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PROBLEMS IN INCREASING INNOVATIVE SUSTAINABILITY OF REGIONAL DEVELOPMENT

The article provides a comparative analysis of innovative and technological development in Russia and other countries. The paper shows that the innovation sector of the Russian Federation lags behind most developed and developing countries: Russia has almost left the market of high technologies, the main expenditures on innovations are incurred in the sectors of low and medium technology industries; the self-sufficiency in the Russian economy in a number of key types of manufacturing equipment is significantly below the threshold marks determined by national security requirements. The authors describe the differentiation of innovative development in the Russian regions. The study of Russian innovation space has revealed that there are fairly intensive processes of science decay on the periphery, which causes serious problems for the spread of innovative impulses across the country. The article elaborates the methodology for comprehensive assessment of innovative security in the region and presents the relevant calculations for the regions of the Ural Federal District (UFD). It identifies the factors of innovative sustainability that are the most critical for these regions. The authors present the forecast and built long-term forecast trajectories for the level of innovative security in UFD by using the modernized Hurst method. They define the main barriers to the innovative development of Russian regions. The article presents the methodological approaches to substantiating the priority areas for building the innovative systems of regions by taking into account the characteristics of their science and manufacturing complexes. The authors propose a methodology to formally assess the priority of establishing in the region the centers of innovative activity aimed at supporting the competitiveness of industries with different levels of technology intensity. The paper presents the results of calculations with regard to priority of establishing the centers of innovative activity aimed at supporting the development of industries with different level of technology intensity using the example of UFD, one of the leading Russian regions in terms of innovation and production capacity.

Keywords: innovative sustainability, innovative and technological development, innovative security of the region, innovation system, innovation capacity, innovation development strategy, innovation centers, priorities of innovative activity, high-tech industries, medium-tech industries, low-tech industries

Introduction

The beginning of the 21st century is characterized by increased interest in the innovation as the key factor for sustainable development of territories. This is largely due to the currently ongoing shift from the 5th techno-economic paradigm to the 6th techno-economic paradigm in which, according to Richard Feynman, the primary role will be played by nanotechnology [1]. In this environment, the issue of increasing the innovative sustainability of Russian regions (i.e., the capacity of the territory for an adequate response to internal and external challenges through the use of scientific advances and new technology, while ensuring on a long-term basis the improvement in the people' quality of life) acquires a particular relevance.

The Current State of Innovation Processes in the Russian Federation

Russia substantially lags behind the most developed and developing countries in terms of innovative development. Currently, Russia has almost gone from the high technology market. For example, by volume of high-tech exports, we lag today behind the USA by almost 16 times and behind China, by 57 times (Fig. 1).

This situation is caused by the existence of powerful resource lobby structure of the economy that largely remains unchanged since the Soviet times. As a result, the high-tech and high medium-tech industries found themselves in discriminatory conditions. The net financial result per worker employed in mechanical engineering in 2015 was only 1.4 % of the similar figure for fuel and energy complex, while in the manufacturing of electrical, electronic, and optical equipment it stood at 4.4 %. Overall in Russia, the net financial result for transport engineering

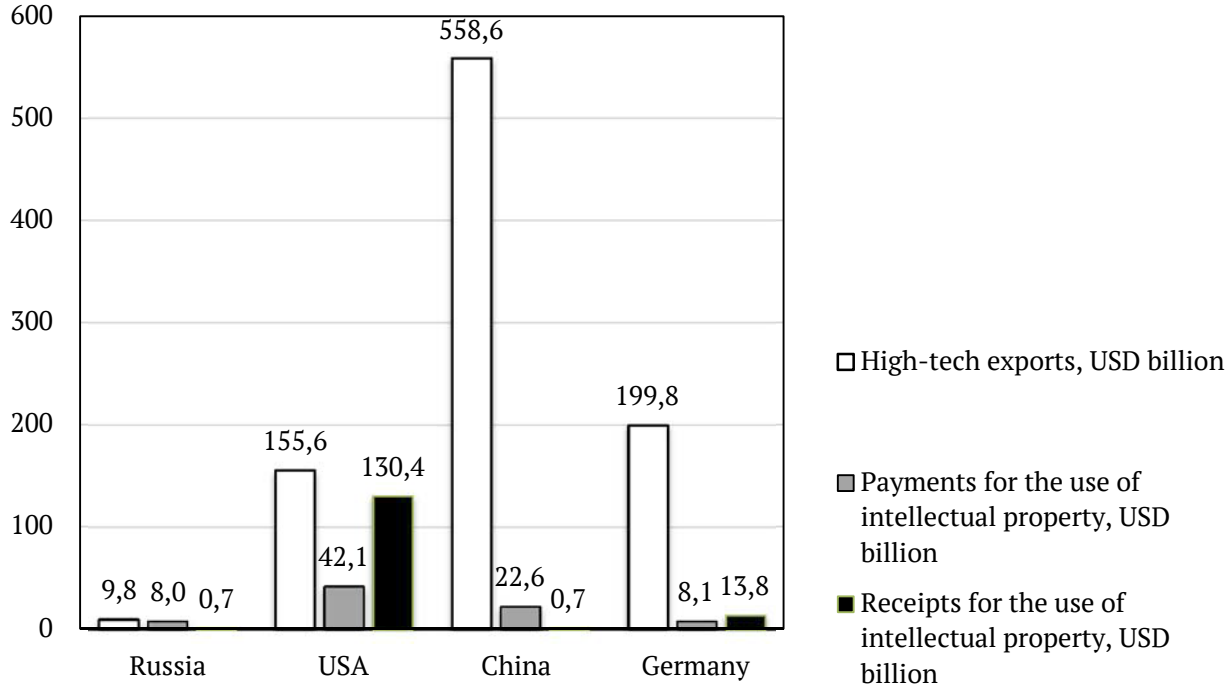

Fig. 1. *The International comparisons by indicators of innovative and technological development (as of 2014 or nearest years; based on data from the World Bank. Retrieved from: http://data.worldbank.org/indicator (date of access: 6/20/2016)*

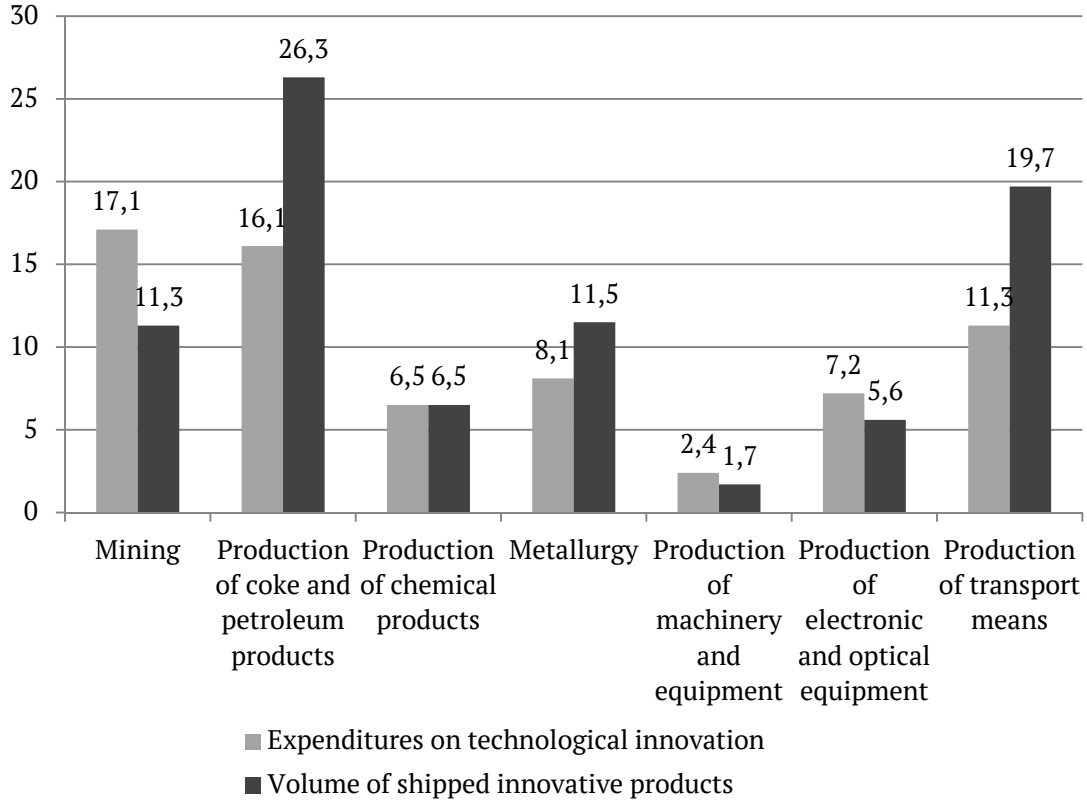

Fig. 2. *The expenditures on technological innovation and the volume of shipped innovative products for a number of industries in 2015, % of the total for the industrial sector (based on the data from Industrial Production in Russia. 2016: Statistical Book / Rosstat. Moscow, 2014. 326 P. (in Russian))*

had a negative value. This undermines the foundations of innovative activities in the high-tech sector of Russia[1].

Today, the main expenditures on innovations are incurred in low-tech and medium-tech industries. The mechanical engineering sector, which is responsible for production of machinery and renewal of

[1] Promyshlennoye proisvodstvo v Rossii. 2016. Stat. sb. In Russian [Industrial Production in Russia. 2016: Statistical Book]. (2014). Rosstat. Moscow, 326.

technological base (without which it is impossible to address the problems of import substitution), accounts for only 2.4 % of general expenditures on technological innovation in the industrial sector of the Russian Federation and only 1.7 % of the output of innovative products (Fig. 2).

It should be stated that in today's Russia any large-scale production of machines by machines is severely undermined. Compared to 1992, the production of cutting machine and press-forging equipment fell by 15 times, and the production of CNC machines dropped by 25 times [2, P. 127]. As a result, today the self-sufficiency of the Russian economy for a number of key types of production equipment is significantly below the threshold marks determined by the national security requirements. Thus, for cutting machines, self-sufficiency of the Russian market today is only 6 %; for excavators, 15 %; for metallurgical equipment, 25 %; for equipment used in oil and gas production, 30 % [3, P. 84]. Improving technical and technological level of Russian machine engineering industry, especially in terms of its ability to create designs that could compete with foreign products not only in terms of the price but also in terms of quality, is one of the most pressing issues for innovative support to technological development and creating prerequisites to implement the innovative growth paradigm [4].

The innovative space of Russia is very differentiated. As shown in Table 1, the maximum number of those employed in R&D per 10 thousand of people employed in the economy exceeds for the Russian regions the median value by more than 10 times, and in terms of innovative products and services (also per 10 thousand of people employed in the economy) by almost 100 times. With the maximum value of provision with scientific personnel in the subjects of the Russian Federation standing at 353.3 persons per 10 thousand people employed in the economy (Moscow), the median value stands at only 32.4 people per 10 thousand of people employed in the economy. Our analysis of dynamics in the transformation of Russian innovation space [4] shows that there are currently quite intensive processes of ongoing decay of science on the periphery. This creates some problems for the propagation of innovative impulses across Russia.

Table 1

The differentiation of innovative development of Russian regions (2014)

Indicator	Value of indicator	
Number of those involved in R&D per 10 thousand of people employed in the economy, people	maximum	353.3
	median	32.4
	minimum	2.8
R&D expenditures per 10 thousand people employed in the economy, thousand rubles	maximum	440.0
	median	27.9
	minimum	2.7
Share of actively innovative enterprises in the total number of surveyed enterprises, %	maximum	29.2
	median	8.7
	minimum	0.5
Volume of innovative products and services per 10 thousand people employed in the economy, thousand rubles	maximum	14852.7
	median	167.0
	minimum	0.0
Expenditures on technological innovations per 10 thousand people employed in the economy, thousand rubles	maximum	1483.9
	median	55.0
	minimum	0.4

Methodological Aspects of the Study of the Region's Innovative Security

One of the key characteristics of the region's capacity to innovative development is the extent of its innovative security. In this case, we propose to understand the innovative security as the state of innovation processes, which ensures the successful long-term socio-economic development of the territory in terms of its scientific, technical, and technological parameters. The structure of comprehensive assessment of innovative security [5] elaborated with the participation of the authors is presented in Figure 3.

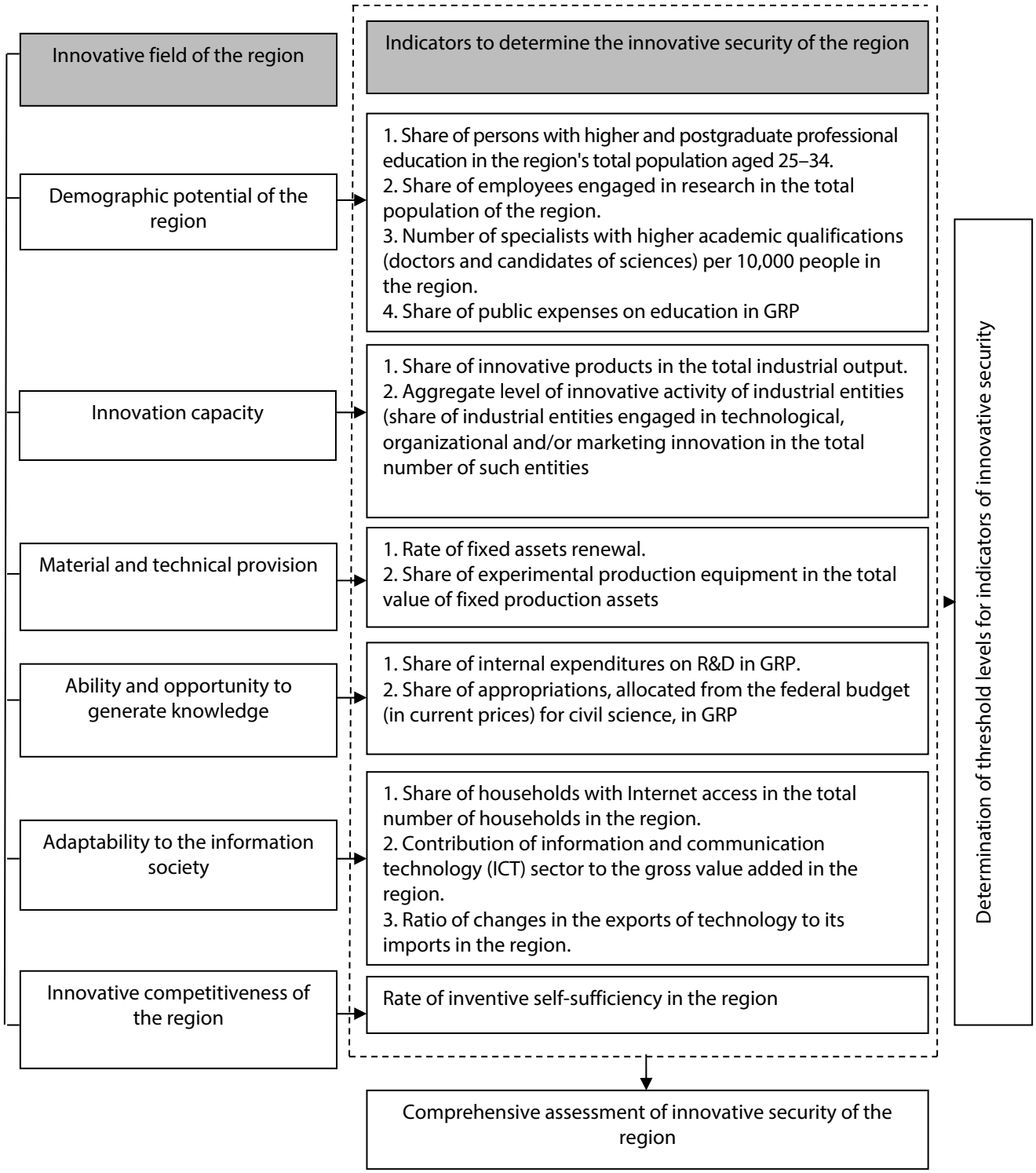

Fig. 3. *The structure of the comprehensive assessment of innovative security*

The Assessment and Forecast of Innovative Security for the Regions of Ural Federal District

The calculations of dynamics in the comprehensive assessment of innovative security for the Ural Federal District (Fig. 4) show that, in the period from 2000 to 2011, the region as a whole demonstrated a trend towards improving the innovative security. It should be noted that the quality of innovative activity continued to deteriorate even in these relatively good years. The renewal of technological base in the industrial sector proceeded primarily through the purchase of imported equipment, while the capacity for creating high-level domestic innovation continued to decline. For example, the average annual pace of decline in the number of personnel involved in R&D was 1.1 % for the district in general, and for the leading regions in terms of science and technology it was 1.9 % (Sverdlovsk Region) and

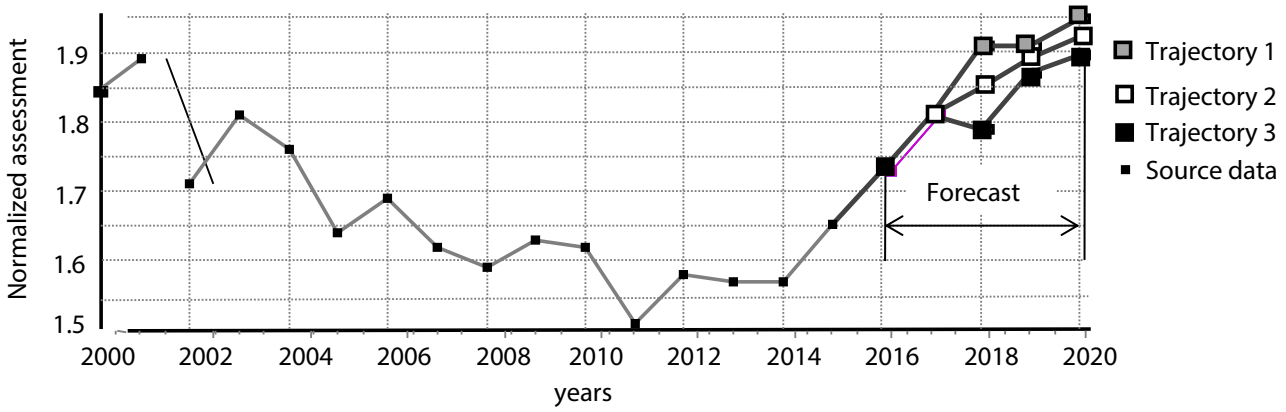

Fig. 4. *The forecast of innovative security in UFD*

1.6 (Chelyabinsk Region) (calculated by the authors based on the data from Rosstat[2]). The weakening of local base of innovative activity leads to deterioration in the resilience of innovation system of the region to external shocks. As a result, the start of the latest economic crisis and especially the default marked the beginning of a sharp deterioration in the innovative development of all regions in the Ural Federal District.

In the forecast calculations, we used the modernized Hurst method [6]. This approach involves studying the time series of statistical indicators, and allows to determine the risks and other basic characteristics of nonlinear development. The model apparatus allows to make forecasts for the next several years and simultaneously build several predicted trajectories.

The resulting graph shows that without the state measures aimed at creating a favorable environment for developing the innovative sector of the economy that relies on the local base, the region should expect a sharp deterioration of innovation security in the coming years (Fig. 4). Another fairly serious risk factor is the potential introduction of international restrictions on the sale of advanced oil and gas production technology to Russia.

We assessed how critical is the situation in the area of innovative sustainability in the region in terms of such key factors as a human factor, innovation capacity, innovative competitiveness, etc. The methodological approaches to the selection of thresholds for specific indicators of innovative security are examined in another paper [5].

The data in Table 2 show that currently, the subjects of UFD are in a crisis or pre-crisis condition by most of the indicators of innovative security.

Table 2

The state of innovative security by modules in the context of subjects of UFD in 2015 [4]

Module	UFD	Kurgan Region	Sverdlovsk Region	Tyumen Region	Khanty-Mansi Autonomous District	Yamalo-Nenets Autonomous District	Chelyabinsk Region
Human potential	C1	C3	PC3	C3	C2	C3	C2
Innovation capacity	C2	C3	C1	C2	C3	C2	C2
Innovative competitiveness	N	N	PC2	PC3	C2	C3	N
Adaptability to the information society	N	N	PC2	N	N	N	C1
Ability and opportunity to generate knowledge	C3	C3	PC2	C3	C3	C3	C3
Material and technical provision	C3	C2	C3	C3	C3	C2	C2
Innovative security	C2	C3	C1	C3	C3	C3	C2

Note: PC1—pre-crisis initial state; PC2—developing pre-crisis state; PC3—critical pre-crisis state; C1—unstable crisis state; C2—threatening crisis state; C3—emergency crisis state.

[2] Regiony Rossii. Sotsialno-ekonomicheskie pokazateli. 2016: stat. sb. [The Regions of Russia: Socio-Economic Indicators. 2016: Statistical Book]. (2016). Rosstat. Moscow, 1326; Regiony Rossii. Sotsialno-ekonomicheskie pokazateli. 2002: stat. sb. [The Regions of Russia. Socio-Economic Indicators. 2002: Statistical Book]. (2002). State Statistics Committee of the Russian Federation. Moscow, 863. (in Russian).

In general, for UFD, the most dangerous situation emerges in the modules "Ability and opportunity to generate knowledge," "Material and technical provision", and "Innovation capacity." Compared to 2000 only, the number of researchers in the region declined by over 20 % and continues to fall.

The level of innovative security by the module "Adaptability to the information society" in Sverdlovsk Region and Chelyabinsk Region is lower than in other regions of UFD, because, on the one hand, they are somewhat lagging behind the regions of Tyumen north in terms of home internet access (these subjects of the Russian Federation have the highest per capita income after Moscow), and on the other hand, Kurgan Region in recent years leads in the terms of growth rates of high-tech manufacturing in defense industry enterprises.

A number of problems pose barriers to overcoming the negative trends in scientific, technical, and innovative activities in the Russian Federation:

— Lack of understanding of the real role played by science and innovation in ensuring national independence and competitiveness on the part of decision makers.

— Ineffectiveness of existing system of state administration in the area of science and innovation; lack of clear innovation strategy and concept of restructuring the research sector, their misalignment with the general requirements of innovation-oriented development paradigm to socio-economic systems.

— High monopolization and predominance of vertically-integrated structures in the currently most profitable industries, the emergence of state-oligarchic clans.

— Simplification of the structure of Russian businesses; the strong gap between the solvency of enterprises in the raw materials sector and those in high-tech sector; locking out the defense industry, where the main innovation capacity of the Russian Federation is concentrated, into a self-contained research and production system controlled from the federal center. Today, in Russia only 10.1 % of enterprises are actively involved in innovation, while in Germany this figure is 65.4 %, and in China 28.8 %[3]. This determines the absence of demand for scientific ideas and designs on the part of the Russian practice and marginal position of Russian innovative businesses as economic entities.

— Degradation of human resources potential in science, destruction of processes ensuring the reproduction of scientific human resources. Currently, the number of researchers in Russia declined by more than half compared to 1990. Today in Russia the number of researchers (in terms of full employment) per 10,000 people employed in the economy is 66, while in Japan this figure is 104, in the USA 95, in Germany 85[4]. The average age of researchers is in the range of 50–55 years old, and in the applied science sector it is 57 years old.

— Lack of funding for research and deformed structure of science. In terms of domestic R&D expenditures, Russia substantially lags behind virtually all developed and developing countries. While R&D expenditures in Russia account for only 1.13 % of GDP, in the USA this figure is 2.81 %; in China 2.01 %; in Israel 4.21 %[5]. In Russia, the sector of applied science has practically ceased to exist. While in developed countries the share of "company" science accounts for about 60–70 % of qualified scientific personnel, in Russia, applied R&D sector employs about 6 % of the total number of researchers. This interferes with the normal transfer of R&D results to the economy and increases the gap between science and industry.

We believe that, given the depth of the technological gap with the leading industrialized countries, the innovative strategy of Russia should be refocused on the active development and implementation of technologies associated with the latest 6th techno-economic paradigm [7, 8] (nanotechnology, nanoelectronics, biotechnology, technology used for the creation of artificial intelligence, and others) [9]. Otherwise, the technological gap between Russia and developed countries will only worsen.

At the same time, it is obvious that without addressing the root problems of modern Russian social and economic policy, including the need for changes in the prevailing sentiment of the political elites about the future of Russia and sources of its development, ensuring the effective protection of private property and free enterprise, it is hard to expect any significant improvement in the situation with regard to innovative activity.

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[3] Indikatory innovatsionnoy deyatelnosti. 2014: stat. sb. [Indicators of Innovation: 2014: statistical book]. (2014). Moscow: Higher School of Economics, 472. (446). (in Russian).

[4] Indikatory nauki: 2014.: stat. sb. [Indicators of Science: 2014.: statistical book]. (2014). Moscow: Higher School of Economics, 400. (in Russian).

[5] According to the World Bank. Retrieved from: http://data.worldbank.org/indicator (date of access: 6/20/2016).

The Methodological Approaches to Choosing the Priority Areas for Building Regional Innovation Systems

Improving the sustainability of socio-economic development of the Russian Federation as a whole and its regions requires a transition to responsible state innovation, science, and technology policy based on the clear awareness of objective relationships between productive, technological, and innovative components of sustainable growth and the role played by innovation in addressing the challenges of improving the competitiveness and technological independence of Russia.

Today, we see one of the key tasks of strategic development of Russia in binding together socio-economic and innovative processes. Meanwhile, the relevant scientific and methodological apparatus, which would ensure an adequate implementation of this approach to shaping the strategy of socio-economic development of Russia based on its specificity, is not yet elaborated.

We propose the methodological approaches to substantiating the priority areas for building regional innovation systems taking into account specific aspects of both scientific and industrial systems existing in the territories. The need to consider specific aspects of the productive and technological type of the territory in the elaboration of the strategy for the development of innovation system is caused by the fact that the success and scale of innovative activity as a type of commercial activity substantially depend not only on the capability of science to offer innovative solutions and technologies, but also on the structure of demand for innovation by specific socio-economic entities, receptivity of their economy to the products and technologies with varying degrees of scientific novelty, readiness of industrial enterprises to participate in innovative projects related to the further elaboration and development of innovations.

The theory of "Triple Helix" (University-Industry-Government) [10], which gained a widespread use in the scientific literature in the 2000s, also focuses on the necessity of a meticulous study of the region's needs for innovation as a factor of success and its specialization in selecting the contours of the innovation system that is being built. In addition, we should keep in mind that, as demonstrated by the analysis of international experience, the success of an innovative strategy is largely determined by such economic and geographical factors as the quality of life, agglomeration effects, accessibility, etc. [11], which are "non-specific" for innovative activity as such.

Therefore, the issue of selecting the priorities for the strategy of innovative development of Russian regions should be considered in relation to the productive and technological type of specific territories by taking into account the preferred transformations in the future based on the requirements of improving social and economic sustainability. On the one hand, this is caused by the continued high production specialization of most industrialized regions of the Russian Federation and, on the other hand, by fundamentally different needs in innovative activity as a competitiveness factor (by taking into account its scale and quality) of the regions with predominance of industries that have various degree of knowledge intensity.

This approach allows to implement the concept of building a multi-level echelon innovative system in Russia , where the regions that are the leaders in terms of scientific and technical capacity development, as well as in generating and developing the innovations, could play the role of engine for innovative transformation of the economy and, at the same time, ensure the adoption of more balanced decisions on the priorities and the specific characteristics of the development of regional innovative systems. This is fundamentally important for Russia, given the high differentiation of its regions in terms of innovation capability.

The methodology proposed by authors for a formal assessment of priority of establishing the centers of innovative activity in the region was built based on identified patterns of ensuring the innovative sustainability of territories of productive and technological types that are the most characteristic for Russian regions. The methodology is based on the rating method and takes into account the specific aspects of Russian statistics and needs of practical management of innovative development in terms of its spatial aspect. The level of priority in the formation of innovation centers focused on creating the innovation with varying degrees of scientific novelty and specialization is assessed on the basis of indices that allow to obtain an objective view of the region's capabilities in the area of research and innovative activity, and the region's level of concentration of industries with varying degrees of technological intensity.

The total index of innovative activity is generated on the basis of summarized indices describing the level of development of scientific and technical activity, innovative activity, innovative infrastructure

and enabling an environment for the use of innovations as a factor for sustainable growth in the region. The structure of the indices is sufficiently clear and is based on global practices of forming indices of competitiveness and innovation (e.g., see [12, 13]). More details on the structure of these indices are provided in the paper [14]. The enabling environment index for the use of innovation as a factor of sustainable growth in the region is generated on the basis of data on the level of development of the manufacturing sector of the economy, the state of the system of higher education, and other. The resulting index is calculated as a weighted average. The weighted coefficients of all sub-indices are equaled to one, except the innovation infrastructure sub-index, which coefficient is equaled to 0.1. This is caused by insufficient reliability and the scarcity of information on the state of innovation infrastructure in the Russian Federation and its poor effectiveness [15].

The proposed system of indices allows to generate a fairly informative base for adopting informed decisions on selecting the regional innovation priorities and, to a large extent, formalize this process.

Proposals for Establishing the Centres of Innovative Activity in the Regions of Ural Federal District

Table 3 shows the results of calculations on priorities of establishing the centers of innovative activity focused on supporting the development of industries with varying level of technology intensity by providing the example of the regions of UFD, which is one of the leading federal districts in terms of the development of high-tech, medium-tech, and low-tech industries.

Table 3

The rank of UFD regions in terms of priorities of establishing the centers of innovative activity focused on supporting the development of industries with varying level of technology intensity

Subject of the Russian Federation	Rank in the index of innovative activity	Rank in terms of priorities of establishing the centers of innovative activity focused on supporting the development:		
		Development index of high-tech and medium-tech industries of high level	Metallurgy (medium-tech group)	Extractive industries (low-tech group)
Kurgan Region	59	56	55	67
Sverdlovsk Region	10	7	1	11
Chelyabinsk Region	12	10	13	8
Tyumen Region	37	41	37	1
including Khanty-Mansi Autonomous District	50	58	63	2
Yamalo-Nenets Autonomous District	73	74	73	22

Among the subjects of the Russian Federation included in UFD, old industrial regions, first of all, Sverdlovsk Region and Chelyabinsk Region are of greatest interest for establishing the innovation centers focused on supporting the development of high-tech activities. A significant place in the industrial structure of these regions is held by the enterprises of machine engineering and defense sectors. In terms of the development of high-tech and medium-tech industries of high level, Sverdlovsk Region is ranked today the 8th and Chelyabinsk Region is ranked the 11th among the subjects of the Russian Federation. Both regions are promising consumers of import substitution products. Some population centers of Kurgan Region also have a certain capacity for developing the innovative industries. Another characteristic of old industrial regions in the Urals is their fairly well-developed science, technology and innovative capacity. More than 2/3 of all UFD organizations engaged in R&D are concentrated in Sverdlovsk Region and Chelyabinsk Region.

As shown by the calculations (Table 3), Sverdlovsk Region and Chelyabinsk Region are very promising platforms for the development of innovative activity focused on creating a high level of innovation (7th and 10th rank among the subjects of the Russian Federation, respectively). The scientific potential of the regions allows to address the problems of import substitution in a variety of

industries, including information technology, medicines, machine engineering, and others. There are also very good prerequisites, both on the part of science and the industrial structure, for creating the innovations oriented at import substitution in metallurgy, a strategically important industry for the Ural region.

Given the insufficient provision of the northern oil and gas producing territories of UFD with local scientific human resources and developed ties with the neighboring regions of the district, one of the strategic areas in re-industrialization of old industrial areas in the Urals could be the establishment of innovation centers specializing in addressing the problems of mining companies in Tyumen Region, Khanty-Mansi Autonomous District, and Yamalo-Nenets Autonomous District).

The implementation of described methodological provisions allows to increase the soundness of decisions adopted in order to ensure the innovative sustainability of socio-economic development of Russian regions by taking into account the specific aspects of their research and innovation capacity, as well as the specifics of their industrial system. The results of calculations can provide a reference point for substantiating the most promising areas of innovation support to re-industrialization processes.

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