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Examining the Growth of Regional Science and Technology Clusters in the Global Economy

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ABSTRACT

Relevance. Creating policies to stimulate innovation as part of national economic development requires a more in-depth understanding of the current trends, especially the role of science and technology (S&T) clusters. In this study, we use patent and publication data to identify key S&T clusters and leading countries. The lessons learned from their experiences offer valuable guidance for other nations striving for consistent progress in research and development.

Research objective. The study aims to assess how well innovation processes are organized in S&T clusters; to identify the factors and drivers influencing the development of these clusters in the global economy; and to determine the competitive advantages of the top countries in terms of patent applications and publication activity.

Data and methods. Using the cluster approach employed in the methodology of the Global Innovation Index, we conducted a comparative analysis of the annual data and indicators published in this index related to patent and publication activity.

Results. Our analysis has revealed 20 key fields in S&T clusters, the leading positions being occupied by medical, digital, and computer technologies, as well as the pharmaceutical industry. In terms of patent and publication activity, the top countries in the ranking of S&T clusters are the USA, Japan, Germany, and China. Although these countries maintained their leadership in the given period (2017-2021), all of them, except for China, demonstrated a decrease in their share in the indicators under consideration.

Conclusions. A country is included in the ranking of the Global Innovation Index of S&T clusters when it exhibits a high quality of fundamental and applied research, as evidenced by its levels of publication and patent activity. To establish successful clusters eligible for ranking, a country should primarily formulate policies aimed at improving the quality of research and development. These policies should also facilitate growth in the key performance indicators, such as the number of patent applications and publication activity.

KEYWORDS

science and technology cluster, Global Innovation Index, ranking, patent, academic publication, publication activity, competitiveness

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Анализ развития региональных научно-технических кластеров в мировой экономике

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АННОТАЦИЯ

Актуальность. Формирование политики научного и инновационного развития национальной экономики требует глубокого анализа тенденций развития данной области, значительную роль в которой играют научно-технические кластеры. Опыт стран-лидеров патентной и публикационной активности, на основе которой осуществляется выявление науч-

КЛЮЧЕВЫЕ СЛОВА

научно-технический кластер, Глобальный инновационный индекс, рейтинг, патент, научная публикация, публикационная активность, конкурентоспособность

но-технических кластеров, послужит примером для стран, стремящихся к достижению прогресса в данной области.
Цель исследования. Исследование было проведено с целью анализа эффективности организации инновационных процессов в аспекте научно-технических кластеров, выявления факторов и драйверов развития региональных научно-технических кластеров в мировой экономике, а также определения конкурентных преимуществ стран-лидеров по подаче патентных заявок и публикационной активности.
Данные и методы. На основе кластерного подхода, используемого в методологии Глобального инновационного индекса, в исследовании проведен сравнительный анализ ежегодно публикуемых данных и индикаторов данного индекса в области патентной и публикационной активности.
Результаты. Анализ развития региональных научно-технических кластеров в мировой экономике позволил выявить 20 основных научных направлений научно-технических кластеров, лидирующие позиции в которых занимают медицинские, цифровые и компьютерные технологии, а также фармацевтика. В результате анализа патентной и публикационной активности определены страны-лидеры в рейтинге научно-технических кластеров – США, Япония, Германия и Китай. Несмотря на то, что данные страны на протяжении рассматриваемого периода (2017–2021 годы) сохраняют свое лидерство, было выявлено уменьшение их доли (кроме Китая) в общей сумме анализируемых показателей.
Выводы. Возможность участия страны в рейтинге научно-технических кластеров Глобального инновационного индекса определяется качеством проводимых фундаментальных и прикладных исследований, о котором, в частности, свидетельствует уровень публикационной и патентной активности научного сообщества. Для вхождения в рейтинг научно-технических кластеров государству необходимо формировать такую научно-технологическую политику, которая бы способствовала как повышению качества исследований и разработок, так и росту ключевых показателей эффективности (количество патентных заявок и публикационная активность).

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分析世界经济中地区科技集群的发展情况

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摘要
现实性：制定国民经济科学和创新发展政策需要先对该领域的趋势进行深入分析，而科技集群在其中发挥着重要作用。在确定科技集群的基础上，领先国家在专利和出版活动方面的经验将为寻求在这一领域突破的国家树立榜样。
研究目标：这项研究旨在分析科技集群创新过程的组织效率，确定世界经济中区域科技集群发展的因素和驱动力，以及确定领先国家在专利申请和出版活动方面的竞争优势。
数据与方法：根据全球创新指数方法中使用的分组方法，本研究比较了该指数在专利和出版活动领域每年公布的数据和指标。
研究结果：通过对全球经济中区域科技集群发展的分析，我们确定了科技集群的20个主要科学领域，其中医疗、数字和计算机技术以及制药占据领先地位。文章根据专利和出版物的分析，确定了科技集群领先国家：美国、日本、德国和中国。尽管这些国家在本报告所述期间（2017-2021年）一直保持领先地位，但其在世界分析指标总和中所占份额（除中国外）均有所下降。
结论：一个国家能否参与全球创新指数的科技集群评级，取决于基础研究和应用研究的质量，特别是科学界的出版和专利活动水平。为了纳入科技集群排名，国家需要制定既有助于提高研发质量，又有助于关键绩效指标（专利申请数和出版活动数）增长的科技政策。

关键词
科技集群、全球创新指数、评级、专利、科学出版物、出版活动、竞争力

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Introduction

The early 21st century saw a rapid formation of the global market space (Karanina & Karauliov, 2023), leading to heightened international competition. This competition extended to both strategic raw material markets (Kheyfets & Chernova, 2022) and markets associated with the sale of innovative products, technologies, and high-value-added services (Mirziyoyeva, 2019).

According to the Global Innovation Index (hereinafter referred to as GII), one of the aspects used to assess a country's innovation development is the consideration of science and technology (S&T) clusters. The latter are defined as geographical areas in different parts of the world with the highest number of inventors and authors of scientific publications. The emerging clusters often span multiple municipalities, federal states, and sometimes even two or more countries. The Global Innovation Index annually announces the top S&T clusters in the world (Dutta et al., 2022).

The goal of our research was to analyze the efficiency of innovations[1] from the perspective of their geographical concentration; to identify factors and drivers of the development of regional S&T clusters; and to determine the competitive advantages of the top countries in terms of patent applications and publication activity.

To achieve this goal, we studied the methodology underpinning the ranking of S&T clusters and identified the main fields of R&D of the top countries in terms of patent and publication activity in the global economy.

The results of this study can be useful for policy-making in regions actively involved in innovation. They provide insights that can inform the creation of strategies to stimulate the development of S&T clusters, making them more appealing to investors and fostering their global recognition.

Literature review

The concept of innovation became a part of economic theory during the 1930s, largely due to the contributions of J. Schumpeter, who is credited as the pioneer of contemporary innovation theory. He was the first to consider innovation as the primary driver of economic growth and believed that production cannot exist without constant changes in technology, the exploration of new markets, and the transformation of market structures (Schumpeter, 1939; Schumpeter, 1942). Schumpeter's concepts were corroborated by D. Ricardo, who studied the impact of innovations on the economy. In the third edition of his work «On the Principles of Political Economy and Taxation,» he included a chapter titled «On Machinery,» noting that «the discovery, and useful application of machinery, always leads to the increase of the net produce of the country» (Ricardo, 1955).

Gradually, innovations became the focus of attention for an increasing number of researchers who further developed this concept or enriched it with new content. J. Allen links innovation to the introduction and mass consumption of new products, processes, or behaviors (Allen, 1966), while A. Harman views innovation in line with the ideas of J. Schumpeter and defines it as the implementation of new or significantly modernized production processes (Harman, 1971).

The development of innovation theory continues in our time. N. D. Kondratiev made a significant contribution by showing the importance of innovations and establishing the connection between long economic cycles and waves of technological inventions, as well as the duration of their practical utilization (Kondratiev 2002). Polterovich (2009) argues that innovative development should be based on robust institutions and high-quality human capital, which are necessary to ensure sustainable economic growth. Development is considered innovative when it leads to a qualitative leap in the economic structure of an entity by harnessing its innovative potential (Kochetkov & Kochetkova, 2017).

The development of innovation theory has led to the emergence of the theory of clusters. It was developed by such scholars as H. Schmitz, D. Audretsch and M. Feldman, R. Voigt, C. Tiffin, B. Preissl, and others.

Schmitz (1995) defines a cluster as the sectoral or geographical concentration of businesses. Altenburg and Meyer-Stamer (1999) define an industrial cluster as a large concentration of firms in a limited geographical area, possessing a specific specialization profile and characterized by a significant volume of inter-firm specialization and trade. These researchers list the following cluster characteristics:

- positive external impacts resulting from having a local pool of skilled workers and attraction of potential buyers;

[1] In this study, the economic efficiency of innovation and research is understood as based on minimal production costs for goods or services, maximum output/provision, and maximum profit from market operation. Economic efficiency can be viewed as a combination and outcome of the static and dynamic aspects of efficiency (Petrou 2014; see also Cabral 2000; Church & Ware 2000).

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- forward and backward linkages between firms inside the clusters;
- intensive exchange of information among companies, institutions, and individuals within the cluster, fostering a creative environment;
- joint effort aimed at creating locational advantages;
- diversified institutional infrastructure which supports the specific activities of the cluster;
- socio-cultural identity consisting of common values and the involvement of local actors in a local milieu which enhances trust (Altenburg & Meyer-Stamer, 1999).

According to Voyer (1998), who studied clusters extensively for many years as a scholar, policy developer, and promoter of the cluster approach in the private sector, the concept of industrial clustering closely resembles the concept of innovation systems because both involve opportunities and relationships. In his work, Voyer uses the term "knowledge-based industrial cluster", which he defines as regional or urban concentrations of firms including manufacturers, suppliers and service providers, in one or several industrial sectors. The operations of these firms are supported by infrastructure, which includes universities and other higher education institutions, research institutes, financial organizations, incubators, business service providers, and advanced communication/transportation systems (Voyer, 1998).

Audretsch (1995) and Feldman (1996) highlight that close relationships among member organizations are a key characteristic of a cluster. They define innovation clusters as interconnected organizations that facilitate the implementation of innovations in specific economic sectors or specialties.

Thus, an innovation cluster can be seen as a type of industrial cluster, with high-tech or knowledge-intensive companies at its core, where scientific and technological knowledge drive the development of new products and business growth.

As mentioned earlier, a distinctive feature of an innovation cluster is its geographical confinement. According to Tiffin and Bortagaray (2000), innovative clusters should be formed in science parks – administrative structures designed to promote their development, with a focus on the most technological types of production. They define an innovation cluster as an organizational structure that generates new products and enterprises through collective industrial production in a geographically limited area. This effect is achieved through a high concentration of knowledge exchange, interactive learning, and shared social values. Following Voyer, Tiffin and Bortagaray (2000) emphasize that a university, a high-tech company, or an incubator are only elements of a cluster, not the cluster itself.

Preissl (2003) considers the concept of an innovation cluster from a slightly different perspective: she considers an innovation cluster as a system of new goods and technologies existing in a specific economic sphere and at a specific time. It is evident that Preissl's concept excludes the geographical limitation of the cluster, its infrastructure elements, and the system of interaction between them. However, most researchers now consider the regional aspect of an innovation cluster as its defining characteristic, and when studying innovations, it is often the regional factor that captures the attention of scholars.

In his study, Napolskikh (2019) summarized the key areas of innovation development and methods to analyze it at the regional level. He also proposed a criterion to evaluate the effectiveness of innovation development in regional innovation clusters.

In their study of regional-level innovation processes, Cherkasova and Ignatova (2020) pointed out the archaization of socio-economic relationships that happens while inefficient institutions gradually fade away and are replaced by new ones. In their study, they also address the issue of preserving social identity and maintaining the competitive advantages of the regional economy in the context of digitalization. They propose prospective solutions based on regional globalization management.

Surovitskaya et al. (2021) identify areas of growth in regional innovation ecosystems that drive the establishment of world-class scientific and educational centers. The human potential of these centers is considered an important factor of sustainable regional development. The competitiveness of scientific and educational centers hinges on the research and development (R&D) capabilities of the universities within these centers. Consequently, it is crucial to establish mechanisms that facilitate universities' active engagement in the endeavors of global research and educational centers and consortia while also maintaining and supporting these mechanisms through integrated digital technologies.

Alexeev et al. (2022) consider the implementation of closed-loop economy principles from the perspective of sustainable economic development and propose methods for identifying and creating sources of financing for S&T clusters.

Golsalves et al. (2023) stress the need to formalize the operations of technology innovation centers in scientific, technical, and innovation institutions. They assert that such formalization is critical, benefiting both the development of these institutions and environmental conservation efforts.

The analysis of academic literature discussed above highlights the importance of the innovation factor in both national and global economic development. One of the ways to assess the economic efficiency of innovative activities is to view them through the lens of S&T clusters. This approach requires further theoretical exploration to understand the principles and mechanisms of cluster operation and the role of clusters in the innovative economy, both at the national and regional levels, a task that our research aims to address.

Method and data

The GII methodology employs a cluster approach to identify factors influencing innovation efficiency through geographical concentration. This way we can also identify the most innovative economies globally, helping to show strengths, weaknesses, and gaps in their innovation indicators.

The geographical boundaries of innovation clusters typically do not align with geographical units for which governments or other organizations collect statistical data. S&T clusters are identified by using data from geocoded addresses of inventors listed in patent applications filed under the World Intellectual Property Organization's (WIPO) Patent Cooperation Treaty (PCT) and authors of scientific publications in the "Science and Technology" category indexed in the Web of Science database. It should be noted that publications in the social sciences and humanities were excluded from this analysis.

The names of S&T clusters in the GII are based on the names of one or several cities that form the cluster. The sizes of S&T clusters are determined using an empirical approach, which involves the following stages. First, the addresses of patent authors and scientific article authors are identified and geocoded. Then, an algorithm is applied to map the clusters based on the obtained data. Once the geocoding process is complete, the S&T clusters are identified, and detailed descriptions of the top 100 clusters are provided.

Originally, clusters were identified exclusively through patent data, which was deemed the most reliable indicator for evaluating the efficiency of inventive activities. Since 2018, the GII and S&T cluster ranking have relied on information about the authors of scientific publications from the expanded scientific citation index of Web of Science. According to GII experts, the incorporation of author details to identify S&T clusters had but a limited impact on both the results and the sizes of the clusters (Bergquist et al., 2017).

Our research on the dynamics of regional S&T clusters in the global economy is based on a comparative analysis of annually published data and indicators from the GII in the field of patent and publication activity. We intend to determine the factors affecting innovation efficiency and identify the drivers of regional S&T cluster development.

The study comprised two stages. In the first stage, the primary areas of patent performance in S&T clusters were identified for the years 2017-2020. In the second stage, the patent and publication activity of the leading S&T cluster countries was analyzed for the same period.

Results and discussion

Our analysis of the global ranking of S&T clusters across various disciplines has revealed the specific trends in patent and publication activity of the leading countries. Additionally, it has provided insights into the most productive areas of research worldwide. We also identified the key areas of S&T clusters' patent performance in 2017-2020 as well as priority areas of their research activity (Table 1).

Table 1 illustrates that out of the top 20 areas of clusters' patent performance, the leading position in the given period is occupied by medical technologies. Other top positions are held by such fields as digital technologies, pharmaceuticals, and computer technologies.

By 2020, some of the fields had been removed from the list (these included "furniture, games," "textile and paper machinery," and "special machinery") and some had been added ("other consumer goods" and "measurements"). Patent activity significantly decreased in fields such as "transport," "organic chemistry," and "semiconductors." However, there was a significant increase in the number of S&T clusters in the "electrical machinery" and "computer technologies" sectors, while the growth in the number of clusters operating in civil engineering and biotechnologies was less pronounced. The increase in the number of S&T clusters in these fields indicates their high innovative potential and reflects the trends in the development of the real sector of the global economy.

Table 1

Key areas of S&T clusters' patent performance in 2017-2020

	Specialization of clusters	Number of clusters	
		2017	2020
	Total	**100**	**100**
1	Medical technologies	17	18
2	Digital technologies	16	15
3	Pharmaceuticals	15	15
4	Computer technologies	11	15
5	Transport	7	2
6	Electrical machinery	7	12
7	Organic chemistry	6	2
8	Basic materials chemistry	4	4
9	Biotechnologies	2	3
10	Engines, pumps, turbines	2	-
11	Civil engineering	2	4
12	Optics	2	2
13	Semiconductors	4	1
14	Food chemistry	1	1
15	Mechanical parts	1	1
16	Furniture, games	1	-
17	Textile and paper machines	1	-
18	Other specialized equipment	1	-
19	Other consumer goods	-	3
20	Measurement	-	2

Sources: Compiled by the authors by using the data from the Global Innovation Index (Dutta et al. 2017, 173-176; Dutta et. al. 2020, 44-45).

We summarized the patent applications data of S&T clusters for 2017-2021 as a percentage of the total number of patents worldwide and the number of S&T clusters. This allowed us to identify the top countries in terms of patent activity in the analyzed period (see Table 2).

As Table 2 shows, in 2017, the three global leaders in terms of patent activity were the United States (28.10%), Japan (25.01%), and China (12.15%). In 2021, these countries maintained their leadership, but compared to 2017, the indicators significantly decreased for the United States and Japan and slightly increased for China.

Overall, in the period under consideration, a significant decrease in patent activity is observed in countries such as France, Belgium, Canada, Switzerland, Australia, Israel, India, and Spain. In some countries (Belgium, Canada, India, Spain, etc.), the number of clusters remains the same, while in others, it changes, either decreasing (France, Switzerland, Israel) or increasing (Australia, the United Kingdom). It is necessary, however, to note that over the four years, in several countries the share of patent applications remained approximately the same with small fluctuations (Australia, Israel, India, etc.).

The analysis of the publication activity in the countries participating in the GII ranking shows that out of the 27 countries, the largest share of publications is attributed to the USA, followed by China, Japan, Germany, and others (Table 3).

Table 2

Leading countries in terms of S&T clusters' patent performance, 2017-2021 (1 - the share of patent applications from the global number in the current year (in %), 2 - the number of S&T clusters)

	Countries	Percentage of patent applications from the global number (1) and the number of S&T clusters (2)									
		2017		2018		2019		2020		2021	
		1	2	1	2	1	2	1	2	1	2
1	USA	28.10	31	16.97	26	16.98	26	16.50	25	15.67	24
2	Japan	25.01	8	15.82	3	15.64	3	16.09	5	16.05	5
3	China	12.15	7	9.14	16	10.67	18	12.36	17	14.17	19
4	Germany	9.35	12	4.30	8	7.72	8	3.98	8	3.93	8
5	South Korea	7.56	4	4.87	3	4.93	3	4.90	3	5.16	4
6	France	3.49	5	1.84	3	1.77	3	1.71	3	1.48	2
7	Belgium	1.65	2	1.07	2	1.13	2	1.09	2	1.06	2
8	UK	1.73	3	0.88	4	0.89	4	0.89	4	0.91	4
9	Sweden	1.50	3	0.92	3	0.75	2	0.91	3	0.92	3
10	Canada	1.28	4	0.78	4	0.76	4	0.74	4	0.72	4
11	Switzerland	1.43	3	0.73	3	0.70	3	0.67	3	0.46	2
12	Australia	1.00	3	0.71	4	0.71	4	0.69	4	0.67	4
13	Israel	1.24	2	0.69	1	0.70	1	0.68	1	0.66	1
14	India	0.80	3	0.52	3	0.51	3	0.50	3	0.54	3
15	Netherlands	0.59	2	0.46	1	0.45	1	0.42	1	0.40	1
16	Singapore	0.54	1	0.39	1	0.39	1	0.38	1	0.38	1
17	Spain	0.68	2	0.41	2	0.39	2	0.37	2	0.35	2
18	Italy	0.34	1	0.32	2	0.30	2	0.29	2	0.29	2
19	Denmark	0.47	1	0.28	1	0.29	1	0.28	1	0.28	1
20	Finland	0.54	1	0.31	1	0.28	1	0.27	1	0.25	1
21	Russia	0.34	1	0.23	1	0.21	1	0.20	1	0.18	1
22	Taiwan	-	-	0.19	2	0.14	1	0.26	1	0.29	1
23	Turkey	-	-	0.14	2	0.28	2	0.30	2	0.32	2
24	Brazil	-	-	0.08	1	0.08	1	0.07	1	0.07	1
25	Poland	-	-	0.04	1	0.04	1	0.04	1	0.04	1
26	Iran	-	-	0.01	1	0.01	1	0.01	1	0.02	1
27	Ireland	-	-	0.08	1	0.08	1	-	-	-	-
28	Malaysia	0.19	1	-	-	-	-	-	-	-	-

Sources: Compiled by the author by using the data from the Global Innovation Index (Dutta et al. 2017, 173-176; Dutta et al. 2018, 203-207; Dutta et al. 2019, 68-70; Dutta et al. 2020, 44-45; Dutta et al. 2021, 30-31).

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Table 3

Leading countries in terms of S&T clusters' publications activity, 2018–2021 (1 - the share of publications from the global number in the current year (in %), 2 - the number of S&T clusters)

	Countries	Percentage (%) of publications from the global number (%) and the number of S&T clusters (2)							
		2018		2019		2020		2021	
		1	2	1	2	1	2	1	2
1	USA	13.77	26	13.31	26	13.08	25	12.55	24
2	China	9.88	16	11.34	18	12.16	17	13.76	19
3	Japan	2.93	3	2.80	3	2.77	4	2.66	5
4	Germany	2.44	8	2.41	8	2.36	8	2.32	8
5	South Korea	2.15	3	2.15	3	2.14	3	2.26	4
6	UK	2.14	4	2.16	4	2.09	4	2.04	4
7	Australia	1.84	4	1.80	4	1.79	4	1.82	4
8	France	1.54	3	1.49	3	1.41	3	1.21	2
9	Canada	1.21	3	1.51	4	1.44	4	1.41	4
10	Spain	1.14	2	1.11	2	1.08	2	1.07	2
11	Italy	0.95	2	0.90	2	0.91	2	0.89	2
12	Netherlands	0.97	1	0.94	1	0.91	1	0.88	1
13	India	0.79	3	0.79	3	0.80	3	0.82	3
14	Turkey	0.71	2	0.71	2	0.69	2	0.66	2
15	Iran	0.69	1	0.71	1	0.72	1	0.74	1
16	Switzerland	0.68	3	0.66	3	0.66	3	0.51	2
17	Russia	0.66	1	0.66	1	0.67	1	0.68	1
18	Sweden	0.63	3	0.46	2	0.61	2	0.58	3
19	Singapore	0.53	1	0.54	1	0.53	1	0.52	1
20	Belgium	0.48	2	0.54	2	0.52	2	0.51	2
21	Brazil	0.48	1	0.46	1	0.43	1	0.41	1
22	Israel	0.37	1	0.37	1	0.36	1	0.35	1
23	Denmark	0.32	1	0.32	1	0.31	1	0.3	1
24	Finland	0.21	1	0.20	1	0.20	1	0.19	1
25	Poland	0.28	1	0.28	1	0.28	1	0.28	1
26	Taiwan	0.93	2	0.61	1	-	-	0.69	1
27	Ireland	0.25	1	0.25	1	-	-	-	-

Source: compiled by the authors by using the data from the Global Innovation Index (Dutta et al. 2018, 203–207; Dutta et al. 2019, 68–70; Dutta et al. 2020, 44–45; Dutta et al. 2021, 30–31).

In the given period, China showed the most significant increase in the share of scientific publications compared to other countries. Therefore, it can be assumed that the increase in the number of clusters in China has had a positive impact on publication activity, although such a result is not observed in other countries. For example, the increase in the number of clusters in Japan did not lead to an increase in the share of publications, which may indicate insufficient activity of Japanese S&T clusters (this conclusion can be extended to other countries demonstrating the same trend). In the United States, France, Switzerland, and other countries, a decrease in the number of clusters predictably led to a decrease in researchers' publication activity.

Conclusion

The process of identifying and ranking S&T clusters, as part of the Global Innovation Index preparation, helps us assess the efficiency of research and innovation development. Our analysis of the GII data related to the activities of the top 100 clusters worldwide from 2017 to 2021 has shown the following.

Firstly, we found that the most in-demand scientific fields are medical technologies, digital technologies, pharmaceuticals, and computer technologies. Additionally, the following areas possess high innovation potential: electric machinery, computer technologies, civil construction, and biotechnology.

Secondly, we have identified the top three countries in the ranking of S&T clusters: the United States, Japan, and China (with Germany in the fourth place). However, despite the continued leadership of these top three countries by 2021, the shares of patent applications and scientific publications for the United States and Japan decreased in the global total, while China's shares increased. As it appears, China's success may be linked to the increase in the number of S&T clusters.

The analysis of the S&T cluster ranking highlights the high competitiveness of Chinese clusters on a global scale. In 2017-2018, the number of S&T clusters in China rose sharply, more than doubling, and then continued to grow slowly thereafter (Table 2). Furthermore, it's important to note the rise in the rankings of all Chinese S&T clusters in the GII over a short period of time—both those that existed in 2017 (Nanjing, Hangzhou, Wuhan, Xi'an, Chengdu, etc.) and new ones (Qingdao and Chongqing).

The research findings on the development of regional S&T clusters in the global economy can help shape national policies for science and economy. Particularly, the ongoing science and innovation reforms in Uzbekistan require a comprehensive analysis of global scientific and economic trends and best practices. In the future, these findings will be valuable when making a decision on Uzbekistan's participation in the Science and Technology (S&T) Cluster ranking of the GII. Such research evidence can also serve as a guide in shaping the agenda for scientific and innovation development of the national economy.

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