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Challenges to Ukraine's Innovative Development in a Digital Environment

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Abstract
The purpose of the paper is to analyze the positioning of Ukraine in the global indices of innovative development and competitiveness, to evaluate the indicators of innovation activity and, based on the outcomes of the research, to determine the place of Ukraine in the global innovation space. The dynamics of innovation activity on an international scale based on the consolidated indicators of the Global Innovation Index are presented. Ukraine's position in it and progress in achieving goals to better understand the processes that stimulate or constrain innovation are determined. Econometric methods to generalize the positioning of Ukraine in the global innovation space and the DEA method to study the relative individual effectiveness of the innovation environment and innovation activities in Europe are used.

Keywords
Innovations, Digitalization, Evaluation, Statistical data, Competitiveness, Statistical methodology, GII, DEA.

Introduction

Under current conditions, the constant updating of technologies, increasing knowledge and competencies is a necessity. The struggle for the competitiveness of national economies is exacerbated, as only highly competitive economies are able to provide security, high standards and quality of life for their citizens. According to the innovative theory by J. Schumpeter, overcoming the crisis and economic downturns can be ensured only through innovative development (Schumpeter, 2013).

The Organization for Economic Co-operation and Development (OECD) notes that a reliable assessment of innovation potential is important for the proper development of public policy and emphasizes that current benchmarks do not fully reflect the role it plays in the modern economy (OECD, 2012). Against this background, this study focuses on the analysis of components, which determine the formation of the Global Innovation Index. The hypothesis tested in the paper is that it is not always true that a higher level of innovation determines a stronger economy with greater development potential. The aim here is to measure the effectiveness of innovation management through statistical analysis of a number of observed variables obtained from the Global Innovation Index during 2013–2020. This index provides an annual ranking of the world's largest economies in terms of innovation and their impact on development. The economies included in the index account for 92.8% of the world's population and 97.9% of world GDP.

According to the European Commission, innovation is the application of knowledge to transform an idea into a new or upgraded product, service or manufacturing process. Therefore, it is obvious that innovation is especially important for the development and competitiveness of developing economies (OECD, 2012).

For Ukraine, whose economy has now taken the form of deindustrialization, the intensification of innovation is a necessary, extremely important condition for its further development (Karpenko et al., 2020, Voronenko et al., 2022). Against the background of

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a significant slowdown in global economic growth in 2020, there is a need to study the trends of the Global Innovation Index (GII).

Literature review

Innovation is considered to be the primary driving force of progress and prosperity (Henk et al., 2013). Support for innovation is provided in the development plans of all countries, where innovation policy is formed as a key element of industrial policy. Ukraine, on the other hand, faces problems typical of developing economies, such as poor coordination, high levels of corruption, shortages of skilled human capital, and limited ability of governments to act (Navarro and Olivari, 2016), which reduces the effectiveness of public policy (Klymenko et al., 2019, Voronenko et al., 2021).

The theory of innovation radicalness categorises types of innovations as: incremental and radical (Gupta, 2018).

The innovation can address the challenges that these economies face, such as cleaner production (Kadiyevskyy and Klymenko, 2014; Skrypnyk et al., 2021), overcoming poverty and social insecurity (Starychenko et al., 2021), importing technology and adapting to modernize production, particularly agriculture (Hyk, 2021; Kaminskyi et al., 2021).

Many scientific studies propose various interpretations of innovation. The main ones include a technology incentive model that encompasses the innovation process, starting with science and technology, up to the commercialization of an economically viable product or process (Rothwell, 1994). The emphasis on the role of the market as a source of innovative ideas and a determining factor of research and development later led to the development of a demand model. An alternative interpretation of innovation is a chain model in which different areas based on information and knowledge successfully link the three main areas in the process of technological innovation (research, knowledge and the central chain of technological innovation), which requires interaction between technological capabilities and requirements of the market (Kline and Rosenberg, 1986). Some scholars argue that innovation is driven by industrialization, and is conditioned by the market growth (Tiberius et al., 2021; Ruoslahti, 2020). However, for innovation to have a significant social impact, research efforts must focus on addressing and improving the well-being of the population, a task that should undoubtedly involve both private and public entities (World Bank, 2010).

Innovation involves different processes, depending on whether the country is highly developed or developing (Gil-Alana et al., 2020; Bogliacino et al., 2009). Strategies to encourage innovation in high-income countries often include creating the conditions for factor mobility in markets, open trade and investment. However, emerging economies need to focus on knowledge and infrastructure management, being the strategies able to bridge the gap with developed countries (Ruoslahti, 2020).

Innovation is a creative process encompassing opportunity recognition, developing research design, commercialising, marketing, and distributing it. The need for innovation is more relevant today than ever before. This is due, firstly, to the need to recover economies after the global financial crisis, as innovation can be an effective means to achieve this goal, and secondly, to the changing ways of functioning of the economy and society due to modern technological transformations, especially in ICT – introduction of technologies of artificial intelligence, blockchain, Internet of Things and Industrial Internet of Things, 3-D printing, 5G communication, augmented and virtual reality, etc., which radically change the processes of production, trade and logistics, training and accumulation of knowledge, and the like. Technology transfer is the movement of knowledge or technology from one organization to another, from universities and research institutions to business, where knowledge can be transformed into innovation – new products and services that will benefit society, new forms of work and communication and people's lives on the whole (Rothwell,1994; Granaturov et al., 2015; Granaturov et al., 2016; Pouri and Hilty, 2021).

In fact, the pandemic has not changed much, as breakthrough technologies and innovations retain their potential. Thus, advanced companies in the information technology sector have significant potential, and the accelerated development of digitalization will support innovation. In addition, the crisis caused by COVID-19 can be a catalyst for innovation in many traditional industries, such as tourism, education, trade.

Results and discussion

The digital transformation of Ukraine is a huge investment resource, as it allows freeing up the millions of hours that people spend in queues, paperwork, reconciling registers or certificates, and directing them to economic development. According to experts, the use of digital technologies in business accelerates its development by 2–3 times (Pouri and Hilty, 2021). The

use of digital technologies has a number of advantages. Digitalization is the creation of high added value for the state, increasing the efficiency of the economy and business. All these measures will become a geopolitical advantage of Ukraine (Apostolov, and Coco, 2020; Skrypnyk et al., 2020).

The Concept of Development of the Digital Economy and Society for 2018–2020 was adopted by the Order of the Cabinet of Ministers of Ukraine dated January 17, 18, No. 67-p (CMU, 2018). This document provided for the implementation of measures to introduce appropriate incentives for the digitization of the economy, public and social spheres, awareness of the existing challenges and tools for the development of digital infrastructures, the acquisition of digital competencies by citizens. The main rating goals of the Concept implementation are the achievements in 2020:

- rated 30 in Networked Readiness Index (NRI) (rated 64 in 2016);
- rated 40 in Global Innovation Index (GII) (rated 56 in 2016);
- rated 60 in Global Competitiveness Index (GCI) (rated 85 in 2016).

The results of the study in Figure 1 make it possible to assess the degree of achievement of the relevant indicators.

Judging by the dynamics shown, it can be seen that no level of global indices has been achieved, but the Global Innovation Index (GII) is close to the expected level and if the upward trend of our place in the world ranking continues, Ukraine's position will be strengthened over a short period of time. It is therefore worth analyzing this index in more detail. For positioning in the global space, we compare 10 countries, according to their place in the world by the Global Innovation Index, which approximates the Ukrainian one in 2013 and 2020 (Fig. 2).

The transformations are significant: in 2013 Ukraine was ranked 71th, while in 2020 it is ranked 45th with Romania, Thailand and Greece, next in rank.

Analysis of variables and indicators of the Global Innovation Index

Innovation dynamics require analytical research, which involves the identification of innovation indicators, the analysis itself and the identification of major development trends. There is considerable interest in studying the experience of countries around the world in monitoring innovation indicators, as this process is very dynamic and is influenced by new development trends, namely: globalization, the emergence of the knowledge economy, open innovation.

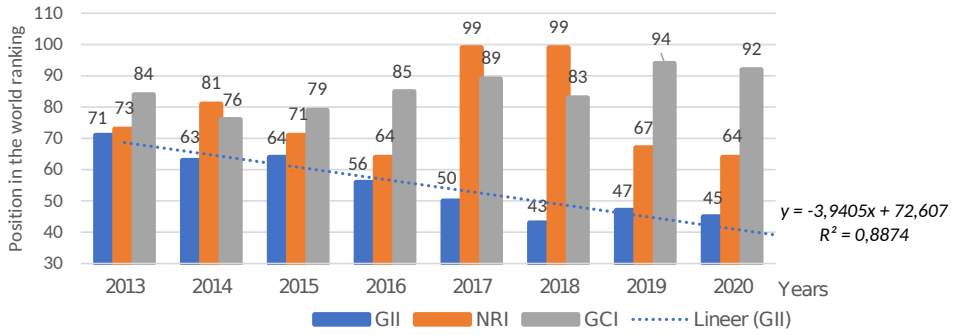


Fig. 1. Dynamics of the main indicators of digitalization of Ukraine's economy

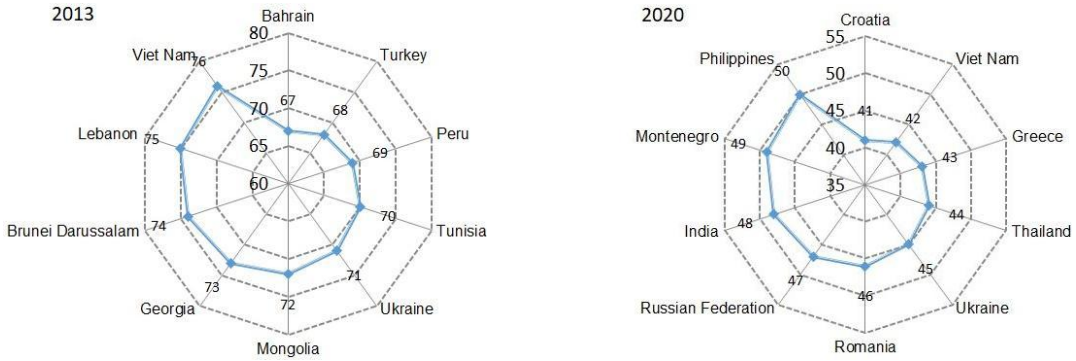


Fig. 2. Ukraine's position in the vicinity of countries with approximate GII

It is determined that an important condition for sustainable economic development of the country and increasing competitiveness is the effective implementation of innovations. Innovation is recognized as a central driver of economic growth and development (Andersson et al., 2021).

The purpose of the Global Innovation Index is to provide in-depth data on innovation and, in turn, to assist economies in assessing their innovation performance and informed thinking on innovation policy.

GII is published jointly by Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO), a specialized agency of the United Nations. In 2020, the GII model includes 131 countries/economies representing 93.5% of the world's population and 97.4% of the world's GDP at purchasing power parity. GII has two sub-indices, the Innovation Input Sub-Index (Input) and the Innovation Output Sub-Index (Output), each of which is built on a series of indicators.

Innovation Input Sub-Index: Five Input criteria include the components of the national economy that support innovation.

Innovation Output Sub-Index: Innovation Output is the result of innovation in the economy. Although the original sub-index includes only two criteria, it has the same weight in calculating total GII scores as the input sub-index.

The total GII score is the average of the input and output sub-indices. With reference to the GII publication for 2020, Switzerland has been in the leading position for 10 consecutive years, followed by Sweden and the United States. The other EU member states in the top 10 are the Netherlands (5th position), Denmark (6th), Finland (7th) and Germany (9th). Among the EU member states with the lowest rating are Romania (46th position), Greece (43rd) and Croatia (41st). In general, the country with the lowest rating is Yemen. Ukraine ranks 45th in the world under the GII rating (Report GII, 2020).

The index comprises 21 indicators, grouped in 7 pillars: 15 input indicators (promoting innovation) and 6 output indicators (resulting from innovation) (Table 1).

The partial concept of input and output sub-indices clearly demonstrates their limitations in determining the innovation performance index. The general index treats input and output elements in the same way, which does not contribute to the understanding of how they are used to obtain the latter, and hence the effectiveness of innovation (Table 2).

Table 1
Composition of the Global Innovation Index (GII), 2020

Type of pillar	Pillar (identifier)	Pillar indicators
Input	Institutions	Political environment, regulatory environment and business environment.
	Human capital and research	Education, tertiary education and research and development (R&D).
	Infrastructure	Information and communication technologies (ICTs), general infrastructure and ecological sustainability.
	Market sophistication	Credit, investment, and trade, competition and market scale.
	Business sophistication	Knowledge workers, innovation linkages and knowledge absorption.
Output	Knowledge and technology	Knowledge creation, knowledge impact and knowledge diffusion.
	Creativity	Intangible assets, creative goods and services and online creativity.

Table 2
Innovation, revenue and efficiency indicators according to the Global Innovation Index (GII) for Ukraine

Years	Global Innovation Index (GII)	Rank (world rankings)	Innovation Performance Index	Ukraine's GDP per capita, US dollars	Capital investments, million USD
2013	35.8	71	0.9	4030.3	8329.1
2014	36.3	63	0.9	3014.6	7314.0
2015	36.5	64	0.9	2115.4	9103.9
2016	35.7	56	0.8	2185.9	11973.9
2017	37.6	50	0.8	2640.3	14948.7
2018	38.5	43	0.9	3095.2	19290.9
2019	37.4	47	0.8	3659.8	20799.3

The study found that the correlation between GDP per capita and the efficiency ratio is 0.17, the correlation between GDP per capita and the overall index is only 0.35 and only the correlation between capital investment and the overall GII index at 79.75% indicates that that there is a strong correlation between the level of income of the population and the level of contributions for innovation (which have a large weight in the overall index). However, the relationship between the efficiency of these resources and the level of wealth in the national economy is weak.

Since it is desirable that performance be measured in such units, this study is geographically limited to European countries as defined by the World Bank. It is assumed that the countries of this group share the economic and social problems associated with the development of innovation potential, regardless of the fact that there are significant differences in income and human development, type of political regime and innovation models of these countries.

Figure 3 shows a radial shape that visualizes the location of European countries by GII, which confirms the significant difference between countries by this indicator.

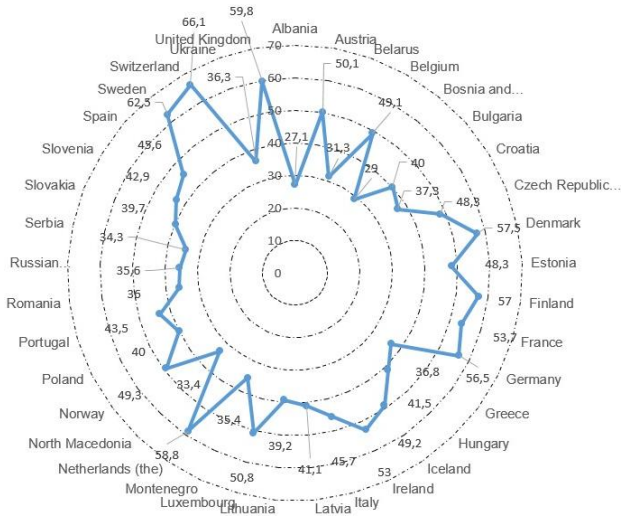


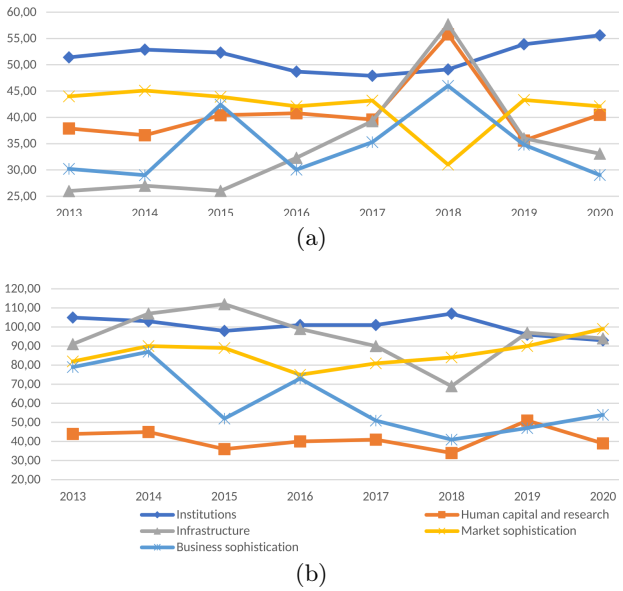
Fig. 3. Positioning of European countries by GII

The highest positions are occupied by Sweden and Switzerland (the first and the second position in the world rankings), the lowest – by Albania (83rd), Bosnia and Herzegovina (74th position in the world rankings). Ukraine ranks 45th in the ranking along with Greece and Romania.

The paper analyses the main components of the sub-indices of the Global Innovation Index, related to the creation and use of environments conducive to innovation in Ukraine.

Innovation Input Sub-index consists of five main areas, covering components of the national economy that promote innovation: Institutions, Human Capital and Research, Infrastructure, Market sophistication and Business sophistication.

Figure 4 analyses the dynamics during 2013–2020 of these components for Ukraine in terms of importance and rank on the global scale.



(a)

(b)

Fig. 4. Dynamics of the components of Innovation Input Sub-index: (a) the value of the indicator, (b) position in the world ranking

Innovation Output Sub-index provides information on the outcomes, which are the results of innovation in the economy. There are two directions of initial data: Knowledge and technology results and Creativity results. Figure 5 analyzes the dynamics of the components of this sub-index for Ukraine by value and the world ranking.

So, the hypothesis about significant differences in the efficiency of input and output indicators in Ukraine has been confirmed. Let us visualize whether a similar property is observed for European countries in Fig. 6.

According to these data, the average evaluation of the results of the innovative output is not only much lower than the input estimate, but there is a noticeable lack of parallel between the spirals that make up the two scores in the selected countries.

According to research, Ukraine has an Input sub-index (40.1), ranking only 71st in the world and 35th in Europe out of 37 countries, which is lower than would be expected in a downward spiral. On the other hand, the level of the Output sub-index (32.5) does

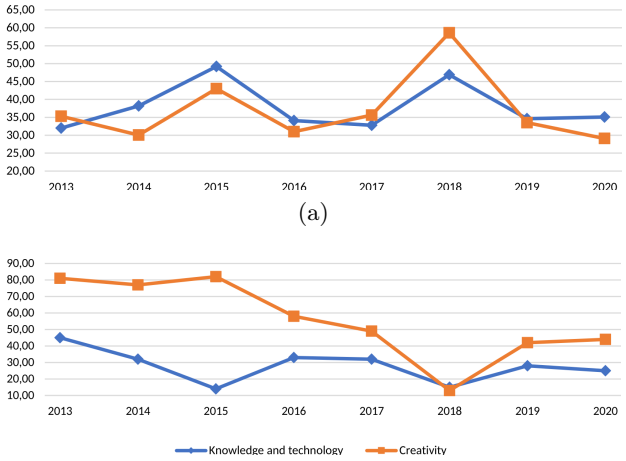


Fig. 5. Dynamics of the components of Innovation Output Sub-index: (a) the value of the indicator, (b) position in the world ranking)

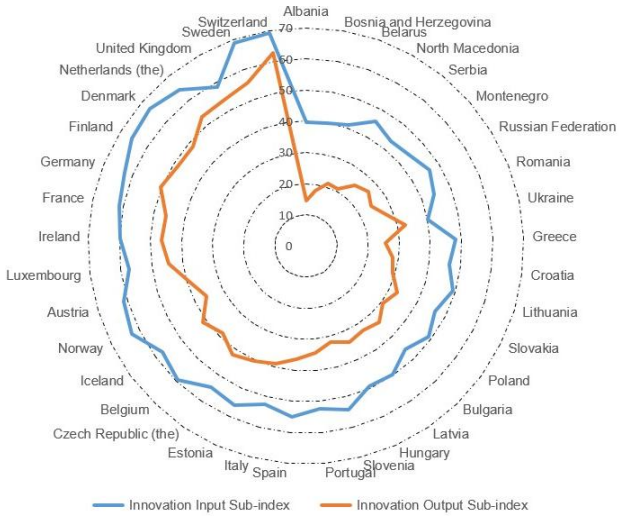


Fig. 6. Radial form of GII sub-indices for the European countries

not correspond to the availability of input resources and allows Ukraine to take the 37th position in the overall ranking and 24th position in Europe, along with Latvia and Slovenia. Therefore, it is advisable to consider the Innovation Efficiency Ratio, according to which Ukraine ranks 2nd in Europe with a ratio of 0.8. The Innovation Efficiency Ratio is the ratio of the Output Sub-index to the Input Sub-index. It shows how much innovation output a given country is getting for its inputs (Fig. 7).

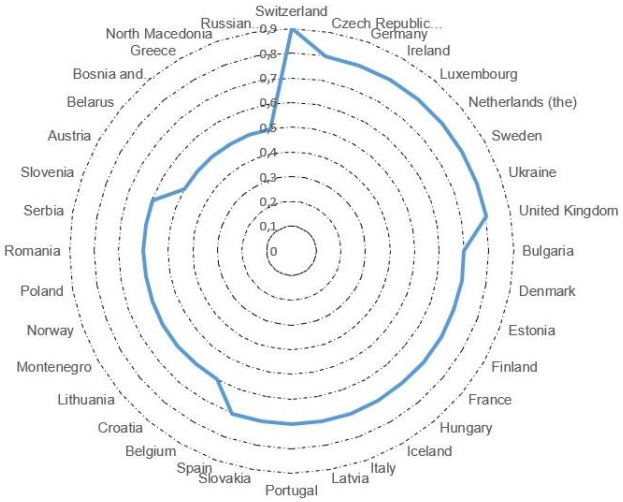


Fig. 7. Evaluation of innovation efficiency ratio for European countries

In addition, significant variability was found in the positions of economies, estimated as the difference between the position they occupy for the performance indicator and their position in the overall index.

Relationship between the GII Output and Input Sub-indices in Ukraine

At first glance, one would expect a positive relationship between the scores of the input and output indicators for the group of countries under study, and this is generally confirmed.

Research shows a close direct relationship between the Global Innovation Index and the Infrastructure Input Sub-Index (0.87) and the Creativity Output Sub-Index (0.71). The constructed regression model (Table 3) will allow predicting the increase of these sub-indices to increase the overall index (GII).

Table 3
Statistical model for estimating the impact of GII sub-indices

Model	R Square	Significance F	P-value of the coefficients
$Y_{GII} = 33.76 + 0.07_{\text{Infrastructure}} + 0.02_{\text{Creativity}}$	0.86	0.0276	$a_0 = 1.88\text{E}{-07}$ $a_{\text{Infrastructure}} = 0.018057$ $a_{\text{Creativity}} = 0.049116$

We will analyze which of the components of the Infrastructure sub-index determines its result in the first place. Correlation coefficients confirm that the greatest impact on the Infrastructure sub-index is 3.1.2. (0.83) 3.1.3. (0.79), 3.3.1 (0.84), and 3.3.3. (0.89), while the Creativity sub-index is primarily impacted by the Intangible assets (0.63) and online creativity factor (0.65).

Studies show a close direct relationship only between the Innovation Input Sub-index and the Infrastructure sub-index (0.68). In contrast to the Innovation Output Sub-index, the Human capital and research components (0.67), Infrastructure (0.71), Market sophistication (0.69), and Creativity (0.83) are closely related.

Data envelopment analysis methodology

The evaluation of the effectiveness of innovation policy is based on the evaluation of the effectiveness of several indicators to find the optimum (Broekel et al., 2018). Data Envelopment Analysis (DEA) is a mathematical programming approach for assessing the relative effectiveness of decision makers (DMU). In 1978, the first DEA model was proposed as a nonlinear fractional model of mathematical programming, known as the CCR model. The target function in this model is considered to be the achievement of the best set of weights for a single weighted input ratio for a specific DMU, defined as DMUo. In this model, along with the performance evaluation, all DMU will be projected to an effective border separately.

Based on this prerequisite, one approach to establishing the level of effectiveness was to compare what the decision-maker did with what he had to do to maximize its impact. However, it is unlikely that full information will be available on the context in which our selected European countries operate and, therefore, on the maximum potential effect of each. Based on the above definition of efficiency, it is important to consider more closely the differences between technical and distributive efficiency. The first is achieved when it is technologically impossible to increase some output or reduce some input due to another (Pareto optimality), while the second means minimizing resource consumption, which is equivalent to choosing the cheapest option among efficient Input/Output combinations. Because this study assumes that countries have asymmetric information and varying degrees of risk, it will focus on technical performance analysis. The DEA method can be used to study the relative individual effectiveness of the behavior of such subjects, starting with the construction of an effective boundary. The DEA data analysis method has two strengths: the degree of standardization and the ability to work with multiple inputs and outputs.

In the traditional context of performance evaluation, data analysis shows that, there is p of input data $(x_1, x_2, \ldots, x_p)$, which are used to obtain q outputs $(y_1, y_2, \ldots, y_q)$ in which n subjects are involved, and technical efficiency can be assessed using the following model:

$$\max_{u_r, v_i} \frac{\hat{A}_{r=1}^{q} u_r y_{r0}}{\hat{A}_{r=1}^{q} u_r y_{r0}} \quad \frac{\sum_{r=1}^{q} u_r y_{rj}}{\sum_{r=1}^{q} u_r y_{rj}} \leq 1 \tag{1}$$

where $j = 1, \ldots, n$, $r = 1, \ldots, q$ and $i = 1, \ldots, p$. Further, $ui, vi \geq e$, where e is a value that is infinitesimally small but greater than zero. The basic idea is to maximize the overall factor performance (the unit of output that is generated per unit of input) for each entity. The index numerator summarizes all outputs in one virtual metric in the same way as in the denominator, where a single virtual input captures all the factors involved in the process. For these units, a set of weights $(u_1, \ldots, u_q; v_1, \ldots, v_p)$, is used, the values of which should be sought so that they maximize the ratios for each unit, keeping the ratios of the others below 1.

In addition to this baseline result, data volume analysis provides additional information such as virtual inputs and outputs, i.e., the contribution of each factor to the estimated efficiency index or levels of inputs and outputs that could make an inefficient unit effective. One of the main advantages of this technique is that it allows you to balance the objective and subjective elements of the studied aspect, making it easier to identify the strengths and weaknesses of each of the subjects being compared.

Evaluation of the effectiveness of innovation based on GII data and the DEA method

The DEA was used to measure and compare performance in sectors, which are considered critical to the national development. However, the method also contains limitations and risks. One of the main disadvantages of the DEA method is the problem of adequate definition of input and output data (in this paper, this definition is based on the external classification of GII). For this analysis, the indicators of 7 inputs

of the input and output sub-indices were used as input, and the indicators of GII, the country's rank in the world ranking and the indicator of innovation efficiency – as output. Regarding the countries that were involved in this model, Ukraine was evaluated on a set of 19 economies, which among European countries are close to the value of GII. The results of the model are shown in Table 4.

The purpose of this study is to assess the effectiveness of creating innovative environments for Ukraine in comparison with European countries. The difference between the maximum possible efficiency value (1) and the observed value reflects the degree of inefficiency. The closer the value is to its maximum, the closer the relevant economy is to the efficiency limit.

Analyzing Ukraine, we see indicators of its inefficiency, so it is worth analyzing the indicators of DEA input. The weakness analysis shows the direction and magnitude of the adjustment needed for the levels of economic performance to make a weak investment economy efficient. Table 5 shows, for example, that Ukraine needs changes in its four input and output indicators to approach the efficiency limit. In particular, improvements (by amount of adjustment) are required by the Institutions (11.17), Infrastructure (0.25), Business sophistication (16.99), and Creative output sub-indices (15.57), which were used as input for the DEA method. Analyzing the entire studied sample of countries for comparison, it can be stated that in most countries the components of the entry subindex Institutions and Business sophistication need significant improvement (these components are indicators of weakness), and the least – Market sophistication and Human capital and research. The sources of the current type of economic growth are innovation, transformation of markets and human capital.

So, the place and role of a person in the information economy, as well as motives for its activity is inevitably transformed in comparison with the industrial economy.

Table 4
Analysis of technical efficiency of innovation

DMU No.	DMU Name	Input-Oriented CRS model Efficiency	Sum of lambdas	RTS	Optimal Lambdas with Benchmarks
1	Belgium	1.00000	1.000	Constant	1.000
2	Bulgaria	0.94967	1.173	Decreasing	0.044
3	Croatia	0.90592	1.060	Decreasing	0.428
4	Czech Republic	1.00000	1.000	Constant	1.000
5	Estonia	1.00000	1.000	Constant	1.000
6	Greece	1.00000	1.000	Constant	1.000
7	Hungary	0.98138	0.980	Increasing	0.415
8	Iceland	1.00000	1.000	Constant	1.000
9	Italy	1.00000	1.000	Constant	1.000
10	Latvia	0.93763	0.991	Increasing	0.192
11	Lithuania	0.92186	0.994	Increasing	0.157
12	Montenegro	0.94037	0.991	Increasing	0.147
13	Poland	1.00000	1.000	Constant	1.000
14	Romania	0.82112	0.993	Increasing	0.378
15	Russian Federation	0.82946	0.983	Increasing	0.403
16	Slovakia	0.84730	1.047	Decreasing	0.242
17	Slovenia	0.95298	0.990	Increasing	0.006
18	Spain	1.00000	1.000	Constant	1.000
19	Ukraine	0.87606	0.979	Increasing	0.249

Table 5
Analysis of input slacks by the DEA method

No DMU	DMU Name	Input Slacks						
		Institutions	Human capital and research	Infrastructure	Market sophistication	Business sophistication	Knowledge and technology outputs	Creative outputs
1	Belgium	–	–	–	–	–	–	–
2	Bulgaria	3.89	9.97	–	–	16.09	2.86	–
3	Croatia	–	2.00	–	–	9.22	6.70	3.11
4	Czech Republic	–	–	–	–	–	–	–
5	Estonia	–	–	–	–	–	–	–
6	Greece	–	–	–	–	–	–	–
7	Hungary	6.09	2.00	5.50	–	7.37	5.81	–
8	Iceland	–	–	–	–	–	–	–
9	Italy	–	–	–	–	–	–	–
10	Latvia	8.08	–	–	3.42	4.95	–	2.14
11	Lithuania	2.49	–	–	0.14	2.05	–	–
12	Montenegro	6.33	–	3.98	–	4.99	–	–
13	Poland	–	–	–	–	–	–	–
14	Romania	–	–	2.01	3.78	1.11	–	5.34
15	Russian Federation	0.28	–	4.26	–	–	1.62	–
16	Slovakia	1.62	–	9.68	–	0.45	–	–
17	Slovenia	20.52	5.31	14.06	–	12.20	–	–
18	Spain	–	–	–	–	–	–	–
19	Ukraine	11.17	–	0.25	–	16.99	–	15.57

Conclusions

The paper summarises the main theoretical approaches of the Global Innovation Index and dynamics of innovation activity assessment, emphasises determining Ukraine's position in it. Based on the study, we can conclude that Ukraine is demonstrating the growing dynamics of innovation. In particular, the paper offers the analysis of the country's positioning on the Global Innovation Index. The authors proved, that the problems of innovative development of Ukraine include: insufficient development of innovation infrastructure: clusters, technology parks, industrial zones; low level of attracting foreign direct investment and technology transfer; insufficient level of funding for applied research and their weak connection with industry, etc.

Ukraine, along with most European countries, is trying to adapt to the constant changes required by the world economy in search of development, thus, innovation has become a key element in this. Using data from the Global Innovation Index 2020 (WEF, 2020), it was possible to assess the effectiveness of the economies of 19 countries in terms of creating an environment conducive to innovation.The study identified key challenges for these countries in managing and using key inputs, regardless of the income levels of these economies. In fact, countries with the highest incomes and the highest GII are not always at the forefront of performance management, confirming that there is only a moderate relationship between these variables.

Although most of the policies and actions undertaken by the countries in the region to promote an innovation environment are consistent with their capabilities and relative advantages in a heterogeneous context, some challenges remain. One them is to strengthen resources that have traditionally performed poorly and, above all, to strategically use the Input / Output ratios that have the most reliable results so as to maximize their impact first on produc-

tivity and then on development. It should be noted that this study is a partial analysis of the performance of the European countries, since due to technical limitations it takes into account only the most representative interrelationships of the phenomenon as indicated in the references. In other words, the authors evaluated only the relationship between input and output indicators, but not the processes and mechanisms associated with them.

The maximum effectiveness of digitalization of the economy can be fully achieved only under the conditions of using innovations as one of the identified factors of successful business operation and economic growth. Directions for further research may be associated with quantification the connection between indicators of competitiveness and innovativeness at the level of countries with the goal establishing the most influential components of innovative development to ensure strong competitive positions.

Regarding the innovative development of Ukraine during the war, the opportunities for it are significantly reduced. This is very difficult, because the Ukrainian economy is experiencing a powerful negative impact as a result of aggression on the part of the Russian Federation, and the "traditional" barriers to innovative development have not gone anywhere.

During the period of martial law, the Ministry of Digital Transformation of Ukraine and the Committee on Digital Transformation of the Verkhovna Rada of Ukraine, together with other executive power bodies and local self-government bodies, are deepening the use of digital technologies to restore the country and implement innovative digital economy projects. A lot of work is being done to join Ukraine to the new EU strategic financing program and to implement modern technological solutions in the economy and society.

References

Andersson J., Hellsmark H. and Sandén B. (2021), The outcomes of directionality: Towards a morphology of sociotechnical systems, *Environmental Innovation and Societal Transitions*, No. 40, pp. 108–131. DOI: 10.1016/j.eist.2021.06.008.

Apostolov M. and Coco N.(2020), Digitalization-Based Innovation – A Case Study Framework. *International Journal of Innovation and Technology Management* 0 0:0, 1-25. DOI: 10.1142/S021987702050025X.

Bogliacino F. and others (2009), *Innovation in Developing Countries: The Evidence from Innovation Surveys, Milan, Bocconi University* http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.455.3127&rep=rep1&type=pdf.

Broekel T., Rogge N. and Brenner T. (2018), The innovation efficiency of German regions – a shared-input DEA approach, *Review of Regional Research*, No. 1, Vol. 38, Springer.

CMU (2018), CONCEPT development of the digital economy and society of Ukraine for 2018–2020 Document 67-2018-đ https://zakon.rada.gov.ua/laws/show/ 67-2018-%D1%80?lang=en#Text.

Gil-Alana L., Škare M. and Claudio-Quiroga G. (2020), Innovation and knowledge as drivers of the 'great decoupling' in China: Using long memory methods, *Journal of Innovation & Knowledge*, Issue 4, Vol. 5, pp. 266–278. DOI: 10.1016/j.jik.2020.08.003.

Granaturov V., Kaptur V. and Politova I. (2015), Determination of tariffs on telecommunication services based on modeling the cost of their providing: methodological and practical aspects of application, *Economic Annals – XXI*, Vol. 147, issue 1–2 (1), pp. 52–56. http://ea21journal.world/index.php/147_1-2-1_2015/

Granaturov V., Kaptur V. and Politova I. (2016), Determination of tariffs for telecommunication services on the cost simulation modeling. *Economic Annals-XXI*, No. 156, pp. 83–87. DOI: 10.21003/EA.V156-0019.

Gupta M. (2018), The innovation process from an idea to a final product: a review of the literature, *International Journal of Comparative Management*, No. 4, Vol. 1, pp. 400–421.

Henk W. Volberda, Frans A.J., Van Den Bosch, Cornelis V. Heij (2013), Management Innovation: Management as Fertile Ground for Innovation, *European Management Review*, Issue 1, Vol. 10, pp. 1–15. DOI: 10.1111/emre.12007.

Hyk V. (2021), Optimization of costs for innovations of industrial enterprises Western Ukraine in ensuring sustainable environmental development, *E3S Web Conf.*, 234, 00049. DOI: 10.1051/e3sconf/202123400049.

Kadiyevskyy V.A. and Klymenko N.A. (2014), Systemic vision of ecological and economic interaction of land-use factors in modern agrosphere, *Actual Problems of Economics*, No. 2, Vol. 152, pp. 313–320.

Kaminskyi A.B., Nehrey, M.V. and Zomchak L.M. (2021), COVID-19: crisis or new opportunities time for the agricultural sector of Ukraine, *IOP Conference Series: Earth and Environmental Science*, No. 1, Vol. 628, p. 012030.

Karpenko L., Zhylinska O., Dmytrenko H., Poprozman N.V. and Koltun V.(2020), Synergetic management tools for enterprise economic security, *Journal of Security and Sustainability Issues*, No. 4, Vol. 9, pp. 1421–1430.

Kline S. and N. Rosenberg (1986), *An overview of innovation, The Positive Sum Strategy: Harnessing Technology for Economic Growth*, Washington, D.C., The National Academies Press.

Klymenko N., Nosovets O., Sokolenko L., Hryshchenko O. and Pisochenko T. (2019), Off-balance accounting in the modern information system of an enterprise, *Academy of Accounting and Financial Studies Journal*, No. 23. http://repo.snau.edu.ua/handle/123456789/7167.

Navarro J.C. and J. Olivari (2016), *La política de innovación en América Latina y el Caribe: nuevos caminos*, Washington, D.C., Inter-American Development Bank (IDB).

OECD (Organization for Economic Cooperation and Development) (2012), *Innovation for Development: A Discussion of the Issues and an Overview of Work of the OECD Directorate for Science, Technology and Industry*, Paris, OECD Publishing.

Pouri Maria J. and Hilty Lorenz M. (2021), The digital sharing economy: A confluence of technical and social sharing, *Environmental Innovation and Societal Transitions*, No. 38, pp. 127–139. DOI: 10.1016/j.eist.2020.12.003.

Report GII 2020 Cornell University, INSEAD, WIPO (2020), *The Global Innovation Index 2020: Who Will Finance Innovation?*, available at: https://www.globalinnovationindex.org.

Rothwell R. (1994), Towards the fifth-generation innovation process, *International Marketing Review*, No. 1, Vol. 11, Bingley, Emerald Publishing.

Ruoslahti H.(2020), Complexity in project co-creation of knowledge for innovation, *Journal of Innovation & Knowledge*, Issue 4, Vol, 5, pp. 228–235. DOI: 10.1016/j.jik.2019.12.004.

Schumpeter J. (2013), *Economic Theory and Entrepreneurial History*. Explorations in Enterprise, edited by Hugh G.J. Aitken, Cambridge, MA and London, England: Harvard University Press, pp. 45–64. DOI: 10.4159/harvard.9780674594470.c5.

Skrypnyk A., Zhemoyda O., Klymenko N., Galaieva L., and Koval T.(2021), Econometric Analysis of the Impact of Climate Change on the Sustainability of Agricultural Production in Ukraine, *Journal of Ecological Engineering*, No.22, Vol. 3, pp. 275–288.

Skrypnyk A., Klimenko N. and Kostenko I. (2020), The formation of digital competence for the population as a way to economic growth Information, *Technologies and Learning Tools*, No. 4, Vol. 7, pp. 278–297. DOI: 10.33407/itlt.v78i4.2948

Starychenko Y., Skrypnyk A., Babenko V., Klymenko N. and Tuzhyk K. (2021), Food security indices in Ukraine: Forecast methods and trends, *Estudios de Economia Aplicada*, No. 4, Vol. 38.

Tiberius V., Schwarzer H., Roig-Dobón S. (2021), Radical innovations: Between established knowledge and future research opportunities, *Journal of Innovation & Knowledge*, No. 3, Vol. 6, pp. 145–153. DOI: 10.1016/j.jik.2020.09.001.

Voronenko I., Klymenko N. and Nahorna O. (2022), Priority areas of Ukraine's innovative potential in the conditions of digital transformation, *Financial and Credit Activity Problems of Theory and Practice*, No.1, Vol. 42, pp. 313–321. DOI: 10.55643/fcaptp.1.42.2022.3684.

Voronenko I., Nehrey M., Kostenko S., Panchyshyn A. and Lashchyk I. (2021), Advertising Strategy Management in Internet Marketing, *Journal of Information Technology Management*, Special Issue, pp. 35–47.

WEF (2020), *Global Competitiveness Report Special Edition 2020: How Countries are Performing on the Road to Recovery*. https://www.weforum.org/reports/the-global-competitiveness-report-2020.

World Bank (2010), *Innovation Policy: A Guide for Developing Countries*, Washington, D.C.