Abstract. The article examines the features of current trends in the digitalization of the economy of Ukraine and Poland at the national and regional levels. The essence of digitalization of the economy, its relationship with economic growth, the position of the world on the level of development of the digital economy, and its components (Internet access, cyber security, digital competencies of the population, etc.). The positions of Ukraine and Poland in the international ratings of digitalization, innovation, and competitiveness are compared, Ukraine lags behind Poland in places in the respective rankings. The main reasons for this lag have been identified and the possibilities of improving Ukraine’s position through the implementation of state initiatives of strategic and program nature have been substantiated. National and regional differences in providing the population with Internet access in Ukraine and Poland are assessed. Taking into account the current trends in the digital economy in both countries, proposals have been developed for state assistance to intensify the mechanism of accelerated digitalization for Ukraine’s economy, in order to converge digital indicators (distribution and access to broadband Internet, use of European integration opportunities through EU4Digital at the present stage.

Keywords: Digital Economy; Digitalization; Innovation; Competitiveness; Poland; Ukraine; Regions; Digital Transformation

JEL Classifications: O33; O47; O57; L86

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The intensification of globalization processes due to the spread of Internet technologies has contributed to the emergence of new features of the economy, which in recent decades has acquired signs of accelerated digitalization. Digitalization as a phenomenon of economic globalization significantly transforms economic relations at different levels of economic activity: the state, regions, society. In an effort to increase the competitiveness of the digital economy, governments in many countries are adopting appropriate strategies and roadmaps for the future introduction of new technologies into the national economy to gain new competitive advantages. Under the influence of digital technologies, opportunities have emerged for the growing role of regions in the global economic architecture, where information and communication technologies are transforming the economy,
increasing its efficiency, creating new jobs. At the same time, the digitalization of the national economy is a powerful stimulus to the economic growth of states, regions, cities, creating the preconditions for the implementation of the Smart City concept, and so on. These benefits have already been highlighted in the World Bank’s World Development Report (2016) “Digital Dividends” [1], where important conditions for achieving economic growth, new jobs, improving the quality of services, social welfare are recognized as digital (information and telecommunications infrastructure) and non-digital components (regulation, human capital, business climate, and innovation environment).

The focus of scientists and experts is on the digitalization of the state economy as a source and consequence of socio-economic transformation, renewal of information and transport infrastructure, cooperation between government, business and the public. Of particular importance were the measures of accelerated digital transformation with the introduction of quarantine measures caused by the COVID-19 pandemic, which revealed both the readiness and unwillingness of society to operate in the digital environment of a number of domestic businesses, education and science, transport and retail, creative industries and more. The competitiveness of states and regions depends on the vision of their future and the ability to achieve their goals with the help of the latest information technologies, so the growing importance of research on the digitalization of the economy of regions and regions requires a comprehensive analysis of not only advantages but also possible risks and disadvantages. Can the digital transformation of the economy of states and their regions ensure sustainable economic growth, a sufficient level of inclusion, and the achievement of the Millennium Development Goals? In early 2019, the World Economic Forum published the results of a study that confirmed that 84% of Internet of Things (IoT) technologies contribute to the achievement of the UN Global Sustainable Development Goals [2]. The global pandemic COVID-19 acted as an accelerator of digitalization, and in the report of the World Economic Forum as potential risks in 2021 named digital inequality (Digital inequality) and the concentration of digital power (Digital power concentration) [3]. Therefore, the study of the state and trends of digitalization of the Polish and Ukrainian economies is important not only for comparative analysis and study and exchange of best practices, but also for accelerated integration into the European digital space, Ukraine’s compliance with the Association Agreement with the EU (Appendix XVII-3), including in terms of providing access to broadband Internet, e-commerce and information services. Poland’s geographical proximity to Ukraine contributes to the implementation of a number of cross-border projects, including in the field of digitalization, establishing contacts and opportunities for cooperation and developing a common policy of digital transformation of the economy. Given the later start of Ukraine and its regions in the digitalization of the economy, the development of a unified state policy of digitalization by the Ministry of Digital Transformation of Ukraine (2019) there is a problem of digitalization lag behind the nearest neighbouring countries that are members of the EU. Poland has a long experience in shaping the digitalization policy, which can be useful for Ukraine and will contribute to deeper European integration.

Thus, the scientific hypotheses of the study are:

· identification of the connection between the processes of digitalization and innovation of the economy, digital transformation and competitiveness of the world;
· carrying out a comparative analysis of the digitalization of the economy of Ukraine and Poland in order to determine the prospects for improving digitalization measures at the state and regional levels;
· outlining the possibility of cooperation in the field of digitalization of the economy between Poland and Ukraine in the context of integration into the EU Digital Single Market, development of measures to reduce digital inequality and digital inclusion through cooperation in cyber security, IT, and state regulation of digitalization in the new EU program «Digital Europe»(2021), which aims to increase the competitiveness of the economy through the introduction of key technologies and digital services and Ukraine’s commitment to digitalization under the Cooperation Agreement with the EU, as well as Ukraine’s participation in «EU4Digital: Supporting the Digital Economy and societies in the Eastern Partnership».

2. Brief Literature Review

Digitization of the economy of states and regions are in the field of scientific interests and research of well-known foreign and domestic scientists: M. Castells (1989) [4] (revealed the features of the information society, the impact of information technology on the economy); R. Hicks (2016) [5] (clarified the meaning of the concept of «digitalization» as a basic term of the digital economy);

The research of Polish scientists evaluates the digital transformation of the economy of Poland and its regions: J. Gajewski, W. Paprocki, J. Pieriegud, B. Mazur (2016) [10] (the processes of digitalization of the socio-economic system of Poland from the standpoint of opportunities and challenges for the infrastructural sectors of the economy are revealed); M. Grewiński (2018) [11] (studied the phenomenon of digitalization as a social innovation, which consists not only in the introduction of digital technologies but also in the search for new ideas and social values, including solutions in the field of social economy); M. Afonasova, E. Panfilova, M. Galichkina, B. Ślusarczyk (2019) [12] (cross-country comparisons were made by positions in the ratings of the digital economy and society on the example of individual EU countries, Poland and Russia); P. Arak, A. Bobinski (2016) [13] (studied the preconditions for accelerating the digitalization of the Polish economy).

Ukrainian researchers L. Fedulova and S. Davymuk (2018) [14] studied topical issues of institutional support for digitalization of Ukraine’s economy, features of coordination of strategic development goals, the role of regions as flagships of innovation in the digital transformation of the economy. M. Kulynych (2019) [15] revealed the essence of the digital economy in its relationship with the traditional economy, the peculiarities of formation in modern society. Despite the sufficient number of theoretical and empirical studies of digitalization of the economy, the comparative analysis of the practical implementation of digitalization of the economy of Ukraine and other countries, including Poland, is given insufficient attention. This article is devoted to solving the problematic issues of the digitalization of Ukraine’s economy, which stand in the way of its entry into the EU digital single market and the use of opportunities for Polish-Ukrainian cooperation.

3. Purpose

Based on the numerous priorities of digitalization of the Ukrainian and Polish economies in the context of deepening European integration, the article aims to determine the relationship between the digital economy and increase competitiveness, a comparative analysis of key indicators of digitalization in international rankings of both countries for the development of measures to accelerate the digitalization of economies at the level of individual regions in order to eliminate digital inequality.

4. Results

According to the definition of the World Bank, the concept of the digital economy is considered as a system of economic, social, and cultural relations based on the use of digital information and communication technologies [1].

Based on the analyzed scientific literature on the content of the category «digitalization», we believe that it should be understood as the process of the widespread introduction of the latest network technologies (blockchain, cloud computing, big data, Internet of Things, artificial intelligence), which can generate new species and forms of production of information and content, to ensure changes in the activities of traditional economic activities in terms of promoting goods and services, the formation of new economic models of behaviour of producers and consumers, increasing productivity, quality, transparency of socio-economic processes. Note that the digitalization of the economy is carried out in close connection with the digitalization of society, which widely produces and uses digital technologies for various needs: work, study, rehabilitation, financial operations, recreation, and implementation of public communication functions, communication with authorities and more.
International ratings of the development of the information environment, IT sector, innovation, globalization of the world allow us to reveal both the potential and dynamics of their development. The assessment of the positions of Ukraine and Poland in the international rankings will outline the directions of increasing competitive advantages in the globalized economy of the digitalization stage. To make such an assessment, we will use international indices that reflect the digital transformation of the structure of the economy and society. The use of the above ratings in the practical work of government agencies will allow assessing the effectiveness of measures aimed at achieving the goals of digital transformation of the economy and to determine the next steps based on these ratings. We analyzed the positions of Ukraine and Poland in ten international rankings on digitalization, innovation, and competitiveness of the economy, which indicate a widespread lag in Ukraine’s performance from Poland (Table 1).

For Ukraine, the highest places in the analyzed rankings were 41\textsuperscript{st} and 49\textsuperscript{th} position in the Global Innovation Index, 2021 and Global Connectedness Index, 2020, i.e. it is in the top 50 countries, only 10 and 9 positions behind Poland, although during 2019-2021. Ukraine lowered its rating in the Global Innovation Index by two positions (in terms of increase by three countries analyzed).

The composite results of the digitization development indices analyzed by us showed a high correlation with the economic result indicators: the level of global competitiveness, global innovation, etc. Correlation analysis indicated the existence of a close relationship ($R^2 = 0.834$, Figure 1).

The level of global innovation from the level of development of digital evolution (as part of the Digital Intelligence Index, which is a research initiative of the Fletcher School at Tufts University and Mastercard (The Fletcher School at Tufts University and Mastercard).

Table 1:

<table>
<thead>
<tr>
<th>International Development Index</th>
<th>Ukraine</th>
<th>Poland</th>
<th>Leader</th>
<th>Outsider</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Global Innovation Index, 2021</td>
<td>49</td>
<td>40</td>
<td>Switzerland</td>
<td>132 Angola</td>
</tr>
<tr>
<td>2 The Global Competitiveness Index, 2019</td>
<td>85</td>
<td>37</td>
<td>Singapore</td>
<td>141 Chad</td>
</tr>
<tr>
<td>3 IMD World Competitiveness Ranking, 2021</td>
<td>54</td>
<td>47</td>
<td>Switzerland</td>
<td>64 Venezuela</td>
</tr>
<tr>
<td>4 Digital Evolution Index, 2021</td>
<td>62</td>
<td>34</td>
<td>Singapore</td>
<td>90 Ethiopia</td>
</tr>
<tr>
<td>5 E-Government-Survey Index, 2020</td>
<td>69</td>
<td>24</td>
<td>Denmark</td>
<td>193 South Sudan</td>
</tr>
<tr>
<td>6 Digital Economy and Society Index (DESI), 2020</td>
<td>No data</td>
<td>23</td>
<td>Finland</td>
<td>28 Bulgaria</td>
</tr>
<tr>
<td>7 Networked-Readiness Index, 2020</td>
<td>64</td>
<td>33</td>
<td>Sweden</td>
<td>134 Chad</td>
</tr>
<tr>
<td>8 Global Cybersecurity Index, 2020</td>
<td>78</td>
<td>30</td>
<td>USA</td>
<td>182 Yemen</td>
</tr>
<tr>
<td>9 Global Knowledge Index, 2020</td>
<td>56</td>
<td>38</td>
<td>Switzerland</td>
<td>138 Chad</td>
</tr>
<tr>
<td>10 Global Connectedness Index, 2020</td>
<td>41</td>
<td>51</td>
<td>Netherlands</td>
<td>169 Burundi</td>
</tr>
</tbody>
</table>

Source: Compiled according to the data [16-25]

Figure 1:

**Dependence of the data of the Global Innovation Index on the level of the state of digital evolution**

Source: Compiled according to the data [16; 19]
As can be seen from Figure 1, Poland is ahead of Ukraine in terms of the correlation between the indicators of both indices. An important long-term task for Ukraine is to stimulate the growth of opportunities for digital evolution in the components of the index (supply conditions, demand conditions, institutional environment, innovations and changes).

Correlation analysis of the Network Readiness Index and the Global Competitiveness Index also showed a high relationship between them ($R^2 = 0.928$, Figure 2), which proves the importance of increasing the competitiveness of the network as a basis for digitization and digital transformation.

![Figure 2: Dependence between the Network Readiness Index and the Global Competitiveness Index](image)

Ukraine’s lag behind Poland shows unrealized potential as innovative development, part of which are network technologies and innovations, as well as low development of information and communication network, on the improvement of which the Government of Ukraine is actively working with EU partners, one of the strategic goals until 2024 is providing 95% of the population, social facilities, and major highways with high-speed Internet coverage [26].

State support and stimulation of digitalization development, in particular in the implementation of e-government provisions, is of great importance. Thus, as a result of the correlation analysis between the indicators of the E-Government Development Index and the World Competitiveness Rating, the average level of closeness of the relationship was revealed ($R^2 = 0.484$, Figure 3).

Ukraine also lags behind Poland and most of its western neighbors, confirming the need for additional efforts to improve the level of e-government, communication between residents and the authorities, and facilitating public access to learning digital competencies. Assessment of digital skills of Ukrainians according to a 2019 study, which was based on the methodology of the European Commission’s digital skills for calculating the Digital Economy and Society Index (DESI), showed that 53% of the population has a level below the baseline. Moreover, the share of the rural population with a level below the base was 58.6%, and among the urban - 40.5% [27, p.17-18].

These are quite low compared to the level of digital skills, for example, in Poland 65% of the population has a level above the average, compared to 47% in Ukraine. Therefore, the strategic priorities of the Ministry of Digital Policy of Ukraine until 2024 include the involvement of 6 million Ukrainians in the program of digital skills development [26], which is only a third of those people, the level of digital literacy is below average.

It should be noted that the COVID-19 pandemic has made adjustments to the need for accelerated training of digital skills of the population, as due to quarantine measures and restrictions...
on access to the public, financial, educational institutions, most people were deprived of access. For the most part, this situation has had two consequences: on the one hand, the level of digital skills of those taught at home has increased, and on the other hand, digital exclusion (withdrawal) has increased among single pensioners and residents of remote villages with poor Internet and mobile connection coverage. As a result of expert consultations and borrowing of EU best practices in 2021, the Ministry of Digital Transformation of Ukraine developed a «Digital Competence Framework for Citizens of Ukraine», which is adapted to the requirements of the digital competence model for citizens DigComp 2.1: The Digital Competence Framework for Citizens [28].

It should be noted that Ukraine has one of the lowest levels of access to public services online in Europe, in 2020 only 12.5% of Ukrainians used online services to receive public services. Nevertheless, the indicator of access to public services online in Ukraine shows significant dynamics: from 2019 to 2020, the number of citizens who use the Internet to interact with government agencies has increased 4-5 times. This was due to the launch of the digital application «Action», which has already been used by about 5 million people. As of 2020, only 46 out of about 1,000 types of public services were available online, and by 2024 it is planned to transfer 100% of public services for citizens and businesses to the online environment [26].

The results of assessing the level of dependence of the Global Competitiveness Index and the Digital Economy and Society Index (DESI), published in 2020 according to 2019 data, showed a close relationship between them ($R^2 = 0.631$, Figure 4).

According to the Index of Digital Economy and Society (which consists of five components: accessibility of communication; human capital; use of the Internet; introduction of digital technologies in business; digital public services for the population) in 2019, Poland ranked 23rd among 28 EU member states, rising during 2017-2019 by two positions. The DESI index brings together the main aggregates of the current state of digital policy in the EU and allows analysis of the level of digitalization of member countries. Based on this Index, in 2018 the International Index of Digital Economy and Society (I-DESI) was developed to track progress in the digitalization of the EU and 15 leading countries (including Russia from the post-Soviet space). So far, Ukraine is not included in the calculation of the International Digital Economy and Society Index (I-DESI), although the Ministry of Digital Transformation of Ukraine has declared in the Concept for the development of digital competencies until 2025 [26] in the medium term to increase Ukraine’s position in such...
international rankings as the Global Competitiveness Index (World Economic Forum) on the indicator «Digital skills among the active population» and the introduction of data on Ukraine to the calculation of the International Index of Digital Economy and Society (DESI).

The lack of statistical data on Ukraine in the International Index of Digital Economy and Society is due to the methodology of its calculation and low statistical provision of indicators of digital transformation of the domestic economy. In Ukraine, data are collected on only 13 of the 82 indicators of the DESI Index. With the support of the EU Commission and the Eastern Partnership Statistical Survey Project in 2018, the State Statistics Service of Ukraine was provided with a number of recommendations to improve the accounting and collection of statistical information for the calculation of the Digital Economy and Society Index. It will not be difficult to implement these recommendations with a certain modernization of accounting, as it collects more data related to the I-DESI index than it officially publishes [29, p. 16].

Improving the statistical support for the development of Ukraine’s digital economy and including them in the calculation of the International Index of Digital Economy and Society (I-DESI) (which is methodologically based on the calculation of the DESI index) concerns the following provisions:

• approval by the government of the list of indicators for the calculation of DESI by the State Statistics Service of Ukraine and coordination of activities with the Ministry of Digital Transformation of Ukraine;

• improving the activities of the EU4Digital program to support the digital society, exchange experiences between partner countries and EU countries, encourage interaction and participation in joint projects;

• establishing cooperation with the General Directorate of Statistics of Poland on the collection, analysis, and processing of statistical data on questionnaires on the development of the digital economy, etc.

The results of the analysis of the level of development of Internet access in Ukraine and Poland showed that the level of Internet penetration in Ukraine in 2020 was 70%, which is lower than in Poland - 87% (Figure 5). However, in terms of the growth rate of the share of Internet users, Ukraine was ahead of Poland during 2000-2020: the share of Internet users in Ukraine increased 98 times, and in Poland - 12 times.

The distribution of the number of Internet users in Ukraine by region is very uneven, which is explained by the level of coverage of the territory by the relevant infrastructure and the number of solvent Internet users, as well as the demand for them (Figure 6). In absolute terms, the number of Internet users is led by the city of Kyiv and Odessa region, which account for a total of 11% of all users in the regions of Ukraine, of which 7% are the capitals of Ukraine [31]. For 8 months of 2019, the largest increase in users (almost four times) was observed in Ivano-Frankivsk region.

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Figure 5:
Dynamics of shares of individual Internet users, growth rates of the share of Internet users in Ukraine and Poland, in % to the previous year (right scale)
Source: Compiled according to the data [30]

Figure 6:
Dynamics of regional distribution of Internet users in Ukraine\(^1\) as of April 2019 and January 2020, thousand people

Note: \(^1\) - Excluding the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol, and part of the temporarily occupied territories in Donetsk and Luhansk regions.

Source: Compiled according to the data [31]
Instead, households that had access to the Internet differ not only in the regions of Ukraine but also in their location in urban and rural settlements (Figure 7). In terms of share, urban households with Internet access predominate over rural ones, and the gap at the national level between urban and rural areas was 20% at the beginning of 2020.

The COVID-19 pandemic has made significant adjustments to the accelerated connection of households to the Internet. Thus, according to the Ukrainian regulator - the National Commission for State Regulation of Communications and Informatization (NCCIR) in 2020 increased the number of connections to the fixed Internet, especially in rural areas, where the number of lines (points) increased by 36.5%, and the total number reached 7.8 million lines (points) of fixed access to the Internet [33, p.3].

Adoption in 2020 of the Law of Ukraine «On Electronic Communications» contributed to the shift towards the dynamic development of the digital industry, integration into the domestic market of the EU, and meet the current needs of society in the use of digital products, etc. in the information field [33, p.7].

According to a study of the population’s access to broadband, conducted by the Ministry of Digital Transformation, more than 17,000 settlements in Ukraine, out of a total of 29.7 thousand, do not have fiber-optic networks at all, and about 65% of rural settlements are not covered high-quality Internet connection, and 5.75 million citizens of Ukraine do not have the opportunity to connect to high-quality fixed Internet. Therefore, it is necessary to promote the development of Internet access, especially in rural areas, because it is thanks to high-quality telecommunications infrastructure that progress in the digitalization of the economy and society is possible. As a result, one of the main directions of digitalization of the state should be the development of digital infrastructure and bridging the digital divide at the intraregional level.

Regarding the distribution of Internet users by Polish voivodeships, there is a more uniform distribution and increase in the number of subscribers in almost all voivodeships in 2020 (except Wielkopolske, Lower Silesia, Pomerania, Podkarpackie, Świętokrzyskie, Lubuskie, and Opole) (Figure 8).

The leaders in the number of Internet users among the regions of Poland during the analyzed period were Mazowieckie, Silesia, Greater Poland Voivodeship, Warsaw Capital Region (after the NUTS 2016 reform). Outsiders were Opole, Lubuskie, West Pomeranian, Podlasie.
Świętokrzyskie voivodeships (Figure 9). Lublin and Podkarpackie voivodeships bordering Ukraine have the highest number of Internet users, which is explained not only by a better-developed infrastructure but also by better statistical accounting of information and telecommunications activities in contrast to Ukraine.

In 2020, the Warsaw Capital Region, Mazowieckie, Greater Poland, West Pomerania, and Warmian-Masurian voivodeships were in the lead in terms of the share of households with Internet access, with a mark of over 90% of Internet access. Instead, the Mazowieckie Regional (excluding Warsaw), Łódz, Lublin, Lubuskie, and Podlaskie regions have indicators below this level. For Poland, the digital divide in 2020 between urban and rural settlements was only about 1% (the share of regular Internet users in cities was 90% and in rural areas - 89%).

Therefore, taking into account the current trends of the digital economy in Ukraine and Poland, emphasis should be placed on further state assistance in intensifying the mechanism of accelerated digitalization for the Ukrainian economy, in order to converge digital indicators: dissemination and access to broadband Internet) at the national and regional levels, the use of European
integration opportunities through the implementation of the EU4Digital program in the framework of the Eastern Partnership policy.

5. Conclusions

Thus, the results of the analysis of the state of economic development of the world according to international rankings showed a significant-close relationship and the impact of digitalization on economic growth and the level of its innovation. The predominance of Poland’s indicators over Ukraine’s in the context of digitalization of the economy and society indicates the need to take effective measures to accelerate the digital transformation of Ukraine’s economy and increase its capacity to fight for digital dividends and integration into the EU digital single market. The EU4Digital program within the framework of the Eastern Partnership policy supports the digitalization of Ukraine. At the same time, cross-border projects and Poland’s experience for Ukraine in improving the information and telecommunication infrastructure of regions, increasing the digital literacy of the population, and protecting their personal data could significantly help Ukrainian regions towards European integration and lowering digital barriers between urban and rural areas. Further cooperation between Ukraine and Poland is also considered in terms of improving the statistical support of digitalization of the economy, exchange of experience in the implementation of information and telecommunications technologies by entrepreneurs, national and regional authorities.

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