“The influence of innovative development in the EU countries and Ukraine on the competitiveness of national economies: A comparative analysis”

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THE INFLUENCE OF INNOVATIVE DEVELOPMENT IN THE EU COUNTRIES AND UKRAINE ON THE COMPETITIVENESS OF NATIONAL ECONOMIES: A COMPARATIVE ANALYSIS

Abstract

Russian aggression adversely affected the economy of Ukraine and emphasized the need to adapt the best practices of EU countries to determine steps to restore the country's competitiveness. This study aims to determine the influence of the innovative development of countries on their competitiveness and identify prospects for Ukraine's post-war economic recovery. The study constructed neural networks to assess the relationships between the factors of innovative development and the competitiveness of the EU countries and Ukraine. Six main factors of innovative development of countries are identified: "innovations in business (S1)," "intellectual property (S2)", "innovations in industry (S3)," "eco-innovations (S4)," "innovation management (S5)," and "digital innovations (S5)." Groups of factors are determined by the strength of influence (strong, moderate, or weak). For Ukraine, S1 and S6 have a strong effect (33.3%), S5 shows moderate (16.7%), S2, S3, and S4 show weak effects (50%). For EU countries, S1 and S6 have a strong influence, S2 and S3 – moderate, S5 and S4 – weak. This comparative analysis concluded that EU countries consider intellectual property, green economy, and state innovation policy as key components of their competitiveness. The results discovered a weak relationship between intellectual property protection, innovation in industry, and competitiveness of Ukraine compared to EU countries. However, digital innovations significantly and positively affect Ukraine's competitiveness.

Keywords innovative development, competitiveness, innovations, business environment, eco-innovations, digital innovations, neural networks

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INTRODUCTION

Countries with a favorable attitude toward innovation can achieve a competitive advantage. Innovative development determines the resilience of countries' economic systems to external turbulence and crises and the ability to adapt to changes to maintain stability and competitiveness. Some recent events, e.g., COVID-19 and the Russian invasion of Ukraine, indicate that innovation-oriented economies demonstrate higher resilience. Knowledge-based countries, in particular, the EU states, demonstrate the ability to quickly adjust to changing conditions to strengthen their competitiveness in the world market. Globalization, international labor market, digitalization of all spheres of the national economy, pandemic consequences, full-scale war, and environmental problems caused the expansion of countries' innovative development vectors.

The full-scale Russia's invasion of Ukraine created significant obstacles to the realization of its innovative potential and led to significant losses in industrial infrastructure, economic slowdown, drastically decreased GDP, investment outflow, decreased competitive advantages, and economic stagnation. As a result, Ukraine loses competitive positions on the market, decreases production of knowledge-intensive and innovative products, significantly lags in technologies, and shows poor effectiveness of environmental innovations. Considering the trends of increasing innovative potential in the EU countries, it is interesting to determine the effect of innovative development factors on competitiveness and compare them with the Ukrainian economic trend. This can contribute to the development of effective strategies and policies that may increase countries' competitiveness.

Taking into account Industry 4.0 and the spread of artificial intelligence, one should use advanced methods of intellectual data analysis during analytical research, in particular, deep learning techniques and neural network modeling (Skliar et al., 2020). Such high-quality methodological tools can determine strong and weak sides in countries' innovative development and identify potential directions for the growth of competitiveness.

1. LITERATURE REVIEW

Researchers use various methods to describe innovation from economic, technical, or social points of view (Brodny et al., 2023). Innovation is key to economic competitiveness and development. Thus, EU countries provide substantial financial assistance for innovations (Brodny et al., 2023). Ukraine defines innovation as a strategic development direction, which ensures security and sovereignty (The Cabinet of Ministers of Ukraine, 2019). Innovative development increases competitiveness and innovations boost competitive advantages.

Innovative development is the ability of interested parties to research and search for ideas and ways to increase the country's competitiveness and benefit overall economic development (Osieczko & Stec, 2020). Therefore, a competitive economy demonstrates high effectiveness, efficiency, flexibility, and innovation (Bielińska-Dusza & Hamerska, 2021). The ITIF (2019) report states that countries seeking to maximize innovation outcomes should follow two conditions. Firstly, governments must introduce laws and regulations to increase their innovation potential. Secondly, the world economic and trading landscape should ensure that innovation-based economies can thrive despite excessive competition, providing access to large international markets and ensuring robust intellectual property protection.

Analyzing developed countries, only the effective introduction of creative and innovative outcomes into production, development, and organization can ensure significant competitive advantages (Q. Wang & S. Wang, 2019). The EU regulations to support each member state's innovativeness has led to the establishment of several programs (e.g., Horizon 2021–2027) and initiatives (Brodny et al., 2023). Thus, developing countries have included innovation policies in their legal frameworks, and international corporations substantially value innovations (UNESCO, 2021). Ukraine also uses the opportunities offered by such programs as Horizon 2021–2027. However, the status of a candidate for membership, the lack of comprehensive implementation of the national innovation strategy, the low priority of spending on R&D, and the consequences of a full-scale war limit the prospects of using these opportunities (OECD, 2023). Ukraine is on the way to transforming its inefficient consumer resource-oriented economic model into an inclusive and high-tech industrial model. Several steps include Ukraine's commitment to achieving sustainable development goals (SDGs) and concluding the Association Agreement with the EU. However, there is an urge for further substantial changes. For example, in terms of SDGs, Ukraine promotes an active development of high-tech manufacturing sectors using "education-science-production" interaction and a cluster approach, seeking to create an innovative ecosystem (Ministry of Economic Development and Trade of Ukraine, 2017). Although in 2019 Ukraine adopted the National Innovation Strategy till 2030, it is suspended due to insufficient funding, lack of monitoring, and the full-scale war in Ukraine.

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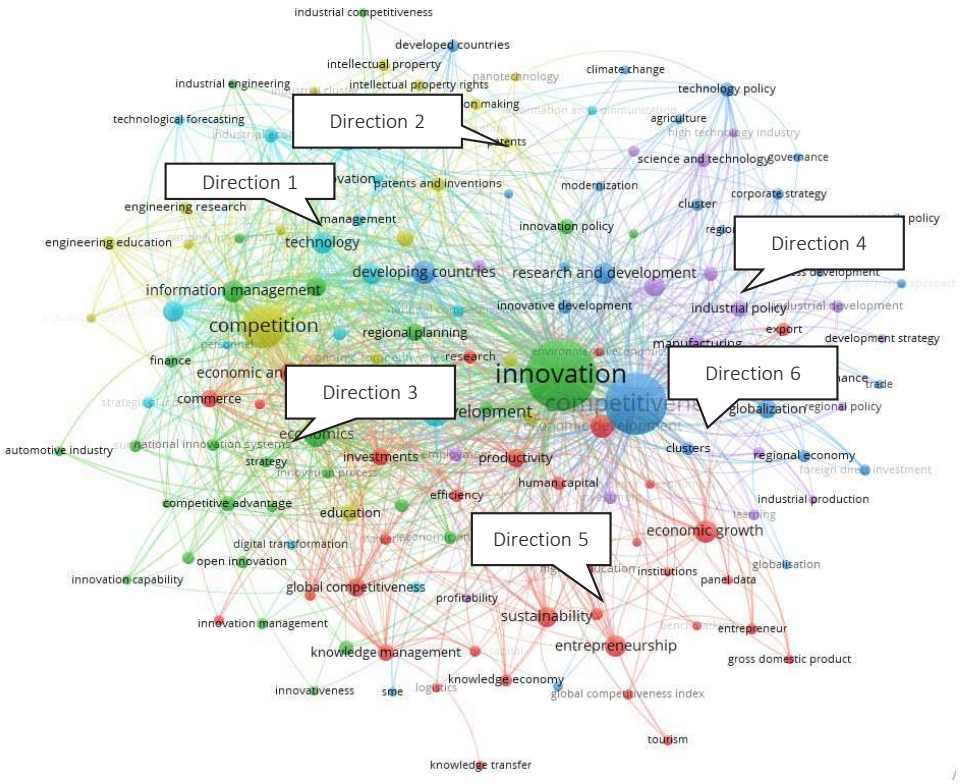
Honcharov et al. (2023) analyzed the state and dynamics of innovativeness of the economy of Ukraine in the system of indicators of innovativeness of other countries of the world. The authors noted the stimulating effect of globalization processes on the spread of innovations, as well as the limitation of access to innovations ("dumping" of second-order technologies in developing countries) in order to maintain the competitive positions of the economically developed countries of the world.

In the context of modern realities, Kocherov et al. (2023) considered financial and economic tools that can be used to create an innovative system, post-war economic recovery in Ukraine.

Research has shown that innovative development affects the competitiveness of countries. However, there are different impact factors. Saqib et al. (2024) examined the influence of environmental innovations, financial expansion, eco-development, renewable and non-renewable energy sources on the economic development of countries. Del-Aguila-Arcentales et al. (2023) noted that the competitiveness of European countries is determined by particular policies that enhance innovative development of various sectors, such as renewable energy. Huang et al. (2023) discovered three approaches to innovation ecosystems that create a country's high competitiveness: investment management, e-government, and research and development. Brodny et al. (2023) used business innovativeness, scientific research sector, and human and social capital to describe the innovativeness of EU countries. Kuzior et al. (2022) proposed 10 factors that ensure European competitiveness and innovative development: ensuring a pan-European approach; digital, retraining, and advanced education; cooperation between the company and the startup; gender diversity; innovation financing; activation of state and public entities; data access and protection; entrepreneurship; digital infrastructure and interoperability; harmonized legal framework.



Note: Tools: VOSviewer; method: keyword co-occurrence; sample base: 2,147 articles in the Scopus scientometric database for the period 1991–2023.

Figure 1. Bibliometric analysis of thematic areas for the influence of countries' innovative development on their competitiveness

Summarizing the literature review on factors influencing the innovative development of countries and their competitiveness, it is possible to identify the key factors of innovative development, which can be conventionally labeled as "Innovations in business " (sky blue), "Intellectual property" (yellow), "Innovations in industry" (green), "Eco-innovations" (purple), " Management of innovations" (red), "Digital innovations" (blue) (Figure 1). The interpretation of vectors is based on the respective keywords; however, this division is rather arbitrary since all vectors are interconnected.

Innovation in business includes the promotion of creation and development of conditions for innovative companies, including infrastructure, legal environment, financial mechanisms, and other tools that stimulate innovation and support their success in business (Bielińska-Dusza & Hamerska, 2021). According to Peng et al. (2022), a "calm" business environment engages entrepreneurial intentions and boosts innovative firm performance.

Intellectual property is a legal system that regulates creative and intellectual resources created by intellectual labor. Increasing investment in R&D, which is intellectual property, is a key factor for companies to improve innovation performance and stimulate sustainable healthy growth (Yin et al., 2023). Robust intellectual property rights act as an effective protection mechanism that allows innovators to safely reap the benefits of risky and costly innovation investments (ITIF, 2019). The development of innovations requires applied research with appropriate funding and protection (Skliar et al., 2020).

Innovations in industry results in novel ideas, technologies, methods, processes, or products that benefit the company's productivity, efficiency, and competitiveness. According to Zhao et al. (2019), this aspect is critical for improving the competitiveness of a country. Innovation in industry boosts country's economic growth and companies' competitiveness (Yin et al., 2023). Innovative activity is closely related to industrial companies, which, thanks to innovative approaches, can implement innovative solutions to strengthen their positions in the market.

Eco-innovations are innovative solutions for products, processes, and technologies that efficiently use resources, minimize waste and reduce the negative impact on nature. Economic growth leads to excessive use of natural resources, which harms the environment. Green innovation is a key factor in creating decentralized innovation systems and supporting a clean future (Saqib et al., 2024). Production managers should carefully implement European standards (Kuzior et al., 2023), which will allow cyclical models for the rational use of natural resources and contribute to the development of ecologically oriented innovations.

Management of innovations is a system of strategic leadership and organizational practices that create, implement, and manage innovations to increase competitiveness and economic development. However, many developed and developing countries need help to effectively transfer innovative technologies and commercialize scientific discoveries (ITIF, 2019). According to Finland's National Innovation Strategy, comprehensive coverage of various policy aspects is critical for the country to achieve leadership in innovation, thus ensuring national growth in productivity and competitiveness (ITIF, 2019). The European Union, having already established agreements and regulations, promotes the joint work of countries and the use of crowdsourcing for the exchange of innovative ideas and knowledge (Del-Aguila-Arcentales et al., 2023).

Digital innovations are innovative solutions that use digital technologies to improve business activities and accelerate development in the digital world. These innovations significantly reduce the costs of obtaining and distributing information. For example, they allow easier access to scientific or business knowledge and help entrepreneurs attract more customers and expand the market. This is especially important for developing countries, where market size and infrastructure limit business productivity (Strilets et al., 2022). Digital innovations also contribute to global value chains, which support industrial and technological development in different countries, allowing the transfer of technology from multinational companies. In addition, highly digitalized countries tend to reduce poverty or social exclusion levels (Kvilinski et al., 2021).

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It is vital to investigate methodological principles for assessing the effect of countries' innovative development on their competitiveness. This can help develop effective strategies and policies that increase competitiveness. Thus, Kuzior et al. (2022), Vetsikas et al. (2017), Polyakov et al. (2023), and Maradana et al. (2019) confirm the complex socio-economic significance of innovative development and its positive correlation with indicators of economic growth in most EU countries. The correlation-regression analysis conducted by Kuzior et al. (2021) confirmed that a change in the country's innovation ecosystems affects the global innovation activity, considering the changes in productivity and innovation potential.

The European Commission uses the European Innovation Scoreboard (Directorate-General for Research and Innovation, 2023) to measure the innovativeness of each member state. The assessment of countries is based on the Composite Index of Innovations, calculated as the arithmetic mean of the indicators of sub-indices. However, this Index lacks theoretical basis, excessively emphasizes high technologies, and lacks universal access to data for all interested parties (Brodny et al., 2023). Szopik-Depczyńska et al. (2020) argue that it is worth revising the approach to calculating this Index as it uses average values of indicators, which can produce distorted results. Bielińska-Dusza and Hamerska (2021) researched factors influencing the Composite Index of Innovations and how the countries are ranked in the European Innovation Scoreboard. Using the innovative approach and linear ordering, they elaborated on a rating similar to the European Innovation Scoreboard (with fewer indicators) using 22 determinants.

When assessing innovation ecosystems of the EU and Ukraine with a focus on sustainable development, Brodny et al. (2023) applied correlation-regression analysis to prove that changes in innovation ecosystems affect innovativeness, depending on the level of the country's productivity and innovation potential. Brodny et al. (2023) used the multi-criteria decision analysis (MCDA) to study the innovative development of countries and non-parametric Kendall Tau tests and Spearman's rank correlation coefficients to establish relationships between innovativeness and economic, ecological, energy, and social factors for each individual country. It is necessary to select representative indicators for assessing the impact of different factors, including economic, social, technological, and institutional aspects, which should be accurate and sensitive enough to detect changes in the level of competitiveness of countries depending on their innovative development.

Following the literature review, this study aims to estimate the effect of innovative development in EU countries and Ukraine on their competitiveness and establish prospects for Ukraine's post-war economic recovery.

2. METHOD

This study evaluates factors influencing the countries' innovative development and competitiveness: innovations in business, innovations in industry, innovation management, eco-innovations, digital innovations, and intellectual property (Pedchenko & Franko, 2021). To collect the data, the paper uses open sources, such as Eurostat, OECD, and the State Statistics Service of Ukraine. In addition, it considers Innovation Index, Doing-business Index, Index of Economic Freedoms, Property Rights Index, International Intellectual Property Index, Industrial Production and High-tech Manufactured Exports Rank, Environmental Performance Index, Government Effectiveness Index, Political Stability Index, Digital Economy and Society Index, and World Digital Competitiveness Index (Figure 2). The study covered 27 EU countries and Ukraine. Indicators that quantitatively describe the factors of innovative development are determined as input data and the country competitiveness index is selected as the output parameter.

IBM Statistic 26 was chosen for neural network modeling; this software was used to prepare the data (normalize data to improve quality and suitability for model training; divide into training and testing sets; establish neural network architecture (recurrent or inverse neural networks); conduct neural network training using appropriate metrics (rms error, precision, F1-score)). As a result, a neural network model with six input layers, one hidden layer and four (for EU countries) and two (for Ukraine) output layers was obtained. To inter-

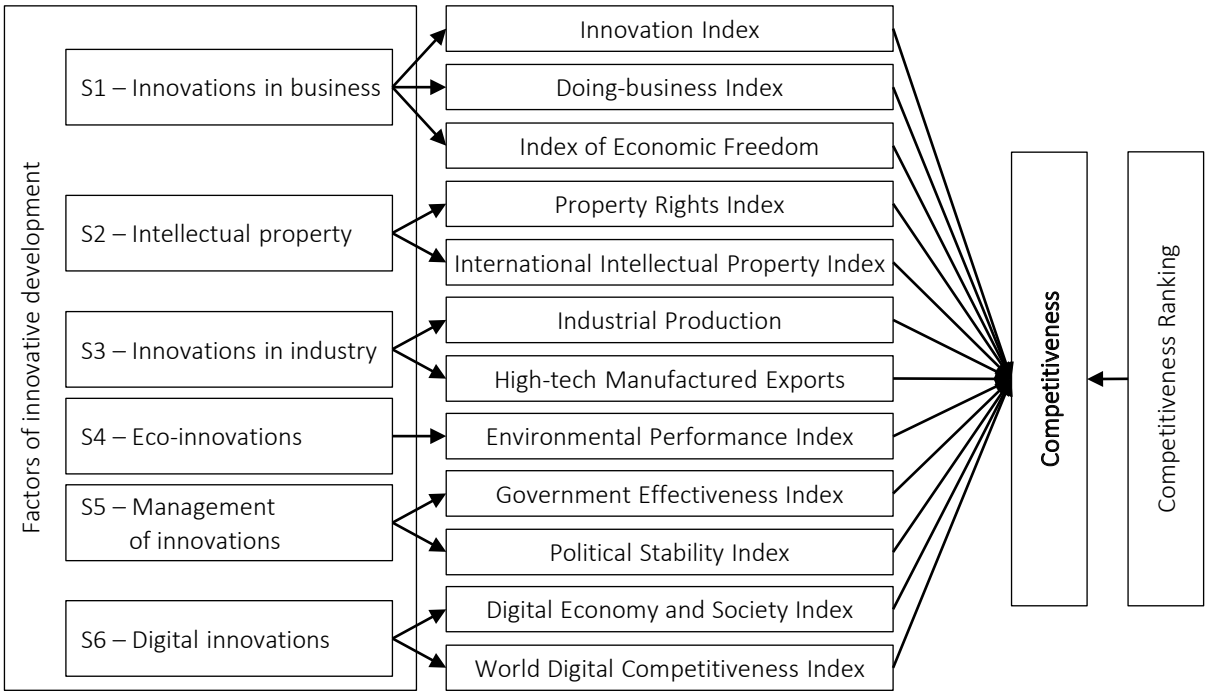

Figure 2. Conceptual framework

pret the results, the parameter weights were analyzed to assess which factors have the greatest impact on competitiveness.

3. RESULTS AND DISCUSSION

Figure 3 shows mathematical substantiation of the impact of innovative development on the competitiveness of countries. The results indicate weak relationships between the level of intellectual property protection, innovations in industry and innovation management, and the competitiveness of Ukraine (Figure 3a). In contrast, there is a close relationship between the innovative development of the economy and digital innovations.

In comparison, Figure 4 shows median values of the EU countries: there are strong relationships between eco-innovations, innovation management, and the competitiveness of countries.

The results show that innovations in business significantly affect the competitiveness of the EU countries and Ukraine. Statistics on the development of the business environment in the EU countries show that in 2021, R&D in the business sector resumed its role as the main driver of the growth of scientific and technical developments, while R&D in government and higher education institutions practically stopped. Starting with the global financial crisis of 2009 and before COVID-19, the share of companies in the total expenditures on the effectiveness of scientific research in OECD countries increased by 75% and led to the growth rate of scientific and technical developments. After lagging behind other sectors in the growth rate of R&D spending in 2020, R&D spending in the business sector increased by 6.3%, while R&D in the higher education and public sectors grew by 0.4% and 0.5%, respectively (Figure 5).

Insufficient state support for the business environment in Ukraine causes a decrease in business activity in the implementation of innovations. Business expenses on R&D in the EU usually make up 60%, but in Ukraine, they reached only 20%, or 0.08% of GDP, in 2020, in contrast to 0.88% in the neighboring Poland, 1.21% in the Czech Republic, and the EU average of 1.53% (OECD, 2022). According to the Statistical Yearbook of Ukraine (State statistics service of Ukraine (2022)), "Expenditures on innovative activities of industrial companies on R&D carried out on their own and R&D carried out by other companies amounted to 3,486 billion UAH, and nominal GDP – 4,192 billion UAH." As a result, Ukraine occupies a low position in the innovativeness rating compared to EU countries (Figure 6).

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Source: Bloomberg (2021), World Bank Group (2022), Directorate-General for Research and Innovation (2022), Eurostat Database, GII (2023), IMD (2020), Kim (2024), The Institute of Economic Research and Policy Consulting (2021), and State Statistics Service of Ukraine.

1. Define the research object: the influence of innovative development factors on the competitiveness of Ukraine and the EU countries

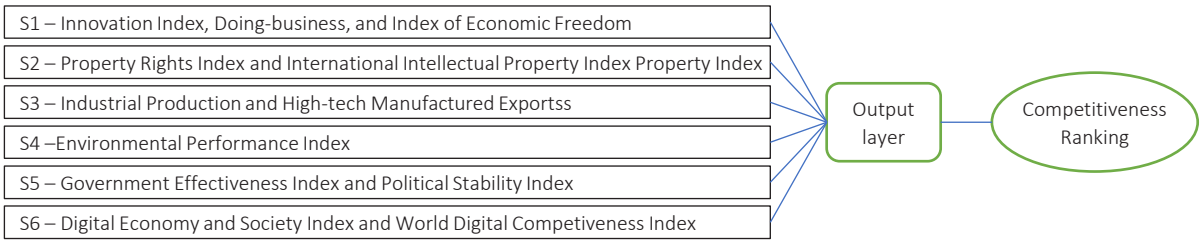
Ukraine	EU countries

Form a system of indicators that quantitatively describe the factors of influence of innovative development on the competitiveness of the national economy:

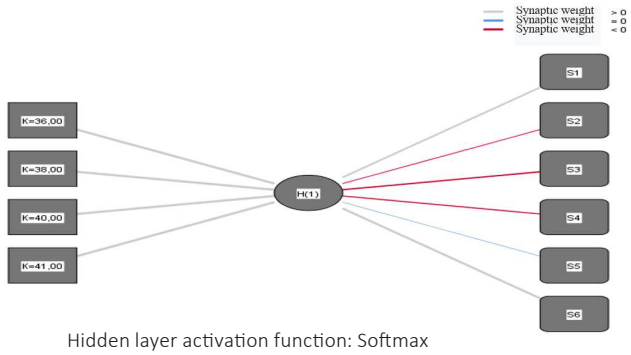
$$F(K) \in (S1; S2; S3; S4; S5; S6),$$

where $S1$ is evaluated using the Innovation Index, Doing-business Index, and Index of Economic Freedom; $S2$ – Property Rights Index; International Intellectual Property Index; $S3$ – Industrial Production and High-tech Manufactured Exports; $S4$ – Environmental Performance Index; $S5$ – Government Efficiency Index and Political Stability index; $S6$ – Digital Economy and Society Index, IMD, and World Digital Competitiveness Index; K – Competitiveness Ranking.*

2. Structure the neural network for the relationship between innovative development and the country's competitiveness

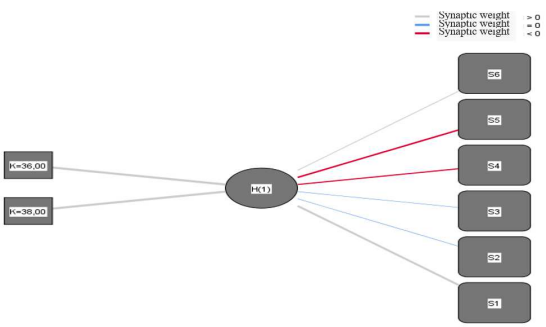


3. Build a neural network between the relevant indicators of innovative development and the country's competitiveness



Hidden layer activation function: Softmax
Output layer activation function: Identity

Figure 3a. Ukraine



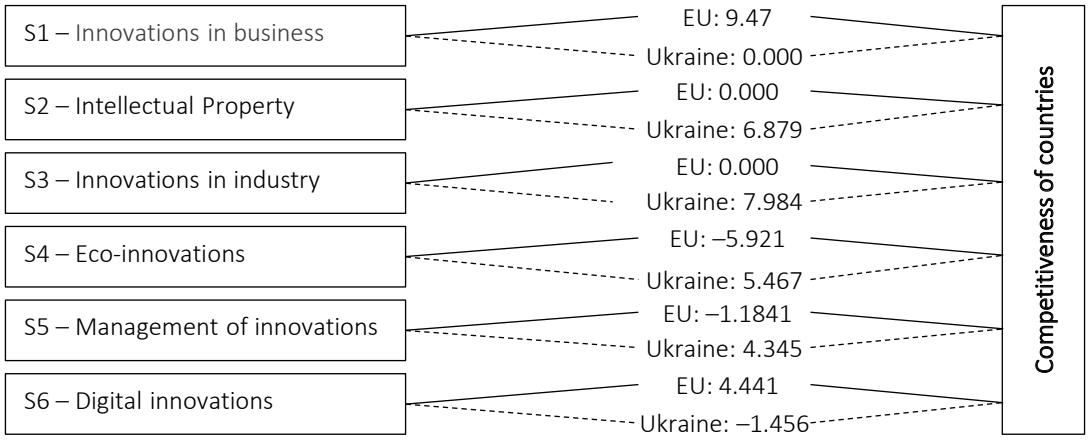
Hidden layer activation function: Softmax
Output layer activation function: Identity.

Figure 3b. EU countries (median value)

Groups of factors by the level of influence on the country's competitiveness	Results: Factor (symbol)		Results: Specific weight of the group in the overall structure, %	
	Ukraine	EU countries	Ukraine	EU countries
Strong	S1, S6	S1, S6	33.3	33.3
Moderate	S5	S2, S3	16.7	33.3
Weak	S2, S3, S4	S5, S4	50	33.3

Note: Integral indicators of prospects are obtained by calculating the weighted average value of standardized index values.

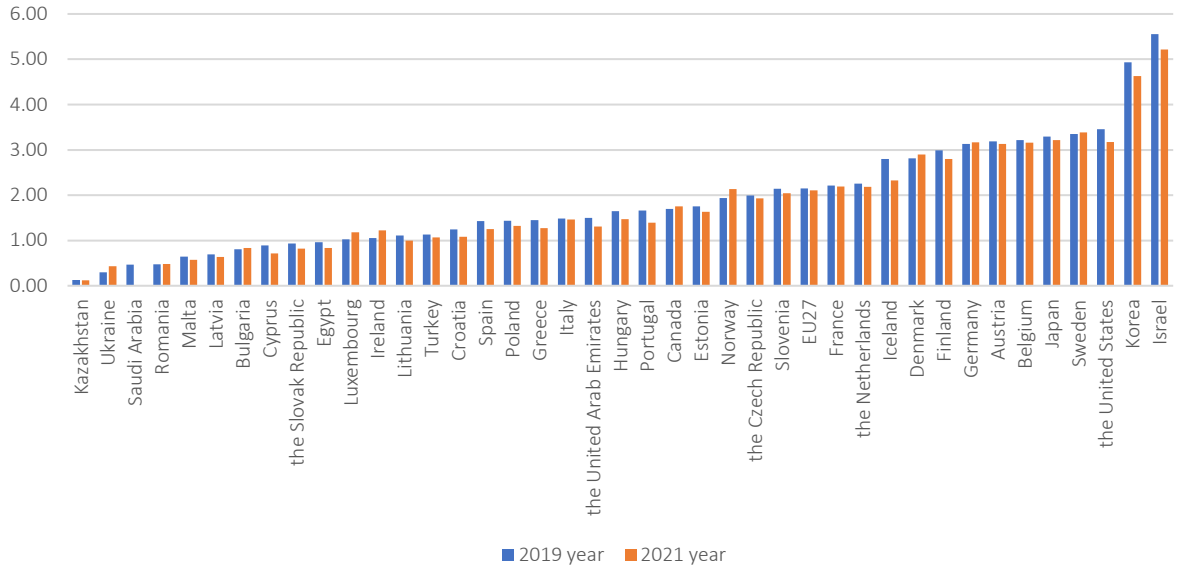
Figure 3. Neural networks for assessing the impact of innovative development factors on the competitiveness of Ukraine and EU countries (median value)



Note: In neural networks, synaptic weight determines the strength of connections between neurons. It indicates the importance of a specific relationship in the transmission of information in a neural network.

Figure 4. Relationships of innovative development indicators and competitiveness of EU countries and Ukraine (by synaptic weight)

Source: OECD (2023).



Note: * Gross Domestic Expenditures on R&D (GERD) (consisting of all resource costs used to perform R&D in a given territory) in % to GDP.

Figure 5. R&D intensity in OECD and other economies

The empirical analysis confirms that the protection of intellectual property positively correlates with increased competitiveness of EU countries and Ukraine. The low technological level of the Ukrainian economy has led to a limited scale of innovative activity in the industry and reduced demand for domestic scientific and technological developments. Thus, companies prefer to purchase ready-made standard solutions, which leads to a decrease in initiatives for cooperation between business and science. Before the Russian invasion of Ukraine, there were numerous initiatives in Ukraine, such as science parks, technology parks, industrial parks, technology transfer centers, innovation centers, intellectual property commercialization centers, and innovation incubators (UNECE, 2020). Figure 7 shows that Ukraine remains relatively low-performing in the use of intellectual property, with rates of payment for intellectual property (21.2) and revenues from it as a percentage of total trade (5.2). Both of these indicators are lower than the average values in EU countries (35.48 and 30.8, respectively).

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Source: GII (2023).

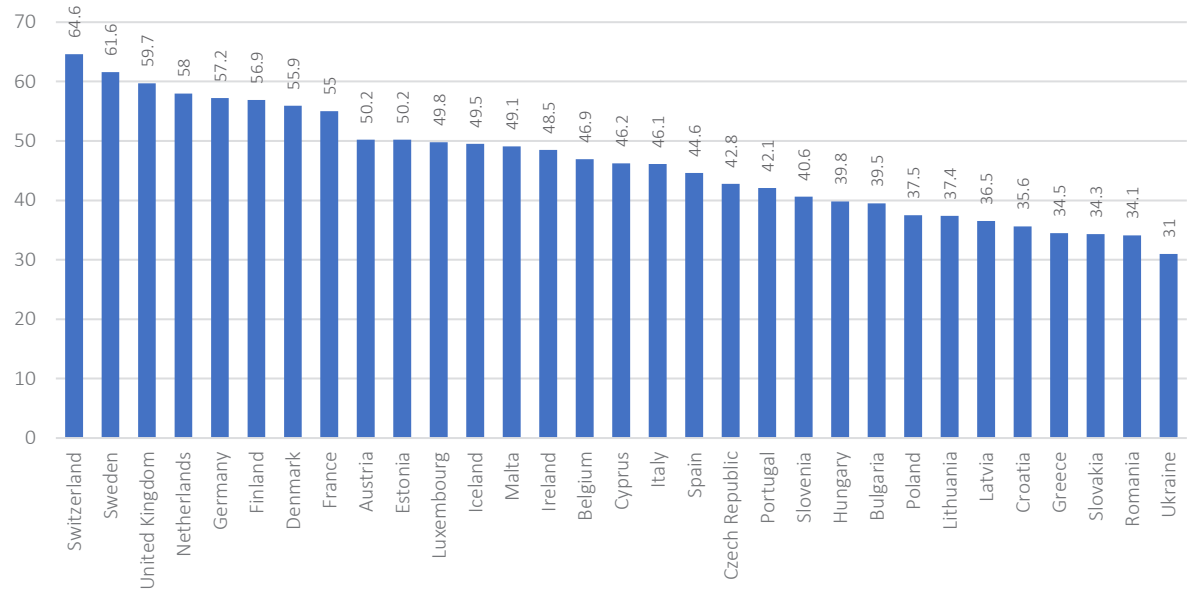

Figure 6. Ukraine and EU countries in the Global Innovation Index rating in 2023

Source: GII (2023).

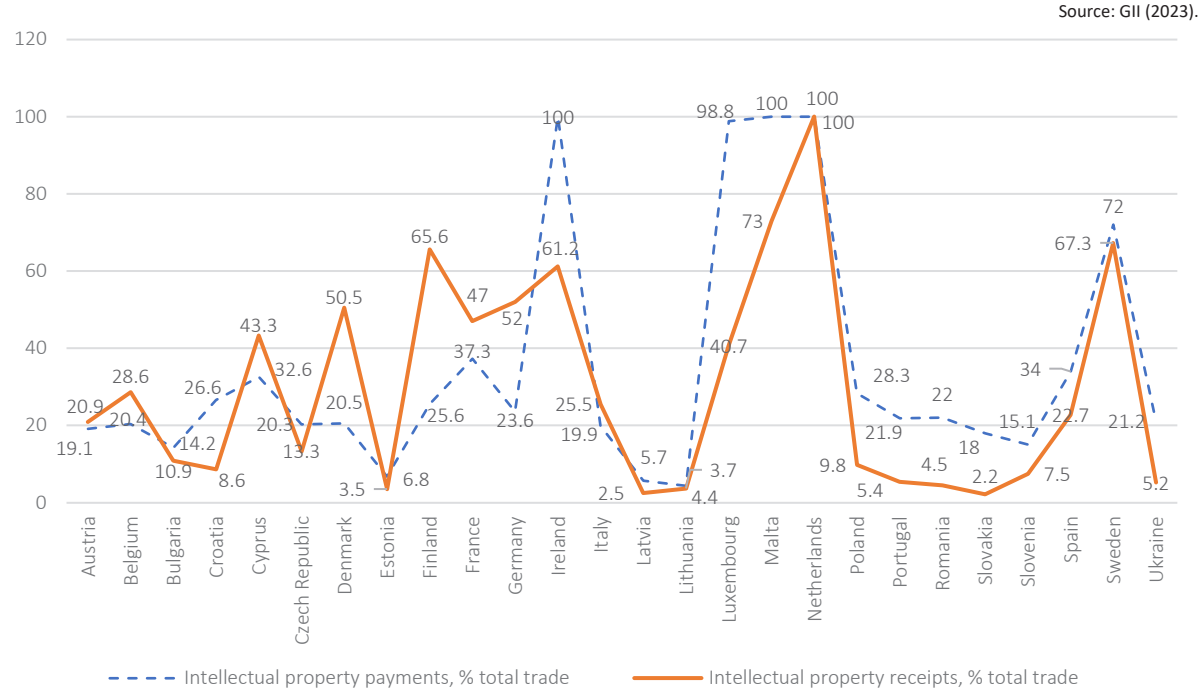

Figure 7. Payments and revenue from intellectual property, % of total trade in 2022

The results confirm that for the EU, innovations in industry significantly increase competitiveness; for Ukraine, the situation is the opposite. For the most part, OECD countries tend to expand the framework of technology transfer, enhancing cooperation between academic institutions and businesses for joint funding, management, and implementation of research activities. This facilitates effective innovation through the mobilization of shared resources (OECD, 2022). The EU countries, such as Italy and Poland, are implementing strong fiscal measures, including extended tax breaks for research and development, investment incentives, and common tax breaks favoring industry.

The findings show certain shortcomings in the system of fiscal benefits for research and development in Germany and the USA. In Germany, fiscal incentives are ineffective, and in the USA, they are limited only to the energy sector. Poland is implementing innovation vouchers and credit programs to support innovation in the industrial sector (OECD, 2022).

The study rejected the assumption that eco-innovations significantly affect the competitiveness of the EU and Ukraine. Countries must rapidly and systematically introduce circular economy principles due to the Fourth Industrial Revolution. This results in improved efficiency of resource usage, support of waste and food waste management projects, and development of the processing sector, industrial symbiosis, and bioeconomy. Ukraine does not pay as much attention to waste management as developed European countries do. According to the volume of garbage per person, Ukraine ranks 9th in the world, reaching 10.6 tons per person. Ukraine annually produces over 474 million tons of waste, of which 448 million are hazardous. Figure 8 highlight a significant discrepancy between Ukraine and the EU in solid industrial waste management. Thus, 92% of solid waste in Ukraine is not disposed of, compared to 1% in Sweden. Currently, there are 6148 landfills in Ukraine, and only 2600 of them are officially recognized (Kuzior et al., 2023). According to the norms of the European Union, their number should be reduced to 500. Ruda et al. (2021), considering circular economy trends in the EU member states, claimed that Ukraine must show more commitment to enhance its transition from linear to a circular economy.

Next, the results confirm that smart innovation management positively affects Ukraine's competitiveness, but this assumption was refuted for the EU. Regarding the management of innovations, Ukraine faces a lack of coordination between the National Council for the Development of Science and Technology of Ukraine (responsible for science and technology management), the Ministry of Education and Science, the National and Branch Academies of Sciences, the National Research Foundation, and central bodies of executive power. These bodies sometimes have the same (repeating) responsibilities and lack a clear hierarchy. The policies are partially outdated and con-

Source: GII (2023).

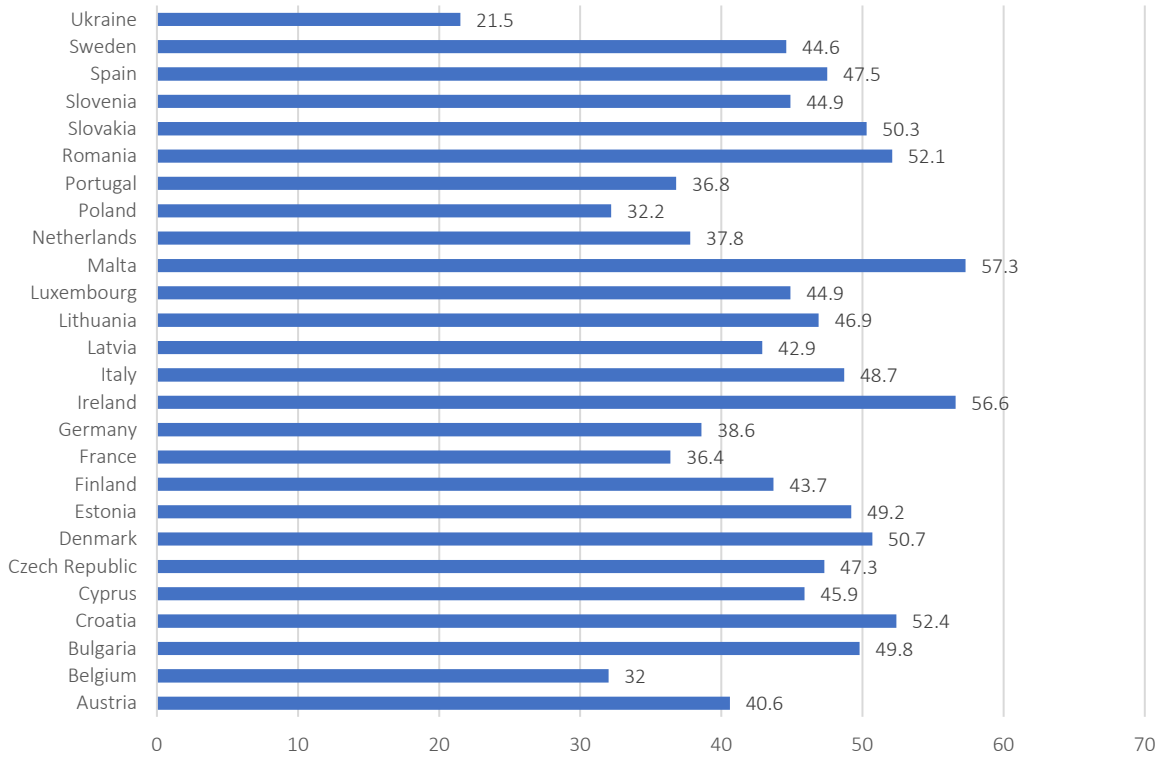

Figure 8. Ecological Stability Index of Ukraine and EU countries (max – 100%) in 2022

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tradictory. In addition, the lack of effective cooperation with the Ministry of Economy of Ukraine, responsible for supporting business innovations, is another area for improvement (OECD, 2022). Moreover, there is no close relationship between business and scientific circles of the Ukrainian economy: high-tech exports make up only 5.9% of the total volume of exports of industrial goods of Ukraine, compared with 12.9% in low-income countries and 18.2% in OECD members for 2020 (World Bank, n.d.). For example, the Netherlands has an Alliance of Leading Sectors for Knowledge and Innovation. It aims to establish partnerships between the governmental and non-governmental sectors, higher education institutions, and research facilities to allow leading industries to market innovative products and services (Government of the Netherlands, 2023). The United Kingdom actively supports innovation at various levels, including funding projects in artificial intelligence for health, agricultural innovation, and battery development (The Government of the UK, n.d.).

A comparative analysis of the effectiveness of the government regarding the innovative development of countries showed that Ukraine has lower efficiency indicators (42 points) compared to the EU countries (average value 72.63 points) (Figure 9).

The findings confirm that digital innovations significantly affect the growth of competitiveness in the EU and Ukraine. EU initiatives use open data as a platform for innovation. The Ministerial Declaration of the European Union on e-Government commits to unification of public e-services of the member states adopting the principle of "once only" (that is, to request data from citizens only once). In addition, there are positive examples of individual EU countries in digital innovation development. For example, Italy supports an initiative called "inclusive digital innovation." This project aims to reduce social inequality; each citizen can acquire digital skills and master how to access modern technologies for social purposes, interaction, and employment and use governmental digital services (Del-Aguila-Arcentales et al., 2023).

The analysis of international ratings of digital technology development demonstrates that Ukraine needs to catch up on EU member states, including new ones that show lower digital development than the EU average. Table 1 shows the dynamics of the digital development of Ukraine and the EU.

According to the EGDI rating, Ukraine ranked 69th among 193 countries and had a 0.7119 score in 2020. It belongs to the countries with excellent e-government systems. Ukraine received the lowest scores for telecommunication infrastructure (0.5942) and online services (0.6824) but the highest for human capital (0.8591). When comparing to the 2018 EGDI ranking, Ukraine improved its performance, moving from 82nd to 69th position (EGDI, 2022). However, Ukraine still needs to catch up on its neighboring countries with

Source: World Bank (n.d.).

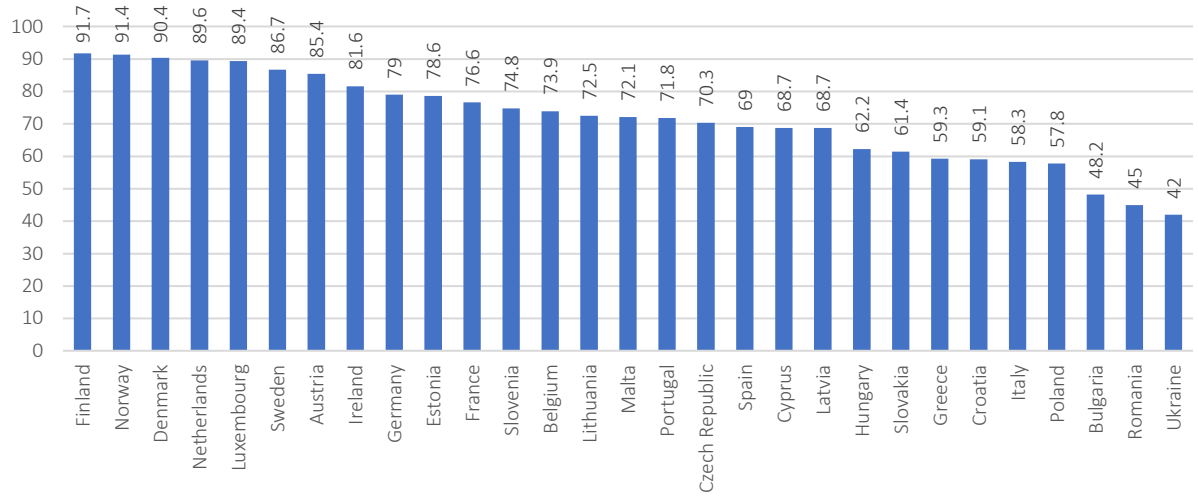

Figure 9. Ukraine and EU countries in the Government Effectiveness Index in 2022

Table 1. Ukraine in international rankings of digital development

International rating	Number of studied countries	Position of Ukraine	Positions of individual EU countries
United Nations E-Government Development Index (EGDI, 2022)	193	46	Estonia – 8, Lithuania – 24, Poland – 34, the Czech Republic – 45, Bulgaria – 52, Latvia – 29, Croatia – 44, Romania – 57
Network Readiness Index (Dutta & Lanvin, 2019)	121	67	Estonia – 23, Lithuania – 31, the Czech Republic – 30, Poland – 37, Latvia – 39, Croatia – 44, Romania – 47, Bulgaria – 49
World Digital Competitiveness Ranking (IMD, 2020)	60	63	Estonia – 29, Lithuania – 30, Poland – 33, Latvia – 36, the Czech Republic – 37, Bulgaria – 45, Romania – 46, Croatia – 51

high e-government development, such as Poland, Hungary, Slovakia, Romania, Bulgaria, Latvia, Lithuania, and others (Iavorskyi et al., 2020).

This study generalized scientific research (Brodny et al., 2023; Deineko et al., 2022; Iavorskyi et al., 2020; Del-Aguila-Arcentales et al., 2023; Kuzior et al., 2022; Maradana et al., 2019; Frolov et al., 2023) and considered measures to improve innovation policies of the EU and Ukraine, using the data of international organizations (OECD, 2022; UNECE, 2020; World Bank, 2023). Moreover, it constructed neural networks to determine weaknesses in Ukrainian practice, which creates a discrepancy in innovative development. Ukraine needs to form an effective policy system, considering Industry 4.0, globalization, destructive consequences of the war, post-pandemic recovery, climate changes, pollution and waste, and rising food and energy prices to achieve high economic competitiveness (Table 2).

If Ukrainian authorities aim to improve the innovation environment, they should focus on reforming the business environment, improving the quality of innovation management, protecting intellectual property, and stimulating digital and eco-innovations.

Table 2. Measures for the formation of a holistic ecosystem of innovative development in Ukraine by vectors

Factors of innovative development	Improvement measures
Innovations in business	Removal of barriers in the foreign market
	Adjustment of logistics
	Deregulation and liberalization of business
	Overcoming corruption
	Synchronization of Ukrainian legislation with European standards
Management of innovations	Adaptation of foreign practices of testbed creation Legislative support for state innovation policy initiatives
	Promotion and strengthening of cooperation between science and business
	Promotion and strengthening of cooperation between the state and business
	Promotion and strengthening of cooperation between the state and science
Innovations in industry	Optimizing equipment performance
	Optimization of production and logistics processes
	Increasing employee potential
	Improving the effectiveness of scientific research and development of new products
	Cost reduction
	Smart specialization
	Promotion of «green production»
Eco-innovations	Climatic modernization
	Creation of a national eco-compliance monitoring system
	Creation of electronic registers of natural resources
	Integration into the European online Shared Ecology Infrastructure System “Environmental patrol”
	Implementation of the principles of green production
	Implementation of the state policy of green bonds

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Table 2 (cont.). Measures for the formation of a holistic ecosystem of innovative development in Ukraine by vectors

Factors of innovative development	Improvement measures
Digital innovations	Ensuring cyber security
	Improvement of qualifications and digitalization skills
	Digital provision of public services
	Integration into the single digital market
	Digitization of business
Intellectual Property	Consulting on the protection of intellectual property and the procedure for submitting applications for industrial property rights
	Legal and technical assistance to owners of intellectual property rights in case of detection of unfair and illegal use of intellectual property objects and ensuring effective protection against unfair competition
	Friendly atmosphere for the transfer of technologies in the countries that receive them
	Facilitating the resolution of private intellectual property disputes
	Development of information technology as a tool for storage, regulation of effective mechanisms of state management of the process of implementing inventions and research proposals, increasing the state's interest in implementing inventions for the country's economic growth

CONCLUSION

The study aimed to determine the impact of innovative development on the EU and Ukraine's competitiveness. The paper used neural network modeling to assess the impact of selected factors (innovations in business, innovation management, innovations in industry, eco-innovations, digital innovations, and intellectual property) on the competitiveness index of countries. The conceptual approach identified three groups of factors according to the level of their influence on the country's competitiveness (strong, moderate, and weak) and their specific weight in the overall structure. A comparative analysis of the impact of innovative development on the competitiveness of EU countries and Ukraine revealed substantial variations. The EU considers intellectual property, green economy, and state innovation policy as critical components of their competitiveness, while Ukraine, lagging behind in some aspects, has room for improvement.

The results identified some innovative practices of the EU countries, which could be adopted in Ukraine. Therefore, Ukraine should focus on reforming the business environment, improving the quality of innovation management, protecting intellectual property, and stimulating digital innovations and eco-innovations to improve its innovation environment. Measures that promote these directions will help Ukraine catch up with its European partners in innovative development. The findings can be used as a reference point for improving countries' innovative strategies, enhancing the competitiveness of the national economy, and stimulating Ukraine's innovative development in the post-war period.

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Resources: Viktoriia Strilets.
Software: Viktoriia Strilets.
Supervision: Viktoriia Strilets.
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Writing – review & editing: Viktoriia Strilets, Liudmyla Franko, Mariia Dykha, Maksym Ivanov, Larysa Rybina.

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