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Assessment of National Innovation Ecosystems of the EU Countries and Ukraine in the Interests of Their Sustainable Development

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Abstract: The purpose of the study is to reveal specific features of modern EU innovation policy in the context of its focus on sustainable European development and to conduct an assessment of the parameters of national innovation ecosystems of the EU member states with different innovation potential and Ukraine from the standpoint of their influence on the innovative development of countries worldwide. With the use of the correlation-regression analysis, the hypothesis of changing the parameters of national innovation ecosystems that affect the innovation of the EU member states and Ukraine in the global context depending on the level of their productivity and innovation potential was reiterated. The factors that have the greatest impact on the ranking of the countries in the Global Innovation Index, depending on which group the countries under study belong to according to the classification of the European Innovation Scoreboard, were identified. It was revealed that the set of such factors in each group of countries varies and has a different degree of influence on the level of their innovation development. Based on the results of the assessment, taking into account the need for a speedy post-war reconstruction of Ukraine, policy recommendations were made for Ukraine. Their implementation will ensure the systemic influence of the state on the national innovation ecosystem of the country.

Keywords: innovation; innovation policy; national innovation ecosystem; mission tool; smart specialization; sustainable development

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1. Introduction

Beginning with the Lisbon Strategy adopted in March 2000, the strategic development goals of the European Union (EU) cover three key dimensions—economic, social and environmental. Thus, in the original wording, the strategic goal of the Lisbon Strategy was defined as: "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" [1]. A year later, at the Gothenburg European Summit, an environmental dimension was added to this end. In 2010, as part of the Europe 2020 strategy, the EU's strategic agenda was detailed, supplemented with an "intelligent" component, and the following strategic goal was formulated: "smart growth, sustainable growth, and inclusive growth" [2]. These political objectives were seen as equally important in ensuring the sustainable development of Europe and were intended to complement and reinforce each other.

Europe moved to a new narrative in 2019—the European Green Deal. This course is based on the intention to turn Europe into a "fair and prosperous society, with modern, resource-efficient and competitive economy", in which the health and well-being of the population will be protected from the negative effects of the environment, and the transition to a green economy will be fair and comprehensive [3]. Particularly, the European Commission aims to make Europe the world's first climate-neutral continent by 2050 [4].

These ambitious strategic goals have now been supplemented with the goal of overcoming the negative socio-economic consequences of the COVID-19 pandemic. To remedy this, the EU has adopted the NextGenerationEU recovery plan with over EUR 800 billion in funding to create a greener, more digital and sustainable Europe. Within its framework, areas requiring priority support are identified, including the field of research and innovation.

Accordingly, the EU's innovation policy priorities shift from innovation-driven growth per se to sustainable and inclusive growth based on smart specialization strategies. In other words, smart specialization strategies (Smart Specialisation Strategies, S3) are designed to 'work' towards sustainable and inclusive growth in Europe (Smart Specialization Strategies for Sustainable and Inclusive Growth, S4+). In fact, the current equivalence of political goals is being eroded, the directions of development are being revised, and the emphasis in the EU's strategic agenda is shifting from S3 to S4+. Innovation policy should no longer focus on the creation of innovation. Whatever its target orientation, it should contribute to the generation of such scientific knowledge and innovation as well as contribute to the solution of social, economic and environmental challenges and will be seen as an «intermediate step towards the longer-term goals of fostering sustainability and inclusiveness» [5], c. 19.

Thus, sustainable development is a central element of the new long-term political and practical development model of the European Union.

In addition, Europe has proclaimed an ambitious goal—to fight for global innovation leadership, for which it intends to develop its own innovative development model, the basis of which is considered ten fundamental blocks to ensure the competitiveness of European innovation ecosystems [6], c. 4: Pan-European approach; corporate-start-up collaboration; innovation funding; enabled government and public institutions; data access and protection; entrepreneurial talent; digital education, reskilling and upskilling; gender diversity; digital infrastructure and interoperability; harmonized legislation and standards.

The success of achieving all these goals depends not only on the common and coordinated policy of the EU member states but also on the policy of the EU neighboring countries, particularly Ukraine. They must join forces to develop effective national innovation ecosystems capable of producing scientific knowledge and innovation for Europe's sustainable and inclusive growth.

In Ukraine, the need for innovative transformations in the direction of sustainable development is due to the existing raw materials-oriented model of the economy. It does not contribute to economic growth at the level capable of ensuring a high quality of life and economic security. The dominance of this model for many years has led to imbalances in economic, social and environmental spheres, primitivization of innovation in the industry, which is dominated by resource- and energy-intensive low- and medium-low-tech industries that use cheap labor and, consequently, preserve technological backwardness and low innovative competitiveness of the country [7,8].

By joining the global process of sustainable development and signing the Association Agreement with the European Union, Ukraine has committed itself to changing the inefficient consumer resource-based model of the economy to an inclusive high-tech industrial model, which is possible only with structural and innovative changes in the economy. Thus, the National Sustainable Development Goals for the period up to 2030 set task 9.4 to "Promote the accelerated development of high- and medium-high-tech sectors of the processing industry, which are formed through the use of chains "education—science—production" and cluster approach", including the development of an innovation ecosystem [9]. The implementation of this task should give a spur to the process of new smart industrialization as the basis for the transition from labor, energy, resource-intensive and environmentally depleting activities to high-tech and medium-high-tech industries based on human capital, innovation and a friendly environment.

This task is even more intensified in the context of the ongoing Russian military aggression against Ukraine. Actually, Ukraine, after what it has had to go through and what its citizens are experiencing so far, simply cannot afford to limit itself to the pre-war level of socio-economic development, which is too modest in relation to its potential. After all, the reproduction of the model of the Ukrainian economy in the pre-war form would mean, without exaggeration, the decline of the country. There are no prospects for such a model of the economy; its only alternative is an innovative development path based on the technological and digital reconstruction of industry in the context of the Fourth Industrial Revolution unfolding in the world.

The latter is based on the digital or computer revolution (1960s—beginning of the 21st century) [10], p. 8; however, it is not an ordinary extension, and it develops exponentially rather than linearly and radically changes all spheres of society's life [11]. For example, machine learning, 3D printing and big data are causing a tsunami of industrial change [12]. According to experts, by 2023, the Industry 4.0 market will reach US 214 billion, compared to US 60 billion in 2017 [13]. In the coming decades, enterprises will create global networks that include their equipment, storage systems, and production facilities in the form of real-time, controlled cyber-physical systems. These flexible networks of value creation networks will also require new forms of cooperation between all participants in the national innovation ecosystems—from scientists to entrepreneurs, government institutions and citizens.

At present, the concept of the national innovation ecosystem is in the state of formation, is the result of the development of the evolutionary theory of innovation and is based on the ideas:

- Neo-Schumpeter school of economics, whose representatives proposed the concept of a national innovation system [14–18];
- The evolutionary paradigm of institutional economic theory, according to which the creation of innovation depends not only on the activities of organizations but also on the institutional environment in which they operate and interact;
- Ecological theory and its key concept of the ecosystem.

Perceptions of the nature of innovation ecosystems are also expanding by the models of the Open Innovation [19,20], the Triple Helix [21], the Quadruple Helix [22–24], the Collaborative Innovation Networks [25], and the Rainforest model [26].

One of the first to use the analogy of biological ecosystems in economics was M. Rothschild [27]. He identifies the economy with the biological ecosystem, but while in nature, every living organism is determined by genes and relationships with predators and prey, in the economy, companies depend on their customers, suppliers, competitors and other economic entities, and their success is determined by technology and innovation.

However, the widespread use of the term "ecosystem" in social sciences and the humanities was started by J. Moore. In the publication [28], he presented the concept of the business ecosystem as the external environment of the company. Referring to the research of biologists who have noticed that natural ecosystems are sometimes destroyed when environmental conditions change too radically and, in their place, new ecosystems are formed with previously marginal plants and animals at the center, J. Moore draws an analogy between this situation and business. He points out that companies facing the challenges of innovation experience similar profound impacts, and to mitigate them, a change in the perception of companies is necessary, namely seeing them not as participants in the industry but as part of a larger business ecosystem, where participants come together to achieve a common goal—creating value and meeting customer needs.

In recent years, interest in the concept of an ecosystem as a new way of reflecting the competitive environment has increased significantly. Searching for the keywords "ecosystem", "business ecosystem", "industry ecosystem", "digital ecosystem", and "entrepreneurial ecosystem" in the database Scopus (on the example of a scientific publishing house Elsevier) for 1996–2021 reveals that their frequency of mention has increased many times over the past ten years, and the phrases "innovation ecosystem—dozens of times, and now it is growing exponentially".

Modern problems of ecosystem development in relation to innovations, including in the context of sustainable development goals, are studied in [29–37]. The concept of "ecosystem" in different contexts is increasingly used by international organizations, international consulting and audit companies [6,38–43].

We consider the national innovation ecosystem as an open, holistic, dynamic network consisting of a spatial community of organizations and individuals with different competencies and roles united by stable relationships that evolve in a certain institutional environment under the influence of business, regulatory and innovation environment factors, exchange knowledge and resources, allocate obligations, risks and rewards in the process of creating innovations in which consumers are interested. This definition, in contrast to the existing one, takes into account all the components by analogy with biological systems, emphasizes key features of innovation ecosystems and corresponds to the paradigm of Open Innovation 2.0 [44].

In the context of modern global challenges, the key technological transformations, and the need to ensure the sustainable, innovative development of Europe, the issue of national innovation ecosystems and their impact on the prospects for innovative development requires further in-depth research.

Considering the above-mentioned, the *purpose* of the article is to reveal specific features of modern EU innovation policy in the context of its focus on sustainable European development and to conduct the assessment of the parameters of national innovation ecosystems of the EU member states with different innovation potential and Ukraine from the standpoint of their influence on innovative development of countries worldwide.

The research question is: Does the set of components of national innovation ecosystems, which determine the innovative development of the EU member states and Ukraine in the global context, change depending on their productivity and innovative potential?

The article is structured as follows. First, the key approaches that form the basis of the modern innovation policy of the EU focused on sustainable development are disclosed. They are a smart specialization approach and approach to mission-oriented innovation. Then, the research methodology is presented to assess the national innovation ecosystems of the EU Member States and Ukraine. Below are the results of the assessment and the statistical significance of the regression models. The next part of the article describes the parameters of the national innovation ecosystems of the EU member states and Ukraine, which have the greatest impact on the prospects for their innovative development in the global context, given which group the countries under study belong to according to the classification of the European Innovation Scoreboard. Further, political recommendations for Ukraine are proposed, which consist in developing an approach to the formation of an integral system of state strategic planning for the development of the scientific, technological and innovation sphere of Ukraine. The implementation of this approach will make it possible to systematically influence the strengthening of the national innovation ecosystem of Ukraine. The article ends with conclusions and summing up the results of the study.

2. Modern EU Innovation Policy and Sustainable Development

The new EU innovation policy is based on two approaches designed to mutually reinforce and complement each other.

2.1. Smart Specialization Approach

Smart specialization is an innovative approach that aims to boost economic growth and jobs in Europe by enabling each region to identify and develop its own competitive advantages [45]. It is implemented through Smart Specialization Strategies [46], which obtained a new interpretation in 2012—Research and Innovation Strategies for Smart Specialization. Currently, these concepts are used as the equivalent.

Smart Specialization Strategies are national or regional innovation strategies that set priorities aimed at creating a competitive advantage by developing their own scientific and innovative potential in accordance with business needs to take full advantage of existing market opportunities and trends, avoiding duplication and fragmentation of efforts [47]. The smart specialization approach was first outlined in analytical reports by European researchers [48,49]. Later, it quickly gained popularity outside the EU and was prioritized in OECD and the United Nations policy documents [50,51]. Currently, it is being actively implemented in non-EU countries [52], including Ukraine [53–55].

An important area of today's research on the smart specialization approach is the study of the RIS3 shaping features in regions of different types. M. Trippl et al. [56] examine smart specialization practices in less-developed, intermediate and advanced regions and conclude that the implementation of RIS3 can be accompanied by challenges in all types of regions. Degrees of industrial and organizational thickness and diversity, institutional set-ups, systemic features, policy capabilities, and past experiences with innovation strategies are key place-based factors for a successful smart specialization policy.

In the context of S3, technological challenges are also important. Diversifying into more complex technologies brings extra benefits, including the facilitation of the regional economic growth. According to [57], a 1% increase in regional complexity is associated with a 0.045% GDP per capita growth. However, development of complex technologies is difficult for less-developed regions, so they should search for a new technological base that builds on local related capabilities [58,59]. It is also significant to take into account the degree of relatedness between chosen technological domains [60].

The potential of smart specialization for boosting economic growth in old industrial regions is a separate issue under discussion. R. Hassink and M. Kiese [61] are skeptical about the idea of quickly overcoming the deindustrialization and restructuring of this type of lagging region through smart specialization. The key problem is the weak institutional capacity of such regions, which casts doubts about their ability to organize the entrepreneurial discovery processes properly. In the meantime, according to the latest research on smart specialization methodology [62], the S3 approach has to balance a planning logic and an entrepreneurial discovery logic. The first logic creates a framework from the top, and the other stimulates decentralized entrepreneurial discovery within this framework.

The knowledge of various regional stakeholders and its combination in novel ways forms the starting point of the entrepreneurial discovery process [63]. However, focusing on endogenous knowledge flows only is not sufficient to explain innovation generation processes. Smart specialization policy should combine knowledge flows external and internal to the regional innovation ecosystem [64,65].

Despite numerous research studies and policy initiatives regarding both the smart specialization and the sustainable development, the interaction between these concepts is still poorly understood. A conceptual framework of smart specialization for the Sustainable Development Goals is under formation [66,67]. Selected empirical research on the degree of the Sustainable Development discourse embeddedness in the smart specialization strategies shows strong alignment with the economic and environmental aspects of the 2030 Agenda [68]. The main areas of policy improvement are related to the responses to social challenges, the integration of goals and the development of a national innovation policy toward sustainable development.

In practice, many EU regions have managed to increase innovation and entrepreneurial potential, amplifying their ability to direct investment in innovation. However, inequality in regional and local development still persists, increasing public dissatisfaction with the EU policies, especially in less economically developed regions, which, according to the research [69], is due to economic downturns and declining employment. Moreover, in the coming decades, the problem of social tension may well be exacerbated by the robotization of many production processes, logistics and business processes [70].

Hence, it will lead to the growing threat of mass unemployment of not only routine but also highly skilled occupations, taking into account the continuous development of artificial intelligence and machine learning. In this context, an important task for the European countries is to find effective compensatory mechanisms, which will take the edge off the challenges of automation, informatization and robotics for the middle class.

2.2. Approach to Mission-Oriented Innovation

The idea of missions is not new in itself [71] but was first used as an innovation policy tool at the initiative of the European Commission. Missions are designed to maximize the usefulness of the EU Framework Program for Research and Innovation "Horizon Europe" in addressing global challenges and problems by implementing the European Green Course and the Sustainable Development Goals adopted in 2015 by the UN members [72]. M. Mazzucato [73] was invited to develop the relevant strategic recommendations. This approach is currently set out in a number of EU studies and reports [74]. Thus, *mission-oriented innovation policy* [71,75] is a systemic public policy aimed at addressing a growing number of global social and environmental challenges within a defined time frame and budget by developing and implementing a coordinated package of policies, legislative initiatives and projects in science, technology and innovation. Actually, missions occupy an intermediate position between the Sustainable Development Goals and specific research and innovation projects [71]. The missions will be implemented within the Horizon Europe program. The strategic plan of the program for 2021–2024 identified five missions aimed at solving the most serious global problems of today [76]: the fight against cancer; adaptation to climate change; restoration and purification of oceans and waters; development of climate-neutral cities as centers of innovation; ensuring healthy soil and food.

These missions require discoveries and innovations in many related scientific fields and sectors, as well as involvement and coordinated interaction of various actors—from researchers to entrepreneurs, government institutions and citizens [77–81]. This can be illustrated in the context of the fourth mission, which involves the building of 100 climate-neutral cities by 2030 [71]. Thus, to achieve carbon neutrality in cities, engineers, architects, specialists in energetics, environmental scientists, programers, politicians, social workers, and citizens need to cooperate in the sectors such as urban planning and urban development, ecology, energy efficiency, land use, food, and transport [82]. Launching many research and innovation projects combined with political support, good governance, and citizen involvement in decision-making will strengthen the overall positive impact on shaping a climate-neutral Europe as a global goal by 2050 [83]. The advantage of the mission-oriented policy is in the combination of knowledge, skills, and thinking of professionals belonging to different fields of activity and cultures, in the connection of technologies and infrastructures, and in the exchange of experience and combination of entrepreneurial initiatives. All these factors will provide scientific results and innovative solutions for various applications that will ultimately have a positive effect on the economy, social sphere and environmental situation in Europe and beyond. Thus, successful implementation of missions requires the use of inter-subject, interdisciplinary, inter-sectoral approaches, which are best suited to the concept of the national innovation ecosystem as a tool for analyzing the innovation potential of the countries.

3. Data Source and Research Methods

The literature review was prepared using the systematic literature review and the analysis of the Scopus database (on the example of the scientific publishing house Elsevier).

In the European Union, the European Innovation Scoreboard is used to show the status and provide a comparative assessment of national innovation ecosystems of the EU member states and some other countries, including those associated with the EU. It consists of ten consolidated innovation dimensions, each of which contains 2–3 indicators, on the basis of which the Summary Innovation Index is calculated. These dimensions or sub-indices are conditionally divided into four main types of activity [84] (pp. 86–90):

- Framework conditions (covers external driving forces of innovation in relation to companies)—sub-indices are *"Human resources"* (includes such two indicators: new doctorate graduates per 1000 population aged 25–34; percentage population aged 25–34 having completed tertiary education and lifelong learning), *"Attractive research systems"* (includes three indicators: international scientific co-publication per million population; scientific publications among the to 10% most-cited publications worldwide as a percentage of total scientific publications of the country; foreign doctorate students as a percentage of all doctorate students) *and "Innovation-friendly environment"* (broadband penetration; opportunity-driven entrepreneurship);
- Investments (reflects the level of public and private investment in research and development (R&D) and innovation)—sub-indices *"Finance and support"* (R&D expenditure in the public sector (percentage of GDP); venture capital (percentage of GDP), *"Firm investments"* (R&D expenditure in the business sector (percentage of GDP); Non-R&D innovation expenditures (percentage of turnover); enterprises providing training to develop or upgrade ICT skills of their personnel);
- Innovation activity (measures innovation efforts at the level of companies)—sub-indices *"Innovators"* (SMEs introducing product or process innovations (percentage of SMEs); SMEs introducing marketing or organizational innovations (percentage of SMEs); SMEs innovating in-house (percentage of SMEs)), *"Linkages"* (innovative SMEs collaborating with others (percentage of SMEs); public–private co-publications per million population; private cofounding of public R&D expenditures (percentage of GDP) and *"Intellectual assets"* (PCT patent applications per billion GDP (in PPS); trademark applications per billion GDP (in PPS); design applications per billion GDP (in PPS);
- Impacts (reflects the results of innovation activities of companies)—sub-indices *"Employment impacts"* employment in knowledge-intensive activities (percentage of total employment); employment in fast-growing enterprises (percentage of total employment) and *"Sales impacts"* (exports of medium and high technology products as a share of total product exports; knowledge-intensive services exports as a percentage of total services exports; sales of new-to-market and new-to-firm innovations as a percentage of turnover).

Comparing countries by these parameters makes it possible to identify the strengths and weaknesses of their innovation ecosystems and single out lagging areas of activity on which to focus. At the same time, the European Innovation Scoreboard does not assess which of the selected dimensions has the greatest impact on the innovation productivity of the EU member states and the countries with different innovation potential. Obtaining this assessment would be helpful in establishing priorities of innovation policy in the countries with different productivity of innovation ecosystems in the interests of their innovative development.

To determine this impact, an assessment of the correlation-regression dependence of the performance indicator was carried out. It determines the level of innovative development of the EU member states and Ukraine on a number of indicators that characterize the parameters of their innovation ecosystems. Provided that the relationship between the performance indicator and the factors influencing it is not strictly deterministic, but probable, then models and methods of correlation and regression analysis are used to determine the strength of such a relationship to quantify the measure of impact.

The effective feature (Y) was chosen as the value of the Global Innovation Index. It measures the positions of the world's countries in terms of their level of innovative development (Cornell University, INSEAD, WIPO, 2020). The sub-indices of the European Innovation Scoreboard were chosen as factor features (independent variables) (X_i, $I = 1 \ldots m$; $m = 10$): X_1—*human resources;* X_2—*attractive research systems;* X_3—*innovation-friendly environment;* X_4—*finance and support;* X_5—*firm investments;* X_6–*innovators;* X_7—*linkages;* X_8—*intellectual assets;* X_9—*employment impacts;* X_{10}—*sales impacts*. These sub-indices are the most significant factors influencing the level of innovative development of the countries. They satisfy two main conditions: firstly, their totality is associated with an effective sign by a causal relationship, and secondly, this dependence is stochastic, not functional. Therefore, socio-economic phenomena and processes are characterized by the fact that, along with the reasons that determine the dependence under study, they are affected by numerous random factors. For this reason, dependence does not manifest itself in each case separately (as it usually happens in nature and technology), but only in general and average, in numerous cases. This type of relationship is defined as stochastic in its content.

In this study, we cannot use the Summary Innovation Index of the European Innovation Scoreboard as an effective indicator because, in this case, one of the conditions of correlation-regression analysis will not be met, according to which the selected factors should not be part of the effective feature. Furthermore, we cannot include individual indicators of sub-indices in the model along with the latter since in this case the hierarchy of factors will be violated. Independent variables must also not duplicate each other; that is, they must not be multicollinear. Identification and removal of such factors are carried out at the initial stages of the regression analysis. The degree of growth of multicollinearity is measured by the growth factor of the variance: if the value of the latter is close to 1, then multicollinearity does not exist for a given independent variable.

The identification of regression dependencies is based on the following hypothesis: the set of determining (priority) parameters in terms of ensuring the innovative development of the EU member states and Ukraine in the global context of national innovation ecosystems varies depending on their productivity and innovation potential.

Correlation-regression analysis was performed using the STATISTICA 12.0 package. The analysis was carried out using the stepwise regression method for four groups of countries (n) according to the classification of the European Innovation Scoreboard [84], (pp. 13, 77): Innovation Leaders—this group includes 5 countries; Strong Innovators—7 countries; Moderate Innovators—13 countries; Modest Innovators—2 countries, Ukraine is also included in this group.

Since plotting the regressions for the first, second and fourth groups of countries is impossible due to dissatisfaction with the $\mathrm{n} - 1 \geq m$ condition, it was decided to combine countries close in innovation potential, belonging to the Innovation Leaders and Strong Innovators, in the first group, and Moderate Innovators and Modest Innovators (together with Ukraine) in the second group.

Linear multifactor regression dependencies for two aggregated groups of countries are calculated. The choice of the form of regression dependence is based on the optimal combination of formal approximation criteria: minimum $\sum (y - \overline{y}_x)^2$—the criterion of the least squares method, where $\overline{y}_x$ is the calculated value of the effective feature; maximum Fisher–Snedecor criterion (F-criterion); minimum relative approximation error ($\varepsilon_{relat.}$) the regression model is statistically significant (reliable) by the F-criterion ($F_{calcul.} > F_p$), where F_{calcul}, F_p are the calculated and tabular values of the criterion.

4. Results of the Evaluation

For the *first group*, which includes 12 countries (Sweden, Finland, Denmark, the Netherlands, Luxembourg, Belgium, Germany, Austria, Ireland, France, Estonia, and Portugal), the best approximation is reflected in the following multiple linear regression equation:

$$\mathrm{Y(x_i)} = 19.627 + 0.116\mathrm{x_4} + 0.088\mathrm{x_8} + 0.121\mathrm{x_9} \quad (1)$$

including regression dependence in a standardized form:

$$\mathrm{t\,Y(x_i)} = 0.482\mathrm{tx_4} + 0.626\mathrm{tx_8} + 0.866\mathrm{tx_9} \quad (2)$$

The value of coefficient b indicates a positive relationship between the effective feature (Y) and the independent variables $\mathrm{X_i}$. The values of the parameters of Equation (1) indicate that all factors directly affect the change in the effective feature Y.

In the regression model, the closeness of the relationship between Y and Xi is significant. It is indicated by multiple correlation coefficient R, which is equal to 0.942. Collectively, the factor features that are included in the multifactor regression model (1) by 88.7% cause the variation of Y (Table 1).

Table 1. Results of the consolidated regression analysis for the first group of countries—Innovation Leaders and Strong Innovators.

	b*	Std. Err. of b*	b	Std. Err. of b	t (8)	*p*-Value
Intercept			19.62679	4.551316	4.312333	0.002573
X_4 Finance and support	0.481809	0.131802	0.11567	0.031641	3.655557	0.006442
X_8 Intellectual assets	0.626121	0.152882	0.08756	0.021379	4.095467	0.003459
X_9 Employment impacts	0.865964	0.140593	0.12073	0.019601	6.159367	0.000271
N = 12	R = 0.94202794; R^2 = 0.88741664; Adjusted R^2 = 0.84519788; F (3,8) = 21.019; p = 0.000377, $p \leq 0.05$; Std. Error of estimate: 2.1803					

Source: developed by the authors based on the Cornell University, INSEAD and WIPO, 2020; European Commission, 2020) [84,85].

Hypothesis on the statistical validity the validity of the indicators of the closeness of the connection of the model was checked using the *t*-test or Student's test:

$$t_{calcul.} = \frac{R_{xy}\sqrt{n-m}}{\sqrt{1-R^2{}_{xy}}} \tag{3}$$

where *R*—multiple correlation coefficient; *n* is the size of the set of studied objects (countries); m is the number of estimated parameters in the regression equation.

According to the tables of Student's distribution functions, the tabular value of the criterion was determined, i.e., t_p by the number of degrees of freedom n-m and the given level of statistical significance *p* = 0.05. If $t_{calcul.} > t_p$, then the hypothesis on the statistical validity (reliability) of the correlation is not rejected with a probability equal to 1 – *p*.

The calculation results showed that in the tested regression model $t_{calcul.} = 3.971$, $t_p = 2.919$, i.e., $t_{calcul.} = 3.971$, $t_p = 2.919$, which confirms the hypothesis on the statistical validity of the correlation and indicates that with a probability of 0.95 $(1 - p)$ the regression equation for the first group of countries is statistically reliable.

The statistical significance of the entire regression equation was tested using the Fisher–Snedekor test or F-test. If $F_{calcul.} > F_p$, then the hypothesis of statistical significance (significance) of the correlation is not rejected. The calculation results obtained using the STATISTICA 12.0 package showed that $F_{calcul.} = 21.019$, $F_p = 3.8$, i.e., $F_{calcul.} > F_p$, which indicates the statistical significance of the regression equation for the first group of countries.

According to the results of the analysis, the three most significant factors that are included in the model have been selected and considered as priorities in terms of ensuring the innovative development of this group of countries: *"Finance and support"*, *"Intellectual assets"*, *"Employment impacts"*. These factors are statistically significant (essential) at $p \leq 0.05$ (Table 1). The assessment of the regression model as a whole according to the table of variance analysis (ANOVA) indicates its acceptability (significance level *p* = 0.000377, $p \leq 0.05$).

The *second group* includes 15 EU member states with less innovation potential according to the European Innovation Scoreboard, as well as Ukraine. The study identified the following multifactor regression model for the second group of countries:

$$Y(x_i) = 29.448 + 0.093x_2 + 0.018x_3 + 0.02x_4 + 0.057x_9 \tag{4}$$

including a standardized multiple regression equation:

$$t\,Y(x_i) = 0.661tx_2 + 0.118tx_3 + 0.137tx_4 + 0.475tx_9 \quad (5)$$

Multiple regression (4) indicates a direct relationship between the selected independent variables X_i and effective feature Y. The closeness of this relationship is significant (R = 0.961). Determinants for ensuring the innovative development of this group of countries are "*Attractive research systems*" and "*Employment impacts*", for which the condition $p \leq 0.05$ is met. The factors "Innovation-friendly environment" and "Finance and support" (Table 2) also play a significant role. Taken together, these four factors included in the regression model (4) determine the change of 92.4% in the rating of this group in the Global Innovation Index.

Table 2. Results of the consolidated regression analysis for the second group of countries—Moderate Innovators and Modest Innovators, including Ukraine.

	b*	Std. Err. of b*	b	Std. Err. of b	t (8)	*p*-Value
Intercept			29.44773	1.370316	21.48973	0.000000
X_2 Attractive research systems	0.660525	0.094429	0.09275	0.013259	6.99495	0.000023
X_9 Employment impacts	0.474826	0.088447	0.05737	0.010686	5.36849	0.000227
X_4 Finance and support	0.136551	0.104771	0.02038	0.015639	1.30333	0.219082
X_3 Innovation-friendly environment	0.118050	0.098746	0.01760	0.014724	1.19548	0.257034
N = 16	R = 0.96127913; R^2 = 0.92405756; Adjusted R^2 = 0.89644212; F (4.11) = 33.462; p = 0.000004, $p \leq 0.05$; Std. Error of estimate: 1.3770					

Source: developed by the authors based on the Cornell University, INSEAD and WIPO, 2020; European Commission, 2020 [84,85].

The statistical validity of the regression model for the second group of countries was tested as for the first group of countries—using the Student's test (3) and the Fisher–Snedekor test. The regression model was also tested in terms of its acceptability (significance).

Checking the hypothesis on the statistical validity of the indicators of the closeness of the connection of the model showed that with the number of degrees of freedom n − m = 6 and a given level of statistical significance $p = 0.05$ $t_{calcul.} = 8.541$, $t_p = 1.943$, i.e., $t_{calcul.} > t_p$, which confirms the hypothesis on the statistical validity of the correlation relationship of the model and indicates that with a probability of 0.95 the regression equation for the second group of countries is statistically reliable. The Fisher–Snedekor test $F_{calcul.} = 33.462$, $F_p = 4.11$ ($F_{calcul.} > F_p$) indicated the statistical significance of the regression equation for the second group of countries. The assessment of the regression model as a whole according to the table of variance analysis also indicates its acceptability (significance level $p = 0.000004$, $p \leq 0.05$).

5. Discussions

For the *first group*, the standardized Equation (2) allows determining the force of impact ratio on the position change of the countries in the Global Innovation Index rating of each factor. It shows that the greatest impact on the effective feature *Y* has the level of employment in knowledge-intensive industries and fast-growing enterprises of the "most innovative" sectors [84,86], which reflects the ability of countries to quickly transform the economy according to new needs and demands (factor X_9, $a_9 = 0.866$).

In second place in terms of strength of impact is the ability of companies to develop new products, change and improve their design, and implement innovations in services, which in the Fourth Industrial Revolution largely determines their competitive advantage in European common and global markets (factor X_8, $a_8 = 0.626$). "*Intellectual assets*" sub-index measures this ability of firms by identifying the number of applications for patents, trademark registration and patenting of industrial designs.

The third most important factor is the sub-index *"Finance and support"*, which includes the funding level of public research organizations and higher education institutions and the amount of venture capital expenditures (in % to GDP) (factor X_4, a_4 = 0.482). The importance of this factor is due to the fact that R&D is a condition and one of the main driving forces of sustainable economic growth in a modern country. The importance of science for achieving all 17 Sustainable Development Goals is emphasized in the UNESCO report [87]: Science will be critical to meeting the challenge of sustainable development, as it lays the foundations for new approaches, solutions and technologies that enable us to identify, clarify and tackle local and global problems [24]. The world is increasingly focusing on science and its role in addressing global challenges, including the COVID-19 pandemic [88], which has intensified national research systems and promoted 4.0 industries, especially the biological sciences [89]. Therefore, state support for science, especially fundamental science, is the prerogative and duty of the state. Although business is a driver of innovative changes in the economy, it is focused on short-term benefits with the least risk to itself, which is incompatible with research and development, which is high-risk and unpredictable in terms of profit. It requires patience and time and, accordingly, long-term investments. At the same time, R&D is a prerequisite for any innovative breakthrough. As Max Planck put it 100 years ago, "Knowledge must precede application and the more detailed our knowledge is < . . . >, the richer and more lasting will be the results we can draw from that knowledge" [87]. Thus, investments in R&D today can serve as a kind of indicator of achieving innovative competitiveness and improving the welfare of the population in the future.

The venture capital expenditure indicator is also included in the *"Finance and support"* sub-index. For startups and companies developing new products for the global market, venture capital is often the only available source of financing, as banks and other investors are usually reluctant to lend to high-risk projects, favoring stable businesses. Venture capitalists not only invest in innovative businesses, but they also provide mentoring support to startups and, if successful, receive a reward that is several times higher than their initial investment. Therefore, venture capital accelerates the emergence and development of innovative firms, thus acting as a driver of economic growth.

In general, the determined coefficients ai for the factors of Equation (2) show the following effect: each unit of growth of the sub-index *"Finance and support"* is accompanied by an increase in innovative development by an average of 0.482 points of the Global Innovation Index under the condition that it is simultaneously influenced by other factors included in the model; increasing the value of the sub-index "Intellectual assets" per unit provides an increase in the Global Innovation Index by 0.626 points; the corresponding growth of the sub-index "Employment impacts" is accompanied by an increase in the level of innovative development of countries by an average of 0.866 points of the Global Innovation Index.

The countries of the second group, which belong to *Moderate Innovators and Modest Innovators,* are at a level of innovative development lower than the first group of countries. Therefore, they need to intensify structural reforms in the economy, based on investment in science and human capital, the introduction of knowledge and production improvement, development of key technologies and industries 4.0, stimulation of innovative activity and transition to the model of sustainable development aimed at the formation of the new quality of life in a favorable socio-economic and environmentally friendly environment. As the analysis showed, the key precondition for achieving such goals is the development of international scientific cooperation and ensuring the effectiveness of national research systems (factor X_2). The sub-index *"Attractive research systems"* includes data on a number of scientific publications with at least one co-author from abroad, the number of the most cited scientific publications in the world, as well as the share of foreign doctoral students in the country.

The standardized Equation (5) shows that *factor* X_2 (a_2 = 0.661) has the greatest influence on the position of countries with moderate and low innovation potential in the Global Innovation Index. Indeed, the development of the science-intensive industries of the future is unlikely to be possible by a single country with moderate innovation potential. It requires significant financial and intellectual resources, which are usually lacking. Extensive scientific and technical cooperation with other countries, especially innovative ones, bringing together specialists from different scientific fields, and integrating their knowledge and efforts will form a kind of collective mind—an interethnic, intercultural and interdisciplinary team capable of solving problems of high complexity. Creating conditions for the rise and transformation of industry 4.0 into the mainstream industrial development of the second group will contribute to the structural modernization of their economies in favor of high-tech, environmentally friendly industries instead of resource- and energy-intensive and, therefore, environmentally intensive industries. Most importantly, it will change the structure of employment in the economy through the creation of high-tech jobs with decent wages as an economic condition for improving the quality of life, welfare and well-being of the population. The value of the coefficient a_9 = 0.475 for the factor X_9 of the standardized Equation (5) indicates the priority of the introduction of such structural changes—the strength of factor X_9 ranks second among the four selected factors included in the model (4).

The other two factors of Equation (5) have much smaller and approximately the same impact on the effective feature *Y*—*"Finance and support"* (factor X_4) and *"Innovation-friendly environment"* (factor X_3). Among these two factors, in third place in terms of influence is the factor X_4, the importance of which was discussed above, as indicated by the coefficient a_4 = 0.137 in Equation (5) and, accordingly, in *fourth place factor* X_3 (a_3 = 0.118), as the sub-index *"Innovation-friendly environment"*. This sub-index includes two indicators: the number of enterprises connected to high-speed Internet (at least 100 Mbps), and the so-called motivational index, which reflects the opportunities for entrepreneurship development in the country. Thus, on the one hand, this sub-index reflects the impact of globalization and digitalization on the economic development of the countries [90] through the indicator of the provision of enterprises with high-speed Internet for the development of e-commerce. On the other hand, it emphasizes the importance of entrepreneurship development, but not one that is "driven by necessity" due to the lack of other employment opportunities but focused on improving life by gaining independence in professional activities and/or increasing income. In this case, people have more alternatives for earning, job satisfaction increases, and hence, work inspiration increases, which is an important condition (along with the human mind and technology) for the country to achieve sustainable economic growth. After all, as the experience of some developed countries (for example, Japan or Switzerland) convincingly demonstrates, the combination of inspiration for work and the skill of the population may well compensate for the lack of natural resources for economic growth [91].

Thus, the results of the evaluation showed that the set of factors determining the innovative development of countries with different levels of productivity and innovation potential in the global context is changing. Therefore, for the first group of countries, which includes developed countries with an effective research system, the following are of paramount importance:

- Firstly, the results of innovative activities of companies, or rather the level of employment in new industries and sectors of the economy based on knowledge and innovation (coefficient X_9, a_9 = 0.866). This suggests that the prospect of maintaining or improving the innovative position of developed countries in the world depends on the ability of their companies to quickly adapt to new needs and use emerging demand to their advantage. Accordingly, the innovation policy of developed countries should pay more attention to understanding the needs of consumers, promoting their direct participation in the innovation process as co-creators and co-performers of innovations. This conclusion corresponds to the Open Innovation 2.0 paradigm, according to which all stakeholders—from scientists to entrepreneurs, government institutions and citizens—work together to create innovation;

- Secondly, the innovative effort of companies and, above all, their ability to develop breakthrough innovations (factor X_8, a_8 = 0.626) that create new markets and provide them with a competitive advantage and industry leadership for a certain period of time until competitors start to imitate their solutions. To encourage companies to create truly breakthrough innovations, government support and a proactive innovation policy are needed to: (1) ensure and maintain a high level of government spending on science; (2) create an effective system of intellectual property rights protection and risk sharing between the state and business, as it is difficult for companies to determine in advance what the result of innovation will be, how much time and resources will be required to develop innovation; (3) introduce favorable incentives, tax and credit systems in order to encourage businesses to invest in innovations;
- Thirdly, keeping public R&D expenditure at high levels as one of the main factors for ensuring sustainable economic growth, and maintaining and increasing the wealth and competitiveness of developed countries. Moreover, according to the results of the assessment, the key players in the national innovation ecosystems of this group of countries are high-risk investors, which is quite natural because, for companies developing breakthrough innovations, venture capital is often the only available source of financing (factor X_4, a_4 = 0.482). The volume of venture financing largely determines the dynamics of the creation and development of new innovative enterprises, and thus affects the level of employment in innovative sectors of the economy, which, as mentioned above, is a decisive factor in ensuring innovative leadership in developed countries.

For the second group of countries with lower innovative potential, the set of determinants of ensuring their innovative development covers almost all types of activities according to the European Innovation Scoreboard—framework conditions, investments and results of innovative activities of companies. This indicates the relative weakness of the national innovation ecosystems of this group of countries and the need for their governments to pursue a systematic innovation policy.

The results of the evaluation showed that for the second group of countries, the priority in terms of increasing the level of their innovative development is the driving force of innovative activity external to companies, namely: the attractiveness of research systems (factor X_2, a_2 = 0.661) and the innovation environment (coefficient X_3, a_2 = 0.118). These two factors rank first and fourth, respectively, in terms of the strength of their influence on the effective attribute Y in the regression relationship (5).

In the first case, we are talking about the need to improve: (1) the quality of scientific research through international cooperation, followed by an increase in the number of international jointly published scientific articles, incl. in world high-rank magazines in order to increase the citation rate. In the context of contemporary global challenges triggered by the Russian military aggression against Ukraine and the need to overcome the crisis caused by the COVID-19 pandemic, the following strategic priority areas of international scientific and innovation cooperation can primarily be considered: deepening the partnership of states in the field of ensuring security, military-industrial cooperation, developing cooperation in the field of health and pharmacology, activating research and innovation links in the field of agriculture and food industry and, above all, organic farming to ensure healthy soils, food and food safety, intensifying cooperation in energy in the development of nuclear, solar, wind, hydrogen and other renewable energy sources, conducting joint research in the field of efficient use of natural resources; (2) attractiveness of research organizations for foreign doctoral students as an effective way of acquiring highly qualified staff, their experience and knowledge for the development and dissemination in the local scientific community. When it comes to the innovative environment, we mean:

- Firstly, the degree of integration of companies in these countries with the digital environment, and the degree of their coverage with high-speed Internet as a necessary condition for the development of e-commerce. Taking this into account, as well as the importance of strengthening international cooperation to ensure the innovative development of this group of countries, one of the priority areas of their scientific and innovative cooperation may be the strengthening of digital cooperation, the joint development of digital technologies, cognitive technologies, artificial intelligence and machine learning, the Internet things, cloud computing, virtual and augmented reality, blockchain, additive technologies. The advancement of digital technologies will help national governments overcome the COVID-19 crisis as quickly as possible, and companies will gain international competitive advantages. Benefits for the latter can be obtained in particular by facilitating the implementation of commercial operations, reducing transaction costs, improving communication and building innovative networks, and gaining access to global markets through digital platforms;

- Secondly, opportunities for entrepreneurship development not caused by necessity due to the lack of other employment opportunities for the population, namely innovative ones, aimed at improving the lives of the entrepreneurs themselves and the society as a whole. In order to stimulate the development of innovative entrepreneurship in these countries, it is advisable to apply government measures aimed at improving the regulatory and business environment, facilitating entrepreneurs' access to public procurement, and promoting the development and implementation of digital technologies by them and the development of digital skills.

The other two factors that have a significant impact on the level of innovative development of the second group of countries are the structure of people working in the economy and, above all, in science-intensive industries (factor X_9, $a_9 = 0.475$) and the level of public funding of science and availability of venture capital (factor X_4, $a_4 = 0.137$). These factors were included in the regression models of both groups of countries, which indicates their importance for ensuring and maintaining the level of innovation achieved by them. However, they differ in the strength of their influence on the effective attribute Y. Thus, for less developed economies, ensuring a high level of employment in knowledge-based and innovative sectors is less important than for developed economies. It is quite logical because, for the countries from the second group, the first step towards increasing the level of their innovative development should be the development of global technologies and processes through international cooperation, licensing and trade. National governments need to encourage the application of state-of-the-art innovations in their countries, including digital, in which they do not have comprehensive knowledge yet. By developing the absorptive capacity, companies in these countries will be able to determine the value of foreign technologies themselves, make the necessary changes in them and use the acquired knowledge to develop their own innovations. However, this process is not automatic but requires these countries to improve the innovative environment for companies, increase public funding of science, and promote the development of the venture capital market, as evidenced by the presence of the factor X4 depending on the regression (5) ($a_4 = 0.137$). In less developed countries, science is generally forced to perform primarily cognitive and socio-cultural functions, as it is known from world practice that the possibility for science to influence the level of economic growth arises when it is funded by more than 0.9% of GDP.

In general, the determined coefficients ai for the factors of Equation (5) show the following effect: each unit of growth of the sub-index *"Attractive research systems"* is accompanied by an increase in innovative development by 0.661 points of the Global Innovation Index, under the condition that the latter is influenced by other factors included in the model; increasing the value of the sub-index *"Innovation-friendly environment"* per unit provides an increase in the Global Innovation Index by 0.118 points; the growth of the sub-indices *"Finance and support"* and *"Employment impacts"* is accompanied by an increase in the level of innovative development of countries by an average of 0.137 and 0.475 points of the Global Innovation Index, respectively.

6. Political Recommendations for Ukraine

Based on the results of the assessment, which showed that the parameters of national innovation ecosystems have a positive impact on the level of innovative development of countries in the global context, given the need for early post-war reconstruction of Ukraine, we offer policy recommendations for Ukraine. When developing recommendations, we proceeded from the fact that in Ukraine, the existing structure of the economy should be radically changed from an agrarian-raw material type to an industrial-innovative one, giving these processes a systemic character.

Furthermore, when developing recommendations, we took into account the results of the study presented in [5]. Their generalization made it possible to highlight a number of important conclusions that may be useful for Ukraine in the development and implementation of the state innovation policy at the national, regional and local levels, which are as follows:

- In achieving the new EU strategic goals for 2019–2024, and in the coming years, innovation will play a decisive role in the development of a climate-neutral, greener, digital, fair and democratic Europe;
- Of particular importance will be innovative processes that will be carried out at the local level, and not only at the level of regions but also at the level of cities and communities;
- Local innovation ecosystems should be perceived not just as branches of national innovation ecosystems but as innovation networks aimed at regional and urban economic transformations that exceed the possible effects of implementing strategies adopted at the state and EU levels;
- The regional heterogeneity of the EU territory in terms of geographical, socio-economic, cultural and other characteristics should be considered as an advantage and learn to benefit not only from the national diversity of countries but also from the heterogeneity of their regional and local environments in terms of social and cultural plurality, center and periphery, urbanized and rural areas;
- Research, development and innovation should be tied to regional and local environments, carried out in the interests of the sustainable development of regions, cities and societies in the context of the implementation of a mission-oriented innovation policy that will be more effective at the local level due to the involvement of local stakeholders in its implementation;
- State innovation policy should be developed and implemented in synergy with policies in other areas and sectors of the economy in the long term.

Based on this, we propose an approach to the formation of an integral system of state strategic planning for the development of the scientific, technological and innovation sphere of Ukraine. Such a system, in our opinion, should consist of long- and medium-term documents: (1) a forecast of scientific, technological and innovative development of Ukraine for a period of up to 20 years; (2) interdepartmental strategy for the development of science, technology and innovation in Ukraine for a period of up to 10 years (hereinafter referred to as the Strategy); (3) long- and medium-term state target programs (based on the legislative norms of Ukraine, long-term—with a period of execution up to 10 years and medium-term—up to 5 years); (4) regional and local targeted programs in science, technology and innovation.

The main thing in this system is the Strategy, and all other documents regulating the sphere of innovative legal relations must be consistent with it and be focused on its implementation. In Ukraine, a lot of strategic and conceptual documents related to the development of innovations have been adopted and are in the process of being developed. The practice of multiplying such documents continues throughout the history of Ukraine's independence but has not yet brought the country closer to an innovative economy, which is a consequence of the lack of coordination in strategic planning. In this regard, the proposal to develop an interdepartmental Strategy that would combine all these strategies and concepts into a single document, ensuring communication of all interested participants in the national innovation ecosystem, can help solve this problem and, consequently, reduce the country's lag behind the developed innovation economies of the EU.

The newly created State Agency for the Development of Science, Technology and Innovation should lead the development and subsequent implementation of the Strategy. In Ukraine at the moment, there is no single state structure that would deal with the issues of planning and building up the country's innovative potential. Such an agency, in our opinion, should be endowed with a high status (headed by the Prime Minister) with broad powers to plan and implement economic, financial and institutional measures aimed at developing an effective national innovation system for Ukraine and also be financed by a separate line from the state budget.

State policy should be formed taking into account the five-year cadence within the framework of the interdepartmental Strategy, and political goals should provide for the achievement of the goals formulated by the Strategy. It is important to ensure the continuity and consistency of state policy when changing political elites, that is, outside the time limits of political cycles. State policy should be developed as a horizontal one and affect all areas of activity that contribute to innovation—educational, scientific, industrial, environmental, investment and others. Copying successful policies of other countries should be avoided. Ukraine should use European and world experience, especially in terms of mechanisms for implementing innovation policy but determine the goals and content of its own development model independently, taking into account national socio-cultural and institutional characteristics.

At the regional level, it is proposed to create intersectoral departments in the system of regional governments and give them powers in the development and implementation of state innovation policy in the field. Their activities should be consistent with the activities of the State Agency for the Development of Science, Technology and Innovation in ascending and descending lines of management, with an emphasis on the latter to take into account the needs of Ukrainian society and end-users. The formation of such departments seems possible through the redistribution of part of the specialists in the regional management system with the involvement of representatives of the expert scientific community. Furthermore, at the level of regions (NUTS 2) and districts (NUTS 3) (under regional and district state administrations), in order to coordinate the interests of participants in innovation ecosystems and ensure their real cooperation, it is proposed to create special coordination centers in the form of regional and district innovation councils, which in practice will ensure the formation of proper institutional conditions for strengthening regional and local innovation ecosystems.

With such an intersectoral approach, the management of the country's innovative development will not be carried out by each ministry, agency or department separately from each other but in a comprehensive and coordinated manner—on the weak points of Ukraine's innovative ecosystems at the national, regional and local levels.

7. Conclusions

The new strategic goals for the EU, starting in 2019 and beyond, include the development of a climate-neutral, greener, digital, fair and democratic Europe. The European Commission has adopted a new growth strategy, the European Green Deal, which aims to transform Europe into a prosperous society with a modern, resource-efficient and competitive economy, where the health and well-being of the population are protected from negative environmental influences and the transition to a "green economy" will be fair and conducive to social inclusion. With this in mind, the long-standing equivalence of policy goals for smart, sustainable and inclusive growth enshrined in the Europe 2020 strategy is eroding. In the EU's current focus on inclusive and sustainable growth, the third pillar, smart growth, should contribute to the achievement of the first two. In other words, according to European terminology, there is a shift from S3 (Smart Specialization Strategies) to S4 + (Smart Specialization Strategies for Sustainable and Inclusive Growth). Therefore, the emphasis in the EU innovation policy is changing, which should no longer focus on creating innovation solely for economic purposes but should contribute to the production of knowledge and innovation aimed at solving national and global social and environmental challenges, bringing Europe closer to achieving sustainability and integration.

The modern EU innovation policy is based on two key approaches: smart specialization and mission-oriented approach, which are designed to mutually reinforce and complement each other in building national innovation ecosystems capable of producing scientific knowledge and innovation for sustainable and inclusive growth in Europe. Successful implementation of the policy requires joint concerted efforts of the EU member states as well as the EU neighbors. Today, the EU indeed faces the task of building a self-sustaining, efficient European innovation ecosystem that brings science and business closer together and is able to tackle global challenges. At the same time, the political leadership of the EU and the governments of the EU Member States cannot fail to recognize the complexity of such a task, and it is, therefore, more important than ever for them to expand their cooperation with other democratic European and non-European countries.

Ukraine, as a neighboring country to the EU, following the path of European integration, must coordinate national strategic goals, political activities and decisions concerning national scientific and innovative development with the European ones, striving to ensure their compliance in order to achieve a synergistic effect from joint efforts with European partners and minimize the fragmentation of the policy. This will contribute to the transformation of the structure of the Ukrainian economy and its transition from the consumer resource-based model to an inclusive high-tech industrial one, which is particularly important in the context of new global challenges.

In order to obtain more complete information on the impact strength of certain components in the national innovation ecosystems of the EU member states with different innovation potential and Ukraine on the level of their innovative development in the global context, a correlation-regression analysis was performed. The generalization of the results of the analysis allows us to draw the following conclusions:

1. In both groups of countries under study, the parameters of national innovation ecosystems have a positive effect on the level of innovative development of the countries in the global dimension. In the calculated regression models, the closeness of the relationship between the effective feature Y, which is selected as the value of the Global Innovation Index, and factor features X_i (as selected sub-indexes of the European Innovation Scoreboard) is significant: R = 0.942 for the first group and R = 0.961 for the second group of countries.
2. The results of the analysis revealed the change in the parameters of national innovation ecosystems that affect the ranking of the countries in the Global Innovation Index, depending on their level of productivity. In the first group of countries—*Innovation Leaders and Strong Innovators*—the regression model includes three factors; in the second group of countries—*Moderate Innovators and Modest Innovators*—there are four factors. Of the ten factors, two—*"Finance and support"* and *"Employment impacts"* were included in the regression models of both groups of countries, which indicates their importance in ensuring the innovative direction of development of the countries with both high and low innovation potential. Moreover, in terms of the impact on the performance indicator, the factor *"Finance and support"* in both groups of countries took third place, but in the countries with higher innovation potential, its role is more significant. Similarly, due to the influence of the factor *"Employment impacts"* in the first group, it is almost twice as high as in the countries of the second group.
3. The change in the rating of the first group of countries with high innovation potential in the Global Innovation Index by 88.7% is determined by the dynamics of three factors. Among the selected factors, the *greatest influence* on the effective feature Y has the level of employment in knowledge-intensive industries and fast-growing enterprises of the most innovative sectors. This indicates the ability of the countries to implement innovative transformations in the economy, improving its structure according to new needs and demands. This factor has almost twice as much influence

on the prospects of innovation growth of the countries as the sub-index *"Finance and support"*, which is in third place in terms of influence. Accordingly, the second place is occupied by the ability of companies to develop new products, improve their design, and implement innovations in services, which is assessed by indicators of the number of filed applications for patents, trademark registrations and patenting of industrial designs. These factors relate to the three major types of activities identified in the European Innovation Scoreboard and explained above. They are investment, innovation efforts at the company level and the results of innovation activities of companies.

4. Among the selected factors for the second group of countries with moderate and low innovation potential, the *greatest influence* on the prospects of their innovative development is exerted by international scientific cooperation and the effectiveness of national research systems. Thanks to international cooperation, it is possible to achieve coherence of efforts among countries and synergy of national policies, which in conditions of limited funding in these countries will contribute to the world-class scientific results and increase their research and innovation potential as the basis for a transition to a new model of economic growth based on innovations and principles of sustainable development. *The second most influential factor* is the level of employment in knowledge-intensive industries and fast-growing enterprises in the most innovative sectors. This indicates that countries with low levels of innovation also have prospects for boosting their economies by supporting new industries and markets in response to consumer demand and needs. In *third place* is the level of funding state research organizations and institutions of higher education and the amount of venture funding; in *fourth place* is the provision of enterprises with high-speed Internet and opportunities for business development in the country. Taken together, these four factors determine 92.4% of the change in the ranking of the second group of countries with low innovation potential in the Global Innovation Index. The analysis showed that countries with less innovation potential need to improve the framework conditions to a greater extent: two factors that are included in the regression model (3) belong to the consolidated type of activity of the same name "framework conditions"—factor X_2 ("*Attractive research systems*") and factor X_3 ("*Innovation-friendly environment*"). The other two factors relate to the types of investment activities and the results of firm innovation activities.
   Thus, the correlation-regression analysis confirmed the hypothesis of changing the parameters of national innovation ecosystems that affect the innovation of the EU member states and Ukraine in the global context, depending on the level of their productivity and innovation potential. The analysis revealed the factors that have the greatest impact on the ranking of the countries in the Global Innovation Index, depending on which group the countries under study belong to according to the classification of the European Innovation Scoreboard—*Innovation Leaders* and *Strong Innovators* or *Moderate Innovators* and *Modest Innovators*. It is established that the set of such factors in each group of countries varies and has a different degree of influence on the effective feature Y. The results of the analysis are useful information for policy decisions and can serve as a guidepost for improving the innovation policy of the EU member states and Ukraine through measures and tools aimed at intensification and strengthening the relevant parameters of national innovation ecosystems of the countries with high and low (moderate) innovation potential in the interests of their innovative development.
5. Recommendations are proposed for the formation of an integral system of state strategic planning for the development of the scientific, technological and innovation sphere of Ukraine in order to ensure the systemic influence of the state on the national innovation ecosystem of the country. The implementation of this approach will contribute to the speedy post-war restoration of Ukraine, and the production of innovations in the interestsinterest of the country's sustainable development. The proposed proposals are consistent with the recommendations of European experts,

correspond to the EU framework concept for the formation and implementation of an "integrated" state innovation policy, and satisfy the strategic interests of Ukraine, since they are aimed at producing innovations based on their own science and technologies integrated into production.

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