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National innovation systems and technology transfer of SCO countries

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Abstract. The article considers the forms and conditions of interaction between the participants in the innovation process, the specialties of creating and developing the organizational system of technology transfer in the member countries of the Shanghai Cooperation Organization (SCO). Based on the analysis of transfer systems operating in various countries (China, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Uzbekistan), the authors highlight key and most promising areas for the development of integration of the scientific, educational, industrial spheres and the state in order to form special mechanisms for organizing innovative processes that ensure effective interaction between all its participants. The purpose of the article is to analyze the national innovation systems of SCO member countries, since each of these countries has gone its own way of innovative development, justified by regional characteristics (climatic, cultural, socio-economic, etc.). As basic research methods we used system approach, comparative and statistical analysis of indicative values of innovation and technological development of the SCO member countries.The authors conclude that it is necessary to create an organizational system based on the integration of state institutions, science, business and education in the Shanghai Cooperation Organization member countries in order to form competitive high-tech products, improve the export structure by increasing the share of innovative products in it and reducing the raw materials orientation, and increase the status of countries in the world technology market.

Keywords: transfer of technologies, innovations, hi-tech production, market of technologies, Shanghai Cooperation Organization (SCO)

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Национальные инновационные системы и трансфер технологий стран ШОС

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Резюме. В статье рассматриваются формы и условия взаимодействия участников инновационного процесса, особенности развития систем передачи технологий в странах-членах Шанхайской организации сотрудничества (ШОС). На основе анализа национальных систем трансферта, действующих в различных странах, авторы выделяют ключевые и наиболее перспективные направления развития и интеграции научной, образовательной, промышленной сфер и государства. Авторы делают вывод о необходимости создания организационной системы, основанной на интеграции участников инновационного процесса в странах ШОС с целью создания конкурентоспособной высокотехнологичной продукции и повышения статуса стран на мировом рынке технологий.

Ключевые слова: трансфер технологий, инновации, высокотехнологичная продукция, рынок технологий, Шанхайская организация сотрудничества

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INTRODUCTION

The economic development of almost any country depends on a number of factors that contribute not only to increasing real output, but also to improving the quality of growth, as well as the level of efficiency. In the process of economic development, the list of these factors changes, the assessment of their importance. However, for most of the leading countries of the world, the development of the innovation sector, high technology, the knowledge economy comes first.

Technology transfer is one of the key factors in the development of both national economies and the global economy as a whole. At the same time, the degree of participation of each country in the process of obtaining and implementing the results of intellectual activity largely determines both the prospects for the scientific and technological development of the country and its competitiveness.

A special place in the world high-tech market is occupied by economic organizations and unions. Thus, the member countries of the Shanghai Cooperation Organization (SCO) not only cooperate in various areas (the fight against terrorism, drug trafficking, economic cooperation, partnership in the fuel and energy sphere, scientific, technological and cultural interaction), but also have a significant number of resources important for the world economy:

- China - the 1st economy of the world (in terms of GDP parity) and the 1st exporter in the world ("world factory"), the owner of the world's largest foreign exchange reserves, has the world's largest population, a nuclear power;
- Kazakhstan - the 2nd economy of the post-Soviet space (after Russia), the largest in Central Asia, has huge fossil fuel reserves, and large reserves of other fossil and metals;
- Kyrgyzstan - located at the intersection of the two most important transport axes, leading from North to South and from West to East, has significant potential for the development of transport infrastructure;
- Russia - the 5th-6th economy of the world (in terms of GDP parity), rich in mineral resources, has the largest territory in the world, one of the two largest nuclear powers in the world;
- Tajikistan is rich in minerals. So, on its territory there is the world's largest silver deposit (Bolshoi Konomansur), there are significant deposits of gemstones, uranium (up to 16% of the world's reserves), gold, coal, aluminium and polymetallic ores;
- Uzbekistan - the 11th in the world in natural gas production, the 3rd in the world in exports, the 6th in cotton production, the 7th in the world in uranium reserves (4% of the world's uranium reserves), Uzbekistan ranks 4th in the world in total gold reserves, and 9th in gold production.

The purpose of the article is to analyze the national innovation systems of the Shanghai Cooperation Organization member countries, since each of these countries has gone its own way of innovative development, justified by regional characteristics (climatic, cultural, socio-economic, etc.).

As basic research methods we used system approach, comparative and statistical analysis of indicative values of innovation and technological development of the SCO member countries. So, system approach found reflection in application of all elements of innovative process (the states, spheres of science, the industry, etc.) that allows to reveal prerequisites of technological development of the SCO economy. Investigating problems of technological transfer in the countries of the SCO, the authors analyse both statistical data, and the legislative base which is the cornerstone of formation of national innovative systems of member countries of SCO. Methods of the comparative and statistical analysis of data are for this purpose applied.

RESULTS AND DISCUSSION

The Global Innovation Index (see *tab.* 1) has been calculated annually by the analytical division of the Economist Intelligence Unit since 2007 to assess scientific and innovative potential. So, in 2020, the study covered 131 countries, which account for 99.4% of world GDP. The rating is led by Switzerland with an index of 66.08; Russia, which was in 62nd place in 2013, reached 47th place in 2020.

Table 1. **The Global Innovation Index (SCO member countries), 2020**

Country / Economy	Score (0-100)	Rank	Income	Rank	Region	Rank
China	53.28	14	UM	1	SEAO	4
Russia	35.63	47	UM	6	EUR	32
Kazakhstan	28.56	77	UM	24	CSA	3
Uzbekistan	24.54	93	LM	12	CSA	4
Kyrgyzstan	24.51	94	LM	13	CSA	5
Tajikistan	22.23	109	LM	4	CSA	9
Note: **UM** - upper-middle income, **LM -** lower-middle income (World Bank Income Group Classification). **SEAO** - South East Asia, East Asia and Oceania; **EUR** - Europe; **CSA** - Central and Southern Asia (regions are based on the UN Classification).						

Source: [1].

Economic and technological development of the SCO member countries means forming a regional model of development, which includes intraregional distribution of labour in accordance with geographic location, natural resources, level of economic and innovation-technological development. As note Edler and Fagerberg, «There is a narrow perspective, considering invention only, and there is a broader, more holistic perspective, which emphasizes the importance of looking at the entire innovation cycle from the creation of novel ideas to their implementation and diffusion» [2].

China. The integration of the state, science, education and business structures in China was preceded by the reforms of 1970-1980 and the national development programs adopted on their basis. In March 1986, the state program for the development of science and high technologies "Program 863" was approved, which identified priority industries (microelectronics, computer science, space, fiber-optic technologies, genetic engineering and biotechnology, energy-saving technologies and medicine). The program provided for basic and applied research; the development of new technologies based on the development of traditional industries. The implementation of this program has been quite effective. So, literally in the 10 first years of its operation, over a thousand of the most important scientific and technical achievements were registered, of which 560 developments received worldwide recognition, 73 were awarded state prizes, 266 were patented abroad.

Two years later, China began implementing the «Torch» research and production program, focused on the commercialization and industrialization of high technologies. In 1988, by a resolution of the State Council of China, the first technopark was established - the Beijing High-Technology Industry Development Experimental Zone Zhongguancun (in 1999 Zhongguancun has become the "Zhongguancun Science & Technology Zone" or Z-park).

Z-park is not accidentally located in northwest Beijing. It is here that more than a hundred scientific and technical institutes and laboratories are located, as well as the strongest universities in China - Peking University and Tsinghua University. It was they who became the pillars of the technology park: universities provided both scientific developments, and companies promoting them, and qualified personnel for high-tech business.

The integration component in China has a territorial organization, which is based on the division into the High technology and development zones (HTDZ), formed in the mid-1980s, which are scientific and technological parks.

In 2020, China had 168 HTDZ at various levels, including 53 for strategic purposes. Among Chinese HTDZ, one can distinguish zones located in the central regions (Beijing, Shenyang), as well as in the coastal regions (Shanghai, Hainan). In one of the central regions is the second largest and most important technopark in China - Nanhu, which received state status in 1991. Shenyan, on the territory of which the technopark is located, has 12 universities, 30 research institutes, 210 research laboratories, 220 enterprises of new and high technologies (30 of them with the participation of foreign capital). During the existence of the zone, about 600 new types of high-tech products have been developed and introduced into production [3].

China's state policy is aimed at fully supporting enterprises of new and high technologies, technology park structures, and the effective development of the country's economy, which focuses on its own scientific and technical potential. According to the National Program adopted in 2006, government agencies are obliged to allocate a certain share of costs for products of only innovative Chinese companies (regardless of the profitability of such purchases). In accordance with the new rules, government agencies can purchase foreign products only if there is no alternative to it in China.

Considering the Chinese One Belt, One Road (OBOR) initiative, R.Aoyama notes that «OBOR is not only a regional policy but a grand global strategy for achieving the “Chinese Dream”» [4]. However, as predicted by the Russian economist L.V.Shkvarya et al., «China’s development will slow down, including due to population aging and a labor shortage» [5].

Kazakhstan. The formation of the National Innovation System (NIS) of Kazakhstan was started by the adoption in 2003 of the Industrial and Innovative Development Strategy of the Republic of Kazakhstan for 2003-2015. In accordance with the Strategy, the main directions of the country's development are:

1. assistance in the formation of high-tech industries, including in the creation of an effective technology transfer system both foreign and intersectoral;

2. creating and supporting the activities of modern elements of scientific and innovative infrastructure in cities where there is a network of scientific, technical and industrial organizations and enterprises with high scientific and technological potential;

3. using the existing scientific and technical potential in the development of advanced, from the point of view of the post-industrial economy, industries;

4. creation the necessary conditions for conducting research in the field of modern scientific and technical areas, such as: new materials and chemical technologies; information technology;

5. Improving the legislative framework aimed at stimulating the innovation of scientific, technical and production organizations and enterprises, attracting investments in the field of science and innovation, early entry of innovation into industry and the service sector.

At the initial stage of implementation of the Strategy, a network of state development institutions was formed for the creation of the NIS, which included Development Bank of Kazakhstan, Kazakhstan Investment Fund, Innovation Fund, Export Insurance Corporation.

By 2009, a unified system of National Development Institutions was formed, the list of which included the National Innovation Fund, the Science Fund, the Center for Engineering and Technology Transfer, KazAgroInnovation, the Kazakhstan Center for Modernization and Development of Housing and Communal Services. A significant influence on the development of the National System was made by the creation in 2000 of the Development Bank of Kazakhstan, in accordance with the Charter of which this organization is also assigned to national development institutions.

In March 2010, the State Program for Forced Industrial and Innovative Development of Kazakhstan for 2010-2014 was approved, within the framework of which a number of industry innovation centers, a network of research centers, national laboratories, engineering, design and design bureaus of four technology parks were created. The goal was to market the introduction of local innovations, to create and maintain a database for industrial structures.

The Strategic Plan for the Development of the Republic of Kazakhstan until 2020 defined State support for the formation of a national innovation system on the following principles: 1) the creation of world-class universities and the development of university science to form an advanced R&D system; 2) funding of R&D priorities for the state based on the grant system. The determination of R&D priorities in accordance with the priorities of industrialization of the country will be carried out by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan; 3) introduction of a transparent process for evaluating grant applications with the involvement of experts, including foreign specialists; 4) application of efficient foreign technologies adapted to national needs.

Kyrgyzstan. The main elements of the NIS of Kyrgyzstan are formulated in the Act of the Kyrgyz Republic "On Innovation activity" of November 26, 1999 No. 128. In accordance with the Act, the Government of the Republic's National innovation policy provides for the establishment of a State innovation and investment network with a central office responsible for the preparation and implementation of decisions on national innovation policies; approval of national public innovation programs and proposals for national participation in international innovation programs prepared by the Office; prioritizing public procurement and government orders for products of national innovation actors; development and management of a network of activities aimed at implementing innovation policies, agreed solutions and programs; preparation of bills of the Kyrgyz Republic regulating innovative relations.

The Government of the Kyrgyz Republic is forming State innovation and investment complexes, which are State institutions for the implementation of the full innovation and investment cycle and are created on the basis of existing multidisciplinary higher educational institutions, scientific and project organizations with the maximum use of their resources, while the central division of the complex headed by its general director «is organized mainly on the basis of a leading technical university in the region or another large multidisciplinary state organization with a sufficient number of highly qualified personnel, specialists and scientists who own the main techniques of innovation and scientific activity, as well as a sufficient number of premises and infrastructure for innovative investment activities in the region» [6].

In accordance with the Act (art. 18), in the regions most susceptible to depression and a decline in production, Innovative Centers for Advanced Technology (Technocentres) and New Technologies (Technology Parks) are created, subordinate to industry research institutes and together with them are part of the network. The infrastructure of the centers can be different and include: a scientific laboratory or institute, production, certification and marketing departments, etc.

A significant component of the NIS of Kyrgyzstan is the State Innovation Fund, created to finance and logistical support for the development and use of science and technology, the main content and activities of which are enshrined in the Regulation on the State Innovation Fund. Research institutions subordinate to the National Academy of Sciences of the Kyrgyz Republic, various research institutes and scientific divisions of universities, a network of research centers and laboratories at industrial enterprises engaged in applied research in their industry, technical and implementation zones, a number of technology parks (key - technopark of the National Academy of Sciences of the Kyrgyz Republic) should also be noted as elements of the innovative infrastructure of Kyrgyzstan.

In 2015, with the support of the Fund for Infrastructure and Educational Programs of RUSNANO and the Government of the Kyrgyz Republic, the Center for Innovation Implementation (Bishkek) in Central Asia began its work, the main task of which is to introduce innovative products in Central Asian countries, as well as transfer technologies from Russia to Kyrgyzstan

Uzbekistan. The social and economic transformation of recent years has led to the need to develop and implement effective scientific, technical and innovation policies of the State, the purpose of which was to create

organizational, economic and legal conditions and mechanisms for the development of the scientific and innovative sphere. Thus, the main purpose of the Presidential Decision of 15 July 2008 "On additional measures to stimulate the introduction of innovative projects and technologies into production" was to create effective mechanisms to stimulate the development and introduction into production of scientific and applied research and innovative developments, ensuring a closer connection between science and production. In the same year, the Cabinet of Ministers adopted a resolution on measures to strengthen the material and technical base of scientific, research institutions and organizations, according to which $10 million was allocated from the budget of the Republic for these purposes.

Research and development in Uzbekistan are carried out by State structures, with 20% of organizations belonging to the Academy of Sciences system, 16% to the Ministry of Higher and Secondary Education, 15% to the Ministry of Health, 13% to the Ministry of Agriculture and Water Management, 3% of organizations are concentrated in the Ministry of Education system and 33% of scientific organizations belong to other ministries and departments [7].

It is necessary to emphasize the presence at the moment of an insufficiently developed mechanism for transferring technologies to industry, the weak interconnection of the sectors of science, education and business structures, the underdeveloped system of commercialization of new knowledge and technologies.

Financing of R&D in Uzbekistan is carried out mainly by the State Committee on Science and Technology, including concessional investments in innovative projects for a period of 1-2 years on the condition of return of budget funds. At the same time, financing of scientific and technical developments is carried out at the level of research and development, and implementation practice does not have the necessary financial infrastructure.

Tajikistan. The formation of a national innovation system in the Republic was facilitated by the adoption of a number of regulations. In accordance with the Strategy of the Republic of Tajikistan in the field of science and technology for 2007-2015, science is recognized as one of the national priorities. The Act of the Republic of Tajikistan «About Science and Scientific and Technical Policy» 1998 provides such organizational and economic mechanisms of scientific activity as the organization and conducting scientific and scientific and technical examination at selection of programs and projects for public financing, plurality of sources of financing of scientific and technical activity, transition to a program and target method of financing.

There is also a continuing increase in internal R&D costs (see *tab.* 2).

Table 2. **Internal costs of research and development of the Republic of Tajikistan, USD mln**

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Costs	9.8	11.8	14.1	21.0	21.6	24.3	26.2	26.3	27.8	33.0	30.4

Source: [8, p. 332].

The formation of Tajikistan's innovation system and the intensification of innovation activities were also facilitated by the adoption of such normative legal acts as the Government of the Republic of Tajikistan Decree «On the Council for the Coordination of Research in the Field of Natural, Technical, Medical, Humanities and Social Sciences» (1996), «On Reforming the System of Financing Science» (1997), «On the Concept of State Science and Technology Policy of the Republic of Tajikistan» (1999); Acts «On Copyright and Related Rights» (1998), «On Industrial Samples» (2004), «On Inventions» (2004), etc. However, despite the measures taken to organize the institutional component of the innovation system, regulations have not yet been adopted that enshrine the fundamental concepts, criteria, principles related to innovation, as well as the organizational characteristics of its implementation, forms and methods of state support, there is no single program of innovative development of the country.

Russia. The current technology transfer system in Russia has a number of features characteristic of the transition period. Thus, an effectively developing economy is characterized by the predominance in the structure of imports of new knowledge-intensive technologies, and in the structure of exports - on the contrary, the marketing of mature technologies.

According to Federal State Statistic Service of Russia, only scientific research appeared in the export structure during trade in technologies prevailing from all objects of transactions, while for the remaining objects the share of imports significantly exceeded the share of exports (see *tab.* 3).

Currently, in the system of technology transfer with foreign partners, there is a noticeable significant excess of imports over exports as a whole, which accompanies the preferential import of technologies that do not have a sufficient degree of novelty from the standpoint of the global technology market. Thus, 86.6% of advanced technologies developed are new for Russia, of which only 13.4% are fundamentally new in the global technological market (see *tab.* 4).

The foundations of the now emerging technology transfer system were laid in the USSR in the 1950s. In most academic institutions, as a result of the interaction of scientific organizations with production, with sectoral ministries and departments, scientific and technical associations, scientific and educational and scientific and technical centers and laboratories were created. In the 1970s, inter-university complexes appeared in the USSR, uniting scientific teams of various universities in order to fulfill complex research and scientific and technical tasks.

Table 3. **Trade in Technology with foreign countries by the subject of agreement, 2019**

Subject of agreement	Exports			Imports		
	Agreements	Cost of subject of agreement, USD mln	Receipts for year, USD mln	Agreements	Cost of subject of agreement, USD mln	Payments for year, USD mln
Total	4196	66565	3520	5518	12323	4837
Including by subject of agreement:						
Patent on invention	8	2.4	1.4	34	89.0	4.6
Patent on selection achievement	1	0.0	0.0	19	1.3	0.8
Patent license on invention	163	141	34.0	277	742	220
Utility model	6	1.3	1.3	12	8.7	7.2
Know-how	75	22.7	4.7	235	955	486
Trademark	95	13.4	4.1	416	1017	580
Industrial design	5	1.6	0.1	22	4.1	4.1
Engineering services	1144	64302	2588	2382	7326	2824
Research and development	1142	1230	397	512	157	120
Others	1558	851	490	1628	2023	591

Source: [9, p. 503].

Table 4. **Advanced production technologies developed by groups, 2019 (units)**

Advanced production technologies	Total number of technologies	Category		
		New for Russia	Brand new	Number of technologies using patented inventions
Total	1620	1403	217	530
Including:				
Design and engineering	456	403	53	168
Production, processing and assembly	510	447	63	173
Automated uploading / downloading actions; materials and parts transporting	29	25	4	10
Automated surveillance (monitoring) devices	159	98	61	88
Communication and control	316	295	21	55
Production informational system	81	73	8	18
Integrated control and monitoring systems	69	62	7	18

Source: [10, pp. 447-448].

In the 1990s in Russia, on the one hand, a number of new integrated scientific and educational structures were formed (university complexes, scientific, educational and other centers), on the other - against the background of a sharp reduction in the network of design organizations, experimental plants, scientific and technical services of enterprises (that is, structures that ensure the transfer of scientific results to the innovative sphere), until the beginning of the 2000s, there was an increase in the number of research institutes by creating new or disaggregated existing organizations. This was often done through the formation of new legal persons, rather than

strengthening the research base of universities and enterprises, which, in fact, form the backbone of innovative systems in developed market economies.

Table 5. **Number of research and development organizations**

Number of organizations	1992	1995	2000	2005	2010	2015	2016	2017	2018
Total	4555	4059	4099	3566	3492	4175	4032	3944	3950
Including:									
Scientific research institutes	2077	2284	2686	2115	1840	1708	1673	1755	1574
Construction organizations	865	548	318	489	362	322	304	273	254
Design and exploration organizations	495	207	85	61	36	29	26	23	20
Experimental enterprises	29	23	33	30	47	61	62	63	49
Educational organizations of higher education	446	395	390	406	517	1040	979	970	917
Research and development units in organizations	340	325	284	231	238	371	363	380	419
Other organizations	303	277	303	234	452	644	625	658	717

Source: [10, p. 442].

As a result of the transformation of the country's economy, there is a need to create special mechanisms for organizing innovative processes that ensure effective interaction between all its participants (the state, scientific and educational institutions, industrial enterprises, etc.). A necessary condition for the effective use of the experience of other countries is the formation and development in the Russian economy of an appropriate innovative infrastructure, which includes:

1. The development of a legislative framework aimed at promoting innovative entrepreneurship and guaranteeing the protection of intellectual property rights;
2. Specialized research and educational centers, scientific and technological parks, technology transfer and commercialization centers, business incubators, innovative firms that contribute to the transformation of promising scientific ideas and knowledge into product, information and technological innovations;
3. Increasing funding for research and development through the business sector, through the establishment of legal and financial guarantees of concessional loans, various extrabudgetary and joint funds, and various public incentives;
4. Expansion of telecommunication infrastructure in order to promote information support for Russian science, access of local information networks to global ones, increase the network of electronic libraries and the Internet system, and opportunities for Russian scientists to access international data banks;
5. The development of a network of venture capital firms and foundations, small-scale innovative firms and other elements of the country's innovation infrastructure.

For the formation of an effective NIS of Russia, the regional component also plays a large role. In developing a regional innovation policy aimed at the development of the scientific and technological component and the field of production, each region forms its own approach to technology transfer, taking into account its resource reserves, climatic, sectoral and other regional characteristics.

CONCLUSION

Despite sufficient progress in the theoretical basis of the research on innovative processes, there are still many little-studied and controversial issues. For example, the dynamics of innovation and technological development of countries and regions, the use of effective tools and mechanisms for the transfer of knowledge and technologies, the regulation of innovative processes using various institutional structures, etc.

Create of required organizational structure, aimed at supporting the acquisition process, implementation, and dissemination of research and development results involving all participants of the innovative process to improve the efficiency of technology transfer. The creation of a system based on the integration of the scientific, educational and production spheres in the Shanghai Cooperation Organization member countries will contribute to the formation of competitive high-tech products, improve the export structure by increasing the share of innovative products in it and reducing the raw materials orientation, and increase the status of countries in the world technology market.

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