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## **SPATIAL FORMS OF ORGANIZING INNOVATIVE INFRASTRUCTURE OF UKRAINE IN TERMS OF SUSTAINABLE DEVELOPMENT**

### **Abstract**

The article is devoted to the study of spatial forms of organizing innovative infrastructure of Ukraine in terms of sustainable development. In the course of the study, modern trends of innovative development of the regions in Ukraine are highlighted. The peculiarities of implementing innovative policy in the context of smart specialization strategy are analyzed. Diagnostics of processes of formation and development of innovative infrastructure in regions of Ukraine is carried out. A conceptual approach to assessing the level of innovation infrastructure development is proposed.

### **Keywords**

innovative infrastructure, clusters, smart specialization.

### **Nomenclature, abbreviations**

CERN – Conseil Européen pour la Recherche Nucléaire; EEN – Europe Enterprise Network; EGI – European Grid Infrastructure; EU – European Union; KET – key enabling technologies; RIS3 – Research and Innovation Strategies for Smart Specialization; SME – small and medium-sized enterprise; IT – Information Technology.

### **Introduction**

At the present stage of development, the implementation of innovative activities and the choice of their optimal spatial forms is the main factor in the competitiveness of the regional economies. The situation is so because it contributes to the localization of business activity, the formation of “growth points”, ensuring the development of interregional and intraregional cooperation and activation of local entrepreneurial initiative. Spatial forms of innovative infrastructure development (horizontal and vertical) such as: network structures, production and innovation clusters, science parks, industrial parks, fab labs, training centers, business incubators, and technology transfer centers, from the simplest to the most complex integrated forms, stimulate innovative development of regions thus forming their competitiveness. Ultimately, this allows to reduce territorial disparities and intraregional asymmetry of socio-economic development, primarily by strengthening the economic potential of the territory, including the smallest territorial units.

Spatial forms of innovative infrastructure development are the centers of coordination and accumulation of economic and social relationships between individual regions or countries. The development of new forms of implementation of innovative activities contributes to the formation of competitive advantages of individual territories and their territorial capital due to the localization of transnational corporations and, accordingly, international production networks with the advantages of the introduction and concentration of innovations; development of innovation clusters on the basis of internationalization of economic relations and inclusion

in global innovation systems with high mobility; institutional, market and structural transformations as factors of territorial attractiveness.

The topicality of the study is supported by the project “Concept of the state target economic program for the development of innovative infrastructure for 2017-2021” which was approved by the Cabinet of Ministers of Ukraine in November 2015 in order to provide appropriate conditions for the development of innovative institutions and assistance to scientists, innovators and enterprises. In addition, in June 2015, with the support of the International Fund for investment assistance in Ukraine, a National Scientific and Technological Association was established. This association aims at promoting structural reforms in the national economy and forming a knowledge economy in Ukraine, which will solve existing environmental and economic problems, and significantly improve the standard of living of Ukrainians [13]. In July 2016, the Cabinet of Ministers of Ukraine adopted a Strategy for the development of high-tech industries until 2025 [20], the implementation of which is aimed at creating a new model of economic development – an innovative economy, by increasing technological efficiency and competitiveness as well as improving the efficiency of existing production.

At the same time, modern practice of innovation management poses a list of issues to the scientific community that require additional research in the organization of spatial forms of innovative infrastructure development.

### **Method of the research**

The authors used general scientific and special methods of cognition: structural-logical method – to build the general structure of the research; content analysis and bibliographic search – to study contemporary trends in the implementation of strategies for smart specialization and generalization of spatial forms of innovative activity development in the region; a logical-historical approach – to study the evolution of spatial forms of innovative activity development; cluster analysis – to compare the regions of Ukraine in terms of innovative development; economic and statistical method – to form a conceptual approach for assessing the level of development of innovative infrastructure in the spatial plane; the graphical method – to visualize the results of the study; scientific generalization – to justify the conclusions.

### **Results of the research**

#### **1. Current state of innovative development of regions in Ukraine**

In the conditions of tough international competition and growing globalization processes, national policy only creates a platform for innovation, while the source of innovation activity is the regions where representatives of the business environment, higher education institutions and local authorities interact directly. According to David White, the President of the European Commission for innovation policy, it is the regional level which is the place where innovation appears, where research is transformed into economic results [38]. Centralized innovation systems are replaced by local innovation ecosystems, which retain their global orientation, but their development is based on endogenous factors.

Assessment of the level of innovative development (LID) of regions in Ukraine based on the indicators of 2017 is conducted using the SPSS Statistics program. As a result we obtained a dendrogram showing the similarity of regions (Fig. 1). According to the results of the cluster analysis, four groups were obtained: the first included regions with the highest LID, the second group consisted of regions with high LID, the third group – with medium LID, the fourth group – with low LID.

Thus, Kyiv, which belongs to the first cluster, takes first place in almost all indicators. Dnipro and Kharkiv regions belong to the second group. The first region is in second place in the number of industrial enterprises engaged in innovative activities of Ukraine (484 units). Upon all other indicators, the Kharkiv region occupies the leading position in the cluster.

The group of regions of the third cluster, which is represented by Donetsk, Zaporizhzhia, Kyiv, Lviv, Poltava and Sumy regions, is characterized by an average level of innovative development. For example, the number of innovative active enterprises in the industry in 2017 ranges from 22 units in the Donetsk region to 48 units in the Lviv region. Among them, the Donetsk and Poltava regions are characterized by relatively low levels of investment support for innovative development, which is the reason for the decline of their positions in the rating compared to the previous periods.

The group of regions with a low level of innovative development is represented by Vinnytsia, Volyn, Zhytomyr, Zakarpattia, Ivano-Frankivsk, Kirovohrad, Luhansk, Mykolaiv, Odesa, Rivne, Ternopil, Kherson, Khmelnytsky, Cherkasy, Chernivtsi, Chernihiv regions. The characteristic features of this group are different levels of scientific and technical, educational and investment support for innovative development.

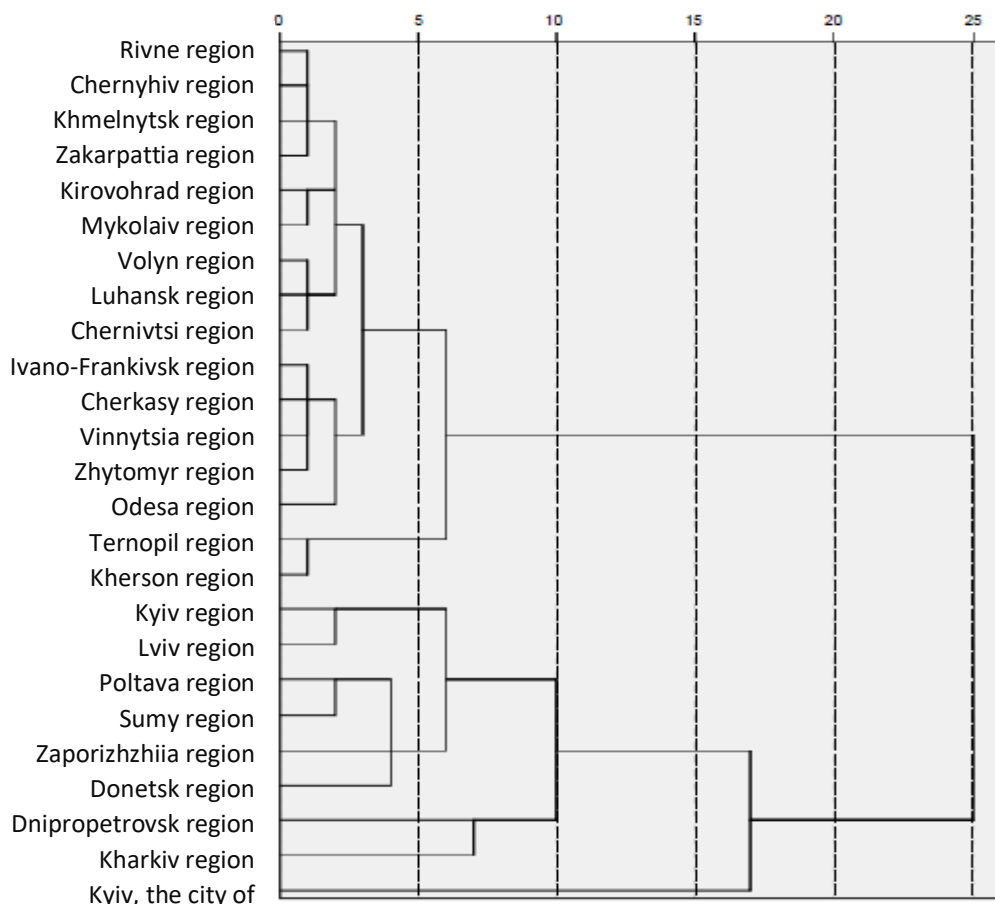


Figure 1. Dendrogram of similarity of regions in Ukraine on the level of innovative development in 2017

Source: Authors'

The greatest differences in the levels of innovative development of regions in Ukraine in 2017 are observed upon indicators which characterize the number of organizations that perform scientific and technical work; the number of innovative enterprises in industry in areas of innovation; the volume of sold innovative products that are new to the market; share in the total volume of realized innovative products outside Ukraine; introduction of innovative technological processes in industry and innovative products in the industry; the number of created enterprises and advanced technologies.

The uneven distribution of innovations in the regions of Ukraine, the reasons for which is the slowdown in the transition to new technologies of the V-VI technological paradigm, the complexity of implementing new formats of interaction between regional authorities and economic agents of the “science-education-production” system, the inability to overcome the “fragmented” nature of the institutional environment and infrastructure support of innovative development, make it necessary to fulfil the transition to a model of regional development management based on smart specialization. This approach [2] to development management is aimed at orienting the basic branches of specialization of the region to the introduction of intelligent technologies in the production and management processes, as well as the creation and development of new areas of activity at the regional level, and the use of new technological and market opportunities to strengthen regional competitive advantages.

## 2. Peculiarities of implementing regional innovation policy in the context of smart specialization strategy

According to D. Foray, P. David and B. Hall, the founders of the concept of regional development based on RIS3, smart specialization of the territory is determined at the intersection of existing capacities, competencies and relevant technologies by analyzing experience, resources, competencies and technologies in other regions in order to intensify interregional cooperation. The latter includes buying / selling technologies, expanding the activities of local businesses and including them in global networks and value chains [30].

V. Deffa, Director General of the Department for Regional and Urban Policy of the European Commission, is convinced that an effective strategy of “smart specialization” should be based on an in-depth analysis of the economic, social and innovative structure of the region. It should also carry out an assessment of all existing assets as well as the potential for future development. The general principle is a broad understanding of innovation that extends to economic activity and includes many sectors of civil society. The analysis should take into account such regional assets as: technological infrastructure; relations with other countries and regions; the place of the region in the national, regional and global economy; the dynamics of the business environment [49].

On November 14, 2018, the Cabinet of Ministers of Ukraine adopted a resolution according to which the strategic planning of regional development should be based on the RIS3 principles, which provide for the construction of local knowledge and innovation economies with subsequent competition between them [15].

A. Markus, the head of the “German-Ukrainian Chamber of Commerce”, is convinced that the time of specialization is coming to the world economy. On the one hand, Ukraine has an old industry and on the other hand, it has a well-developed IT sector. However, there is a gap between these two sectors of economy. Industrial parks are just a platform but at this particular time they have to be created on the basis of new technologies and for such productions which benefit the world. [3] Otherwise, Ukraine will remain only a platform for small-scale production in other countries. This is a strategy for ten years, it is a variant of a strategy used in Poland. Ukraine will not bridge the gap by calling on investors, so it must create industrial parks with smart specialization.

An effective strategy of “smart specialization” should be localized and based on specific regional and national assets and resources, taking into account also the peculiarities of their socio-economic situation. Priorities should not be artificially imposed from above. They should be determined through a multi-stakeholder process focused on “unlocking entrepreneurial potential”. It is an interactive process in which market participants and the private sector uncover and provide information on new areas of activity, and authorities assess the outcomes and encourage those participants who can best unlock the potential of the region [37].

Considering the abovementioned, we can claim that at the present stage of development of Ukraine, smart specialization of its regions is determined at the junction of indicators of business structures, development of innovative infrastructure and the quality of human capital.

A key principle that underpins smart specialization is economic differentiation with an emphasis on conjugate variability, which assumes that a regional economy can realize its competitive advantages by diversifying its unique, localized know-how through new combinations and innovations that are close to or adjacent to these know-hows. It is crucial that the implementation of these new combinations is possible and affordable, taking into account existing assets and the experience gained by regional stakeholders [5].

In such conditions, the key to achieving important multiplicative effects for the development of the region’s economy through an interdisciplinary, intersectoral nature is the development of innovative infrastructure that provides assistance to scientists, innovators and enterprises throughout the innovation process: from turning an idea into an innovation to its implementation in business structures.

### **3. Formation and development of innovative infrastructure in the regions of Ukraine**

The Law of Ukraine “On innovative activity” [16] defines innovative infrastructure as a set of enterprises, organizations, institutions, their unions and associations of any form of ownership which provide services to ensure innovation (financial, consulting, marketing, information and communication, legal, educational, etc.). In fact, we talk about a set of economic entities that ensure the implementation of innovative activities, in particular by ensuring the implementation of innovative projects, i.e. innovative structures.

The scientific literature develops approaches to the classification of innovative structures, according to which innovative structures are distinguished by their specialization, types of scientific and industrial products, types of activities, the nature of the sector of economy, the level of coverage of the innovation cycle, and the facility to improve the principles of creation, etc. [12, 23, 25]. Having studied the existing developments on the subject of the study, the authors developed their approach to the classification of spatial forms of development of innovative infrastructure of the region in accordance with the peculiarities of the organization of innovative activity (Fig. 2).

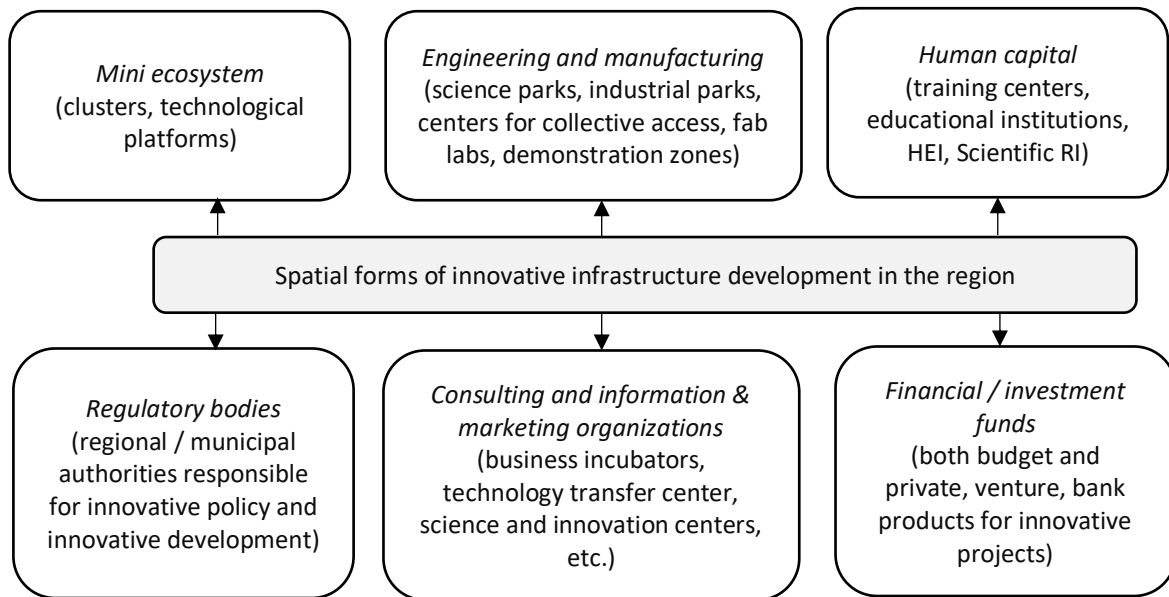


Figure 2. Spatial forms innovative infrastructure development in the region

Source: Authors

According to the Ministry for Development of Economy, Trade and Agriculture, nominally in Ukraine, there are almost all spatial forms of innovative infrastructure development. In particular, as of January 1, 2014, there were 79 business incubators, 480 business centers, 538 leasing centers, 4148 non-bank financial and credit institutions, 226 business support funds, 3034 investment and innovation funds and companies, 4238 information and advisory institutions in the territory of Ukraine [22]. However, their activities do not provide the expected result and do not meet the requirements of the time. A significant part of the spatial forms of innovative infrastructure development exist only formally, they are narrowly localized, for example, in the Kyiv, Donetsk and Kharkiv regions, while in other regions they are poorly developed. In particular, in 13 of the 27 regions of Ukraine there were no science parks, but today the system of science parks of Ukraine is expanding. As of April 1, 2019, 40 economic entities are included in the Register of industrial parks of Ukraine (Fig. 3).



Figure 3. The number of industrial parks in the regions included in the Register of industrial parks of Ukraine (as of 01.10.2019)

Source: [10]

One of the most common forms of innovative infrastructure development in Ukraine's regions is clusters.

M. Porter and his colleagues conducted empirical studies in the United States in 2011. They revealed that the presence of strong clusters encourages the development of the regional economy (growth of employment, an average salary, the number of new companies, entrepreneurial activity), enhances its diversification and accelerates the growth of all other local industries [26]. The synergy effect was also confirmed: the dynamism of the cluster and the companies that are part of it increases with the consolidation of related clusters in this region, as well as similar clusters in the nearest regions [26]. It stands to reason that there is a positive correlation between the level of cluster development and the country's innovation index: according to the Global Ranking of Innovation Ecosystems, it is equal to an average of 0.77 in the European economy and 0.67 in the world economy.

Other sources [36] provide evidence that clusters contribute to the emergence of new, customized markets, as well as fundamentally expanding the possibility of creating new firms and startups while reducing the level of risk in case of project failures. In addition, the territories where clusters are formed can quickly equip economically undeveloped areas, relying on the synergy of collective actions of regional development subjects. Moreover, the involvement of local authorities in cluster projects allows planning the development of the regional economy from the bottom, taking into account the specifics of local realities, which is more effective than the implementation of instructions from the top, which are given by the authorities in the framework of their regional policy.

According to the investment portal of Kharkiv region, this region provides for the formation and development of clusters in the following areas: production and processing of agricultural products and food production; energy and engineering; pharmaceuticals and healthcare; information technology and education; high-tech production [9]. The possibility of cluster initiatives on the basis of newly created united territorial communities is considered. In some of these areas, 8 cluster initiatives are developing dynamically (Fig. 4), however, their activities are concentrated in the territory of the city of Kharkiv.

Unfortunately, information about the activities of clusters in Kharkiv region is fragmentary and insufficient. Only the Kharkiv IT cluster in November 2019 published the results of a large-scale study Kharkiv IT-Research, conducted by PricewaterhouseCoopers and the IRS-Group. According to the study, about 25 thousand specialists in the field of information technology are employed in 445 IT companies that are actively developing. The number of IT specialists in Kharkiv significantly exceeds the number of representatives of other major IT locations in Ukraine, second only to the Kyiv hub. 15% of the country's IT sector representatives work in Kharkiv, which is twice as much as in Dnipro, and three times as much as in Odessa [31].

In 2017, the IT industry of Kharkiv transferred about 5 billion UAH to the state budget of Ukraine, of which 43% was transferred to the local budget of the region. 95% of sales of Kharkiv IT companies are realized for foreign customers, 65% of which – for the USA and 25% – for Europe. Given the current growth rate, it is expected that tax payments to the Kharkiv IT industry will increase to 14.6 billion UAH by 2025. The average income of an IT specialist in Kharkiv is \$1800, which is six times as much as the average income of a Kharkiv citizen (\$265) and five times as much as the average income in Ukraine (\$313).

Given the fact that the Kharkiv IT industry demonstrates stable growth, provides jobs to 25 thousand residents of the region, forms a significant share of tax deductions to the state and local budgets, one of the potential priorities for the reasonable development of Kharkiv region can be Smart IT Solutions.

The experience of leading countries shows that one of the key conditions for the harmonious development of clusters is the availability of a developed research infrastructure of the appropriate level.

Ukraine inherited about 20% of the experimental centers of the Soviet Union, including nuclear reactors, astronomical observatories and ships for marine research, but much of this infrastructure was lost during the times of independence. Today, research infrastructure centers in Ukraine need to be updated due to constant underfunding. According to Yegorov I. Yu. [5], the problem has existed for many years and has so far reached such proportions that neither fast nor inexpensive solutions are acceptable. At the same time, Ukraine, as before, has at its disposal several functioning infrastructure facilities of the R&D sphere, which have received international recognition, despite their insufficient funding. Most of them are in various institutes of the Academy of Sciences of Ukraine. 15 research organizations in Ukraine are included in the List of European Research Infrastructures [8].

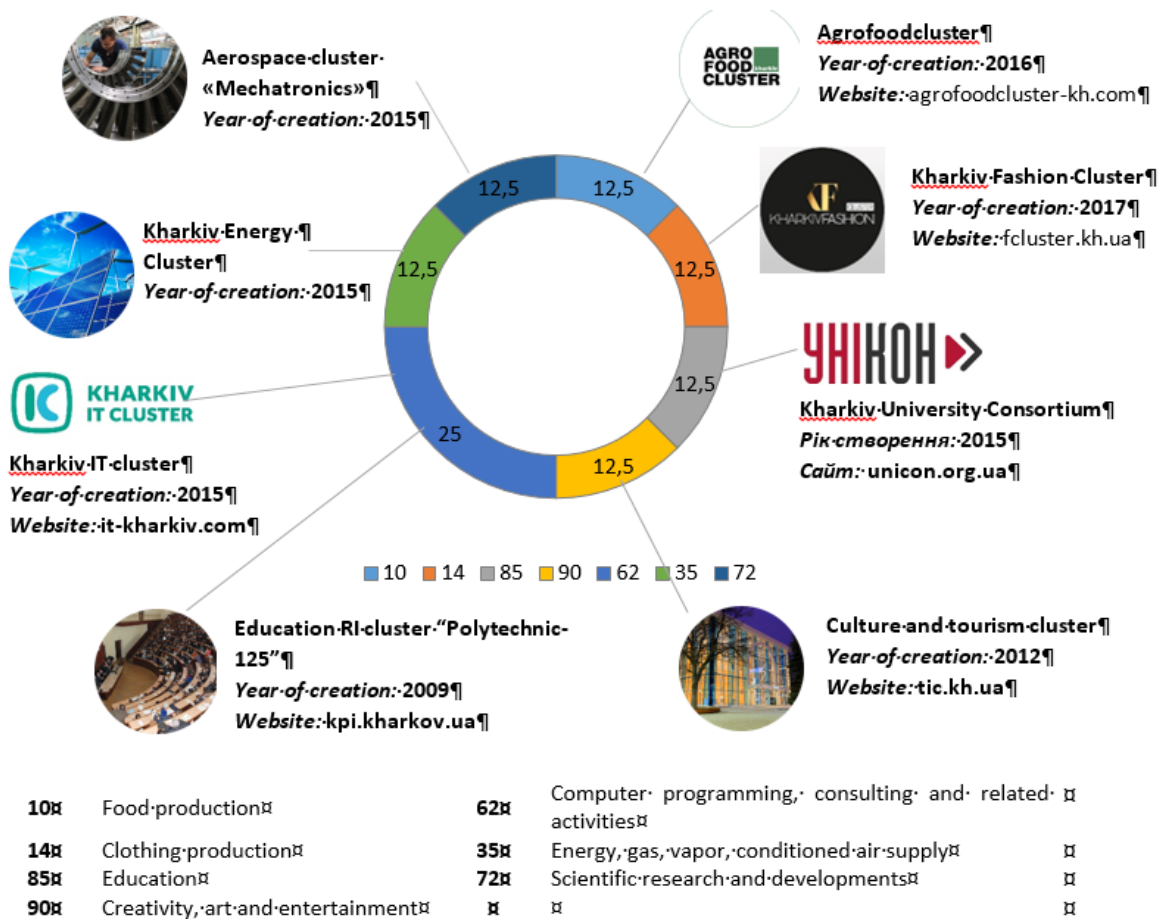


Figure 4. Sector specialization of clusters of Kharkiv region (developed by the authors in accordance with [9])

Today Ukraine participates in two out of eight European Intergovernmental Research Organizations (EIRO), which are part of the European Association EIROForum. Thus, on October 5, 2016, the Agreement on granting Ukraine the status of an associate member in CERN (European Organization for Nuclear Research) was notified, and on January 1, 2017, Ukraine became a member of EUROfusion [4].

Of the entire range of European Research Infrastructures, which now amount to 50, Ukraine takes part in three: DANUBIUS-RI (operational start in 2022), EISCAT\_3D (operational start in 2021) and CTA (preoperative start in 2019, full operational start in 2023) [4].

Of the five most common E-Infrastructures in Europe, Ukraine cooperates with two. At the political level it is GEANT, the pan-European data network for the research and education community (they signed an agreement with Ukrainian scientific and educational telecommunications network URAN), and EGI, the European Grid Infrastructure (they signed a Memorandum of mutual understanding at the technological level with the Ukrainian national Grid in 2012) [4].

As we can see, the national innovation infrastructure does not meet the necessary level of technological readiness to provide high-tech services. Instead, EU member states can improve the state of technological readiness with the help of EU Structural funds, to which Ukraine does not have access. There is no similar mechanism in the country, so it is difficult for Ukraine to bridge the technological gap in research and effectively use their results at the final stage of the value chain in the economy or new values in the social sphere.

The improvement of the state and quality of research infrastructure led to the fact that Ukraine joined the European Union framework program for research and innovation "Horizon 2020" (total funding of 80 billion euros) [19], which is focused on achieving three main objectives: to make Europe a more attractive place for first-class scientists, to promote the development of innovation and competitiveness of European industry and business, and to solve the most pressing issues of modern European society with the help of science.

During 2014-2019, the Horizon 2020 program financed 133 projects, which were implemented with the participation of 184 Ukrainian institutions for the amount of 21.57 million euros [19]. At the same time, the number of projects with the participation of Ukraine is 0.61% of the total number of projects supported by the European Commission for financing, and the budget of these projects is 0.05% of the total amount of project financing by the program.

Funding for the projects is distributed as follows: 11 million euros were received by private business organizations, 6 million euros went to research institutions and 4 million euros went to higher education establishments [19].

Table 1 gives the results of how the countries from Eastern Partnership participated in “Horizon 2020” program. The COSME (Competitiveness of Small and Medium Enterprises) program, which Ukraine joined in May 2016, is aimed at supporting the development of cluster initiatives in Ukraine. The program is designed for 2014-2020, and its total budget is 2.3 billion euros, 900 million euros of which are available for Ukraine [17].

*Table 1. The results of how the countries from Eastern Partnership participated in “Horizon 2020” program (developed by the authors in accordance with [19])*

Country	Number of projects	Number of “participations”	Funding, million euros
Azerbaijan	9	10	0,49
Belarus	40	44	2,26
Armenia	23	29	1,24
Georgia	26	31	2,69
Moldova	44	57	5,13
<i>Ukraine</i>	<i>133</i>	<i>184</i>	<i>21,57</i>

COSME program for Ukrainian SMEs consists of 25 subprograms. They can be systematized in three directions: improvement of access to foreign markets; improvement of conditions for an increase of competitiveness and stability of subjects being managed; assistance for the development of business and business culture. Among the sub-programs, there are such important initiatives as Erasmus for Young Entrepreneurs, European Strategic Cluster Partnerships, European Destinations of Excellence and others.

The financial instrument of the program is not yet available for domestic SMEs, since its use is a rather complex process that requires a high level of development of the Ukrainian SME support infrastructure and an appropriate level of knowledge. However, similar financial instruments work under other international programs (EU4Business, HORIZON-2020, etc.).

Today, within the framework of the COSME program, the European enterprise network (EEN) is already actively working in Ukraine, which is a virtual trading platform for stimulating international cooperation and innovative development of SMEs, as well as for stimulating technology transfer from scientific organizations to business. EEN-Ukraine should search for new customers, suppliers, partners, investors, manufacturers or distributors for SMEs, provide advice on participation in EU-funded programs, hold information days and trainings, international fairs and exhibitions [28].

Another initiative of the European Union for establishing partnerships in the field of research and innovation through the cooperation of clusters and cluster organizations of the EU and Eastern partnership countries is the EaP PLUS project [34]. Within the framework of this project, two Ukrainian clusters received €20,000 in the field of eco-energy and industrial automation: the Carpathian Eco-Energetic Cluster and the Association of Industrial Automation Enterprises of Ukraine [27].

In addition, at the initiative of the European Union, a platform for cluster cooperation (European Cluster Collaboration Platform) was created, where 21 Ukrainian clusters are registered today, among which are 3 clusters of Kharkiv region – Kharkiv Fashion Cluster, Kharkiv IT Cluster, Agrofoodcluster [36].

In Ukraine, there are examples of the formation of national cluster networks. Thus, in May 2018, the project “Tourism clusters 300+” was launched, which provides for the creation of more than 300 clusters with developed infrastructure in 3 years, which will bring in the region of 800 million to 1.5 billion dollars of investments. According to the authors of the project, more and more actors in the tourism business understand the potential for the development of domestic tourism and join the project to create tourism clusters [21].



#### 4. Conceptual approach to assessing the level of innovative infrastructure development

Today, the issue of assessing the innovative infrastructure of the territories is limited by the regional context, and this issue has become an object of study recently. For example, S. Rakitskaia [18] proposes a method of assessing the level of development of innovative infrastructure of the region based on the transformation of the main provisions for assessing the level of infrastructure development proposed by D. Bil [1].

T. V. Kharitonova, and M. T. Krivosheieva [24] propose selecting the necessary indicators from among the indicators of developing an innovative potential of the region that would meet the performance criteria in order to estimate the efficiency of innovative infrastructure of the region. The authors propose seven stages of the methodology and a scoring system (from 1 to 5). The indicators are given in fragments, and the introduction of a weighting factor is proposed. Depending on the number of points, the effectiveness of the innovative infrastructure model and its type are evaluated.

The work by T. Kashizina [11] also deserves attention. She proposes evaluating the innovative infrastructure of the region for quantitative indicators, which are grouped by subsystems of the innovative infrastructure of the region based on the calculation of the integral index taking into account weighting values of each component and determining the area of the polyhedron. It should be noted that there are no statistical data or observations to assess the partial indicators proposed by the author, which prevents the application of this technique.

O. Zhikhov's monograph [7] describes an attempt to assess the infrastructure component of the innovative potential of the region, but only half of the 10 indicators proposed by the author concern the objects of innovative infrastructure.

At the same time, the works of leading researchers increasingly raise the question of assessing the concentration of innovative infrastructure in a space and the prerequisites for its integration, both in the economic systems of countries and global value chains. Thus, Nobel laureate in Economics P. Krugman is convinced that today there is an urgent need to take into account spatial factors in the placement of innovative objects, since they can act as points of growth of individual territories [33]. According to Dutch researchers, K. Kourtit and P. Nijkamp, the key prerequisite for effective collaboration of economic entities from different countries or regions is precisely the innovative infrastructure, as it contributes to the establishment of links between producers and consumers of innovations, government agencies, business and academia [32]. In addition, the need to take into account the spatial factor in the development of innovative sectors of the economy shares the theme of the World Bank Report, which emphasizes that spatial transformations significantly affect the efficiency of the functioning of the national economy and are a prerequisite for its qualitatively new structural transformations based on innovation [39].

The problem of spatial distribution of innovative infrastructure, as a rule, was determined by the principle of belonging to economic centers. On the contrary, the experience of developing the most economically powerful regions of the world proves the effectiveness of network structures that ensure that the objects of innovative infrastructure come closer to the centers of innovation consumption. This proves the relevance of assessing spatial concentration of innovative infrastructure for the regions of Ukraine, as one of the key prerequisites for achieving the trend of exponential growth. It is the objects of innovative infrastructure that can act as one of the key drivers of overcoming imbalances and ensuring balanced development of territories, which is one of the priorities of the decentralization of power reform, which is now actively implemented in Ukraine.

The formation of a conceptual approach to assessing the level of development of innovative infrastructure in the spatial area should take into account a wide range of indicators of innovation. These indicators include: the number of institutions of innovative infrastructure by type (clusters, science parks, higher education establishments, business incubators, etc.); the number of scientific research agents and researchers; the volume of financing for innovative projects; the number of industrial enterprises that have introduced innovations; the number of innovations introduced in industrial enterprises; the volume of innovative products sold; the number of patents for inventions, utility models, industrial designs; the number of publications in journals indexed in scientometrics databases (Scopus, Web of Science) and the like.

Relative values characterizing the level of concentration of innovative infrastructure objects in the area can be used as evaluation indicators:

$$I_k = \frac{Q_n}{S}; \quad (1.1)$$

where  $I_k$  is the index of spatial concentration of innovative infrastructure objects;

$Q_n$  – the number of  $n$ -type innovative infrastructure objects;

$S$  – the space of the territory where a set of objects of innovative infrastructure of  $n$ -type is located.

The integral index of spatial concentration of objects of innovative infrastructure can be defined as a set of the following indices. For each type of objects, it is appropriate to carry out their rationing according to the indicators of the reference regions. Reference regions can be determined by the structural stability index calculated according to the methodology of the joint research Centre of the European Commission. This indicator characterizes the degree of divergence of the structure of the innovation system of the territories. Detailed calculations of the structural stability index for the Kharkiv region are given [34]. That means that the rationing of indexes of spatial concentration of objects of innovative infrastructure is appropriate to carry out according to the formula:

$$I^{nor} = \frac{I_k}{I_k^r}; \quad (1.2)$$

where  $I^{nor}$  – the normalized value of the spatial concentration index of innovative infrastructure objects;

$I_k$  – the index of spatial concentration of objects of innovative infrastructure of the region which are under research;

$I_k^r$  – the index of spatial concentration of objects of innovative infrastructure of the standard region.

The integral two-level (at NUTS-1 and NUTS-2) index of spatial concentration of objects of innovative infrastructure can be calculated by the formula:

$$\bar{I}_k = \sum_{m=1}^n I_m^{nor} \times w_m; \quad (1.3)$$

where  $I_k$  – the integral index of spatial concentration of innovative infrastructure objects;

$I_m^{nor}$  – the normalized value of the spatial concentration index of innovative infrastructure objects of  $m$ -type;

$w_m$  – the weight coefficient of the normalized index value of the spatial concentration of innovative infrastructure objects of  $m$ -type.

The weighting indexes of spatial concentration of innovative infrastructure in a particular area are determined by expert, taking into account the population, the results of economic activities of economic entities, their level of inclusion in the global markets, assessment of the potential economic growth areas, maintaining the principle of  $\sum w_m = 1$ . The proposed approach can be used to assess the uniformity of placement of innovation infrastructure across the country or region.

### Discussion with other scientists

The multidimensional nature of the research directions, the search for approaches to the activation of innovative development of regions, received its coverage in the scientific works of foreign and domestic scientists: O. Amoshi, I. Buzko, V. Geits, H. Barnet, G. Dobrov, E. Mansfield, E. Toffler, D. Chervaniov and others. The problems of regional innovation management are the subject of scientific research of such scientists as V. Onishchenko, R. Mann, D. Solokha, O. Finagina. Various aspects of the study of spatial forms of business organization as a catalyst for the development of innovative activity are studied in the works of I. Bobukh, Yu. Marchuk, M. Melnik, T. Pisarenko, A. Stoyanovsky, S. Tkach. Research of theoretical and practical developments of these authors makes it possible to assert that they formed the theoretical foundations and practical tools of innovative development of regions, but require further solutions to the formation of spatial forms of development of innovative infrastructure in the regions, which led to the choice of research topics.

### Uncertainty and impact of research results on science, economy, environment and society

The article provides justification of spatial factors of innovative infrastructure development in Ukraine, which in the conditions of the fourth industrial revolution becomes a key driver of economic growth and social well-

being. Innovation is the circuit that drives all components of the knowledge economy and ultimately leads to economic growth and changes the quality of life. One the most obvious changes is the introduction of technological innovations to all areas of human life – from the workplace to social life and leisure.

Innovation and the practical use of new ideas become the most essential condition: the preservation and development of new jobs that require highly qualified well-trained personnel; the efficiency and success of businesses that create new and improved products and services; the use of new technologies that reduce the anthropogenic effects of the previous technological base of the industrial economy.

Some results of the article are used in the framework of the policy of innovative development of territories: the policy documents on the development of the united territorial community and structural units of Kharkiv Regional State Administration that are responsible for the coordination and implementation of policies of local development based on innovation.

### **Acknowledgment**

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### **Summary and conclusions**

Nowadays the key task of the authorities and management of most countries is the transition to a post-industrial type of organization of territorial socio-economic systems. Such qualitative changes are aimed primarily at the transition from the mobilization (resource) type of development to the innovative one. The solution to this issue is possible only in the conditions of a steadily growing demand for innovative goods and services; and only clusters are able to provide them.

The strategy of smart specialization is an advanced tool in the field of cluster policy, in particular it concerns estimating the territories where clusters can be placed. This strategy also involves establishing the priorities aimed at obtaining competitive advantages by developing the scientific and innovative potential in accordance with the needs of business, in order to fully use existing opportunities and market trends, but avoid duplication and fragmentation of efforts. Identifying potential poles of regional development based on the analysis of international experience and the potential of regions is a key condition for a national and regional progress. Creating the system of cluster formation which is based on the concept of reasonable specialization will improve the quality of the regions' value proposition for foreign investors by focusing on the unique areas of each region. Registration of Ukrainian regions on the Smart Specialization Platform will allow to position regions of Ukraine and Europe on an equal footing, which will provide an impetus for the formation of international brands with the participation of our country. The development of interregional and interethnic relations will significantly increase the investment attractiveness of the regions of Ukraine.

Implementation of the smart specialization in Ukrainian economy can make positive changes in the process of innovative regional development in such areas as:

- ensuring the transition from the traditional sector to the sector of interaction and cooperation of R&D, engineering and production, which form a knowledge base aimed at the development of a new business activity;
- modernization of existing sectors through technological re-equipment (foresight of the region) through the use of key enabling technologies (KET): photonics, nanotechnology, semiconductors, new materials, etc.;
- achieving synergies between different business areas and regions through their diversification.

However, the development of clusters in the domestic economy within the framework of the smart specialization strategy is associated with a number of problems that are typical for the regions of Ukraine. The solution to these problems involves finding a balance in the interaction of public authorities, business environment, scientific institutions and civil society, involving all participants in the process of entrepreneurial discovery, creating comfortable conditions for innovative development on the part of the state. These aspects require further research, since the strategy of smart specialization is a promising direction for the development of the domestic economy when adapted to the challenges of the market in order to obtain the most effective results from existing assets.

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