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MODEL OF EUROPEAN INTEGRATION OF R&D INSTITUTIONS OF THE NAS OF UKRAINE IN THE CONTEXT OF UKRAINE'S INTEGRATION INTO THE EUROPEAN UNION

Introduction. *Modern challenges increasingly exhibit a systemic nature, disrupting existing development trajectories and requiring effective cooperation among governments, research institutions and universities, business, and society within innovation ecosystems. Such cooperation is necessary to identify effective solutions to contemporary global challenges. The European Research Area (ERA), as a key component of the European innovation ecosystem, has formed a consolidated policy framework in research and innovation, bringing together resources and stakeholders to generate new knowledge and scale innovation solutions.*

Problem Statement. *In the context of Ukraine's integration into the European Union and the integration of Ukraine's national research space into the European Research Area, determining the place and role of R&D institutions of the NAS of Ukraine in the processes of European integration has become an important and relevant task.*

Purpose. *The purpose of this study has been to analyze the approaches of the European research and innovation system, examine the steps of European integration of Ukraine's research and innovation system, and review theoretical and methodological approaches to innovation processes, technology transfer, and innovation systems and ecosystems. Based on this analysis, the study has aimed to develop a model of European integration for R&D institutions of the NAS of Ukraine.*

Materials and Methods. *The methodological framework of the study has been based on the application of comprehensive analytical methods, including theoretical generalization, expert assessment, and*

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synthesis. Reports of European and national governmental institutions and organizations, as well as foreign and Ukrainian scholarly research publications related to the research topic, have been used as primary sources of information.

Results. *The study has summarized the key approaches of the European research and innovation system, the stages of European integration of Ukraine's research and innovation system, and theoretical and methodological approaches to innovation processes, technology transfer, and innovation systems and ecosystems. Based on an analysis of the development of the ecosystem approach, innovation systems and ecosystems, innovation process models, technology transfer models, and the Triple Helix and Quadruple Helix frameworks, the research has proposed a multi-level model of the European integration of R&D institutions of the NAS of Ukraine. Structurally, the model defines the integration of R&D institutions of the NAS of Ukraine into the European Research Area within the broader process of integrating Ukraine's innovation ecosystem into the European innovation ecosystem.*

Conclusions. *The results of the study have demonstrated that the proposed model can support the modernization of Ukraine's R&D sector, facilitate alignment with EU standards, and increase research efficiency through the implementation of European principles of performance evaluation, internationalization, technology transfer, and deeper integration into the European Research Area.*

Keywords: European research and innovation system, European Research Area, European integration, model, R&D institutions of the National Academy of Sciences of Ukraine, innovation ecosystem.

The European global approach to research and innovation confirms Europe's commitment to developing dynamic innovation ecosystems [1]. The European research and innovation system is based on the application of the concept of "open innovation, open science, openness to the world" with an "ecosystem" approach, which determines the main changes in modern European research and innovation activities. It has become more global through the use of networked international cooperation and coordinated joint actions at the city, regional, and national levels [2].

The priorities of the European research and innovation system are: development of education and human capital; open science; financing of open innovation; a balanced approach to intellectual property; promotion of cooperation and competition; orientation toward innovation networks; open government (publication of public data); use of open innovation processes; and support for the commercialization of public technologies [3].

The European innovation model defines: competition for global leadership; Europe as an innovation ecosystem; financial support for innovation; promotion of public/private funds that finance innovation; promotion of entrepreneurship in academic institutions; retraining; digital infrastructure; the promotion of new ways of cooperation between different ecosystems; creation of digital innovation centers around specific supply chains; and coordinated legislative regulation [4].

The driving force behind the innovative development of the countries of the European Union is the innovation ecosystems of regions and cities, which are aimed at developing ways to strengthen regional competitiveness and economic growth and to create new, higher-quality jobs. Innovative regions with successful universities and research institutions that are adapted to the conditions of competition are a powerful tool for stimulating the growth of European innovation ecosystems, which are a key factor in Europe's success in promoting new knowledge and innovative production for increasing technological, economic, and social potential [5].

Modern socio-economic and environmental challenges are increasingly systemic in nature, and their solution requires systemic responses that go beyond the resources of individual economic sectors, spheres of society, countries, communities, R&D organizations/universities, and companies. Systemic changes break the boundaries of societal, economic, and scientific systems and require effective cooperation between governments, R&D organizations/universities, business, and society, as well as the development of new paradigms, concepts, models, and practices that determine the best

ways to address contemporary socio-economic and environmental challenges.

Ecosystem economics is a new economic paradigm that focuses on co-creation, collaboration, and interdependence. In contrast to traditional approaches that focus on individual organizations, ecosystem economics emphasizes the power of collaboration and collective intelligence to create new value [6]. Ecosystem economics involves a transition from the application of sectors and industries to the application of ecosystems [7]. The ecosystem approach becomes the basis for the theoretical and methodological substantiation of the theory of ecosystem economics and socio-economic management [8].

The use of innovation ecosystems is gaining increasing practical significance in the application of the ecosystem approach through connections with the concepts of "open innovation," "open science," the Triple Helix model, and the Quadruple Helix model, the basis of which is cooperation: "government — business — R&D/universities — society."

An effective innovation ecosystem uses open innovation, which opens up the innovation process and uses available means to improve the quantity and quality of new knowledge in order to generate innovation [9].

For the practical implementation and development of an effective European innovation ecosystem, the European Research Area (ERA) is one of the important spaces for implementing European science, technology, and innovation policy. The ERA provides research aimed at creating cutting-edge knowledge and innovations that respond to economic and societal challenges by pooling scientific resources and creating a single EU research and innovation area. The ERA makes a significant contribution to the development of European science, technology, and innovation policy by aligning European and national priorities and objectives.

The creation of the ERA is due to the fact that knowledge production has become globalized, and research and innovation have become more socially relevant; the boundaries between fundamental and applied research are blurring; and the internationalization of research requires new interaction between partner countries and regions to form a socio-economic environment aimed at solving the socio-economic problems of society [10].

The development of the ERA faces new challenges, including a growing demand for research infrastructure, technological progress, and increasingly complex scholarly research. The expansion of fundamental knowledge requires increasingly sophisticated research tools. The complexity of research questions requires the integration of data and observations from multiple sources, as well as an increasing need for the storage, transmission, and analysis of large volumes of research data [11, 12].

These new challenges drive the need to develop the European research and innovation system within the framework of the ERA, taking into account the following aspects: the European research and innovation system becomes more open; the framework conditions for partnerships become more coherent and conducive to private investment; and Europe better coordinates and stimulates national research and innovation [13].

The European Research Area Platform provides researchers, innovators, citizens, and policymakers with a space to connect, collaborate, and access the latest information, data, and resources related to the ERA [14]. The ERA platform identifies four priority areas: deepening the existing knowledge market; jointly addressing the challenges of the green and digital transition with increased public participation; expanding access to research and innovation across the EU; and developing joint investments and reforms in research and innovation [15].

Important directions in the formation and development of European R&D and innovation policy, European innovation ecosystems, and the ERA include the application of theoretical and methodological approaches related to innovation systems and ecosystems [16—24], innovation process models [25, 26], technology transfer models [27—29], and the Triple Helix and Quadruple Helix models [30—36]. The prospects for their application in Ukraine have also been determined [37—39].

Since then, the Triple Helix model, which includes state institutions, science, and business as the main stakeholders, and the Quadruple Helix model, which additionally includes the public or civil society as the fourth helix, have become particularly popular as models of national, regional, and corporate innovation development. Recently, the Quadruple Helix model has gained particular prominence due to the rapid expansion of the role of science in economic development, the emergence of more complex networks of regional stakeholders, and a new understanding of the growing role of civil society in the development of science and technology in public policy aimed at addressing new socio-economic challenges [40, 41].

In order to integrate the national research space of Ukraine into the ERA, the "Roadmap for the Integration of the R&D and Innovation System of Ukraine into the ERA" has been approved [42]. The roadmap to the ERA consists of priorities jointly defined by the European Commission, around which each ERA country forms its own roadmap: increasing the efficiency of national research systems; jointly solving problems caused by global challenges; ensuring a free labor market for researchers; promoting gender equality; advancing open science and open innovation; and developing international cooperation [43].

Important steps on the path toward the European integration of Ukraine's research and innovation system include the following: the National Report *Innovative Ukraine 2020* [44]; the parliamentary hearings "National Innovation System of Ukraine" [45]; the European Audit of the National Research and Innovation System of Ukraine [46]; the creation of the Committee on the Integration of Ukraine into the EU [47]; and the Roadmap for the European Integration of Ukraine [48], among others.

The following strategic documents have also been approved: the Strategy for the Development of the Sphere of Innovation Activity in Ukraine [49]; the Concept for the Development of Artificial Intelligence in Ukraine [50]; the National Plan of Ukraine on Open Science [51]; the Agreement between Ukraine and the EU on participation in the LIFE Programme [52]; and the Agreement between Ukraine and the EU on participation in the Digital Europe Programme [53].

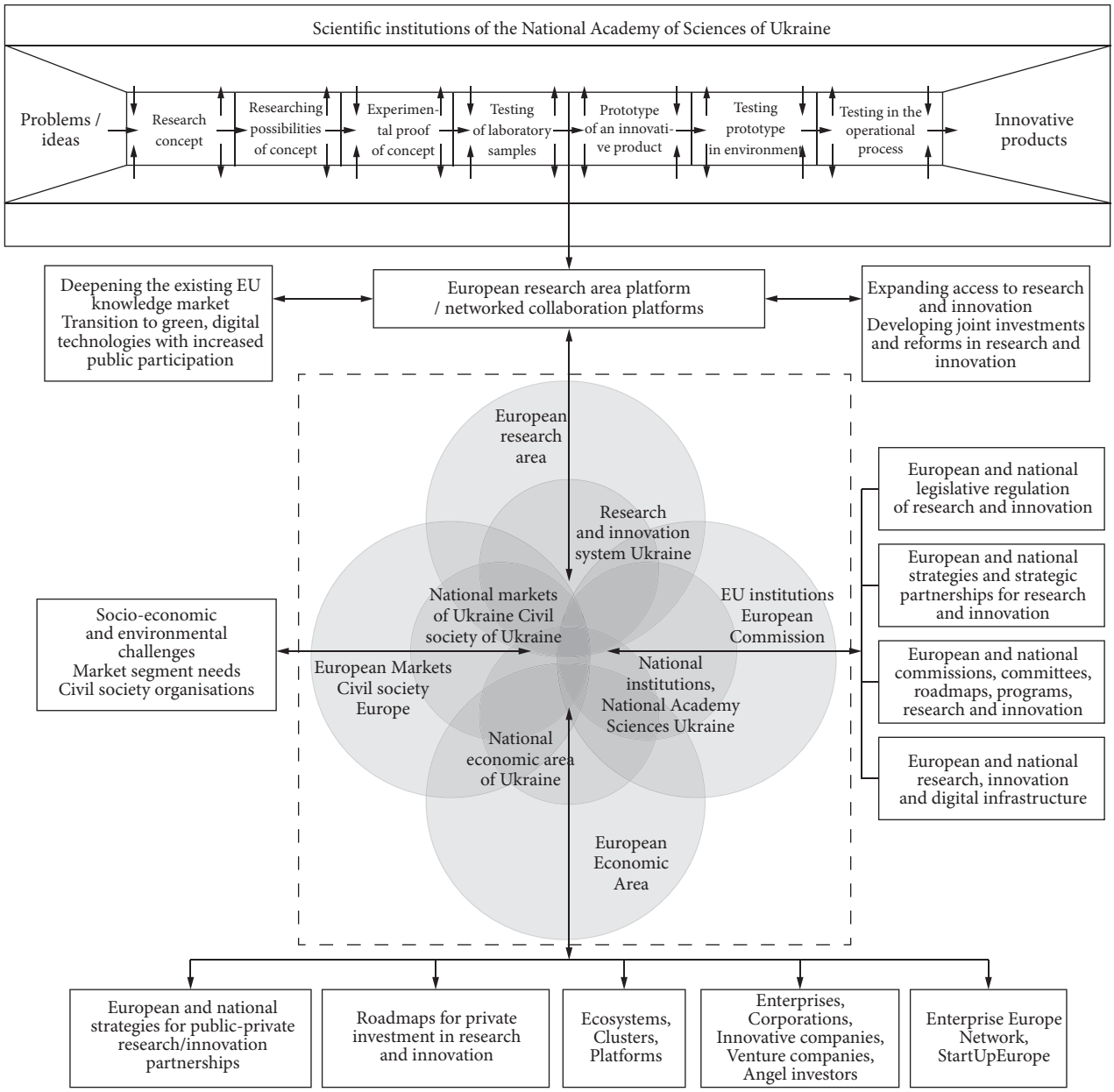
In addition, the Horizon Europe Office in Ukraine has been established [54], as well as the National Contact Points and the Coordination Centre of the EU Framework Programme for Research and Innovation *Horizon Europe* and the European Atomic Energy Community Programme [55], among others.

The implementation of the ERA roadmap can contribute to the harmonization of science and innovation policy in Ukraine with EU standards and norms; expanded access to EU research and innovation programs; the development and integration of Ukraine's research infrastructure into the EU research space; the creation of favorable conditions for the international mobility of scientists; and the adoption of best practices in open science and open innovation.

In accordance with national priorities regarding Ukraine's association with the European Union and the roadmap for integrating the national research space of Ukraine into the ERA, R&D organizations of the NAS of Ukraine need to determine their place and role in these processes.

The main advantages of integrating R&D institutions of the NAS of Ukraine into the ERA include the harmonization of research and innovation policy and integration into the EU research and innovation system; the development of research infrastructure; the application of open science policy; the improvement of research quality and the efficiency of commercialization of scholarly research results; the development of European partnerships and cooperation; and participation in value chains [56].

Important steps taken by the NAS of Ukraine on the path toward the European integration of its R&D organizations include the concept and project "Creation and Implementation of Open Science Infrastructure at the NAS of Ukraine (OPENS)" [57] and the Concept of Implementing European Principles of Open Science at the NAS of Ukraine [58]. The implementation of this concept can en-



Model of European Integration of R&D Institutions of the NAS of Ukraine

sure the formation of a modern model of open science at the NAS of Ukraine that meets European principles.

Based on the analysis of the development of the ecosystem approach, innovation systems and ecosystems, innovation process models, technology transfer models, and the Triple Helix and Quadruple Helix models, a multi-level model of the European integration of R&D institutions of the NAS of Ukraine has been proposed (see Figure).

Structurally, the model defines the European integration of R&D institutions of the NAS of Ukraine into the European Innovation Platform within the framework of the integration of the innovation

ecosystem of Ukraine into the European innovation ecosystem, using cross-functional cooperation between innovation ecosystems, where the knowledge economy, producers of knowledge and innovations, and civil society occupy a central place.

Each Quadruple Helix innovation ecosystem has four spaces: government institutions, science, business, and society. Each space has intersections that create shared spaces of European and national interaction: public institutions, research and innovation systems, business, and society, in which actors and stakeholders can assume the roles of others in order to implement initiatives, both top-down and bottom-up.

Shared spaces combine the financial, material, and intellectual resources of participants and stakeholders to create new knowledge within joint open science research projects and to implement open innovations within joint innovation projects. The model provides conceptual flexibility in involving different participants and stakeholders, which helps create synergies within innovation ecosystems. Each space can provide useful informational, conceptual, analytical, and financial resources to address contemporary socio-economic and environmental challenges of society.

The proposed model determines that modern socio-economic challenges and the increasing complexity of the economy and society can be better solved when there is a clear and simplified understanding of the interaction between governments, R&D organizations/universities, business/industry, and society as the most important participants in building sustainable innovative development of European and national innovation ecosystems.

This approach reduces the complexity of understanding the dynamics of the integration of innovation ecosystems, the creation of new knowledge, and the implementation of systemic sustainable innovations for the development of civil society within the framework of common spaces of cooperation and partnership between government structures, science, business, and society.

The creation of new knowledge and innovations through joint actions in different spaces of innovation ecosystems demonstrates that in modern society and the knowledge economy, in addition to academia, industry, and government, knowledge is located in innovation ecosystems, where the participation of civil society is the most important dimension of innovations that address contemporary socio-economic and environmental challenges.

Each participant in the Quadruple Helix spaces of the Ukrainian innovation ecosystem and the Quadruple Helix of the European innovation ecosystem has specific roles.

At the level of state institutions, it is necessary to develop the European integration of the national state institutions of Ukraine in terms of harmonizing general, R&D, and innovation policies, legislation, practices, and mechanisms of scholarly research, as well as the creation and implementation of innovations in accordance with European principles and approaches. Along this path, state institutions coordinate actions related to Ukraine's integration into the ERA.

These actions should be consistent with the objectives of ERA development: deepening the knowledge market; promoting international cooperation; stimulating reforms and investments in research and innovation; enhancing the sustainability and accessibility of research infrastructure; supporting the green and digital transition with the involvement of society; expanding access to research and innovation; introducing the EU legislative framework on copyright and research data; increasing the scientific and innovation potential of research institutions; promoting reforms of the scholarly research evaluation system; and supporting researcher career mobility.

The role of public institutions has been aimed at creating and applying legislative and financial instruments to stimulate research and innovation within the framework of programs and funds for European and national institutional, scientific, industrial, and social integration and cooperation.

At the level of the NAS of Ukraine, it has been planned to align the policy of the NAS of Ukraine with the policy of the ERA. In this context, it is

important to apply open science approaches and the concept of open innovation, as well as research missions and partnerships with ERA participants, including within the framework of targeted programs of the NAS of Ukraine and public — private partnerships. The application of ERA best practices, including approaches to research infrastructure, the transition to green and digital technologies, monitoring and evaluation mechanisms, researcher career mobility, and the strengthening of connections between science and society, brings science closer to citizens and society.

At the level of R&D institutions and research groups of the NAS of Ukraine, participation has been envisaged in scholarly research missions and partnerships with ERA participants, as well as in European and national research and innovation programs and the development of research and digital infrastructure. Such participation of R&D institutions of the NAS of Ukraine involves the creation of new knowledge within research projects using the open science approach and the implementation of innovative R&D results within innovation projects using the concept of open innovation.

At the level of information and digital support for the European integration of R&D institutions of the NAS of Ukraine, it has been planned to use the ERA platform and network cooperation platforms. The ERA platform and network cooperation platforms serve as spaces for open cooperation among various participants in innovation ecosystems operating in both physical and virtual environments.

Thus, the proposed multi-level model of the European integration of R&D institutions of the NAS of Ukraine envisages the development of common spaces for the creation of new knowledge, which have been transformed into innovative R&D projects with commercial potential that address contemporary socio-economic and environmental challenges of societies.

A significant advantage of the proposed model is the possibility of improving the quality and visibility of R&D institutions of the NAS of Ukraine within the ERA, developing scientific cooperation, generating new advanced knowledge, and accelerating the implementation of innovative R&D projects of NAS institutions of Ukraine.

The proposed model creates and utilizes positive factors that increase the capacity to accelerate the European integration of R&D institutions of the NAS of Ukraine in the context of the integration of the European and national innovation ecosystems through the development of cooperation with European institutions; R&D organizations/universities and research teams of the ERA; clusters and enterprises; and civil society.

The proposed multi-level model defines the European integration of R&D institutions of the NAS of Ukraine into the ERA within the context of integrating the Ukrainian innovation ecosystem into the European innovation ecosystem. The model assumes consistency with the guiding principles of the European research and innovation system, which has a global dimension and involves the development of international relations and dialogue among state institutions, researchers, stakeholders, business, and society in order to strengthen the impact of science on the economy and to address contemporary socio-economic and environmental challenges.

The application of open science and open innovation practices has been identified as a key factor in the European integration of R&D institutions of the NAS of Ukraine into the ERA, contributing to improving the quality of research and accelerating the implementation of innovative R&D projects of academic institutions of the NAS of Ukraine.

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МОДЕЛЬ ЄВРОІНТЕГРАЦІЇ НАУКОВИХ УСТАНОВ НАЦІОНАЛЬНОЇ АКАДЕМІЇ НАУК УКРАЇНИ В КОНТЕКСТІ ІНТЕГРАЦІЇ УКРАЇНИ ДО ЄВРОПЕЙСЬКОГО СОЮЗУ

Вступ. Сучасні виклики мають зростаючий системний характер, вимагають ефективної співпраці між урядами, науковими організаціями/університетами, бізнесом та суспільством у рамках інноваційних екосистем для визначення оптимальних шляхів їх вирішення. Європейський дослідницький простір (ЄДП) як ключова частина Європейської інноваційної екосистеми формує консолідовану політику у сфері досліджень та інновацій, об'єднує ресурси та учасників щодо створення нових знань та масштабування інноваційних рішень.

Проблематика. В умовах інтеграції України до Європейського Союзу, а національного дослідницького простору України до ЄДП, проблема визначення місця та ролі наукових установ НАН України у процесах євроінтеграції є актуальною та потребує вирішення.

Мета. Аналіз підходів Європейської системи досліджень та інновацій, кроків Європейської інтеграції системи досліджень та інновацій України, теоретико-методологічних підходів інноваційного процесу, трансферу технологій та інноваційних систем і екосистем; розробка моделі Євроінтеграції наукових установ НАН України.

Матеріали й методи. Застосовано комплекс аналітичних методів теоретичного узагальнення, експертної оцінки і синтезу. Джерелами інформації слугували звіти Європейських, національних державних установ та організацій, зарубіжні та українські наукові публікації окресленої тематики.

Результати. Узагальнено підходи Європейської системи досліджень та інновацій, кроків Європейської інтеграції системи досліджень та інновацій України, теоретико-методологічні підходи інноваційного процесу, трансферу технологій та інноваційних систем і екосистем. На основі їх аналізу, моделей трансферу технологій, *Triple Helix* та *Quadruple Helix* моделей запропоновано багаторівневу модель Євроінтеграції наукових установ НАН України, яка визначає Євроінтеграцію наукових установ НАН України до ЄДП в рамках інтеграції інноваційної екосистеми України до Європейської інноваційної екосистеми.

Висновки. Результати дослідження можна застосувати для модернізації наукової сфери, наближення до стандартів ЄС та підвищення ефективності досліджень через впровадження європейських принципів оцінювання діяльності, інтернаціоналізацію, трансфер технологій та інтеграцію в ЄДП.

Ключові слова: Європейська система досліджень та інновацій, Європейський дослідницький простір, Євроінтеграція, модель, наукові установи НАН України, інноваційна екосистема.