Вісник Національного університету "Львівська політехніка".
Серія "Проблеми економіки та управління"

Vol. 8, No. 2, 2024

UDK (339.9+330.3+004):(347+332.1)
JEL Classification: F02, F20, O30, O32, O34, R12

K. M. Kraus
Scientific and research part,
Bohdan Khmelnytskyi National University of Cherkasy
ORCID: 0000-0003-4910-8330

GLOBAL EXPERIENCE OF SCIENCE AND TECHNOLOGY CLUSTERIZATION IN THE DIGITAL EPOCH: INTELLECTUAL AND PATENT ACTIVITIES WITHIN ECONOMIC SECTORS

http://doi.org/10.23939/semi2024.02.

Purpose – The purpose of this study is to carry out a comparative analysis of economic results and innovative activity within the scientific and technological clusters of the world, to establish the relationship between the population density of a certain agglomeration and the productivity of its inventors, the effectiveness of researchers and business efficiency, to evaluate the impact of digital technologies on economic success science and technology cluster.

Design/methodology/approach – In the article, the author used the method of analysis to study the scientific literature that sheds light on the understanding of the phenomenon of the science and technology cluster, and the method of abstraction helped to separate the economic results of the activity of scientific and technological clusters from their environment. The formulation of conclusions regarding the patterns of development of modern world leaders among science and technology clusters was implemented using the methods of synthesis and generalization, and the comparison of researchers' views on the priority of cluster activity in the economy was carried out using the method of comparison. The statistical method helped the author establish cause-and-effect relationships in the activity of science and technology clusters in the aspect of general development, and the graphic method provided visualization of the state of development of modern science and technology clusters in the world.

Findings – The modern cluster paradigm of economic development aims to promote the deepening of connections between capital markets and advanced ICT and digital technologies, the development of the knowledge economy and environmental sustainability of production, the social orientation of technologies, and obtaining synergistic effects from joint scientific and research developments. The Global Innovation Index 2023 proved the first place in the rating of the world's science and technology clusters by the economic results of clusters in the Asian region, however, the rating of science and technology clusters by intensity (relative to population density) does not confirm a direct relationship between the population density in a certain territory or in a certain city and economic results cluster. The result of the research was the revealed fact that the field of scientific interests of inventors and researchers of clusters today is expanding as fast as the needs of people, and therefore patent activity can be traced in bio- and medical technologies, pharmaceuticals and optics, information, digital, computer and audiovisual technologies, which is fully justified in the era of digitization and informatization of both the economy and society.

Practical implications – The results of this research are of practical interest to everyone who is a direct participant in the science and technology cluster (scientists, economists, inventors,

programmers, educators, officials, businessmen, etc.) and who is tangential to its activities, because they all get the opportunity to work on the principles mutual assistance for the sake of common goals, stimulated the development of local markets, scaled up their activities, promoted economic growth.

Originality/value – The presented study covers both scientific and real economic results in terms of cluster activity of Japan, the Republic of Korea, the USA, China and other countries of the world, which allows focusing attention on the social behavior and mentality of the people of a certain country, economic and technological maturity, political will and institutional support contribute to the creation and development of science and technology clusters. The author proposes priority directions for strengthening scientific and technological clustering in the developed countries of the world, outlines the expected results from their practical implementation and determines the prerequisites for the beginning of their implementation.

Keywords: science and technology cluster, innovative activity, digital technologies, digitalization of the economy, agglomeration, regional specialization, publishing activity, patent activity, networking of connections.

Statement of the problem and relevance of the research

In the modern world economic space, significant differences in the achieved economic and social results of production and business in different countries are clearly visible. This has an impact on social inequality, deepens the gap in income and purchasing power of citizens and not only across countries, but also in individual territories. Certain achievements in leveling this situation and raising the economic and social level of people's quality of life are possible due to the growth of the investment attractiveness of certain territories, attention to their environmental safety, and the development of accessible and comfortable infrastructure. Despite the dynamic globalization processes of the modern economy, positive changes can be achieved under the condition of regional specialization based on the cluster approach.

A cluster approach to economic development involves consolidating the efforts of various economic agents who adhere to the same (or similar) ways of behaving (institutions) in the market, as well as provide constant assistance and support to each other in order to increase competitiveness and achieve the desired economic results. Modern cluster technologies enable active economic agents to achieve the stability of their economic development, the balance of needs and opportunities, the ability to respond adequately to external challenges and probable risks, to look for new ways of growth and scaling, to obtain additional sources of financing and to expand the partner and consumer network, to create powerful innovative structured industry associations of business entities, state authorities, representatives of science and education, non-profit organizations. Ultimately, it allows increasing the GDP in the country or in the territory where such innovative, technological, scientific, commercial associations (clusters) function and are supported. Taking this into account, we consider it necessary to investigate which science and technology (S&T) clusters of the world are the most advanced today, where they are 'grown', how they are supported and due to which they become the first in innovativeness and intensity of their activities.

Analysis of recent research and publications

Many scientists, experts and economists, both in our country and abroad, devote their work to the issue of creation and development of S&T and industrial clusters. Particularly interesting and relevant are the studies of the representatives of those countries whose S&T clusters are leaders in the ranking of the world's advanced clusters in terms of economic results, because their scientific view, constructive assessment and outline of prospects for cluster activity is quite thorough, comprehensive, and objective.

The modern phenomenon of S&T clusters and the outline of priorities for their growth in the future are considered in their joint scientific work 'Tech Clusters' by researchers from the USA (W.R. Kerr) and Switzerland (F. Robert-Nicoud) [1], and the Australian K. Mohannak [2] studies innovative activities within the cluster and regional interaction of leading companies in the market. Economist from Italy

E. Moretti [3] carried out an in-depth study of the influence of geographical agglomeration on the increase in labor productivity of inventors and the growth of innovations created by them, and the results obtained by him were confirmed by the team of authors S. Kichkoa, W.-J. Liangb, Ch. Maic, J.-F. Thissed, P. Wang [4], who developed a model of spatial equilibrium with a competitive final sector and a monopolistically competitive intermediate sector, which made it possible to identify the necessary and sufficient conditions for the emergence of a technological cluster as an equilibrium result. European researchers L. Sandoval Hamon, S. Ruiz Penalver, E. Thomas, and R. Fitjar also confirm the importance of joint geographical and spatial placement of innovative companies [5].

The Polish scientists M. Mackiewicz and D. Pavelkova [6] study participation in the cluster and the productivity of companies from the point of view of their technological maturity, and the Americans T. Slaper, G. Ortuzar [7] focus their attention on the advantages that provides support for S&T and industrial clusters for economic growth and creation of new jobs, and also consider different conditions for supporting new clusters and those that already exist. Researchers from South Korea, Y. Jung, E. Kim, and W. Kim [8], focus on the interdisciplinarity of research (IDR) within the framework of the activities of the world's S&T clusters, and those from Asia, T. Tong, N. Zainudin, J. Yan, A. Rahman [9] are convinced that now it is necessary to give importance to independent innovation, to encourage talents and improve innovation, which will accelerate the formation of clusters and improve the productivity of high-tech SMEs in the industry.

The American scientist S. Casper [10] examines in his works the role and significance for the economic development of regional technology clusters, and the researcher from Uzbekistan A. Abduvaliyev [11] defines the main directions of the development of S&T clusters according to the leading countries of the Global Innovation Index rating and substantiates leading positions and high competitiveness of Chinese R&D in the world. The European academic community, represented by A. Botti, R. Parente, R. Vesci [12], P. Magliocca [13], assesses the role of S&T and industrial clusters for business development, digitization, and innovation of the economy.

As we can see, researchers and economists from different countries of the world are interested in the activities of S&T clusters – the USA, China, Australia, and Western European countries. Ukrainian scientists are no exception, among whom it is worth mentioning N. Kraus [14], who studies the innovative landscape and institutional environment of the functioning of clusters, as well as I. Babukh, V. Lisitsa, O. Novikova [15], who describe digital platforms on principles of clustering for the sake of European integration of Ukraine into the European space. Taking into account the available studies on the functioning of S&T and industrial clusters in the modern network economy, we consider it necessary to continue the research in terms of developing further prospects for strengthening their productive, rational and innovative activities.

Goal setting

The purpose of the article is a scientific comparison of economic results and results of innovative activity of representatives of S&T clusters; establishment of the dependence between the population density in a geographical agglomeration and the productivity of its inventors, the effectiveness of the scientific activity of its researchers and the efficiency of business; identifying the impact of advanced digital technologies and tools on the economic success of S&T cluster; nomination of priority directions for strengthening S&T clustering with an outline of their expected practical results.

Research methods

The used methodical approaches of scientific research of activity and functionality of S&T clusters are characterized by reliability, detail, and completeness of data, compromise, and availability of information sources. Thus, in particular, the work uses: the method of analysis – when processing the available scientific literature on understanding the phenomenon of the S&T cluster, as well as when identifying modern trends in their development; method of abstraction – when trying to isolate the

economic results of S&T clusters from their environment and the number of existing population in a certain agglomeration; methods of synthesis and generalization – when reviewing the views of scientists on the cluster approach in industry, research and innovation activities, as well as formulating a conclusion regarding the patterns of development of modern world leaders among S&T clusters; the method of comparison – when comparing different points of view of researchers on the priority of cluster activity in the economy and studying foreign experience of network interaction of the scientific community, inventors, representatives of business and the state; statistical method – when exposing cause-and-effect relationships in the activity of S&T clusters in the aspect of general development; graphic method – with visual presentation of the state and development trends of modern S&T clusters of the world.

Presenting main material

In the modern world economy, oriented towards globalization and digitization, those countries that have realized the effectiveness of the cluster paradigm of their development in a timely manner are functioning quite successfully from an economic point of view; focused their efforts and potential on the creation of powerful S&T, industrial and innovative production centers of high technologies, advanced means of labor and production, innovative products; and also managed to build a stimulating institutional environment and supporting infrastructure, which in every way contributes to the efficiency of clusters. The cluster paradigm of economic development envisages the indisputable building up of relationships between capital markets (financial, human, etc.) and the latest information, communication, and digital technologies, the development of the knowledge economy and the environmental friendliness of production, the social orientation of achievements and technologies that are created and produced today, obtaining synergistic effects from joint scientific and research developments, scaling of technology / goods / services markets.

In confirmation of this, the American scientist S. Casper claims that technology clusters are a source of economic growth within the framework of the knowledge economy, and the points of their growth are social networks in their composition and a favorable institutional field for existence. 'Governments of all countries should support the creation of fundamental university research and encourage their commercialization. Clusters can exist in all countries, although more 'radically innovative' clusters appear in countries with a liberal market and not with organized or coordinated institutional structures' [10]. Professor of Business Administration at the Harvard Business School (USA) W. Kerr and Professor at the Geneva School of Economics and Management (Switzerland) F. Robert-Nicoud in their joint work 'Tech Clusters' reflect on whether technological clusters have already reached the maximum of their development, whether they are possible will continue to strengthen. The authors assess the depth and scope of the consequences of the global Covid-19 pandemic on the activities of technology clusters, in particular: they determine the properties that a cluster needs to be technological (availability of patents, venture funding, employment in sectors that intensively research and develop digital means, business promotion, rapidly developing, supporting artificial intelligence researchers); study the specifics of the functioning of technology clusters (establishing differences from the activities of traditional industrial clusters, delineating the specifics of knowledge dissemination within technology clusters, analyzing the impact of population density on the type of innovations created, supporting the scaling of the best projects by technology clusters, evaluating the role of universities, highly qualified immigration and global production connections links to the functioning of leading S&T centers); investigate the origins of technology clusters (the variability and impermanence of technology clusters often lead to their appearance in new places after the emergence of new technologies, the spread of the use of artificial intelligence contributes to the rapid development of individual clusters) [1, pp. 50–51].

In his research, foreign scientist A. Abduvaliyev [11] identifies the main directions of development of S&T clusters in the world and focuses on the leading countries of the Global Innovation Index (GII) rating in terms of patent and publication activity. In addition, the scientist substantiates the leading position and high competitiveness of Chinese research and development in the world, concluding that the leadership

of certain S&T clusters is determined by: a clear description of patent data, the formation of a logical algorithm for displaying data, a transparent methodology for measuring the size of a cluster, changes to obtaining international of patent applications since 2017, the intensification of the publication activity of scientific publications in SCI Expanded WoS since 2018, and the increase in population density since 2020.

And indeed, every year the GII is presented in the context of those global transformations, changes, and events of a global scale that deeply affect the development of humanity, the economy of the countries of the world and determine the vector of further growth and the future. Having analyzed the direction of innovative developments and the criteria taken into account when determining the Global Innovation Index in recent years, we can state that: 2019 was focused on medical innovations and the possibility of predicting how technological and non-technological innovations in the field of medicine can change the global healthcare system; 2020 was spent under the auspices of finding reliable and diversified sources and mechanisms for financing innovative developments; 2021 is the year of assessing the impact of the global Covid-19 pandemic on the effectiveness, efficiency, and demand for innovative activity and its results in different countries of the world; 2022 is the year of finding a balance and the likely trajectory of development of innovation and human civilization as a result of digitization and the spread of practical use of new generation digital technologies; and finally, the year 2023 is represented by an in-depth analysis of global trends in the development of innovations within the framework of the current economic situation both in the world as a whole and in the context of individual countries of the world, taking into account the high level of uncertainty, unpredictability, and turbulence. It should also be noted that GII 2023 contains a number of data on the Covid-19 pandemic and the post-pandemic period, which gives a better idea of the economic policies of individual countries in response to the pandemic, reaction, and adaptation to armed conflicts, which inevitably affected the innovation ratings.

The difference in the rating of 2023 is also the definition of 100 advanced and progressive scientific and technology innovation clusters of the world – a kind of hubs of scientific research developments and technologies, world scientific and innovation centers, which is especially important and relevant in the context of clustering as an innovative technology of socio-economic development systems In 2023, the top five S&T clusters were located in East Asia and look like this: the first – the 'Tokyo – Yokohama' (Japan), the second – the 'Shenzhen – Hong Kong – Guangzhou' (China and Hong Kong, China), the third – the 'Seoul' (Republic of Korea), the fourth – the 'Beijing' (China) and the fifth – 'Shanghai – Suzhou' (China). The data show that China is the leader in terms of the number of S&T clusters in the world – there were 24 of them in the country in 2023, which is 3 more than the figure of 2022 (21 clusters), and thus China is ahead of both the USA and other progressive countries of the world. In 2023, the USA occupied only 21 positions among the 100 best S&T clusters (the best cluster 'San Jose – San Francisco'), Germany – 9 (cluster leader – 'Munich'), while Japan (advanced cluster – 'Tokyo – Yokohama'), Canada (the most successful cluster – 'Toronto'), India (the most effective cluster – 'Bengaluru') and the Republic of Korea (the most progressive cluster – 'Seoul') – shared 4th place [16, pp. 19, 69].

Studying the leadership of Chinese S&T clusters, a team of researchers from China and Malaysia (T. Tong, N. Zainudin, J. Yan, A. Rahman), taking as a basis the theory of independent innovation and competitive advantage, believe that 'the industry cluster has a positive impact on the long-term and short-term productivity of high-tech SMEs, independent innovation has a positive effect on the long-term and short-term productivity of high-tech SMEs, and independent innovation plays a mediating role in the relationship between the industry cluster and the productivity of high-tech SMEs' [9]. Among the ten best S&T clusters in terms of economic results, there are many American ones, in connection with which American economic researchers T. Slaper and H. Ortuzar support the idea that modern cluster associations represent a kind of network of economic relations that create competitive benefits for related economic participants in a certain region. 'The cluster approach starts with industries and assets already present in the region, and regional stakeholders take initiatives to make these industries better. The approach to creating new clusters in the region is a strategy to improve the general conditions of the business environment by

improving skills, access to finance and infrastructure, optimizing government rules and regulations, supporting local demand and openness to foreign investment. While, industry clusters that are present in a region do not necessarily need public sector strategies to exist' [7, p. 7].

The clusters with the most intensive scientific and technical activity in relation to the population density in 2023 are recognized as 'Cambridge' (United Kingdom), 'San Jose – San Francisco' (USA), 'Oxford' (United Kingdom), 'Eindhoven' (Netherlands) and 'Boston – Cambridge' (USA).

By the way, the S&T cluster of London (Great Britain) in 2023 took the 20th place in the world ranking of GII clusters (general) in terms of economic results and improved its position by two positions compared to 2022. Many factors contributed to this, including a mature ecosystem.

British researchers note that recently there has been a 'growth of specialized firms providing services in and around the cluster, in particular in the field of business development, patenting and legal consulting, recruitment, and marketing... In addition, there is an increase in informal contacts between industry and academia, built for a long time on the basis of formal relations. The result of such physical and social proximity is the rapid circulation and dissemination of knowledge and ideas in the cluster, well-developed social networks, and easy access to global contacts. People easily change jobs, move from industry to academia and vice versa, transferring their knowledge' [17, p. 42].

The results of studies of cluster associations in Great Britain are particularly valuable, because they accumulate both large-scale national observations and local monitoring of the activities of representatives of science and education, business, industry, authorities and other interested parties, which are aimed at overcoming obstacles to growth clusters and maximizing benefits from scientific research.

As a result, it is possible to obtain an effective tool that not only indicates where the centers of cluster activity are located, but also analyzes various indicators of activity, identifies potential growth points, focuses attention on strengths for the purpose of developing innovative strategies and achieving synergistic effects of interaction [18, pp. 43–44]. Researchers from China [20] consider the joint development of industrial clusters as an effective way to increase regional industrial competitiveness and the regional economy as a whole, and they consider the platform of scientific and technological services as a carrier of a corporate cluster to achieve a common positive result.

But not only in high-income countries are there progressive S&T clusters. So, in India, where the average level of income per capita is observed, the growth of S&T production has also been noted recently – there are 4 innovative S&T clusters, in particular such clusters as 'Chennai' and 'Bengaluru' – these are the clusters where the fastest the density of inventors and scientists is increasing. It should also be noted those successful S&T clusters that operate successfully in individual countries with developing economies, primarily in Brazil and Turkey.

Considering the positional rating of S&T clusters of the world by economic results according to the version of GII 2023, we can clearly trace the primacy of the clusters of the Asian region (Fig. 1), because neither European nor American S&T clusters are among the five leaders in 2023, in contrast to the fact that in 2022 the top five was closed by the cluster 'San Jose – San Francisco' (USA) – a year later it was only 6 in the ranking.

In 2023, S&T clusters of the USA will even more firmly consolidate their positions among the leaders in terms of economic results, because the top three innovation clusters in 2022 ('San Jose – San Francisco', 'Boston – Cambridge', 'New York City') was joined by another – 'San Diego', which confirms the favorable institutional and economic environment for the progressive development of science, technology, and innovation in the country.

Also interesting from a scientific point of view is the one presented in Fig. 1 rating of S&T clusters in the GII 2023 by intensity (relative to population density), because the graph clearly shows that there is no direct relationship between the population density in a certain territory or in a certain city and the economic results of the cluster. The first three S&T clusters in terms of their economic results in terms of intensity are far from advanced – the cluster 'Tokyo – Yokohama' (Japan) is 18th in the ranking, the cluster 'Shenzhen – Hong Kong – Guangzhou' (China, Hong Kong) is only 32nd in ranking, and the 'Seoul'

cluster (Republic of Korea) is 25th in the ranking in terms of intensity. An even bigger gap in the mentioned ratings can be seen in the S&T clusters 'Shanghai – Suzhou' (China) – in terms of economic results, it ranks 5th, and in terms of intensity – 74th, and the S&T clusters 'New York' (USA) – 10th place in ranking in terms of economic benefits and 64 in terms of intensity. It is noteworthy that all ten leaders of the GII rating (general) by economic results in 2023 demonstrated positive dynamics of changes in their positions in the rating of the S&T cluster by intensity (relative to population density) in 2023 compared to 2022.

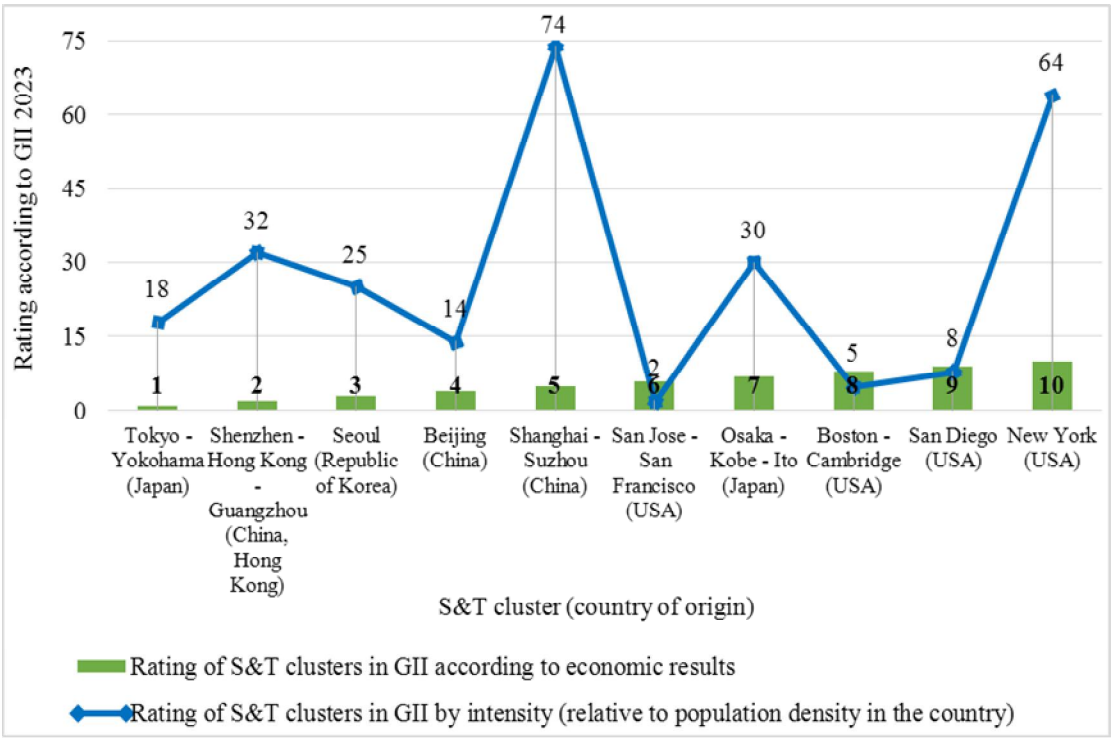

Fig. 1. Ranking of advanced S&T clusters of the world by economic results and by intensity according to the version of the Global Innovation Index 2023 (built on the basis of the source [19])

A researcher at the School of Management (Australia) K. Mohannak, studying cluster activity in Melbourne, concludes that innovative firms in megacities are united both because they need to use strong intra-industry networks and connections, and because they use the numerous opportunities provided by urbanization. 'The concentration of such firms in one area, particularly to meet logistical requirements, creates effective demand and more developed markets for more of these important local factors of production... A professional environment that is attractive to people with similar interests and is an additional lifestyle factor that provides benefit of clustering…' [2, pp. 96–97]. This opinion is also supported by scientists from Spain and Norway (L. Sandoval Hamon, S. Ruiz Penalver, E. Thomas, R. Fitjar), because they note that the joint geographical and spatial placement of innovative companies and universities strengthens the exchange of knowledge between educational institutions and industry, which ultimately promotes the spread of innovation [5].

The success of S&T clusters of the world is influenced by many factors, but among the most important ones that are taken into account are the publication activity of the scientists of the cluster and the number of PCT applications submitted by inventors (Fig. 2).

Analyzing the PCT applications submitted by S&T cluster per 1 million inhabitants over the past 5 years (2019–2023), we note that in 2023 the primacy belongs to the two American clusters 'San Jose – San Francisco' – 7,547 applications and 'San Diego' – 6,064 applications. Instead, the smallest number of PCT applications was submitted by S&T cluster of China 'Shanghai – Suzhou', however, in this case, such

statistics should not be negatively evaluated, one should take into account the fact that the number of applications is taken per 1 million inhabitants, and the last in Chinese cities more than in cities of competing clusters. Quite often, S&T clusters submit PCT applications in cooperation with other inventors, in order to facilitate obtaining the results of their research activities and obtaining a synergistic effect from the innovation process. Thus, in 2023, the 'Boston – Cambridge' cluster (USA) submitted 31% of joint applications, the 'New York City' cluster (USA) – 37%, and the 'San Jose – San Francisco' cluster (USA).

The number of scientific articles published by scientists of the cluster per 1 million inhabitants also has an impact on the ranking of S&T cluster (Fig. 2). The leadership in 2023 was secured by the American cluster 'Boston – Cambridge' – 18,046 articles for the period 2019–2023, and the second position was held by the Chinese cluster 'Beijing' – 14,487 articles. Scientists from the 'Shenzhen – Hong Kong – Guangzhou' (China, Hong Kong) and 'Tokyo – Yokohama' (Japan) clusters had the smallest number of published works for 2019–2023 – 3,092 and 3,178 articles, respectively. Remote interaction and cooperation between scientists, exchange of experience based on the latest digital technologies and the possibilities of the virtual world contribute to the achievement of better results of research and innovation activities and the production of new knowledge and technologies. Such joint work is often accompanied by joint scientific research and published works. In 2023, the first place in the share of articles in cooperation with other organizations belongs to three S&T clusters of the USA ('San Jose – San Francisco', 'Boston – Cambridge', 'San Diego') – 76% each, and the cluster 'Seoul' (Republic of Korea) presented the fewest joint publications – 43%.

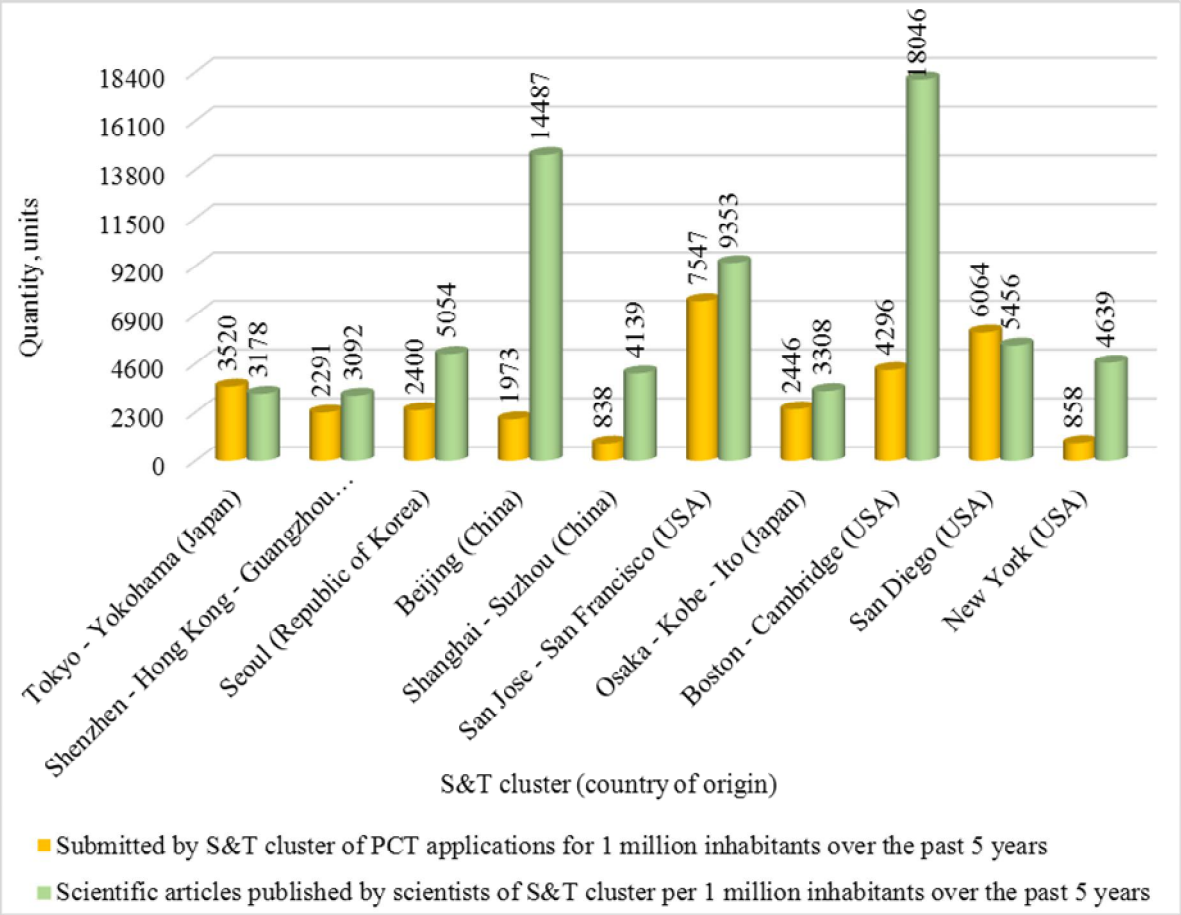

Fig. 2. The number of scientific articles published by researchers and PCT applications submitted by advanced S&T clusters of the world (by economic results) according to the Global Innovation Index 2023 (built on the basis of source [19])

South Korean researchers Y. Jung, E. Kim, and W. Kim, analyzing the co-authorship of scientific articles and patents created by government research institutes in South Korea's largest innovation cluster (Daedeok Innopolis), conclude that IDRs increase over time regardless of discipline, and the scope of IDR itself is expanding. Scientists prove that greater interdisciplinarity in scientific publications and patents significantly correlates with higher efficiency of research works [8].

Among the important results of the activities of S&T clusters of the world is the number of issued patents within the framework of innovative activities in a wide variety of industries and spheres (Fig. 3). In particular, the Italian economist E. Moretti notes that now: the effect of productivity spillover in the high-tech sector, which is the result of geographical agglomeration, is clearly visible; larger clusters allow more effective dissemination of knowledge and ideas, their innovations become recognizable, and patents are of higher quality; spatial redistribution (agglomeration) increases the productivity of inventors in smaller-than-average clusters and reduces the productivity of inventors in larger-than-average clusters [3, pp. 3328–3332].

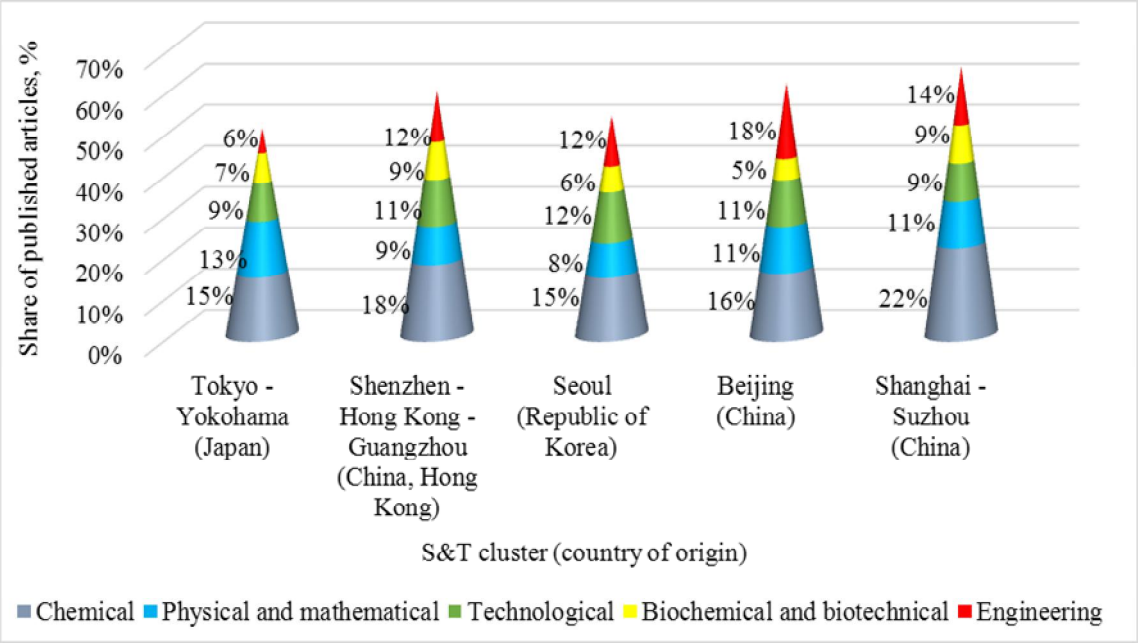

Fig. 3. The most popular fields of technology for filing patents as part of the innovative activity of the first five S&T clusters of the world (according to economic results) and the share of patents filed by them according to the Global Innovation Index 2023 (built on the basis of the source [19])

The sphere of interests of inventors and researchers of S&T clusters today is expanding at the same speed as the emergence of new needs and requests from the side of humanity, and therefore the areas of patent activity range from bio- and medical technologies, pharmaceuticals, and optics to information, digital, computer and audiovisual technologies. As part of our research, we consider it necessary to find out which areas of innovative activity guaranteed leaders the highest economic results. According to the GII 2023, technologies and means that contribute to digitization, innovation, and virtualization of activities (personal, economic, commercial, administrative, etc.) and interaction between people, organizations, universities, state authorities and states, etc., occupy the first place.

The most popular fields of technology for filing patents as part of the innovative activities of the first five S&T clusters of the world (by economic results) and the share of patents issued by them was the field of digital communications – 26% in the cluster 'Shenzhen – Hong Kong – Guangzhou' (China, Hong Kong) and 25% in the cluster 'Beijing' (China), and the field of computer technologies in the same clusters – 20% and 17%, respectively. In 2023, the leadership in the number of issued patents within the framework

of innovative activities of the cluster in the field of audiovisual technologies, which make the virtual world as convenient, realistic and effective as possible, was secured by the cluster 'Beijing' (China) – 9%, and 7% was share of issued patents by S&T clusters 'Shenzhen – Hong Kong – Guangzhou' (China, Hong Kong) and 'Seoul' (Republic of Korea). It can be seen from Fig. 3 that the leader of the innovativeness rating (by economic results) according to the GII 2023 is the S&T cluster 'Tokyo – Yokohama' (Japan), which among the 5 leaders of the rating issued the largest number of patents in the field of electrical equipment production.

High productivity and efficiency of scientific and research activity, and as a result of innovation, is achieved as a result of deep specialization and the use of the principle of comparative advantages, even if it concerns the fields for writing scientific articles by researchers of S&T clusters. Recent years have been marked by the deepening of such trends, and in Fig. 4 we can see a visualization of the preferences of scientists in writing their publications on the issues of a certain field.

The largest number of scientific works was presented in chemistry – 22% by the cluster 'Shanghai – Suzhou' (China) and 18% by the cluster 'Shenzhen – Hong Kong – Guangzhou' (China, Hong Kong); in physics and mathematics – 13% cluster 'Tokyo-Yokohama' (Japan) and 11% clusters of China 'Beijing' and 'Shanghai – Suzhou'; from engineering – 18% cluster 'Beijing' and 14% 'Shanghai – Suzhou' (China); in the field of biochemistry and biotechnology – 9% each for the clusters 'Shenzhen – Hong Kong – Guangzhou' (China, Hong Kong) and 'Shanghai – Suzhou' (China); in the technological sector – 12% 'Seoul' (Republic of Korea) and 11% clusters 'Shenzhen – Hong Kong – Guangzhou' and 'Beijing'. However, the mentioned fields of writing scientific articles by researchers within the framework of the innovative activities of S&T clusters of the world were not the only ones, publications in medical sciences, fundamental and applied biology, engineering, and earth science were also popular in 2023.

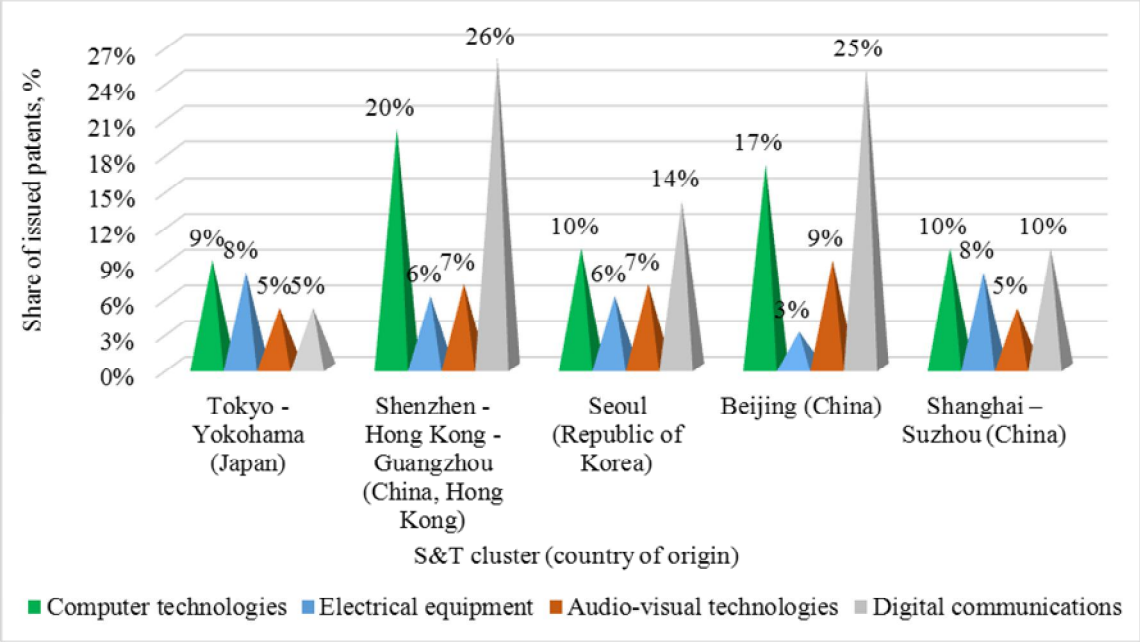

Fig. 4. The most popular fields for writing scientific articles by researchers within the innovative activities of the top five S&T clusters of the world (by economic results) and the share of articles published by them according to the Global Innovation Index 2023 (built on the basis of the source [19])

From the above, it follows that the conclusions of the research of scientists led by S. Kichkoa are correct, because nowadays clusters really 'play a growing role in the knowledge-based economy, uniting high-tech firms and providing an environment that promotes the overflow of knowledge, dependent on place location, and contributes to the investment of companies in research and development' [4, p. 1]. And

according to Polish researchers M. Mackiewicz and D. Pavelkova, 'membership in a cluster has a number of advantages related to the transfer of knowledge and opportunities for cooperation. They create an environment conducive to collaboration between different types of subjects in research and project development, which can influence the number of patents, trademarks, designs and technological advances' [6, p. 1865].

Therefore, countries that claim global technological and innovative leadership and see the creation and development of S&T clusters as a source of strength should be clearly aware that digital competitiveness is now determined by the factors of knowledge, technology and readiness for the future. In this context, we propose several important directions for strengthening S&T clustering in countries that are focused on economic prosperity and social well-being (Table).

Expected results from the practical implementation of priority directions for strengthening scientific and technological clustering in developed countries of the world (author's development)

Directions for strengthening S&T clustering	Prerequisites for the implementation of the direction and expected results for the S&T cluster
1	2
Formation of new priorities of members of society (education, innovation, technology)	*Source of achievement:* favorable educational and scientific environment, developed labor and capital market. *Expected result:* 1. An increase in the level of well-being of citizens (expressed, in particular, in GDP per capita), which stimulates the growth of solvent demand for innovative goods / services, digital technologies and tools. 2. Encouraging members of society, in particular young people, instead of looking for work and earning money immediately after reaching working age, continue to get an education, gain new knowledge, make attempts at inventive and innovative activities, participate in the creation of high-tech and innovative products. Such steps have a positive effect on the education of a highly intellectual society, the general education of the nation, the world rating of national educational institutions and research organizations, and involvement in the world academic community. 3. Creating attractive working conditions in the country, and not abroad, for educated workers, stimulating their involvement in starting their own business, expanding business connections and opportunities, opening access to unique knowledge and gaining practical experience.
'Cultivation' and support of domestic scientists, researchers, innovators, inventors	*Source of achievement:* comfortable and safe conditions for learning, experimentation, and work; supportive institutional support; innovative ecosystem; extensive and multifunctional market infrastructure. *Expected result:* 1. State and corporate (private) programs for the development of innovations and digital technologies have a priority focus on supporting national scientific institutions, research centers, scientists, inventors, innovators, business startups, innovative companies, which ultimately restrains the outflow of capital abroad and opens new horizons of opportunities for domestic players. 2. Preservation within the country of domestic representatives of scientific and research circles who can potentially bring success to the country, ensure S&T progress and prepare for future changes, stop the outflow of highly intellectually developed persons abroad.
Involvement of external participants in cooperation (scientists, researchers, entrepreneurs, investors, etc.)	*Source of achievement:* increasing investments, in particular venture investments; availability of quality education and progressive science. *Expected result:* 1. Involved external leading scientific organizations, research centers, famous scientists, economic schools and investment funds, make a significant contribution to the creation of powerful and effective S&T clusters by sharing experience, revealing the 'keys' to success, focusing on ways to minimize risks and avoid unnecessary bureaucracy, additional investment, a high level of flexibility and maneuverability.

Continuation of the Table

1	2
	2. International cluster interaction makes it possible not only to create international and intercontinental network connections, but also to form multinational collectives of like-minded people united by a common idea and values, but who have different experience in conducting economic, scientific and research activities. 3. Create breakthrough innovations and advanced digital technologies as a result of high concentration of a large number of all necessary resources (human, natural, technical and technological, investment) in one place (agglomeration, city, certain territory).
Creation of comfortable and safe conditions for conducting innovative and high-tech business	*Source of achievement:* transparent institutional support, comfortable business environment, clarity and ambiguity of the regulatory framework, high-quality infrastructure support, absence of shadowy economic ties and corruption schemes, stimulating tax policy of the state. *Expected result:* 1. Simplifying the procedure for starting a business and facilitating the ease of its management, because within the framework of cluster interaction, it is possible to avoid a significant number of unnecessary bureaucratic procedures, and to direct the saved time and money to a quick exit to the market with the results of one's activity. 2. Promoting the emergence of domestic business leaders on the global market, who in the future will join the formation of the global innovative entrepreneurial ecosystem that actively uses information, communication and digital technologies. 3. Creation of favorable institutional conditions for conducting business, strengthening its flexibility, adaptability and mobility in the dynamically changing conditions of today.
Support and stimulation of clustering at the state level and at the level of international institutions	*Source of achievement:* access to global capital markets, equality of rights and freedoms of citizens of different countries, rule of law. *Expected result:* 1. The emergence of new powerful players in the market of innovations and high-tech solutions that can potentially act as partners and participants in scientific, technological and industrial clusters. 2. Strengthening cluster interaction and network connections between leading innovative companies, powerful venture investors, well-known scientists and inventors, etc., which, in turn, increase the level of the country's involvement in world trade in high-tech products, stimulate the growth of export potential in the field of ICT and digital technologies, improve digital infrastructure. 3. Increasing the digital competitiveness of the country on the international market, building trust in it as a reliable and progressive partner (which is focused not only on economic benefits, but also on achieving social equality, cyber security, environmental protection).

The proposals given in Table regarding directions for strengthening S&T clustering, as well as the outlined sources of achieving this and the expected results, can have both scientific and practical value. This is important from the point of view of creating and supporting centers of S&T activity, which will contribute to the general adaptability of the country to the dynamically changing conditions of today, the economic stability of the country with the perspective of sustainable economic growth, technological independence and stimulation of the development of national scientific and technological potential, increasing digital competitiveness country and economic leadership in the long term.

The conducted research proved that in order to create prerequisites for the organization, and in the future, for the successful development of S&T clusters, it is necessary to carry out a deep analysis of the integration and modification of modern representatives of the scientific and academic community, inventors, business, production systems and state authorities for the further formation and maintenance of high level of competitiveness of innovative clusters. This, in turn, requires a study of the processes of integration of various economic agents and business structures, justification and implementation of a synergistic approach to the creation of S&T clusters, a retrospective analysis of the institutional, organizational, and economic evolution of cluster participants.

All this is necessary in order to get the maximum benefit from the activities of the cluster. Cluster interaction of various firms, enterprises, institutions, universities, and researchers contributes to the generation of innovative resources and the creation of innovations; provides a favorable, comfortable and transparent institutional environment; creates the basis for financial assistance and technical support; forms a research network for technological innovation in the region and the country as a whole. Another advantage of activity clustering is synergy from the work of talented inventors, innovators, scientists, researchers, because their role in S&T clusters is almost the most important, they become the driving force that successfully combines advanced information, communication and digital technologies, spreads knowledge, create innovative developments and distribute innovative technologies. Each of the direct participants of the cluster, or those who are related to its activities, are able to work on the principles of mutual assistance for common goals, reducing, at the same time, competition in the geographical agglomeration; stimulated the development of local markets and their counterparties; scale up your activity; promote economic growth not only within a certain region, but also within the country as a whole.

Conclusions

The cluster form of interaction between science, business, and the state enables significant success, namely: researchers to fully realize their main competence – scientific potential, by publishing and popularizing their scientific works in world-class publications; get access to private and public funding sources; strengthen leadership in society, business, country; to raise the qualification level of researchers and make them practically oriented; strengthen and activate business opportunities of economic agents; ensure the growing demand for products (goods / works / services) produced by the cluster; formation of advanced digital infrastructure; creation of a high-tech innovation ecosystem for the creation of innovations and their commercialization; ensuring a favorable regulatory and institutional environment for economic agents; creation of prerequisites for the training of a qualified workforce with a strategic, innovative type of thinking.

The formation of high-tech Industry 5.0 and digital Society 5.0 has recently increasingly strengthened the scale and depth of involvement of S&T clusters in the creation of innovative products, the formation of new scientific knowledge and technological solutions. In this context, we see the productivity and efficiency of S&T clusters in a close combination of educational, scientific, and production potential. This should be preceded by: the well-being of society and a high level of purchasing power of its members, an extensive and high-quality innovative infrastructure, investment attractiveness and tax loyalty, an effective structure of the economy and its innovativeness, a high-quality system of education and science, a progressive technological policy, research openness and accessibility. As a result, it will allow to prepare highly intelligent human resources for the implementation of innovative economy, create high-tech products and develop digital solutions to strengthen digital competitiveness, stimulate the activity of ICT and digital technology exports and reduce their imports, which will allow to achieve technological independence.

Prospects for further research

Development of methodological tools for institutional support for the sustainable development of S&T clusters in order to accelerate the processes of digital transformation of the country's economy can be promising research.

1. Kerr W. R., Robert-Nicoud F. Tech Clusters. *Journal of Economic Perspectives*. 2020. Vol. 34. no. 3. Pp. 50–76. URL: https://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.34.3.50 (assessed 2.06.2024). DOI: https://doi.org/10.1257/jep.34.3.50.

2. Mohannak K. Innovation and Clustering among Information Technology Firms in Melbourne. *Prometheus*. 2004. Vol. 22. no. 1. Pp. 83–98. DOI https://doi.org/10.1080/0810902032000194047.

3. Moretti E. The Effect of High-Tech Clusters on the Productivity of Top Inventors. *American Economic Review*. 2021. Vol. 111. Iss. 10. Pp. 3328–3375. URL: https://eml.berkeley.edu/~moretti/clusters.pdf (assessed 12.05.2024). DOI https://doi.org/10.1257/aer.20191277.

4. Kichkoa S., Liangb W.-J., Maic Ch.-Ch., Thissed J.-F., Wang P. The rise (and fall) of tech clusters. *Papers in Regional Science.* 2024. Vol. 103. Iss. 3. # 100022. URL: https://1ll.ink/dIDtR (assessed 20.05.2024). DOI https://doi.org/10.1016/j.pirs.2024.100022.

5. Sandoval Hamon L. A., Ruiz Penalver S. M., Thomas E., Fitjar R. D. From high-tech clusters to open innovation ecosystems: a systematic literature review of the relationship between science and technology parks and universities. *The Journal of Technology Transfer.* 2024. Vol. 49. Pp. 689–714. DOI https://doi.org/10.1007/s10961-022-09990-6.

6. Mackiewicz M., Pavelkova D. Clusters and innovation: the relationship between membership in clusters organisations and technological maturity of companies in Poland. *Technological and Economic Development of Economy.* 2022. Vol. 28. Iss. 6. Pp. 1854–1870. URL: https://gc.vgtu.lt/index.php/TEDE/article/view/18005/11447 (assessed 27.05.2024). DOI https://doi.org/10.3846/tede.2022.18005.

7. Slaper T., Ortuzar G. Industry Clusters and Economic Development. *Indiana Business Review.* 2015. Vol. 90. no. 1. Pp. 7–9. URL: https://www.ibrc.indiana.edu/ibr/2015/spring/pdfs/article2.pdf (assessed 1.06.2024).

8. Jung Y., Kim E., Kim W. The scientific and technological interdisciplinary research of government research institutes: network analysis of the innovation cluster in South Korea. *Policy Studies.* 2019. Vol. 42. Iss. 2. Pp. 132–151. DOI https://doi.org/10.1080/01442872.2019.1593343.

9. Tong T., Zainudin N. B., Yan J., Rahman A. A. The Impact of Industry Clusters on the Performance of High Technology Small and Middle Size Enterprises. *Sustainability*. 2023. Vol. 15. Iss. 12. # 9333. DOI https://doi.org/10.3390/su15129333.

10. Casper S. New-technology clusters and public policy: Three perspectives. *Social Science Information.* 2013. Vol. 52. Iss. 4. Pp. 628–652. DOI https://doi.org/10.1177/0539018413501236.

11. Abduvaliyev A. A. Development Trend of Science and Technology Clusters in the World by the Global Ranking Innovation Index. *Scientific and Technical Information Processing.* 2022. Vol. 49. Iss. 4. Pp. 211–219. DOI https://doi.org/10.3103/S0147688222040025.

12. Botti A., Parente R., Vesci, R. (Ed.). How to do business in digital era? A casebook. Salerno-Cracow: Cracow University of Economics, 2021. URL: https://ted.uek.krakow.pl/wp-content/uploads/2021/12/Casebook-31122021.pdf#page=38 (assessed 24.05.2024).

13. Magliocca P. (Ed.). Doing business digitally. A textbook. Foggia-Cracow: Małopolska School of Public Administration, Cracow University of Economics, 2021. URL: https://ted.uek.krakow.pl/wp-content/uploads/2021/12/Textbook-31122021.pdf (assessed 24.05.2024).

14. Краус Н. М., Краус К. М. Інноваційний ландшафт кластеру на базі інноваційного хабу. *Автомобільний транспорт та інфраструктура* : матеріали ІІ міжнар. наук.-практ. конф. (11–13 квіт. 2019 р.). Київ, 2019. С. 182–184.

15. Kraus N., Kraus K., Babukh I., Lisitsa V., Novikova O. Activities of Digital Platforms on the Basis of Clusterization and Innovative Development Strategies in the Conditions of European Integration. *WSEAS Transactions on Environment and Development.* 2023. Vol. 19. Art. #108. Pp. 1179–1195. URL: https://wseas.com/journals/ead/2023/c205115-1122.pdf (assessed 2.06.2024). DOI https://doi.org/10.37394/232015.2023.19.108.

16. Global Innovation Index 2023: Innovation in the face of uncertainty. 16th Edition by Soumitra Dutta, Bruno Lanvin, Lorena Rivera León and Sacha Wunsch-Vincent. *World Intellectual Property Organization (WIPO).* Geneva : WIPO, 2023. 249 p. URL: https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2023-en-main-report-global-innovation-index-2023-16th-edition.pdf (assessed 29.05.2024).

17. Research and innovation clusters: Policy briefing. UK: The Royal Society. 2020. 44 p.

18. Identifying and describing UK Innovation clusters: Analytical Report (2024). UK: Cambridge Econometrics, Department for Science, Innovation and Technology, № 001. 55 p.

19. Science and Technology Cluster Ranking 2023. Global Innovation Index 2023. *World Intellectual Property Organization (WIPO).* 2023. URL: https://www.wipo.int/global_innovation_index/en/2023/science-technology-clusters.html (assessed 14.05.2024).

20. Zhang L., Zhao H., Liao X., Ji Y. The construction of scientific and technological service platform in industrial clusters. *Proceedings of the 2015 International Conference on Economy, Management and Education Technology (ICEMET 2015). Series: Advances in Social Science, Education and Humanities Research.* Published by Atlantis Press, 2015. Pp. 302–307. DOI https://doi.org/10.2991/icemet-15.2015.65.

1. Kerr, W. R., & Robert-Nicoud, F. (2020). Tech Clusters. *Journal of Economic Perspectives,* 34, 3, 50–76. Retrieved from https://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.34.3.50 (assessed 2.06.2024). DOI https://doi.org/10.1257/jep.34.3.50 (in English).

2. Mohannak, K. (2004). Innovation and Clustering among Information Technology Firms in Melbourne. *Prometheus,* 22, 1, 83–98. DOI https://doi.org/10.1080/0810902032000194047 (in English).

3. Moretti, E. (2021). The Effect of High-Tech Clusters on the Productivity of Top Inventors. *American Economic Review,* 111, 10, 3328–3375. Retrieved from https://eml.berkeley.edu/~moretti/clusters.pdf (assessed 12.05.2024). DOI https://doi.org/10.1257/aer.20191277. (in English).

4. Kichkoa, S., Liangb, W.-J., Maic, Ch.-Ch., Thissed, J.-F., & Wang P. (2024). The rise (and fall) of tech clusters. *Papers in Regional Science,* 103, 3, # 100022. Retrieved from https://1ll.ink/dIDtR (assessed 20.05.2024). DOI https://doi.org/10.1016/j.pirs.2024.100022 (in English).

5. Sandoval Hamon, L.A., Ruiz Penalver, S. M., Thomas, E., Fitjar, R. D. (2024). From high-tech clusters to open innovation ecosystems: a systematic literature review of the relationship between science and technology parks and universities. *The Journal of Technology Transfer,* 49, 689–714. DOI https://doi.org/10.1007/s10961-022-09990-6 (in English).

6. Mackiewicz, M., & Pavelkova, D. (2022). Clusters and innovation: the relationship between membership in clusters organisations and technological maturity of companies in Poland. *Technological and Economic Development of Economy,* 28, 6, 1854–1870. Retrieved from https://gc.vgtu.lt/index.php/TEDE/article/view/18005/11447 (assessed 27.05.2024). DOI https://doi.org/10.3846/tede.2022.18005 (in English).

7. Slaper, T., & Ortuzar, G. (2015). Industry Clusters and Economic Development. *Indiana Business Review,* 90, 1, 7–9. Retrieved from https://www.ibrc.indiana.edu/ibr/2015/spring/pdfs/article2.pdf (assessed 1.06.2024) (in English).

8. Jung, Y., Kim, E., & Kim, W. (2019). The scientific and technological interdisciplinary research of government research institutes: network analysis of the innovation cluster in South Korea. *Policy Studies,* 42, 2, 132–151. DOI https://doi.org/10.1080/01442872.2019.1593343 (in English).

9. Tong, T., Zainudin, N. B., Yan, J., & Rahman, A. A. (2023). The Impact of Industry Clusters on the Performance of High Technology Small and Middle Size Enterprises. *Sustainability*, 15, 12, # 9333. DOI https://doi.org/10.3390/su15129333 (in English).

10. Casper, S. (2013). New-technology clusters and public policy: Three perspectives. *Social Science Information,* 52, 4, 628–652. DOI https://doi.org/10.1177/0539018413501236 (in English).

11. Abduvaliyev, A. A. (2022). Development Trend of Science and Technology Clusters in the World by the Global Ranking Innovation Index. *Scientific and Technical Information Processing,* 49, 4, 211–219. DOI https://doi.org/10.3103/S0147688222040025 (in English).

12. Botti, A., Parente, R., & Vesci, R. (Ed.). (2021). How to do business in digital era? A casebook. Salerno-Cracow: Cracow University of Economics. Retrieved from https://ted.uek.krakow.pl/wp-content/uploads/2021/12/Casebook-31122021.pdf#page=38 (assessed 24.05.2024) (in English).

13. Magliocca, P. (Ed.) (2021). Doing business digitally. A textbook. Foggia-Cracow: Małopolska School of Public Administration, Cracow University of Economics. Retrieved from https://ted.uek.krakow.pl/wp-content/uploads/2021/12/Textbook-31122021.pdf (assessed 24.05.2024) (in English).

14. Kraus, N. M., & Kraus, K. M. (2019). Innovatsiinyi landshaft klastery n abazi inovatsiinogo khabu [Innovation landscape of the cluster based on the innovation hub]. *Motor transport and infrastructure: materials of the II international science and practice conf.* (April 11–13, 2019). Kyiv, 182–184 (in Ukrainian).

15. Kraus, N., Kraus, K., Babukh, I., Lisitsa, V., & Novikova, O. (2023). Activities of Digital Platforms on the Basis of Clusterization and Innovative Development Strategies in the Conditions of European Integration. *WSEAS Transactions on Environment and Development,* 19, #108, 1179–1195. Retrieved from https://wseas.com/journals/ead/2023/c205115-1122.pdf (assessed 2.06.2024). DOI https://doi.org/10.37394/232015.2023.19.108 (in English).

16. Global Innovation Index 2023: Innovation in the face of uncertainty (2023). 16th Edition by Soumitra Dutta, Bruno Lanvin, Lorena Rivera León and Sacha Wunsch-Vincent. *World Intellectual Property Organization (WIPO).* Geneva: WIPO. Retrieved from https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2023-en-main-report-global-innovation-index-2023-16th-edition.pdf (assessed 29.05.2024) (in English).

17. Research and innovation clusters: Policy briefing (2020). UK: The Royal Society (in English).

18. Identifying and describing UK Innovation clusters: Analytical Report (2024). UK: Cambridge Econometrics, Department for Science, Innovation and Technology, № 001. 55 p. (in English).

19. Science and Technology Cluster Ranking 2023. Global Innovation Index 2023 (2023). *World Intellectual Property Organization (WIPO).* Retrieved from https://www.wipo.int/global_innovation_index/en/2023/science-technology-clusters.html (assessed 14.05.2024) (in English).

20. Zhang, L., Zhao, H., Liao, X., & Ji, Y. (2015). The construction of scientific and technological service platform in industrial clusters. *Proceedings of the 2015 International Conference on Economy, Management and Education Technology (ICEMET 2015). Series: Advances in Social Science, Education and Humanities Research.* Published by Atlantis Press, 302–307. DOI https://doi.org/10.2991/icemet-15.2015.65 (in English).

К. М. Краус
Науково-дослідна частина,
Черкаський національний університет імені Богдана Хмельницького,
k23k@ukr.net

СВІТОВИЙ ДОСВІД НАУКОВО-ТЕХНОЛОГІЧНОЇ КЛАСТЕРИЗАЦІЇ В ЦИФРОВУ ЕПОХУ: ІНТЕЛЕКТУАЛЬНА ТА ПАТЕНТНА ДІЯЛЬНІСТЬ В РОЗРІЗІ ГАЛУЗЕЙ ЕКОНОМІКИ

Сучасна кластерна парадигма економічного розвитку має на меті сприяти поглибленню зв'язків між ринками капіталу та передовими ІКТ і цифровими технологіями, розвитком економіки знань та екологічністю виробництва, соціальною спрямованістю технологій, отримання синергетичних ефектів від спільних науково-дослідних розробок. GII 2023 засвідчив першість у рейтингу науково-технологічних кластерів світу за економічними результатами кластерів Азійського регіону, однак рейтинг науково-технологічних кластерів за інтенсивністю не підтверджує прямої залежності між щільністю населення на певній території чи в певному місті та економічними результатами кластеру. Результатом дослідження став виявлений факт того, що сфера наукових інтересів винахідників та дослідників кластерів сьогодні розширюється так само швидко, як і потреби людей, а тому патентна активність простежується в біо- та медичних технологіях, фармацевтиці та оптиці, інформаційних, цифрових, комп'ютерних та аудіовізуальних технологіях, що цілком виправдано в еру цифровізації та інформатизації як економіки, так і суспільства. Запропоновано низку пріоритетних напрямів посилення науково-технологічної кластеризації в розвинених країнах світу та окреслено їх очікувані практичні результати.

Ключові слова: науково-технологічний кластер, інноваційна діяльність, цифрові технології, цифровізація економіки, агломерація, регіональна спеціалізація, публікаційна активність, патентна діяльність, мережевість зв'язків.