a country to take full advantage of information and communication technologies (ICT) to increase competitiveness and prosperity, which consists of six main components: infrastructure, household choices, business choices, costs, regulation and government choice [27]. The Digital Economy and Society Index (DESI) measures the progress of the digital economy in the EU [28], consists of 5 main indices such as measurement of communication, human capital, use of Internet servers, integration into digital technologies, and indicators of the e-development environment. IMD digital competitiveness rating, forming a rating consists of such indicators as knowledge, technology, and future-readiness of countries to implement digital technologies [29]. An in-depth analysis of the issues outlined in the scientific article allows us to conclude that foreign and Ukrainian scientists study the influence of factors on the level of digitalization of world economies, in terms of in-depth integration of national economies into the structure of world innovation and technology and economic space sufficiently.

Thus, the problem of the influence of factors on the level of digitalization of world economies is widely reflected in scientific publications in the form of theoretical research and practical research. However, the impact of factors on the level of digitalization of world economies remains relevant and open for further research, taking into account the reports of the European Commission, UNCTAD, Asian Development Bank, DiGiX Index, IMD Digital Competitiveness Rating, and DESI Index on the impact of factors on digitalization of world economies.

3. Methods and Materials

The realization of the purpose of this exploration involves the involvement of such research methods as:

– analysis of the rating of countries by DiGiX indices, IMD and DESI digital competitiveness rating in 2020;

– systematic and logical analysis, method of synthesis of information on the progress of EU member states for the period 2015-2020 according to the DESI index;

– systematization, generalization of the latest scientific publications and statistics published by governments and accountable organizations on the features of the use of advanced cloud computing and analysis of large data in the EU by company size in 2018.

To determine some features of the level of digitalization of the world's economies, the method of generalizing the implementation of e-government in EU member states in 2020 was used. To display a dependence of the influence of factors on the level of digitalization in 25 economies of the world according to the rating of digital competitiveness IMD between the results of future readiness of countries to implement digital technologies

and the use of information and communication technologies used regression analysis.

4. Results

Table 1 shows the results of regression modeling, which allow displaying the dependence the influence of factors on the level of digitalization in 25 economies around the world according to the IMD digital competitiveness rating between the results future readiness of countries for the introduction of digital technologies and application of information and communication technologies:

$$Level\ of\ digitalization = 0{,}95 + 0{,}89 * Future\ readiness + 2{,}34 * Technology$$

Therefore, the influence of factors on the level of digitalization in 25 economies around the world according to the IMD digital competitiveness rating depends on the future-readiness of countries for the introduction of digital technologies and application of information and communication technologies. The model parameters are statistically significant, as indicated by t Stat in size 0.58 and 0.83; a P-value in size 0.57 and 0.41.

Table 1: The results of regression modeling

Regression Statistics							
Multiple R	0.89						
R Square	0.79						
Adjusted R Square	0.78						
Standard Error	3.73						
Observations	25						
ANOVA							
	df	*SS*	*MS*	*F*	*Significance F*		
Regression	1	1180,86	1180,86	84.83	0,0000000035		
Residual	23	320,18	13.92				
Total	24	1501,04					
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.95	0.10	9.21	0,0000000035	0.74	1.17	0.74	1.17
Future readiness	0.89	1.54	0.58	0.57	-2.29	4.07	-2.29	4.07
Technology	2.34	2.80	0.83	0.41	-3.46	8.14	-3.46	8.14

Source: Compiled by the authors based on official data of IMD [29]

The value of the coefficient of determination indicates that the model by 78% explains the relationship between the future readiness of countries to implement digital technologies and the application of information and communication technologies. This suggests that there is still a small number of other influencing factors (to the level of digitalization in 25 economies of the world), which are not included in the regression model [29].

According to the ranking of countries by the Index DiGiX, which fully uses information and communication technologies to increase the competitiveness of the level of digitalization of economies, the TOP-10 included Denmark, Hong Kong, Singapore, USA, Netherlands, Luxembourg, Finland, Switzerland, UAE, Sweden. IMD Digital Competitiveness Rating in 2020 demonstrates that the top 10 economies in the world remain the same as last year. The United States continues to lead the IMD digital competitiveness ranking for the third year in a row, followed by Singapore, Denmark (3rd place), Sweden (4th place), Hong Kong (5th place), Switzerland (6th place), the Netherlands (7th place), and the Republic of Korea (8th place), Norway (9th place), and Finland close the ranking of the top 10 countries (see Table 2).

Table 2: TOP-30 countries by Index DiGiX and IMD Digital Competitiveness Rating 2020

DiGiX			IMD Digital Competitiveness Rating			
Rank	Country	Score	Overall	Technology	Future readiness	Knowledge
1	Denmark	1.00	USA	Singapore	Denmark	USA
2	Hong Kong	0.97	Singapore	Hong Kong SAR	USA	Singapore
3	Singapore	0.94	Denmark	Norway	Korea Rep.	Switzerland
4	United States	0.92	Sweden	UAE	Netherlands	Sweden
5	Netherlands	0.91	Hong Kong SAR	Taiwan, China	Switzerland	Canada
6	Luxembourg	0.90	Switzerland	Sweden	Norway	Denmark
7	Finland	0.88	Netherlands	USA	Sweden	Hong Kong SAR

8	Switzerland	0.87	Korea Rep.	Netherlands	Taiwan, China	China
9	United Arab Emirates	0.84	Norway	Denmark	Finland	Israel
10	Sweden	0.83	Finland	Finland	Hong Kong SAR	Korea Rep.
11	Estonia	0.82	Taiwan, China	Switzerland	UAE	Austria
12	New Zealand	0.81	Canada	Korea Rep.	Singapore	Germany
13	Iceland	0.81	United Kingdom	Canada	United Kingdom	United Kingdom
14	Germany	0.81	UAE	Australia	Ireland	Netherlands
15	Japan	0.80	Australia	France	Canada	Finland
16	United Kingdom	0.80	China	United Kingdom	Austria	Norway
17	Canada	0.78	Austria	Luxembourg	Australia	Australia
18	Norway	0.77	Germany	New Zealand	China	Taiwan, China
19	Australia	0.77	Israel	Belgium	Germany	Malaysia
20	Israel	0.77	Ireland	Malaysia	Estonia	France
21	Ireland	0.76	Estonia	Iceland	New Zealand	Belgium
22	Korea, Rep.	0.74	New Zealand	Thailand	Iceland	Japan
23	Malaysia	0.73	Iceland	Estonia	Israel	Estonia
24	Austria	0.73	France	Saudi Arabia	Qatar	Ireland
25	France	0.73	Belgium	Qatar	Belgium	Lithuania
26	Saudi Arabia	0.68	Malaysia	Japan	Japan	Russia
27	Qatar	0.67	Japan	China	Luxembourg	Iceland
28	China	0.67	Luxembourg	Austria	Saudi Arabia	New Zealand
29	Belgium	0.67	Lithuania	Lithuania	Cyprus	Slovenia
30	Oman	0.65	Qatar	Ireland	Lithuania	Poland

Source: Compiled by the authors based on official data of IMD [29], DiGiX [27]

Fig. 1 shows the progress of EU Member States on the overall level of digitalization of the economy and society over the last 5 years, as measured by the progress of the DESI score. The most significant progress is in Ireland, followed by the Netherlands, Malta, and Spain. These countries reflect results that are higher than the EU average, as measured by the DESI scale. Common to these Member States is a tough policy and targeted investment in all areas measured by DESI. Finland and Sweden are among the leaders in overall digital performance, but progress over the past five years has been above average. Denmark, Estonia, and Luxembourg have shown relatively low levels of digitalization over the last five years, although they remain among the best member countries in the overall DESI ranking. In Denmark, the biggest challenge is to improve further advanced digital skills while in Luxembourg business digitalization is relatively low. In Estonia, there is a relative weakness in communication and business digitalization. It is important to note that most countries that are below the overall EU level in terms of digitalization have not made much progress in the last five years. This applies in particular to Bulgaria, Greece, and Romania.

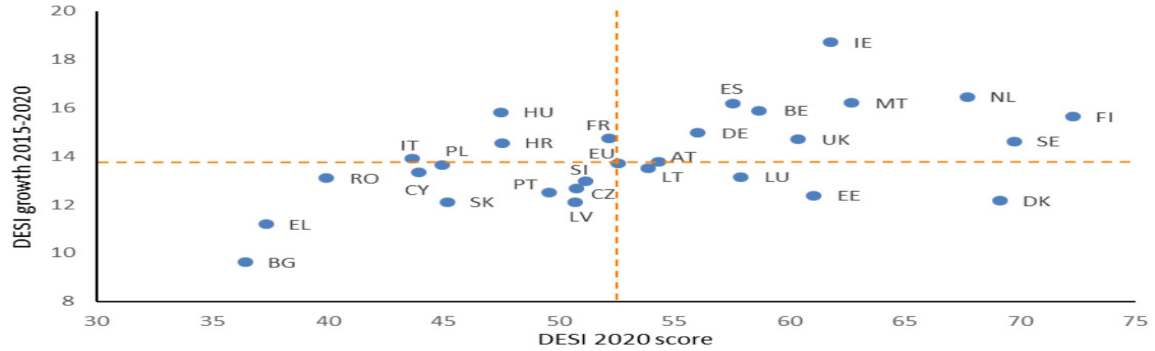

Fig. 1. Digital Economy and Society Index - Member States' progress, 2015-2020
Source: Compiled by the authors based on official data of DESI [28], European Commission [30]

Figure 2 shows the ranking of Member States according to the Digital Economy and Society Index in 2020 based on 2019 data. Finland, Sweden, Denmark, and the Netherlands have the most developed digital economies in the EU, followed by Malta, Ireland, and Estonia. Bulgaria, Greece, Romania, and Italy have the lowest rates.

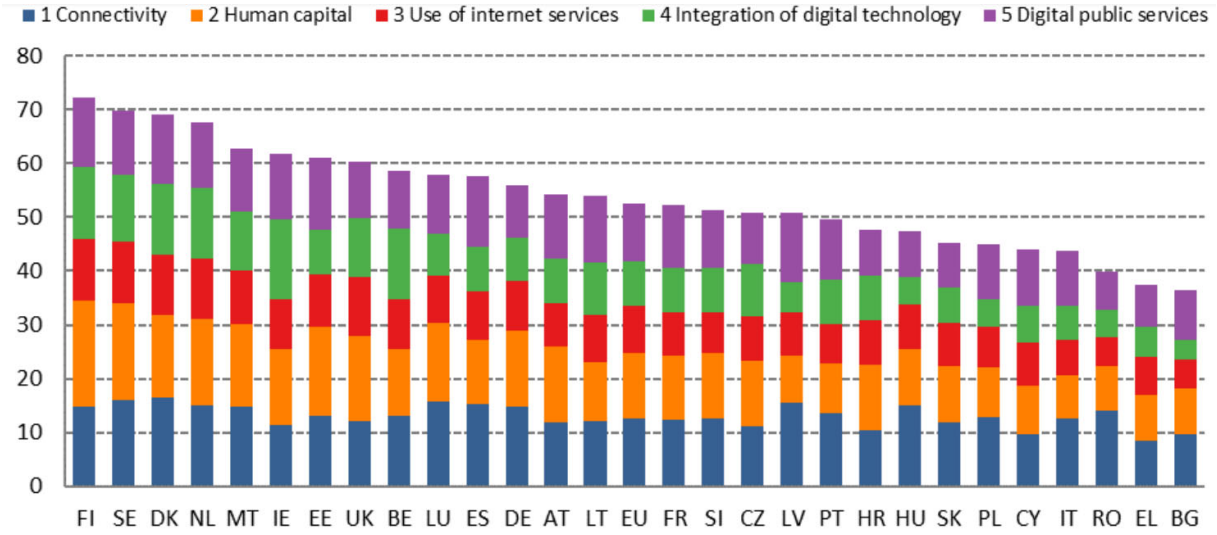

Fig. 2. Digital Economy and Society Index, 2020
Source: Compiled by the authors based on official data of DESI [28], European Commission [30]

The use of advanced digital technologies, such as artificial intelligence, cloud computing, and big data analysis, will increase productivity and efficiency and open up new opportunities for European businesses in all sectors that are crucial for economic recovery. While businesses are becoming increasingly digital, only a small and medium-sized enterprise relies on cloud computing (17%) and big data analysis applications (12%). Malta is the European leader in the big data sector (24% of companies); while Finland is the most advanced in the use of cloud computing (50% of companies). There is a significant gap between large companies and small and medium-sized enterprises, which exists not only for advanced technologies but also for basic digital solutions, such as the availability of enterprise resource planning (ERP) and e-commerce software (see Figure 3).

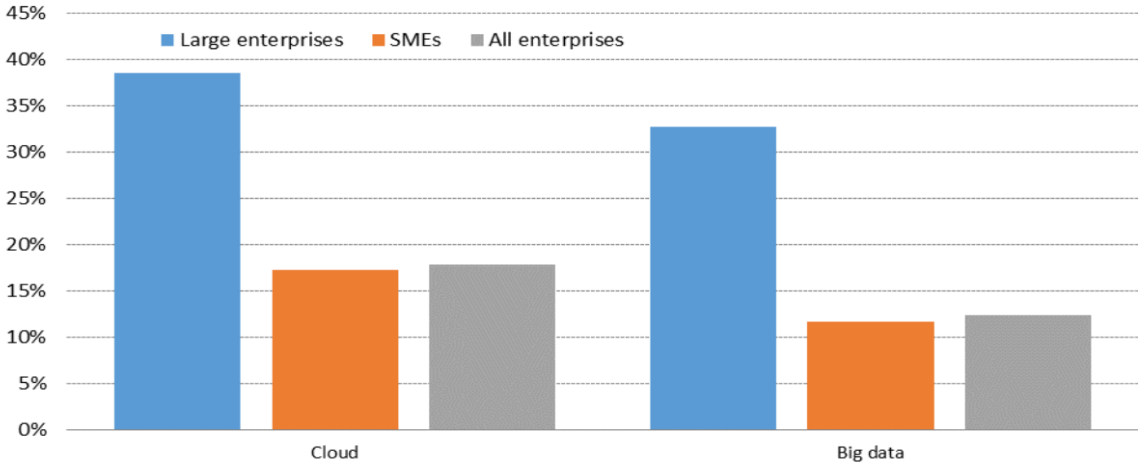

Fig. 3. Use of advanced cloud services and big data in the EU by company size (% of enterprises), 2018
Source: Compiled by the authors based on official data of Eurostat [31]

Implementing e-government can provide greater efficiency and savings for governments, businesses, and citizens. Digital public services, including e-health and the use of advanced technologies to improve public services, will help overcome the current pandemic through the development of a successful digitalization-based strategy. DESI monitors the supply and demand of e-government services, as well as the policies and implementation of open data, which are summarized in the assessment to measure digital public services. Estonia, Spain, and Denmark lead the DESI rankings, while Romania, Greece, and Slovakia have the lowest rates in the EU.

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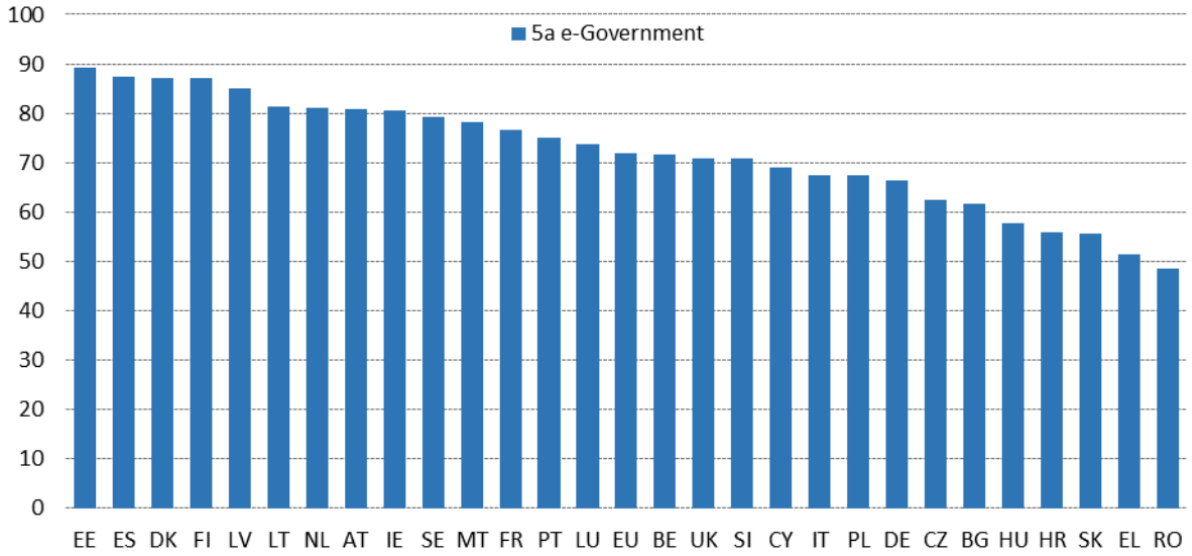

Fig. 4. Digital Economy and Society Index (DESI) 2020, Digital public services
Source: Compiled by the authors based on official data of DESI [28], European Commission [30]

Thus, further determination of the impact of factors on the level of digitalization of world economies will contribute to the formation and implementation of effective policies that will improve the functioning of economic systems and create favorable conditions for deeper integration of countries into the global information technology environment.

5. Discussion

In this article, examining the impact of factors on the level of digitalization of world economies, we found that digitalization serves an important purpose, namely the formation of economic and social benefits for societies and communities. First, the current scientific literature on the impact of factors on the level of digitalization of world economies often combines the driving forces of an efficient economy with the factors underlying entrepreneurship [4; 6; 9; 10; 13; 16; 18; 26].

The findings of a significant number of researchers explain that a sufficient level of digitalization is obtained using information technology resources, which helps sectors of the economy to digitalize their processes. Besides, the relevant sectors of the economy affect the ability of enterprises to digital transformation, and positive beliefs and practices with the use of information technology resources increase the ability to digital transformation. Once the factors influencing the level of digitalization of the world's economies are known, they will help shape policy and develop strategies to enhance the adoption of digital technologies. Therefore, governments must develop strategies and policies that will facilitate the digital transformation of their sectors of the economy through its promising role in business and economic growth. To increase international competitiveness, governments must invest in digital technologies and their components, as they have been shown to have a significant impact on business performance and economic growth, and they must take into account the greatest stakeholder support to help transform the economy into digital [32].

Ever since Adam Smith proposed the theory of absolute advantages that a country enjoys in the production of a good or service, politicians have been developing strategies to create and maintain that advantage in key sectors of the country's economy. Digitalization is a new tool to build and maintain such absolute advantages, and in some cases even to allow countries to claim the "right to win" and beat the competition in certain sectors. Creating digital markets and stimulating digitalization can bring significant economic benefits and lead to significant social benefits for societies and communities. Digitalization has the potential to increase productivity, create new jobs and improve the quality of life in society as a whole [33].

Due to globalization processes, economic sectors will have to operate in a more complex information technology environment, as the world's economies will be integrated into a new level of digitalization, which is significantly different from the current state of information technology. Thus, economic sectors will face new challenges, as the transition to a new level of digitalization of the world's economies will lead to increased attention to improving legislation in the information technology environment.

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Therefore, the research conducted by scientists does not provide relevant information on the impact of factors on the level of digitalization of world economies. Thus, we consider it expedient to orient further research in this direction for the analysis of the impact of factors on the level of digitalization of world economies.

6. Conclusion

Because of the analysis of the impact of factors on the level of digitalization of the world's economies, it was found that due to the conditions of intensification of information technology processes, improving the functioning of sectors of the economy is becoming increasingly important. The fourth wave of the industrial revolution in the early 21st century creates a digital space that combines the virtual world with the physical. Information and communication technologies are the driving forces of this evolution. The future of countries depends on how national governments can coordinate business and individuals to work with digital technologies to ensure an appropriate level of digitalization of economies.

To ensure an effective level of digitalization of economies, it is necessary to address issues such as the appropriate infrastructure of the Internet, the regulatory framework in the digital economy, business readiness for the implementation of information and communication technologies. Governments should develop policies that support basic infrastructure development in close collaboration with other stakeholders, promptly implement the universal long-term goals of modern technological development, and manage the adaptation of the information environment to ensure effective digitalization of economies and maximize ICT benefits. Digitalization has become a promising vector for the world economy, but digital development remains an ongoing process rather than an effective solution to the problems of every national economy. National governments must redouble their efforts to create a better and larger infrastructure for the growth of the digital economy.

Thus, ensuring the proper level of digitalization of the world's economies will be achieved through the creation of a system that allows for the improvement and application of the best innovations around the world, where this process remains a key goal of governments. As a result, the implementation of legislation in the digital economy sector is becoming a topic of great interest both for the entities themselves and for the public sector as a whole.

The practical significance of the study is that the theoretical provisions, conclusions, and recommendations developed by the author and proposed in the article can be used to: increase the level of digitalization economies of the world and reduction dependencies the influence of factors on the level of digitalization, etc.

Further research may focus on improving legislation to facilitate the implementation of policies in the digital economy, which will reduce dependencies on the impact of factors on the level of digitalization and improve the economic activity of entities and the current level of the economy. Empowerment and widespread use of innovative, information technology, economic, policy, and research approaches to policy regulation in the digital economy at the interstate level can serve as a basis for future strategies.

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