DYNAMICS OF INNOVATION ACTIVITY IN THE FEDERAL DISTRICTS OF RUSSIA

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ABSTRACT

In the context of modern geopolitical challenges and the need to achieve technological sovereignty, the issue of regional inequality of innovative development is becoming particularly acute ***(Semenova, Churrana, 2025; Ignatyeva, Yurak, Dushin, 2023; Korableva, Nikiforova, Nikiforov, 2024; Yurak, Ignat'eva, Komarova, 2025)****. The article presents the results of an analysis of the dynamics and structural features of innovation activity in the federal districts of Russia for the period 2010–2023. The empirical base consists of the official statistical data of Rosstat (Federal State Statistics Service), characterizing the human capital and financial potential of science, innovation expenditures, as well as their output in terms of the volume of innovative goods, works and services. The study employs time series analysis, comparative analysis, and structural analysis methods to identify long-term trends and assess the degree of interregional differentiation* ***(Kerosinskiy, 2025).*** *Particular attention is devoted to the correlation between innovation activity indicators and the level of regional socio-economic development, specifically gross regional product (GRP) per capita and average per capita monetary income. The study confirms a persistent trend toward the concentration of scientific and technical potential in a limited number of districts, primarily the Central and North-Western federal districts. Based on a comprehensive assessment of indicator dynamics, the authors propose a classification of federal districts, distinguishing regions with accelerated innovation activity growth, relative stability, and intensifying decline. The revealed patterns underscore the need for a transition to a differentiated state policy that account for the specific characteristics and actual potential of various regional types to ensure the effective development of their innovation systems.*

Keywords: *Innovation Activity; Regional Differentiation; Federal Districts; Dynamics of Indicators; Technological Sovereignty; Socio-Economic Development.*

➢ INTRODUCTION

In the contemporary economy, the capacity of economic entities to generate, implement, and effectively utilize innovations is regarded not only as a factor of competitiveness, but also as a fundamental prerequisite for sustainable development and national security **(Lyubek, Y. V., Marinina, O. A., &**

Tesovskaya, 2026; Kachelin, 2023; Zavarukhin, Solomentseva, Solopova, 2024; Shatalova, 2025). For Russia, confronting recent unprecedented external constraints and the imperative of rapid technological sovereignty, this issue has become particularly acute and practically significant **(Nikitin, Tronina, Tatenko, Grekova, 2021; Chechurina, Shchebarova, Spitsyn, 2024)**. Innovation activity becomes a critical resource capable of ensuring the structural transformation of the economy **(Semenova, Churrana, 2025)**, the substitution of imported technologies and the consolidation of domestic producers in new markets **(Vereschagin, Gloukhov, Kozlova, 2025)**.

However, the transition to an innovation-driven development model is unattainable without accounting for the specificities of the Russian economic space, characterized primarily by profound interregional differentiation **(Kerosinskiy, 2025)**. The federal districts and their constituent entities within the Russian Federation initially possess varying levels of scientific, technical, industrial and human resources, which underlies the unevenness of their innovative development **(Garmashova, Drebot, 2020; Kulagina, Bobin, Efimova, Yusupov, 2024)**.

The objective of this study is to identify and analyze the primary trends and patterns in the dynamics of innovation activity across the federal districts of Russia over the period 2010–2023, as well as to assess their differentiation in relation to the level of socio-economic development.

➢ MATERIALS AND METHODS

The empirical base of this study comprises official statistical data from the Federal State Statistics Service of the Russian Federation (Rosstat) [13, 14]. To ensure data comparability, the analysis covers the period from 2010 to 2023. The methodological framework employs an integrated approach incorporating time series analysis, comparative analysis and structural analysis. To validate the findings and identify associations between innovation development and the socio-economic conditions of regions, a comparative analysis of data series was applied (20). Federal districts were classified based on their innovation dynamics by comparing their average indicator growth rates over the study period against the national average for the Russian Federation.

➢ THEORETICAL AND PRACTICAL APPROACHES TO REGIONAL INNOVATION DEVELOPMENT IN SCIENTIFIC LITERATURE

The works of French economist François Perroux, who developed the theory of growth poles as generators of technological change **(2007)**, and Gunnar Myrdal, who proposed the concept of cumulative causation **(1972)**, are fundamental to understanding the spatial unevenness of innovation activity. In the context of innovation, this manifests in regions with high scientific and educational potential attracting the most qualified human capital **(Sazonov, Fedotova, Polyanskaya, Solodova, 2017)** and investment in high-tech projects, whereas peripheral territories lose their already limited resources **(Lyubek, Y. V., Marinina, O. A., & Tesovskaya, 2026)**. The concept of national and regional innovation systems plays a particular role in understanding contemporary processes. These systems comprise interconnected macro-blocks: the entrepreneurial environment and market; the knowledge production environment; and mechanisms for knowledge transfer and diffusion. At the regional level, analyzing the efficiency of these systems makes it possible to identify factors that facilitate or hinder the innovative development of specific territories **(Barkhatov, 2022; Golichenko, 2017; Shcherbakov, Mishin, Raiko, Khazbulatov, T.-A. M., Selivankin, 2025)**.

Significant contributions to understanding the regional specifics of innovation processes have been made by studies focused on assessing regional innovation potential **(Solodova, S. V., Sigidov, Y. I., & Ilyasov, 2021)** and the nature of innovation behavior **(Kulibanova, Pak, Batsunov, 2023; Terskaya, 2022; Shcherbakov, Lipatova, Baksheev, 2025)**. The results indicate that economically weaker regions strive to create radical innovations by establishing links with the scientific and educational sector, whereas regions with strong economic potential are primarily oriented toward developing relationships with market entities. This indicates fundamentally different models of innovation behavior characteristic of regions at different development levels.

In contemporary Russian scholarship the issue of regional innovation differentiation is also explored in the works of V.L. Makarov **(2014)**, M.A. Barinov **(2025)**, Y.I. Valovaya **(2025)** and other researchers. Works by the Institute for Statistical Studies and Economics of Knowledge (ISSEK) at HSE University systematically analyze statistical indicators of innovation activity across regions, creating an

empirical base for identifying sustainable trends and patterns **(Vlasova, Gokhberg, Gracheva, 2024)**.

➢ RESULTS AND DISCUSSION

Analysis of the resource base for innovation activity.

The analysis of the resource base for innovative development should be started with an examination of its most critical component: the human capital potential of science.

The number of personnel engaged in research and development (R&D) serves as a fundamental indicator reflecting a region's capacity to generate new knowledge and technologies. Over the study period (2010–2023), the Russian Federation as a whole exhibited a persistent decline in this metric from 736.5 thousand to 670.6 thousand persons, representing a decrease of 8.9%.

However, these averaged national figures mask profound interregional disparities, the nature and direction of which are presented in Table 1.

Table 1. Dynamics of R&D Personnel by federal districts of the Russian Federation (thousand persons)

Federal district	2010	2015	2020	2023	2023 to 2010, %	Share in the Russian Federation, 2023, %
Russian Federation	736,5	738,9	679,3	736,5	91,0	100
Central FD	381,8	380,1	345,8	381,8	88,5	50,4
North-Western FD	95,8	98,1	87,4	95,8	90,3	12,9
Southern FD	28,1	30,1	26,7	28,1	94,1	3,9
North Caucasian FD	6,1	7,5	6,8	6,1	111,1	1,0
Volga FD	116,3	107,7	101,9	116,3	88,6	15,4
Ural FD	42,7	46,5	44,5	42,7	104,0	6,6
Siberian FD	51,8	53,4	52,3	51,8	101,3	7,8
Far Eastern FD	14,1	15,4	13,9	14,1	93,8	2,0

Note: Calculated from Rosstat (Federal State Statistics Service [Rosstat], 2023, 2024).

The presented data reveal an unprecedented concentration of scientific personnel in the Central federal district, which accounted for more than half of the country's total research staff in 2023 — 50.4%. Notably, the majority of researchers are concentrated in Moscow and Moscow oblast, making this macro-region the undisputed hub of scientific potential. The Volga federal district ranks second with a share of 15.4%, where Nizhny Novgorod oblast, the Republic of Tatarstan, Samara oblast and Perm krai — regions traditionally possessing developed industrial and scientific bases — play a leading role. The North-Western federal district completes the top three with a share of 12.9%, with the overwhelming majority of researchers concentrated in Saint Petersburg.

A notable feature of the dynamics is the growth in R&D personnel in the North Caucasian, Ural and Siberian federal districts, where 2023 figures exceeded 2010 levels by 11.1%, 4.0% and 1.3% respectively. However, in absolute terms, the increase in the North Caucasian district amounted to only 671 persons, which is insufficient to offset the nationwide decline trend. The most intensive reduction in human capital potential occurred in the Volga and Central federal districts — by 11.4% and 11.5% respectively — which corresponds to a loss of 13.2 thousand and 43.9 thousand researchers in absolute terms. This represents a concerning signal of systemic challenges in the reproduction of scientific personnel even in leading regions.

Analysis of the financial component of the resource base — domestic expenditures on scientific research and development — complements the picture emerging from the human capital assessment. In contrast to personnel numbers, science expenditures demonstrate sustained positive dynamics both nationally and across all federal districts. The national volume of expenditures increased from 523.4 billion rubles in 2010 to 1.65 trillion rubles in 2023, representing a 3.15-fold increase in nominal terms. However, this growth masks an even greater concentration of financial resources than observed for personnel. In 2023, the Central federal district accounted for 52.5% of all domestic science expenditures in the country — a share that even exceeds its proportion of research staff. This indirectly suggests higher levels of equipment and funding per researcher in this macro-region.

The Volga federal district ranks second in expenditure volume with a share of 16.9%, followed by the North-Western Federal District at 13.0%. The combined share of the remaining five federal districts does not reach 18% of the national total, with the North

Caucasian and Far Eastern federal districts demonstrating the lowest shares — 0.5% and 1.5% respectively. Thus, analysis of the resource base supports a preliminary conclusion regarding the formation of three leading scientific and innovation macro-regions in Russia — the Central, Volga, and North-Western federal districts — which accumulate the overwhelming majority of the country's human capital and financial potential for science and innovation.

Investment activity and expenditures on innovation. Transitioning from fundamental science to innovation activity at the organizational level, it is essential to analyze the dynamics of innovation expenditures. This indicator reflects the readiness of businesses to invest in technological modernization and the adoption of new products and processes. Table 2 presents the dynamics of organizational innovation expenditures by federal district over the period 2020–2023, for which comparable data are available.

Table 2. Dynamics of organizational innovation expenditures by federal district of the Russian Federation (billion rubles)

Federal district	2020	2021	2022	2023	2023 to 2020, %	Share in the Russian Federation, 2023, %
Russian Federation	2134,0	2379,7	2662,6	3519,5	164,9	100
Central FD	890,7	1038,7	1115,1	1729,5	194,2	49,1
North-Western FD	178,4	209,7	211,0	264,9	148,4	7,5
Southern FD	124,0	75,0	99,3	117,0	94,4	3,3
North Caucasian FD	5,2	7,5	8,3	12,7	243,4	0,4
Volga FD	516,4	589,8	630,3	754,6	146,1	21,4
Ural FD	120,0	158,1	190,3	262,1	218,5	7,4
Siberian FD	180,7	167,9	263,5	263,1	145,6	7,5
Far Eastern FD	118,6	133,1	144,8	115,6	97,5	3,3

Note: Calculated from Rosstat (Federal State Statistics Service [Rosstat], 2023, 2024).

The presented data reveal an even higher concentration of innovation activity compared to fundamental science. In 2023 the Central federal district accounted for 49.1% of all national innovation expenditures — nearly half of the country's total. The Volga federal district ranks second with a share of 21.4%; together, these two districts represent over 70% of nationwide innovation spending. Third place is shared by three Federal Districts — North-Western, Siberian, and Ural — with shares ranging from 7.4% to 7.5%, indicating their comparable contributions to the country's innovation activity. The growth in innovation activity in the Ural Federal District is largely attributable to research and development efforts in Russia's coal industry **(Materova, Aksenova, Stolbovskaya, Galimova, Sharafullina, Zhironkin, 2025)**.

Expenditure dynamics warrant particular attention. Against a national growth factor of 1.65 over the four-year period, the most impressive rates were observed in the North Caucasian, Ural and Central federal districts — increasing by factors of 2.43, 2.18, and 1.94 respectively. However, in the case of the North Caucasian District this high growth rate is attributable to an extremely low baseline in 2020; in absolute terms, the increase amounted to only approximately 7.5 billion rubles, which is incomparable to the growth in the Central federal district, exceeding 838 billion rubles. A declining trend is evident in the Southern and Far Eastern federal districts, where 2023 expenditures fell to 94.4% and 97.5% of 2020 levels respectively. This indicates a contraction of innovation activity in these macro-regions against the backdrop of national growth.

It is important to note that the share of innovation expenditures in the total volume of shipped goods, works, and services — an indicator characterizing the intensity of innovation activity — amounted to 2.5% for the Russian Federation as a whole in 2023. The highest values of this indicator were observed in the Central and Volga federal districts: 3.6% and 3.3% respectively. In all other districts the indicator fell below the national average, with the lowest values recorded in the North Caucasian federal district at only 0.9%, followed by the Southern and Far Eastern federal districts at 1.6% each. This confirms the conclusion that not only absolute scales but also the relative intensity of innovation activity vary substantially across macro-regions.

Innovation performance outcomes. The most critical indicator reflecting the final outcome of innovation activity is the volume of innovative goods, works and

services. This metric captures the capacity of regional economies not merely to allocate resources to innovation, but to generate tangible returns in the form of new competitive output. The dynamics of this indicator are presented in Table 3.

Table 3. Dynamics of the volume of innovative goods, works and services by federal district of the Russian Federation (trillion rubles)

Federal district	2020	2021	2022	2023	2023 to 2020, %	Share in the Russian Federation, 2023, %
Russian Federation	5,2	6,0	6,4	8,3	160,4	100
Central FD	1,7	2,0	2,1	2,9	174,3	34,6
North-Western FD	0,7	0,9	0,9	0,9	135,0	11,0
Southern FD	0,2	0,2	0,3	0,3	162,8	3,4
North Caucasian FD	0,0	0,1	0,1	0,1	142,4	0,8
Volga FD	1,6	1,9	2,0	2,8	176,8	34,1
Ural FD	0,5	0,5	0,7	0,9	174,5	10,5
Siberian FD	0,4	0,3	0,3	0,3	84,3	3,9
Far Eastern FD	0,2	0,1	0,1	0,1	97,2	1,8

Note: Calculated from Rosstat (Federal State Statistics Service [Rosstat], 2023, 2024).

Analysis of innovation performance yields findings that may appear counterintuitive at first glance. Despite a 1.6-fold increase in the volume of innovative output nationwide over the four-year period, the distribution of shares across federal districts differs substantially from the distribution of expenditures. The Volga federal district emerges as the clear leader in innovative output volume, accounting for 34.1% of the national total — nearly matching the Central federal district's share of 34.6%. This implies that the Volga district, despite considerably lower absolute innovation expenditures (21.4% versus 49.1% for the Central district), achieves comparable output results. This finding suggests higher efficiency of innovation activity in the Volga region, where historically established industrial complexes are capable of rapidly implementing developments and bringing new products to market.

The North-Western federal district ranks third in innovative output volume with a share of 11.0%, followed by the Ural federal district at 10.5%. The contributions of the remaining districts are markedly more modest: the Siberian federal district, which ranks fourth in innovation expenditures, falls to sixth place in performance with a share of only 3.9%, trailing the Southern federal district (3.4%). This may indicate structural challenges within the Siberian economy, where a significant portion of innovation spending does not translate into marketable output.

The dynamics of innovative output volume warrant particular attention. The Siberian federal district recorded a substantial decline in this indicator — to 84.3% of its 2020 level — even though innovation expenditures there increased by a factor of 1.46. This points to a sharp decrease in the efficiency of innovation activity within this macro-region. A negative trend was also observed in the Far Eastern federal district (97.2% of the 2020 level), which correlates with reduced expenditures. The most pronounced growth in innovative output was demonstrated by the Volga, Ural and Central federal districts, with increases ranging from 1.75- to 1.77-fold, exceeding the national average.

The share of innovative products in the total volume of shipped goods, works, and services amounted to 6.0% for the Russian Federation as a whole in 2023. The highest value of this indicator was recorded in the Volga federal district at 12.5% — more than double the national average. In the Central federal district the indicator stood at 6.1%; in the Ural federal district at 3.8%; and in the remaining districts it ranged from 1.9% to 5.6%. The lowest values were observed in the Far Eastern and North Caucasian federal districts, at 1.9% and 4.6% respectively. Thus, the Volga federal district emerges as the undisputed leader in the intensity of innovative production.

Differentiation and socio-economic context. The identified patterns of innovative development take on particular significance when compared with indicators of population living standards and regional economic development. To analyze this relationship, it is appropriate to examine two fundamental indicators — gross regional product (GRP) per capita and average per capita monetary income — in relation to innovation activity metrics.

The leaders in innovation development — the Central, Volga, and North-Western federal districts — also demonstrate the highest GRP per capita figures. In 2022, this indicator amounted to 1.18 million rubles in the Central federal district, 1.36 million rubles in the

North-Western federal district, 1.64 million rubles in the Ural federal District (driven by a substantial oil and gas component) and 683.4 thousand rubles in the Volga federal district. However, structural specifics must be considered: the elevated figures for the Ural district are primarily attributable to the extractive sector rather than manufacturing or innovation-intensive industries.

Comparison with household income levels provides a more illustrative picture. In 2023, average monthly per capita monetary income stood at 71.9 thousand rubles in the Central federal district, 58.7 thousand rubles in the North-Western federal district, 53.5 thousand rubles in the Ural federal district and 41.8 thousand rubles in the Volga federal district. By contrast, in the North Caucasian federal district — which lags in innovation metrics — income amounted to only 35.4 thousand rubles, while in the Siberian federal district it reached 43.0 thousand rubles and in the Far Eastern federal district 57.9 thousand rubles. The Far Eastern district represents an exception: its relatively high income levels (third nationally) are sustained by northern wage supplements and extractive industries rather than by innovation activity.

The situation in the Siberian federal district warrants particular attention. Despite income levels close to the national average (43.0 thousand rubles) and significant scientific and technical potential (third in R&D personnel and fourth in science expenditures), the region has experienced a sharp decline in innovation performance. This suggests systemic challenges related to the gap between scientific developments and their commercialization, as well as potential outflow of the most successful innovation projects to other regions.

Thus, the analysis confirms a persistent correlation between innovation activity and the level of socio-economic development, although this relationship is neither linear nor rigidly deterministic. Regions that have succeeded in establishing effective regional innovation systems — such as the Republic of Tatarstan and Nizhny Novgorod oblast within the Volga federal district — demonstrate leading performance both in innovation outcomes and in population living standards.

Classification of federal districts by innovation development rates. Based on the analysis of innovation activity indicator dynamics over the period 2010–2023 (for resource indicators) and 2020–2023 (for expenditures and performance outcomes), it is feasible to classify the federal districts according to the nature of their innovation development. The criteria for distinguishing groups include the growth rates of indicators relative to the national average, as well as the stability of positive dynamics.

The first group, characterized by accelerated growth of innovation activity indicators above the national average, comprises the Central and Volga federal districts. These macro-regions demonstrate not only high absolute values for nearly all analyzed indicators but also leading dynamics in innovation expenditures and the volume of innovative output. The Volga federal district deserves special mention: achieving results comparable to the Central district while possessing a significantly lower resource potential, it demonstrates high efficiency of its innovation system. The Ural federal district can be included in this group with certain caveats; it shows high growth rates in expenditures and performance but possesses structural features related to the dominance of the extractive sector.

The second group, distinguished by relative stability of indicator dynamics at a level close to the national average, comprises the North-Western and Southern federal districts. The North-Western federal district, possessing significant scientific potential concentrated in Saint Petersburg, demonstrates stable but not outstanding innovation performance indicators, while its share of national expenditures and innovative output volume remains stable. The Southern federal district recorded growth in innovative output despite a modest decline in innovation expenditures during 2021–2023. This divergence points to the emergence of a distinct innovation development model, potentially driven by the agro-industrial complex and tourism sectors.

The third group, characterized by intensifying decline or stagnation of innovation activity indicators, comprises the North Caucasian, Siberian and Far Eastern federal districts. In the North Caucasian federal district, despite high nominal growth rates of expenditures, absolute values remain extremely low and the volume of innovative output decreased in 2023 compared to 2022. The Siberian federal district demonstrates the most alarming dynamics: despite significant scientific potential and growth in innovation expenditures, there is a sharp decline in the volume of innovative output, indicating a deep crisis of the regional innovation system. The Far Eastern federal district shows a decline in both innovation

expenditures and innovative output volume, despite the implementation of large-scale state programs for the macro-region's development.

The proposed classification is not rigid and allows for the presence of individual exception regions within each group demonstrating different dynamics. However, at the macro level, it enables the identification of stable trends and patterns that should be taken into account when forming state regional policy in the sphere of science and innovation.

➢ POLICY RECOMMENDATIONS

Given the identified profound differentiation of regions by the nature and pace of innovation activity, the proposed measures must be differentiated, taking into account the specifics of each identified group.

For the federal districts of the first group, demonstrating accelerated growth of innovation indicators — the Central, Volga and Ural federal districts — the priority option is to support fundamental research and stimulate breakthrough studies capable of ensuring the country's technological leadership at the global level. In these regions, it is advisable to create conditions for the formation of large research consortia uniting leading universities, academic institutes and high-tech companies focused on producing high value-added products. Special attention should be paid to developing public-private partnership mechanisms in the sphere of innovation, as well as supporting the export of innovative products, including through the instruments of trade representations and financing for foreign buyers. For the Volga federal district, which demonstrates high efficiency of innovation activity, it is important to disseminate the best practices of leading regions — the Republic of Tatarstan, Nizhny Novgorod oblast and Samara oblast — to other constituent entities of the district through mechanisms of interregional cooperation and experience exchange.

The federal districts of the second group — the North-Western and Southern federal districts — require policies aimed at identifying and developing their own innovation niches corresponding to their economic specialization. Given its concentrated scientific potential in Saint Petersburg, the North-Western federal district should prioritize transferring technology from academia to industry. Key measures include fostering small innovative enterprises and establishing technology intermediaries. For the Southern federal district a promising direction may be supporting innovations in the agro-industrial complex, food and processing industries, and the recreation sector, as well as developing biotechnology. An important tool could be the formation of sector-specific innovation clusters uniting scientific organizations, specialized universities, and real-sector enterprises on the principles of cooperation and specialization.

The situation in the federal districts of the third group — the North Caucasian, Siberian and Far Eastern federal districts — appears to be the most complex and requires urgent intervention. Here, it is necessary to implement a set of measures aimed at overcoming negative trends and creating basic conditions for innovation development. Primarily, targeted support is required for existing «growth centers» — university centers, scientific organizations and individual high-tech enterprises capable of acting as cores for emerging innovation clusters. Given the decline in innovation performance despite strong scientific potential, the Siberian federal district requires an efficiency audit of science funding and a restructuring of research organizations to focus on regional socio-economic goals. Conversely, the Far Eastern and North Caucasian districts need special conditions to attract high-tech investment, such as tax incentives and streamlined regulations. Retaining skilled personnel and preventing brain drain to central regions are also top priorities.

At the federal level, authorities should shift from uniform support measures to differentiated policies that reflect the unique potential of each region. An important tool could be the conclusion of «innovation contracts» with regions, which would fix mutual commitments of the federal center and regional authorities to achieve specific target indicators with a guaranteed volume of resource support. Furthermore, it is necessary to develop and implement a monitoring system for the efficiency of regional innovation systems, allowing for the operational identification of emerging imbalances and timely adjustment of policy measures. Implementation of the proposed recommendations, based on accounting for the identified features and patterns, will contribute to more balanced and sustainable development of the innovation space of the Russian Federation.

➢ CONCLUSION

The statistical analysis confirmed the initial hypothesis regarding the persistence and deepening of interregional differentiation in science and innovation, consistent with theoretical concepts of the cumulative

nature of regional development and polarization effects.

The findings underscore the necessity of shifting from a uniform model of state innovation support to a differentiated regional policy that accounts for the specific characteristics, potential and actual challenges of each type of territory.

Only this approach can ensure a more balanced development of the country's innovation space and create conditions for the effective utilization of the scientific and technical potential of all Federal Districts to achieve national technological sovereignty.

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