

# ANALYSIS OF DIGITAL TRANSFORMATION IN UKRAINE

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**Abstract.** *This article analyzes the main indicators of the digital transformation of the management of the national economy of Ukraine in order to identify the strengths and weaknesses of the country's network readiness and assess the demand and supply in IT, the level of involvement of economic stakeholders in digital technologies, and the prospects for the digital economy and its impact on the achievement of sustainable development goals. The principles of the relationship between electronic business and the population are developed.*

*The paper considers the main tasks of digital transformation. Its advantages and risks are revealed both for the country as a whole and at the level of individual companies and industries. A brief overview of the digital transformation in Ukraine is given, involving: the banking and financial sector, the service and industry sectors, and the social sphere. The share of services and social sectors is predicted to grow by more than 20%.*

*For the effectiveness of decision-making, an analysis of the problems of digitalization of the economy of Ukraine at the micro and macro levels was carried out. A grouping of indicators for evaluating the effectiveness of digital transformation was conducted, which makes it possible to comprehensively assess the scale of economic transformation in order to develop proposals for digital support of key national socioeconomic processes. Due to its implementation, the main factors and indicators of the development of the digital economy of Ukraine were identified. To analyze the indicators of the digital transformation of the national economy of Ukraine, the following were chosen as the information base: global connectivity, IT maturity, indicators of investment and innovation activity, and the relationship between GDP and digital transformation. Among the indicators of connectivity for end users, the level of services of telecom operators received the highest ratings. E-government scores, the number of users accessing the Internet, the cost of broadband, and cybersecurity awareness were above average. At the same time, all of these indicators, except for the cost of broadband access, had a positive trend. A set of measures are proposed to restore and develop the economy in areas of specialization.*

**Keywords:** *digitalization, digital economy, transformation, digitalization.*

## Introduction

The spread and constant updating of digital technologies significantly changes ways of life and the behavior of economic entities, and necessitates the improvement of business processes and the emergence of new business models. Experts, scientists and politicians are widely discussing these changes. At the same time, it is expedient to be aware of actual transformations, their gradual nature, and the essential properties which make up the basis of their effective activity. The aim of the work is to analyze the main indicators of digital transformation of Ukraine and develop actions to improve the innovative state of the country.

General scientific methods are used in the research, in particular: generalizations, comparisons, methods of theoretical and empirical research, analysis and synthesis, deduction, expert evaluation, and statistical analysis.

## Main part

The use of the digital economy for the country is becoming a daily norm. Today, such areas of life as medicine, security, education, transport, ecology, and tourism cannot be imagined without the use of information and communication technologies. Therefore, the question constantly arises regarding the expansion of methodological research approaches to the development of the digital economy. The speed of technological change determines the pace

of analysis of the impact of digital technologies on economic processes. There has been a significant amount of in-depth research in recent years.

The COVID-19 pandemic significantly accelerated digitization processes, creating not only new needs and opportunities, but also new dependencies and problems. In modern conditions, the urgent need is not only for a theoretical understanding of the threats or opportunities posed by digital technologies, but also to determine the speed of effective transformation of business processes, which will optimize transformation costs.

Competitive advantages and innovations in the digital world are based on accurate analysis and understanding the vast array of data that is constantly being created. In order to use big data knowledge and act on it in real time, it is important for business analysts to become the most sought-after professionals in the next decade of the 21st century – from startups to large corporations.

The system of state bodies, as a key element of the mechanism for managing the development of the national economy, consists of legislative and executive bodies. The only state legislative body in Ukraine is the Verkhovna Rada. On August 29, 2019, the Verkhovna Rada Committee on Digital Transformation was established, the main tasks of which are the drafting of law and the preparation and preliminary considerations of issues, as well as the implementation of control functions for the digitalization of society in Ukraine.

The legislative basis for the process of digitalization of the national economy currently consists of 16 laws, 15 bills, 5 international documents (conventions, declarations, directives), the resolutions of the Verkhovna Rada and the Cabinet of Ministers, and orders of Ministries.

The purpose of digital transformation is to change the logic of companies' processes and transition to risk-oriented management based on the introduction of digital technologies and big data analysis. Big data refers to very large data sets that can be mathematically analyzed to identify patterns, trends, and correlations, especially with respect to human behavior and interaction.

The tasks of the digital transformation are:

1. Ensuring the adaptability of the company to new tasks and challenges.
2. Improving the reliability of electricity supply to consumers.
3. Improving the efficiency of the enterprise.
4. Increasing the availability of electricity grid infrastructure.
5. Developing human resources and new competencies.
6. Diversifying the enterprise's business with the help of additional services.

The high speed of digitalization in all aspects of life is due primarily to its possible positive manifestations and consequences at all levels.

The benefits at the level of the whole society are:

- economic and social effects of digital technologies for business and society;
- improving the quality of life, primarily by improving the satisfaction of specific preexisting and new needs of people;
- increasing the productivity of all social labor by increasing it at the level of individual industries and enterprises;
- the emergence of new models and forms of business that can increase profitability and competitiveness;
- increasing the transparency of economic transactions and ensuring the possibility of their monitoring;
- ensuring the availability and promotion of goods and services, both public and commercial, at the global scale;
- the emergence of human-replaceable control systems, for example, for enterprises of certain classes.

Advantages at the level of individual companies and industries include:

- getting rid of intermediaries. Digitization allows manufacturers to arrange on their websites the sale of their products or services and reach out to potential customers. Consumers get the opportunity to independently choose the goods and services offered on the servers of airlines, hotels, e-shops, etc.;
- cost optimization, which involves, above all, reducing the cost of information retrieval, identification and measurement of transaction costs; the costs of promoting goods and services; and the costs of concluding and conducting negotiations, etc.;
- acceleration of all business processes, including by reducing the time of communications;
- reduction of reaction time to market changes, reduction of terms of development of products and services and their introduction on the market;
- better understanding of customers and improving the quality of products and services;
- creation of new products and services, increasing the flexibility of the offered products and their high adaptability to the new expectations or needs of the consumer.

The technological advantages due to digitalization include:

- information sharing and lack of competition in the consumption of knowledge and information, as the use of a database or knowledge base by one consumer does not prevent its simultaneous use by other consumers;
- accumulation of large amounts of data and their automatic processing and analysis;
- synchronization of information flows, the possibility of point-by-point distribution of data throughout the business and, as a consequence, the ability to track a large number of chains between suppliers and consumers, as well as conducting intellectual and point analysis;
- not just mastering new technologies at the applied level, but the transition to an awareness of the potential of new innovations, to create new innovative products focused on the development of technological intelligence (for example, data management technologies);
- transition from paper to electronic documents (sick leaves, employment records, etc.).

The tangible consumer and employee benefits are:

- reduction in the cost of payments and the emergence of new sources of income;
- the cost of Internet services is much lower than in the traditional economy (mainly due to reduced marketing costs), which makes services more accessible (both commercial and public), and goods and services become available anywhere in the world to any buyer;
- goods and services take into account the consumer preferences and needs of customers;
- the range of information, educational and entertainment services is significantly expanding, the level of provision and speed of which are also increasing (Ukrainian Institute of the Future, 2018).

However, not everything is so optimistic. The digital economy carries with it corresponding risks (OECD, 2017). For privacy, these risks are:

1. The penetration of third-party IT technologies in all aspects of life and activity significantly limits our privacy and increases its vulnerability.
2. There is a real threat to national cybersecurity: finance, transport and energy infrastructure, economic management, social engineering and modeling.

The risks to society are:

1. This significantly increases the number of people who lose their jobs due to the robotization of firms and companies.
2. Poverty and human resources. A significant proportion of people are more likely to be unable to cope with modern work due to their unpreparedness.
3. Children's access to personal computers from an early age leads to the formation of machine thinking (instantaneous, mathematical-linear, fragmentary, superficial) to the detriment of systemic thinking (multifaceted, holistic, philosophical, complex). The disappearance of the latter from our lives causes problems regarding the optimal resolution of everyday

contradictions. The development of driving innovative ideas requires non-trivial mental capabilities.

4. In the absence of economic need, the individual decreases and then disappears altogether.

5. The child loses qualities such as imagination, replaced by a false version – a man-made reality on which modern culture and art are based.

For spirituality and moral climate, these risks include:

1. The connection with the real world will soon be broken. The current computer generation is interested in almost nothing but modern gadgets. Over time, people become locked only in communication with artificial intelligence. Through this, they build communication with others.

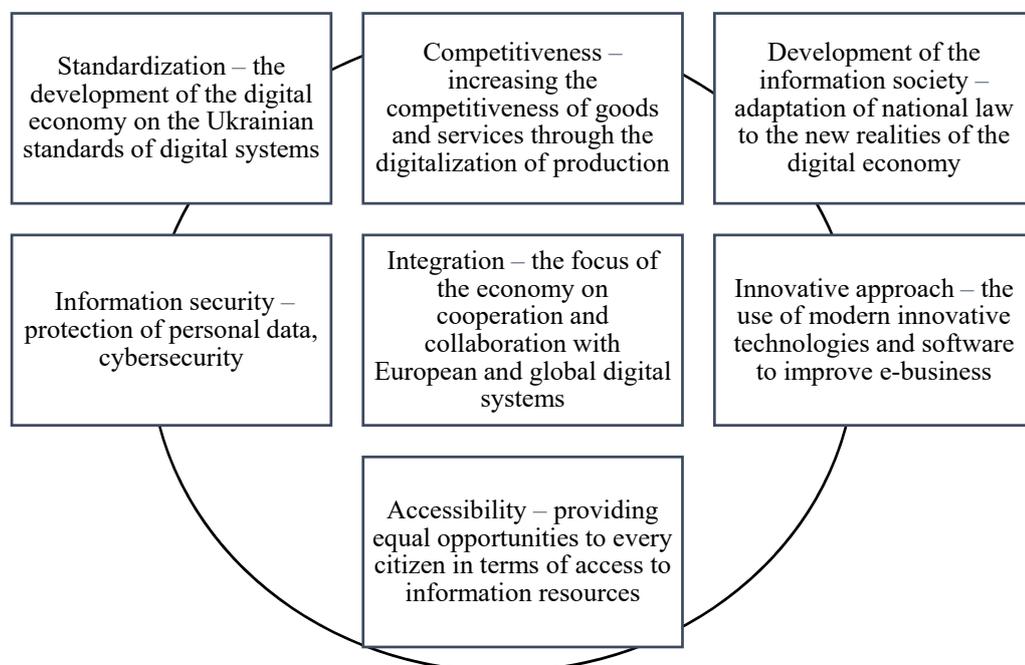
2. The machine has no feelings, such as morality. Given that morality is a purely sensual concept, it disappears along with human emotions. The ability to empathize – the main goal and criterion of personal development – disappears completely.

There are also macroeconomic threats posed by digitalization. Slow productivity growth will threaten progress in improving global living standards, the viability of social protection systems, and the ability of economic policies to respond to future shocks (Pisarenko et al., 2019). However, according to World Bank experts, pessimism about global prospects is felt not because of the development of digital technologies, but against it. Thus, the world is experiencing a trend of declining global productivity, increasing global inequality, and the crisis of global governance.

In the field of IT, there is a decrease in the number of patents issued annually.

Despite this, digital technologies in the economy continue to develop and expand the scope of their use (Delo.ua, 2019). The digital economy has very bright prospects.

The development of Ukraine's digital economy requires new types of relationships between e-business and the population, which should be based on the basic principles of formation and development of these processes (Figure 1).



**Figure 1. The principles of the digitalization of Ukraine's economy**

*Source: Author's own development*

The growth of data and new tools for their analysis have allowed the world to move from situational to integrated digital transformation.

Global spending on digital transformation in 2020 amounted to \$1.3 trillion, according to the Worldwide Digital Transformation Guide (IDC, n.d.). According to calculations in Statista (2022), in 2022 these costs will amount to \$1.78 trillion – and in 2024, to \$2.39 trillion. This shows that the whole world has chosen a rapid vector for the development of digital technologies, and the COVID-19 pandemic was the impetus for this. It is pertinent to consider a brief overview of the digital transformations of Ukraine.

*Digitalization of banks.* Over the last few years, the banking system has undergone major changes. The advantage of providing digital services and exceptional interaction with customers were caused by the restructuring of the financial market, including the development of cryptocurrency, bitcoin and blockchain. The main directions of the modern banking system in terms of digitalization are:

- Digital transformation of bank transfers. This process becomes automated – now, customers do not need bank staff to make a transaction.
- Rethinking the banking business model. A good example is the use of blockchain technology, which reduces fraud in the banking sector. This is already used in transactions such as payments, direct investment transfers, trade and production management, mortgage, credit reports, etc.

*Cloud technologies in the banking sector.* Thanks to the provision of network access, banks have many new opportunities, including cooperation with partners for the development of digital products and optimization of business processes.

*Digitalization of the financial market.* Experts from PwC, a consulting and auditing company, believe that the digitization of the financial market is caused by two factors:

- Complete adaptation of generation C to the digital environment. Consumers are constantly ready to share their personal experiences and impressions on social networks.
- The emergence of new economic benefits. Digitalization has shifted capital to social networks and websites.

Financial and accounting calculations require highly qualified IT specialists who will be able to optimize business processes. Now, more and more financial companies are investing in digital technology to increase the efficiency of their operations, as well as make extra profit.

*Digitalization of the market.* The IT solutions segment dominates and is expected to reach \$798.44 billion in 2025 in the USA. This trend can be explained by the rapid development of new technologies.

In the coming years, we will see an increase in the share of services by 19.5%. Regarding the analytics segment, there is growing demand due to the synthesis of large amounts of data and an increase in the number of devices and applications with built-in artificial intelligence.

The sphere of social networks will be the fastest-growing, with an increase of more than 20.6%. This is due to the promotion of a social networking platform that helps companies identify their target audience and understand their behavior when purchasing goods or services. Experts expect the professional services segment to grow by 19.9% over the next 7 years. The increase in the number of digital technologies stimulates the demand for higher education programs to train the existing workforce, which is successfully adapting to new technologies. The healthcare sector will achieve the highest growth – 19.5% – due to increased demand for electronic devices with built-in artificial intelligence and the ability to monitor the general condition of the patient online.

The share of small and medium-sized businesses will increase by 20.1% by 2025. Phenomenal growth can be explained by factors such as lower device costs and increased attention to cloud and peripheral computing.

The economic effect of the digitalization of industry can be multifaceted, and can involve both the digitalization of technological processes and ways of organizing production and the

digitalization of means of labor (equipment, devices, machines) with the best quality characteristics.

Analysis shows that digitalization has almost no effect on Ukrainian industry, which is showing a tendency to rapidly reduce its pace of development. For Ukraine, the critical problem is the technological backwardness and the preservation of this backwardness. Ukraine not only failed to make a technological breakthrough in this regard in recent years, but also lost its position.

It is important to note that the concept of digitalization of the economy in Ukraine is fundamentally different from what is currently happening in the world. In Ukraine, the concept of digitalization is focused exclusively on creating new types of services based on the collection and analysis of data from various physical objects (buildings and structures, vehicles, industrial equipment, etc.), and does not cover the issue of radical change in the production system. Nor does it concern approaches to the design, production, marketing and operation of these physical objects, which is enshrined in the concept of Industry 4.0.

It should be noted that according to experts, Ukrainian industrialists understand Industry 4.0 mainly as the purchase of imported equipment that is relatively modern and, preferably, inexpensive. This is the end of their vision of modernization. It is estimated that the key problem is low business culture. The choice of contractors in Ukrainian companies is often carried out on the basis of the cost of the proposed solution, while nobody pays attention to the criterion of quality (Grigorenko & Yurchak, 2019). However, Industry 4.0 technologies involve the full digital integration of the enterprise vertically and horizontally, the creation of more smart products and services, and the transition to new business models.

Analysis of the implementation of the concept of Industry 4.0 allowed us to identify the common problems that hinder the development of digital trends in Ukraine and the transformation of the Ukrainian economy into a digital form (Table 1).

In 2019, 782 enterprises carried out innovative activities in industry. At the same time, the share of the number of industrial enterprises that implemented innovations (products and/or technological processes) in the total number of industrial enterprises was 13.8%.

Of the total number of innovative enterprises, the following areas were targeted for innovation: internal and external research – 24.4%; purchase of machinery, equipment and software – 64.7%; acquisition of external knowledge – 4.5%; other works – 20.6%. By types of economic activity, the largest shares of innovative enterprises were involved in the production of food products – 16.8% – and most innovation concerned the production of machinery and equipment. Enterprises not included in other groups accounted for 10.2% of innovation.

In 2019, companies spent 14,220.90 million UAH on innovations, including: 10,185.11 million UAH for the purchase of machinery, equipment and software; 2,918.85 million UAH for internal and external research and development; 37.49 million UAH for other external knowledge (acquisition of new technologies); and 1,079.45 million UAH for other works related to the creation and implementation of innovations (other costs). The share of expenditures on the purchase of machinery, equipment and software compared to 2018 increased from 68.1% to 71.6%. At the same time, the share of expenditures on research and development (R&D) decreased from 26.3% in 2018 to 20.5% in 2019, and on the acquisition of other external knowledge from 0.4% to 0.3%. The share of other expenses also increased, including for marketing and advertising – from 5.2% to 7.6% (State Statistics Service of Ukraine, <http://www.ukrstat.gov.ua/>).

The share of innovative products sold in the volume of industry in 2019 was 1.3%.

*Digitalization of education.* The field of education is also undergoing irreversible changes. The most important trend now is to receive additional education. Bitkom, Germany's digital association, conducted a survey in which three out of four respondents complained that they did not have enough time in the workplace to gain additional knowledge. This is due to the rapid development of information technology. Therefore, in such an era, it is important to be

constantly capable of learning, and employees need to be able to combine the individual components of information, approach problems creatively, and respond quickly to requirements.

**Table 1. Problems of the digitalization of Ukraine's economy**

*Source: structured by the author on the basis of Ukrainian Institute of the Future (2018); Grigorenko & Yurchak (2019); World Economic Forum (2019); The World Bank (n.d.)*

Direction	Essence
<b>Macro level</b>	
Institutional	<ul style="list-style-type: none"> <li>- Low involvement of government agencies in the implementation of the Concept of Digital Economy and Society</li> <li>- Inconsistency of relevant legislation with global challenges and opportunities</li> <li>- Inconsistency of national, regional, sectoral strategies and development programs with digital opportunities</li> </ul>
Infrastructural	<ul style="list-style-type: none"> <li>- Low level of coverage of the country's territory by digital infrastructures</li> <li>- Lack of separate digital infrastructures</li> <li>- Unequal access of citizens to digital technologies and new opportunities (digital divide)</li> </ul>
Ecosystem	<ul style="list-style-type: none"> <li>- Weak state policy on incentives for the development of innovative economy</li> <li>- Immature investment capital market</li> <li>- Outdated education system and teaching methods, lack of focus on STEM education, soft skills and entrepreneurial skills, imperfect models of technology transfer and consolidation of knowledge and skills</li> </ul>
State	<ul style="list-style-type: none"> <li>- Low level of automation and digitalization of public services due to weak motivation of government agencies</li> </ul>
<b>Micro level</b>	
Business culture	<ul style="list-style-type: none"> <li>- Most entrepreneurs understand Industry 4.0 mainly as purchasing imported equipment. When purchasing, the fundamental factor is price</li> <li>- Low level of business culture. The choice of contractors in Ukrainian companies is often based on the criterion of cheapness of the proposed solution, while no one pays attention to the criterion of quality</li> </ul>
Production potential	<ul style="list-style-type: none"> <li>- Shortage of highly qualified personnel for the full development of the digital economy and digitalization in general</li> <li>- Outdated and underdeveloped hardware</li> </ul>

The main vectors of educational development are:

- speed – learning keeps up with the times, because the usual accumulation of knowledge has long lost its relevance;
- enthusiasm and motivation are fundamental principles in education, where teachers become coordinators, guiding students online and offline;
- availability of materials in real time, which simplifies the process of acquiring new knowledge;
- interdisciplinary content – a direction that erases the rigid boundaries between industry, business and other areas, so it requires the combination of knowledge from different walks of life.

The digitalization of professions and processes is challenging traditional jobs. This applies to HR professionals, as the digitization of this area reduces workload when hiring and training.

Thanks to new tools, professionals can communicate with candidates through mobile applications, social networks and cloud technologies. For example, before an interview, a person fills out an electronic form. Thus, the employer promptly receives and processes information. Digitization refers to the following stages of employment and training: video presentations; passing tests instead of interviews; training through special portals. At the same time, digitalization has affected not only the field of HR. Experts predict that in 5–10 years, digitalization will affect professions such as: IT specialists; virtual reality architects; developers

of big data models; appraisers of intellectual property; virtual lawyers; the designers of smart homes, etc.

In future, it will not matter whether one is a virtual lawyer or a developer of big data models – lifelong learning will be mandatory, and a change of profession 8–12 times will be considered the norm.

*Digitalization of society.* Digitalization has begun to dictate new principles in all areas of our lives, from the banking system to health care. Society itself is no exception. Some scientists suggest that the role of people in the future will be insignificant, and it will be replaced by machine work. However, this is not true: in the digital economy, power is in the hands of the individual. Companies promote their products and services on the Internet and social networks, and to do this they need to understand the interests and behavior of their target audience.

Users originally showed low interest in fixed broadband Internet access and the use of cloud technologies. The percentage of households that had a computer, laptop, or tablet (except smartphones) at home corresponded to a fairly mediocre level, but the penetration rates of smartphones and mobile broadband Internet access showed a significant increase and reached the target level. Thus, the growth of demand took place, but insignificantly or in several directions.

To analyze the indicators of the digital transformation of the national economy of Ukraine as an information base, we chose the Global Connectivity Index (GCI). This also enabled us to assess indicators of investment in IT, IT maturity and indicators of digital economy of Ukraine and indicators of innovative economic development. According to the Global Innovation Scoreboard, the relationship between GDP and digital transformation was also analyzed.

**Table 2. An assessment of connectivity for end users and organizations of Ukraine according to the Global Connectivity Index (GCI) during 2016–2019**

*Source: Author's own development*

Indexes	Years				
	2016	2017	2018	2019	2020
Level of services provided by telecom operators (based on survey)	9	9	9	9	9
EGovernment Services (UN Review)	5	7	7	7	7
Number of people who have access to the Internet at least once a year via wired or mobile access, in % of the total population	5	6	6	7	7
The cost of a monthly subscription to the tariff plan for fixed broadband access (minimum 5 GB, speed 256 kbps), in % of the average monthly income per person	8	8	7	7	7
Cybersecurity awareness (according to expert estimates)	4	6	6	7	7
Price of monthly subscription for mobile broadband access, in % to average monthly gross national income per capita	6	7	6	7	7
Broadband download speed (based on relevant test data)	3	3	3	4	4
The total cost of analytical software for analyzing the IoT, per person	1	1	1	2	2
The amount of available data that can be used by the artificial intelligence platform per person	1	1	1	1	1

Among the indicators of connectivity for end users and organizations of Ukraine, the level of services of telecom operators received the highest marks (Table 2). The performance of e-government, the number of users who had access to the Internet, the cost of broadband access, and the level of awareness of cybersecurity were above average. At the same time, all these indicators, except for the cost of broadband access, had a positive trend.

The cost of a monthly subscription for mobile broadband corresponded to the average level, but was characterized by divergent dynamics. Broadband speeds, investment by cloud service providers, total cost of analytics software for analyzing the Internet of Things (IoT), and data

creation for artificial intelligence were low and unsatisfactory. Thus, the same trend is observed as for demand: high rates for mobile communications, medium rates for Internet access, and low rates for IoT and artificial intelligence.

The Network Readiness Index reflects the innovation and technological potential of the world, as well as opportunities for their development in the field of high technology and digital economy (Table 3), based on four factors.

1. Access to technology and Internet infrastructure. This level reflects the availability of digital infrastructures, their quality and focus on new technologies (IoT, artificial intelligence, etc.). Here, Ukraine ranked 62nd place out of 134.

2. Use of technologies by citizens, business and the state. The next step is the use of digital technologies by citizens to increase productivity, achieve certain social and commercial goals. Here, Ukraine ranked 65th place out of 134.

3. Regulation and management of technology. This level is responsible for assessing the state's capacity to regulate and increase confidence in digital technologies. Here, Ukraine ranked 58th place out of 134.

4. The impact of technology on the economy and quality of life. This level determines the extent to which existing digital technologies affect the daily lives of citizens, their quality of life, and doing business. Here, Ukraine ranked 79th place out of 134 (Ukrainian Institute of the Future, 2018).

Analyzing the data in Table 3, we can say that the most popular and recognizable in the modern world is the Global Innovation Index (GII), as the number of mentions when querying Google search sites on the Internet is 457 million units. The second most popular is the Digital Adoption Index (DAI) – 191 million mentions. Our countries are not represented in the Digital Evolution Index (DEI) and the Digital Economy and Society Index (DESI), so we omit them according to the methodology described above.

**Table 3. The most popular indicators of digitization by the number of mentions in the Google search engine**

*Source: Author's own development*

Index name	Popularity of the index (number of mentions when making queries on Google search sites on the Internet), thousand units	Representation of Ukraine	Period of representation of Ukraine (from what year)
Digital Economy and Society Index (DESI)	107,000	-	-
Digital Evolution Index (DEI)	173,000	-	-
Digital Adoption Index (DAI)	191,000	+	Since 2014
IT Development Index (IDI)	70,700	+	Since 2002
Global Innovation Index (GII)	457,000	+	Since 2007
Networked Readiness Index (NRI)	897	+	Since 2002
Economic Digitization Index (Boston Consulting Group – eIntensity)	7,990	+	Since 2011
IMD World Digital Competitiveness Index (WDCI)	16,600	+	Since 2014

The Global Innovation Index (GII) is a global study by the INSEAD International Business School, Cornell University (USA) and the World Intellectual Property Organization. The study analyzes the level of innovation in institutions, education, infrastructure and business (via 82 different variables) on the basis of which the corresponding rating is formed (Rudenko, 2021). In 2020, Ukraine ranked 45th in the overall ranking of the Global Innovation Index 2020 and scored 37.4 points out of 100.

Some individual components of the rating were as follows:

- education – 23rd place (+20 places);
- R&D – 44th place (+10 places);

- creation of knowledge (patents and inventions) – 23rd place (–6 places), according to the registration of utility models we are ranked number 1;
- political and operational stability – 123 place (+2 places);
- government efficiency – 93rd place (+2 places);
- rule of law – 109th place (–2 places);
- regulatory policy – 88th place (+6 places);
- ease of starting a business – 52 place (–4 places).

We also considered other elements of digital transformations:

1. Big data is important, and involves a set of methods and means of processing structured and unstructured different types of data in real time in order to analyze them and use them to make appropriate decisions in different segments. These segments include:

- Smart energy. The introduction of smart grids allows city services to analyze electricity consumption in real time. Using data analytics, they can predict consumption peaks and plan energy distribution accordingly.
- Public transport. Transport infrastructure uses big data to ensure fast and safe travel in the city. The city authorities receive data on traffic, which allows them to effectively manage the transport system. Usually the city's smart transport system consists of an intelligent transport network.
- City infrastructure management. Big data helps control and manage issues such as waste disposal, transportation and resource savings. To do this, sensors are built into the city's physical infrastructure. In order to transform the infrastructure into a smart technical base consisting of a network of sensors and connected devices that collect data, smart applications are installed that process data, translating it into notifications and actions.
- City security. Real-time crime mapping programs use data analysis to identify patterns of crime and problem areas by predicting the number of crimes. This allows the police to increase security in the necessary areas (Westmore, 2013).

Big data has both advantages and disadvantages. Effective use of large amounts of data can accelerate decision-making in many areas, resulting in improving citizens' lives and enabling companies and governments to provide the necessary services in real time. Among the positive effects are simplification and better efficiency of various services for citizens, the ability to obtain data for advanced developments, making more necessary decisions for different businesses in real time, saving money, and the emergence of new types of work. Negative consequences include distrust of the data itself (inability to verify its accuracy) and accountability, as well as concerns about maintaining the confidentiality of private data.

In contrast to this approach, the world's leading industrialized nations (USA, Germany, Italy, Japan, China) do not consider services based on the analysis of big data as an independent and self-sufficient sphere of economic activity. Under the digital economy, they understand the processes of creating and using unified production and service (or product and service, PSS) systems (OECD, n.d.). Outside of such a system, a service component without a physical product, even if it is based on the most advanced technologies such as neural networks and the IoT, will not have a significant economic effect and cannot be fully monetized.

In addition, according to PwC (Imena.ua, 2017), the IT products industry is difficult to assess due to the existence in Ukraine of mostly quasi-product companies. That is, when the company's headquarters and market are abroad, but all production is in Ukraine. As for the hardware, it remains underdeveloped and consists mainly of the production of components for the equipment of previous generations.

2. Cloud computing is the digital technology most used by companies. The latter are increasingly investing in cloud computing services, such as financial and accounting software and customer relationship management software.

3. Artificial intelligence is a combination of technologies that is already radically changing the world. AI is used in various fields and makes it possible to assess the quality of work of workers, look for the causes of defects in products, replace manual labor with automated, and generate new knowledge that helps to make quick decisions.

4. As for robotics, it is multidisciplinary. This affects many professions, from agriculture and industrial production to services and retail.

5. Another common technology is 3D printing, or additive manufacturing – the process of creating a physical object by layer-by-layer printing on a digital drawing in 3D. This is a technology that can reduce the cost of building new infrastructure (housing and offices) and can extend to large-scale infrastructure projects.

6. Blockchain (distributed registry) technology has become popular in recent years, allowing users to create and share unique digital records without the need for a centralized trusted party. Using a smart combination of cryptography and peer-to-peer networks, blockchain ensures transparent and accurate storage and dissemination of information among groups of people, ensures the security and tracking of each transaction, and protects against fraud.

7. Drones combine three technologies: IoT through built-in sensors that collect information and transmit it over the Internet for analysis; advanced battery technology (allows drones to work); and cognitive computing (allows drones to operate autonomously).

It is also necessary to note the direct link between GDP and digital transformation of the state. The amount of expenditures for the implementation of R&D (access to information resources) of Ukraine from all sources in 2020 amounted to 17,022.42 million UAH. The knowledge intensity of GDP is steadily declining – from 0.70% in 2013, to a critical value of 0.41% in 2020 (Figure 2). At such values, science ceases to perform an economic function. According to experts, with a science intensity of less than 0.9% of GDP, science performs only a cognitive function.

The share of expenditures for scientific and technical work in GDP in 2019 was 0.43%.

According to experts, the use of digitalization in Ukraine in the period up to 2030 will contribute to GDP growth of more than 8 times (up to \$1 trillion), which will affect the wellbeing and quality of life of citizens below the European average (Ukrainian Institute of the Future, 2018).

Another indicator of the impact of scientific and technological progress on the economic development of countries is aggregate factor productivity (AFP). Economic growth can be promoted either by increasing the cost of labor and capital used in production, or by increasing the efficiency of resource use (the growth of AFP).

In general, over the last 20 years (except for the crises of 2009, 2014–2015, 2020), the AFP in Ukraine has grown at a high average annual rate of 10.3%. In all crisis years, the AFP fell at an average annual rate of 22.4%, because companies were trying to survive, rather than invest in improving resource efficiency.

The main factors that contributed to the reduction of the AFP in Ukraine in 2020 were, first of all, political factors and the crisis caused by the COVID-19 pandemic, namely:

- slowdown in business activity as a result of the elections of the President and the Verkhovna Rada of Ukraine in 2019, which is typical for Ukraine during all presidential elections;
- reduction of sales in the high-tech sector by industrial enterprises and the share of gross value added in the volume of output of this sector.

The following factors also had a negative impact:

- declining nature of funding for research – from 0.55% of GDP in 2015 to 0.41% of GDP in 2020. SFP, according to OECD research, directly depends on the volume of spending on science and innovation relative to GDP, especially in the business spending sector;

- a significant share of the transfer of results of scientific research and technology without registration of intellectual property rights, which significantly reduces the cost of scientific activities.

Based on the relationship between GDP and digitalization, it is proposed to measure the effectiveness of digital transformation in this direction by estimating the share of value added by the IT sector in GDP, GDP itself, high-tech and net IT exports, the share of new products for consumers, productivity growth, robotics industrial production, etc. In addition, this index also includes indicators that reflect a wide range of social consequences of digital transformation, including those that assess the level of economic inclusion (Pizhuk, 2020). In particular, the latter include indicators of employment and the percentage of IT professionals, gender gap in Internet users, income inequality, etc. (Table 4).

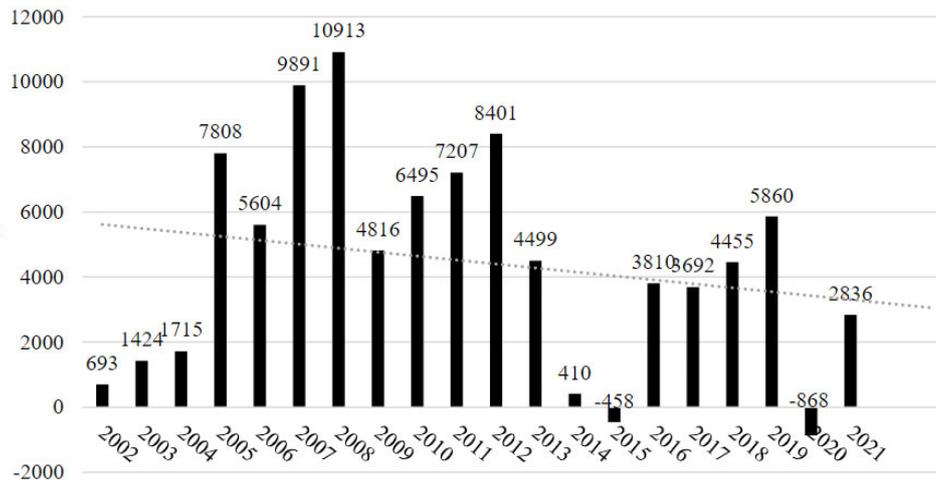
All indices analyzed in the paper allow us to comprehensively assess the scale of digital transformation of Ukraine's economy in order to develop proposals for the digital tracking of key national socioeconomic processes and to save on the unproductive resources of entities, institutions and governments, and to outline management process as an element of generating social value.

**Table 4. Grouping of indicators of the efficiency of the digital transformation of the economy for definition**

*Source: Author's own development*

No.	Groups of indicators	Indexes
1	Share of value added of the IT sector in GDP	The method of calculating GDP by expenditure (sum of final consumption, capital expenditures, government expenditures and net exports related to IT) was used
2	The share of e-commerce in GDP	% of total GDP
3	Development of e-commerce	1. Penetration of e-commerce (%) 2. Share of online buyers (%) 3. Growing e-commerce turnover
4	The share of the IT workforce	% of the total number of employees
5	Net IT exports	Amount of net exports of ICT-related equipment and services and net exports of cross-border e-trade
6	High-tech exports	% of total exports of industrial goods
7	Increasing labor productivity	GDP growth per capita (according to The Conference Board Total Economy Database)
8	Employment rate	Ratio (percentage) of the number of employed persons to the number of unemployed persons registered with the state employment service during a certain period
9	IT specialists	% of those employed in the economy
10	Internet access in schools	% of schools with Internet access for pedagogical purposes
11	Income inequality	Gini Index
12	The presence of a gender gap among Internet users	The difference between the female and male population in the use of the Internet

During the 30 years of Ukraine's independence, one of the priorities of its economic policy has been to attract long-term foreign investment, as well as intensifying activities to promote them. Note that Ukraine has investment-attractive factors that contribute to the expansion of its investment ties, namely: large and competitively unrestricted domestic market; geographical location at the intersection of major transport routes between Europe and Asia; cheap and at the same time skilled labor; high scientific potential, etc.



**Figure 2. Receipt of foreign direct investment in the economy of Ukraine for the 2002–2021 period (first half), million \$**

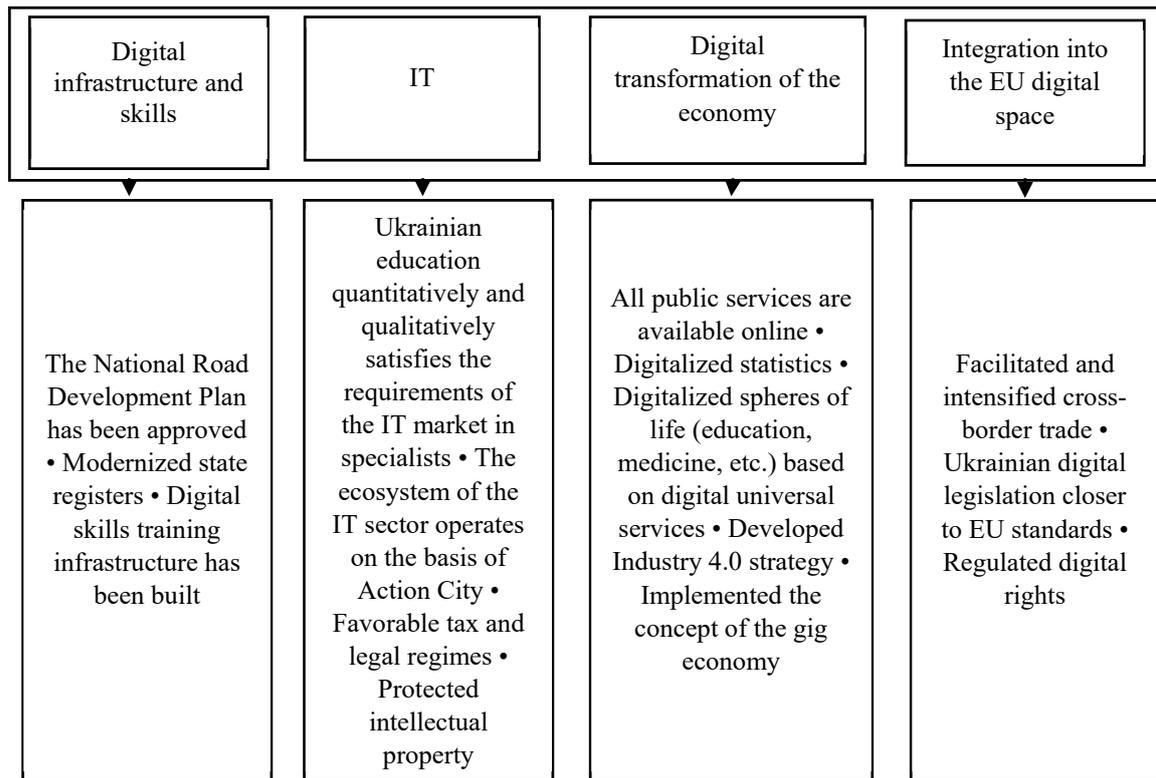
*Source: based on OECD (2021)*

The degree of investment attractiveness is an important indicator of the country's investment climate and the effective socioeconomic development of the state's economy in general, so it is relevant to analyze the annual FDI inflows (Figure 2). The volume of FDI in the economy of Ukraine for the period 2002–2020 reached its maximum. Compared to 2012, in 2019 (before the pandemic) investments decreased from \$8,401.0 million to \$5,680.0 million due to both declining investment activity and an unfavorable investment climate in Ukraine. The structure of Ukraine's foreign direct investment by type of economic activity in 2020 is shown in Figure 2.

Given the need to ensure investment attractiveness in the international market, competitiveness, and the socioeconomic development of Ukraine, the strategic vector of its development is the digitalization of the economy, the conclusion of the Agreement on EU support for e-government and digital economy in Ukraine (Agreement of Financing, 2020), and active digitalization.

To improve the economic condition of Ukraine, a number of measures were proposed (Figure 3) (Ukrainian Institute of the Future, 2018). To improve the situation, it is necessary:

- to increase the volume of investments in scientific and innovative activities, first of all, by the state;
- to promote the transformation of public procurement into a mechanism for supporting innovation and creating demand for innovation;
- to ensure the development of high-tech competitive industries, taking into account the peculiarities of creating added value throughout the innovation chain (from basic science to commercialization, implementation in production and market entry);
- to introduce expanded incentives for the commercialization of the results of scientific and technical activities financed from the state budget and the establishment of closer ties between science and industry;
- to provide institutional and financial support for the development of innovation processes and products, innovation infrastructure, assistance in registration of rights and protection of intellectual property;
- to promote access to foreign markets of goods and services with a high share of gross value added, etc.;
- to closely monitor the impact of new mechanisms on innovation, especially technological SMEs, and gradually introduce additional tools to reach more beneficiaries.



**Figure 3. A set of actions for economic recovery and development in areas of specialization**

*Source: Author's own development*

As a result of the implementation of the proposed actions, improvements in the economic sphere as a whole are expected. Here, we can include:

1. Coverage with new high-speed communication standards. The technological platform of state registers is functioning.
2. A high level of basic and professional digital skills.
3. IT departments have English-language programs and attract students from all over Europe.
4. Ukraine is a European laboratory and a platform for the development of new technologies (FinTech, AgriTech, drones, the IoT, artificial intelligence, digital currencies).
5. Universal digital services are present in key areas of life (education, medicine, etc.).
6. Industries and businesses are being modernized, technological production is being built, and high value-added products are being produced.
7. New industries and new professions create new prospects for economic growth.
8. Digital identification and trust services are harmonized with the EU.
9. Full interoperability of Ukrainian registers.
10. Ethical issues of biotechnology, personal information, and cybertechnology have been settled.

## Conclusions

This study showed that in Ukraine there is a system of state structures regulating the process of digital transformation of national economic management, and the National Strategy for Digital Transformation developed legal, organizational, economic and psychological methods of regulating the digital transformation process. However, there are currently some shortcomings in this activity.

Therefore, in order to restore the economy, which should become more productive, sustainable and inclusive, it is proposed to carry out economic transformation with the use of digital technologies in the following priority areas:

- 1) implementation of strong principles of governance based on long-term forecasting and planning of the country's development, ensuring the strengthening of public confidence in the actions of the government;
- 2) modernization of infrastructure, acceleration of the transition to alternative energy, expansion of access to energy resources and IT;
- 3) transition to more progressive taxation, rethinking the methods of taxation of corporations, wealth, and labor resources at the national level agreed in the framework of international cooperation;
- 4) updating educational programs and increasing investment in mastering the skills needed to create jobs and markets of the future;
- 5) rethinking labor legislation and social protection, taking into account the realities of the needs of the new economy in labor resources;
- 6) expanding the infrastructure of health care facilities, as well as care for the elderly and children, and ensuring access to innovation for the benefit of people and the economy;
- 7) stimulating an increase in the allocation of financial resources for long-term investment in development to strengthen stability and international integration;
- 8) rethinking competition and antitrust law in accordance with the requirements of the fourth industrial revolution, ensuring access to markets at both national and international levels;
- 9) promoting the creation of markets of tomorrow, especially in areas that require the cooperation of public and private sectors;
- 10) stimulating increased investment in research, innovation and inventions that can create new markets of tomorrow;
- 11) encouraging companies to accept diversity, fairness and inclusiveness to increase their creative activity.

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