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Methodology for comprehensive assessment of regional innovative development

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ABSTRACT
Innovative development of territories is strategically important for the prosperity of any country. This article aims at describing original methodology for comprehensive assessment of innovative development of Russian regions. The proposed model takes into account specific features of innovative activity of regions and identifies growth potential and resources of territories, taking into account not only the innovation environment, but also areas of innovative activity. The study relies on the statistical data provided by the Central Statistical Database and the Unified Interdepartmental Information and Statistical System. In the course of processing and analyzing data, the index method, the multidimensional average method, factor-index analysis and other statistical data processing methods are used. The research involves ranking Russian regions according to their levels of innovative development and further dividing them into groups of powerful, strong, medium and weak innovators. We also analyzed the dynamics of innovation in the regions by looking at the changes in their ranking positions. The research findings brought to light the uneven development of Russian regions. The proposed assessment toolkit can be further used for drawing individual profiles for regions and formulating recommendations and guidelines for these regions' development by taking into consideration their strengths and weaknesses. The results of this study have theoretical and practical significance and can be used as a tool for management of innovative activities both at the level of individual territories and at the national level.

KEYWORDS
innovative climate, innovative potential, innovation, regional development, Russian regions

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Практические аспекты оценки и анализа инновационного развития регионов

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АННОТАЦИЯ
Инновационное развитие территорий является стратегически важным для процветания любой страны. Целью данной статьи является описание оригинальной методики комплексной оценки инновационного развития российских регионов. Предложенная модель учитывает особенности инновационной активности регионов и определяет потенциал роста и ресурсы территорий с учетом не только инновационной среды, но и направлений инновационной деятельности. Исследование опирается на статистические данные, предоставленные Центральной статистической базой данных и Единой межведомственной информационно-статистической системой. В процессе обработки и анализа данных используются индексный метод, метод многомерного среднего, факторный индексный анализ и другие статистические методы обработки данных. Исследование включает в себя ранжирование российских регионов по уровням инновационного развития и дальнейшее разделение их на группы наиболее сильных, сильных, средних и слабых новаторов. Мы также проанализировали динамику инноваций в регионах, посмотрев на изменения их рейтинговых позиций. Результаты исследования выявили неравномерность развития российских регионов. Предлагаемый инструментарий оценки может быть далее использован для составления отдельных профилей для регионов и разработки рекомендаций и руководящих принципов для развития этих регионов с учетом их сильных и слабых сторон. Результаты данного исследования имеют теоретическое и практическое значение и могут быть использованы в качестве инструмента управления инновационной деятельностью как на уровне отдельных территорий, так и на национальном уровне.

КЛЮЧЕВЫЕ СЛОВА
инновационный климат, инновационный потенциал, инновации, региональное развитие, российские регионы

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Introduction

Innovation is an important indicator of regional development and development of the country as a whole. Modernization has a significant impact on the country's economic stability and competitiveness on the international arena.

In our study, innovative development is understood as the process of continuous development of science, technology, methods of production, technological processes as well as the creation of conditions to stimulate innovation[1]. Innovative development is a complex process which has two main objectives: to realize innovative projects (sustainable innovative activity) and to develop innovative potential. Innovative activity comprises a complex system of interconnected elements and there is a perceived lack of comprehensive methodologies for assessing innovative activity since the vast majority of the existing tools focus only on individual aspects. Therefore, our research is aimed at designing a tool for integrated assessment and analysis of innovative development in Russian regions by taking into account the shortcomings of the existing assessment methods.

Review of theoretical and methodological approaches to assessment of innovative development

In Russia, methods for assessing innovative potential, innovative activity and the state of innovative environment are developed by such researchers as L. V. Shabaltina [1], S. A. Novikov [2], S. E. Tikhonova [3], T. N. Kosheleva [4], I. V. Shlyakht [5], Yu. P. Anisimov [6], E. A. Lapteva [7], and by various associations and research teams such as the Russian Research Institute of Economics, Politics and Law in the scientific and technical sphere[2]; Higher School of Economics and Management[3]; Center for Research and Statistics of the Russian Federation; Association of Innovative Regions of Russia and the Ministry of Economic Development[4]; National Association of Innovation and Information Technology[5]; and the Institute of Innovative Economics of the Financial University under the Government of the Russian Federation[6].

In our previous studies, we systematized and classified the approaches to assessment of innovative development proposed by Russian researchers [8]. We found that there is currently no agreement among Russian researchers as to how define different categories of innovative development and assess them. The main drawback of these assessment methodologies is that they use a large number of qualitative indicators and, therefore, expert and score assessments (for a more detailed analysis of these approaches see [9]).

International studies are aimed at assessing innovative development of countries (world economies) and individual territories (states or regions). To assess innovation, these studies use specialized competitiveness indices developed by the World Economic Forum (see Table 1).

The above-described indices are used by rankings of world economies and innovation territories. Our analysis has shown, however, that foreign indices are either not applicable for Russia (complex and specialized indices) or require substantial adaptation (specialized indices of innovative development). Thus, while the methodological toolkit proposed by Russian researchers is based on the conceptual apparatus and the interrelationship between the main innovative development categories, in international methodologies, assessment of innovative development of territories is mainly based on the results of innovation implementation and the effects of their use in related areas and industries.

Our research is aimed at developing a methodology for integrated assessment of regional innovative development, which will allow us to take into account the interrelation between the main categories of the innovation environment [8] and the internal and external conditions for innovation [11; 12]. Moreover, such methodology should enable us to assess the impact of

[1] *Russian Federation Government Decree of 08.12.2011 N 2227-r "On approval of the Strategy of Innovative Development of the Russian Federation for the period till 2020"* (2017). Retrieved from: http://innovation.gov.ru/ru/node/5320 (Accessed 10 August 2018)

[2] *Website of the Russian Research Institute of Economics, Politics and Law in the Scientific and Technical Sphere*. Retrieved from: http://riep.ru/activity/publications/drugie-izdaniya/ (Accessed 27 January 2019)

[3] *Website of the Higher School of Economics. Innovative development rating of the Russian Federation regions*. Retrieved from: http://www.hse.ru/primarydata/rir (Accessed 27 January 2019)

[4] *Website of the Association of Innovative Regions of Russia*. Retrieved from: http://www.i-regions.org/materials/regional-research/2304 (Accessed 27 January 2019)

[5] Website of the National Association of Innovation and Information Technology Development. Retrieved from: http://www.nair-it.ru/news (Accessed 27 January 2019)

[6] *Website of the Financial University under the Russian Federation Government. Index of innovative development of Russia*. Retrieved from: http://www.fa.ru/institutes/efo/science/Pages/index.aspx (Accessed 27 January 2019)

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regional innovation on the country's overall economic development. This tool can be also used for designing strategies of regional innovative development.

Methodology for assessing regional innovative development

The point of departure for our study is the assumption that innovative development is a complex and continuous process of improving the conditions of innovative environment [13–15]. Therefore, we need to design an assessment model that will allow us to take into account a complex system of factors. Our methodology is based on a qualitatively new approach, involving the assessment of the innovation component in certain categories (innovative climate, innovative potential, innovative activity) in the context of the main areas of innovation activity.

We identified the following areas of innovation:

– socio-economic (social and economic indicators of the region's development);

– production and technology;

– investment (innovation financing, funding of reconstruction and modernization);

– R&D (development of science and strategies for innovative development in Russian regions);

– human resources for R&D;

– R&D funding.

Table 1

International studies of innovative development

1. Complex competitiveness indices			
Growth Competitiveness Index, GCI (Macroeconomic Competitiveness Index)	Business Competitiveness Index, BCI (Microeconomic Competitiveness Index)	Technology Achievement Index, TAI	Networked Readiness Index, NRI
The aggregated competitiveness index consists of 113 variables combined into 12 blocks, determining the national competitiveness of the countries that are at different levels of economic development. 2/3 of the variables are the result of the global survey of business leaders, 1/3 variables are taken from publicly available sources (statistics and research results of international organizations)[1]		To calculate the integral index, indicators divided into indices that have the same weight are used: the technology creation index, the distribution index of modern innovations, the distribution index of old innovations, the human ability index. There is no specific set of indicators, because it is impossible to cover the whole range of technologies	The index characterizes the close correlation between economic well-being and the development of innovation. It is calculated by using 53 parameters divided into 3 main groups: the presence of conditions, readiness for use and the level of use of ICT. The basis of calculation is the statistical data of the United Nations, the International Telecommunication Union, the World Bank and surveys of top executives[2]
2. Specialized competitiveness indices			
Innovation Capacity Index			
It characterizes the innovation infrastructure (ability of the national economy to develop and commercialize the flow of new technologies). To calculate this index, it is necessary to select indicators, determine the scores and calculate the integral indicator [10]			
3. Specialized competitiveness indices (regional level)			
Regional Innovation Scoreboard, RIS (European Union)[3]		Portfolio Innovation Index, PII (USA)[5]	
Index evaluates innovative activity by 11 indicators divided into 3 blocks: factors of innovative development, data on performance of companies, effectiveness of innovative activities of companies[4]		The composite index of innovation development includes 20–30 indicators divided into 4 blocks with different weight factors: human capital (30%), economic dynamics (30%), productivity and employment (30%), and well-being (10%)[6]	
Indices combine resources and results of innovative activity			

Source:

[1] *Analytical portal by the main directions and humanitarian technologies markets. The Global Competitiveness Index*. Retrieved from: https://gtmarket.ru/ratings/global-competitiveness-index/info (Accessed 27 January 2019)

[2] *Analytical portal by the main directions and humanitarian technologies markets. Networked Readiness Index*. Retrieved from: https://gtmarket.ru/ratings/networked-readiness-index/networked-readiness-index-info (Accessed 27 January 2019)

[3] The Regional Innovation Scoreboard. (2018). Retrieved from: https://ec.europa.eu/growth/industry/innovation/facts-figures/regional_en (Accessed 27 January 2019)

[4] *European Innovation Scoreboard*. (2018). European Commission. Retrieved from: http://ec.europa.eu/growth/industry/ innovation/facts-figures/scoreboa rds_en (Accessed 27 January 2019)

[5] *Portfolio innovation index*. (2018). Source or supplier information. Retrieved from: http://www.statsamerica.org/innovation/reports.html (Accessed 27 January 2019)

[6] *Innovation Index in American regions*. (2018). U. S. Economic Development Administration. Retrieved from: http://www.statsamerica.org/innovation/innovation_index/methodology.html (Accessed 27 January 2019)

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Our model for the assessment of regional innovative development is shown in Figure 1 and reflects the matrix structure of the main innovation categories used for assessment [9]:

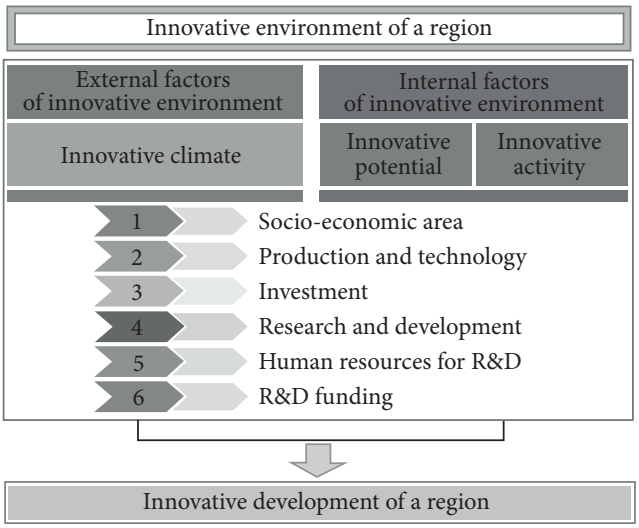

Figure 1. *Matrix structure of the innovative development assessment model [9]*

Assessment results are represented in the form of a ranking. For our model, we combined two methodologies: the methodology proposed by the Higher School of Economics and Management, which evaluates indicators according to areas of innovation implementation, and the methodology of the Association of Innovative Regions of Russia and the Ministry of Economic Development, which evaluates indicators according to innovation categories. The algorithm for calculating the integral index of innovative development is a complex multi-step process.

The stages of assessment reflect the analysis procedure which involves selected indicators and calculation of the integral index used to rank regions according to their level of innovative development.

These steps are as follows:

1. Data normalization

We have managed to achieve homogeneity and comparability of indicators with the help of transition from absolute to weighted values. We propose to normalize the indicators for a mini-max formula (1). This method of rationing the source data is optimal, since it allows to fill a range of values tihtly and evenly. The range of values is, determined by the empirical magnitude of the data from 0 to 1.

$$\tilde{X}_{ij} = \frac{x_{ij} - x_{\min i}}{x_{\max i} - x_{\min i}}, \quad (1)$$

where $\tilde{X}_{ij}$ is the transformed value of the i^{th} indicator in the j^{th} region; x_{ij} is the initial value of the i^{th} indicator in the j^{th} region; $x_{\min i}$ is the minimum value of the i^{th} indicator among Russian regions; $x_{\max i}$ is the maximum value of the i^{th} indicator among Russian regions.

2. Significance of factors and calculation of region-specific indices

In order to assess innovative development of regions, we first need to decide whether our methodology should take into account certain factors or not. The role of these factors can be determined by using expert assessments. To calculate partial indices, it is proposed to use the multidimensional average formula (2). This is a generalized characteristic of a certain phenomenon built on the basis of converging its individual characteristics into a single indicator, which is calculated from the interrelation of attribute values for a unit of aggregate to average values of these attributes.

$$PIs = \frac{\sum_{i=1}^{m} \frac{\tilde{X}_{ij}}{\tilde{X}_{iaver}}}{m}, \quad (2)$$

where PIs is the region-specific index of the region by quantity by the block of indicators (area of implementation // innovation category); $i = 1 \ldots m$ is reduced partial indicators; m is the number of reducible indicators; $\tilde{X}_{ij}$ is the numerical value of the ith indicator for the jth region in each block of indicators (area of implementation // innovation category); $\tilde{X}_{iaver}$ is the average value of the i^{th} indicator among all regions in the block of indicators.

3. Calculation of the Integral Index

We applied three-factor and six-factor models of factor analysis to calculate the final indices for the areas of implementation and innovation categories and to calculate the integral index of innovative development.

Due to the fact that the assessment model has a matrix structure (Figure 1), we need to solve the problem of classifying the indicators which must simultaneously belong to one of the six implementation areas and characterize one of the three categories of innovation environment. Thus, innovation climate characterizes external conditions of the region's environment, that is, how favourable are the existing scientific, technological, industrial and socio-economic conditions for innovation in the region [8].

In its turn, innovative potential characterizes the conditions and reflects the dynamics of in-

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ternal factors of the region's innovative environment – a set of financial, human, scientific and technical, organizational and managerial, informational, methodological and marketing resources that make the region capable of fulfilling a set of innovative tasks [8].

Innovative activity characterizes effectiveness of innovation. The level of innovative activity is an indicator of economic development.

The assessment model uses 54 indicators, which are divided into 3 innovative categories and 6 areas of innovative activity, thus forming 18 region-specific indices. Indicators are taken from such sections of the state statistics as population; labor market, employment and wages; science, innovation and information society; macroeconomic indicators. The proposed approach allows us to calculate not only the integral index, but also to determine development factors, growth drivers, and bottlenecks of innovation activity in regions and specific territories.

For example, in the socio-economic block, the indicators that form the region-specific index by climate category include the index of physical volume of GRP; production and technology includes the coefficient of renewal of fixed assets; the investment activity block, the volume of investment in fixed capital per capita and the growth rate of investment in fixed assets in GRP; R&D, the coefficient of inventive activity; the block of human resources for R&D, the proportion of doctoral candidates and candidates in the total economically active population and the growth rate of researchers' average salary; and, finally, for R&D funding, we used such indicators as the share of domestic expenses on R&D in the expenses of the consolidated budgets of Russian regions and the growth rate of organizations' expenses on technological innovation.

Table 2

Ranking of Russian regions according to the value of the integral index of innovative development for 2014–2016

Regional ranking by the value of the ID index for 2014		Regional ranking by the value of the ID index for 2015		Regional ranking by the value of the ID index for 2016	
No.	Region	No.	Region	No.	Region
1	Moscow	1	Moscow	1	Moscow
2	St. Petersburg	2	Moscow region	2	St. Petersburg
3	Republic of Tatarstan	3	St. Petersburg	3	Moscow region
4	Moscow region	4	Tomsk region	4	Nizhny Novgorod region
5	Nizhny Novgorod region	5	Krasnoyarsk region	5	Krasnoyarsk region
6	Kaluga region	6	Nizhny Novgorod region	6	Tomsk region
7	Perm region	7	Republic of Tatarstan	7	Republic of Tatarstan
8	Tomsk region	8	Perm region	8	Tyumen region without autonomous districts
9	Novosibirsk region	9	Sverdlovsk region	9	Tula region
10	Yaroslavl region	10	Voronezh region	10	Ulyanovsk region
	…		…		…
20	Lipetsk region	20	Novosibirsk region	20	Belgorod region
21	Samara Region	21	Ulyanovsk region	21	Rostov region
22	Republic of Bashkortostan	22	Chelyabinsk region	22	Chelyabinsk region
23	Volgograd region	23	Lipetsk region	23	Lipetsk region
24	Belgorod region	24	Krasnodar region	24	Leningrad region
25	Chelyabinsk region	25	Orenburg region	25	Khabarovsk region
	…		…		…
75	Kostroma region	75	Tyva Republic	75	Chechen Republic
76	Karachay-Cherkess Republic	76	Mari El Republic	76	Republic of Khakassia
77	Amur region	77	Chechen Republic	77	Sevastopol
78	Sevastopol	78	Republic of Khakassia	78	Jewish Autonomous Region
79	Jewish Autonomous Region	79	Sevastopol	79	Karachay-Cherkess Republic
80	Nenets Autonomous Okrug	80	Jewish Autonomous Region	80	Nenets Autonomous Okrug
81	Republic of Ingushetia	81	Nenets Autonomous Okrug	81	Pskov region
82	Republic of Crimea	82	Republic of Ingushetia	82	Republic of Ingushetia
83	Tyva Republic	83	Republic of Crimea	83	Sakhalin region
84	Chukotka Autonomous Okrug	84	Chukotka Autonomous Okrug	84	Chukotka Autonomous Okrug
85	Yamalo-Nenets Autonomous Okrug	85	Yamalo-Nenets Autonomous Okrug	85	Yamalo-Nenets Autonomous Okrug

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Table 3

Groups of regions by value of the integral index of ID for 2014–2016

Group	Group name	Distribution of the regions				
		Value of the integral index of ID	Regions' actual value of the integral index of ID	Number of regions in groups		
				2014	2015	2016
I	"Alpha regions" or powerful innovators	> 100	122.70–44,800.07	2	3	3
II	"Beta regions" or strong innovators	10–100	13.14–96.80	3	5	4
III	"Gamma regions" or medium innovators	1–10	1.07–9.94	16	9	12
IV	"Delta regions" or weak innovators	0–1	0.00–0.82	64	68	66

The integral index of innovative development, calculated with the help of the above-described indicators, allows us to assess continuous development of economy, science, technology, production as well as the development of conditions necessary for innovation. Innovative development is a complex process which has two main objectives: realization of innovation projects (ensuring sustainable innovative activity) and development of innovative potential in the existing innovative environment [8].

Results

The assessment method we propose is a multifunctional tool that has several *levels of possible practical results*.

At *the first level*, this method allows us to form a ranking of Russian regions by the value of the integral index of innovative development (ID index) (see Table 2).

At *the second level*, the regions are divided into four groups according to the value of the integral index of innovative development (ID) (see Table 3).

Regions of the first group – "alfa regions" – have the highest value of the integral index of innovative development: more than 100. This group of powerful innovators includes regions with the highest level of innovation development of the territory.

Regions of the second group – "beta regions" – have the value of the index from 10 to 100 and are called strong innovators.

Regions of the third group – "gamma regions" – have the value of the index from 1 to 10 and are called medium innovators.

Regions of the fourth group – "delta regions" – are weak innovators with an index value from 0 to 1.

In addition, at this level, our methodology allows us to analyze the distribution of regions by the value of the integral index of ID and to analyze the structural shifts in the distribution of regions (see Figure 2).

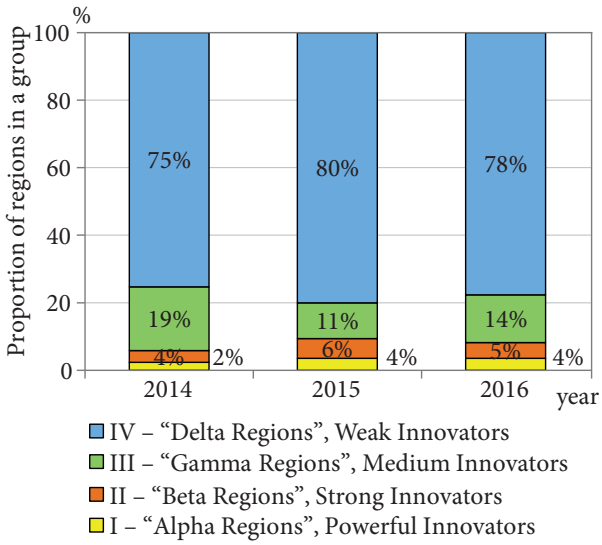

Figure 2. *Groups of regions according to the integral index of ID*

We found that Moscow, the city of federal significance, ranked first and, accordingly, was a member of the alfa-group with the maximum value of the calculated index. The leading positions in 2014 were also held by St. Petersburg; in 2015 and 2016 the group of powerful innovators also included Moscow region.

The second group, "beta regions", in 2014, 2015 and 2016 included 3, 5 and 4 regions respectively such as Nizhny Novgorod region and Tatarstan. Tomsk region, Krasnoyarsk region, Perm region were listed in this group in 2015 and 2016.

As part of the third group, "gamma regions", in 2014 there were 19% of regions; in 2015, 11%; and in 2016, 14%. Kaluga, Sverdlovsk and Voronezh regions as well as Perm region ranked among medium innovators.

The fourth group, "delta regions", with the lowest value of the index were the most numerous – 75% (64 regions), 80% (68) and 78% (66) of all regions in 2014, 2015 and 2016, respectively. It

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Table 4

Structural shifts of regions by value of the integral index of ID

		I Group		II Group		III Group		IV Group		ID per year
		n	average ID	*n*	average ID	*n*	average ID	*n*	average ID	
Comparison 2014 → 2015	2014	2	2,554.83	3	91.95	16	3.92	64	0.08	64.16
	2015	3	15,027.38	5	27.61	9	3.37	68	0.09	532.43
	Remained in the same group	2		2		5		60		Number of regions
	Moved up	1		3		4		–		
	Moved down	-		0		0		8		
Comparison 2015 → 2016	2015	3	15,027.38	5	27.61	9	3.37	68	0.09	532.43
	2016	3	3,343.62	4	45.15	12	3.84	66	0.06	120.73
	Remained in the same group	3		4		4		61		Number of regions
	Moved up	0		0		7		–		
	Moved down	–		0		1		5		

is possible to explain such a high proportion of regions in the group (caused by the decrease in the calculated indicators) by the economic crisis of 2014, its causes and consequences. Stagnation, slowdown, and then sharp weakening of the national currency due to the significant decline in oil prices and economic sanctions led to a rise in inflation, a decline in real incomes of the population and a change in consumer behavior. These factors affected all aspects of regional performance including innovative development, which is illustrated by the changes in regions' ranking positions.

The analysis of the structural shifts focuses on regions' positions in the rankings. For example, sometimes regions remained within one group, moved to an upper group or to a lower group (see Table 4).

Figure 3 below illustrates changes in the number of regions in groups for 2014–2016.

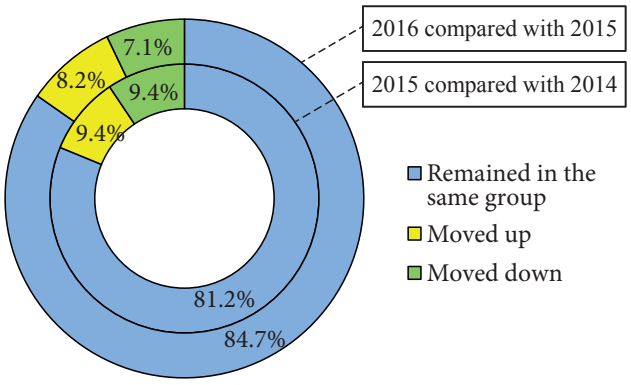

Figure 3. *Changes in the number of regions in groups for 2014–2016*

Thus, 81.2% of the regions (69) remained in the same groups in 2015 in comparison with 2014. Eight regions moved up (9.4%) and Moscow region entered the group of "alfa regions"; three regions joined the group of "beta regions" – Tomsk, Perm and Krasnoyarsk regions; and four regions – Penza, Kaliningrad, Krasnodar and Magadan regions – moved up and joined the group of "gamma regions"; eight regions (9.4%) moved down the ranking – Novosibirsk, Yaroslavl, Ulyanovsk, Sakhalin, Vladimir, Tyumen, Lipetsk regions and the Republic of Komi. All of them joined the group of weak innovators with low values of the innovative development index.

In 2016 compared to 2015, 84.7% of the regions (72) remained in the same groups. Seven regions moved to the group of "gamma regions" and 8.2% of the regions improved their position. Thus, in 2016, among the regions classified as medium innovators, Novosibirsk, Yaroslavl, Ulyanovsk, Tyumen, Kursk, Tver regions and the Republic of Sakha (Yakutia) retained their positions. Six regions (or 7.1%) moved down. Perm region moved from the group of strong innovators to medium ones. Five regions entered the group of weak innovators: Rostov, Samara, Magadan, Penza and Kaliningrad regions.

Division of regions into groups according to the value of the index of ID can be represented in the form of fields or matrices. We compiled distribution fields of the four groups of regions for the period 2014–2016. Thus, in the study we received 12 distribution fields, reflecting the full range of values of the index. The distribution fields of regions by groups for the whole period under review look similar to the field of group I distribution in 2016. This field is presented in Figure 4 (the first group of regions) as an example. The regional distribution matrixes compiled by the fields complete this level of results.

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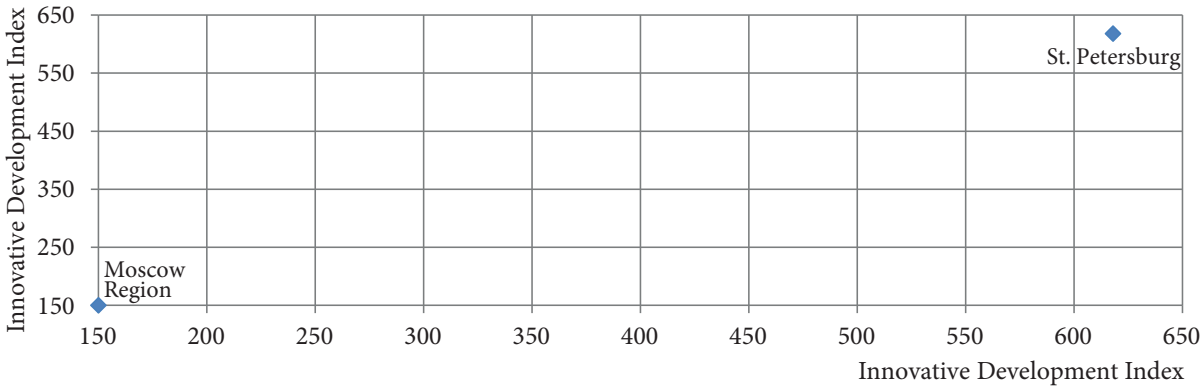

Figure 4. *The field of group I distribution ("alpha region" or powerful innovators), according to the value of the innovative development index in 2016*

The matrix of the distribution of regions for 2016 shows the regions included into selected groups: group I – "alpha regions" or powerful innovators; group II – "beta regions" or strong innovators; group III – 'gamma regions' or medium innovators; and group IV – "delta regions" or weak innovators (see Table 5).

Table 5

Matrix of the distribution of regions in groups, 2016

Groups	Regions
Group I	Moscow, St. Petersburg, Moscow region (3)
Group II	Nizhny Novgorod region, Krasnoyarsk region, Tomsk region, Tatarstan (4)
Group III	Tyumen region without autonomous districts, Tula region, Ulyanovsk region, Republic of Sakha (Yakutia), Kursk region, Sverdlovsk region, Tver region, Novosibirsk region, Kaluga region, Voronezh region, Perm region, Yaroslavl region (12)
Group IV	Belgorod region, Rostov region, Chelyabinsk region, Lipetsk region, Leningrad region, Khabarovsk region, Republic of Mordovia, Republic of Bashkortostan, Novgorod region and others (66)

At this level, it is also possible to analyze the dynamics of average values of the integral index of ID by focusing on specific groups of regions.

The dynamics of average values of the integral index reveals the factors that have the greatest influence on innovative development in different groups of regions. For example, let us consider Figure 5, which reflects the dynamics of the average value of the index in regions of the first group.

The high average value of the index in group I in 2015 was almost 6 times higher than in 2014 and 4.5 times higher than in 2016. The rise in 2015 was caused by a significant increase in indicators (10 times) of Moscow region, which is the leader and which determines the innovative potential of this group. If we look at another region – St. Petersburg, we shall see a simultaneous fivefold decrease in the indicators' values in 2015 and their subsequent fivefold increase in 2016, which generally caused a strong jump in the average value of the index for the whole group in 2015. The same changes in indicators brought the average value of the innovative development index in 2014 and 2016 to a comparable value. Thus, the maximum average index value of the first group was reached in 2015 and the minimum, in 2014.

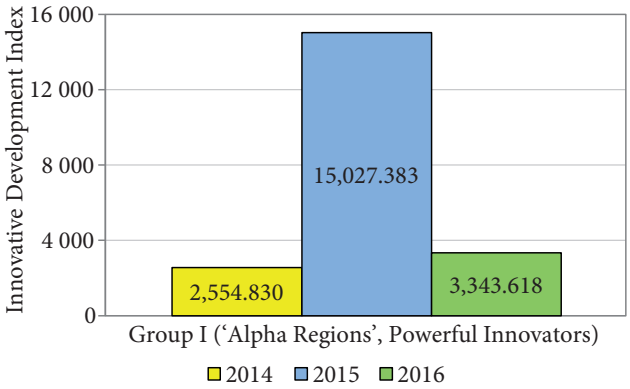

Figure 5. *Dynamics of the average value of the innovative development index in group I for 2014–2016*

At the *third level*, we are going to analyze the dynamics of the rankings positions of the regions.

The regional rankings based on the innovative development index for 2014, 2015 and 2016 allow us to draw a number of conclusions, tracking how the region's position changed and how they either moved up or dropped in the ranking depending on their levels of innovative development.

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For example, in 2014, Novosibirsk region ranked 9th and was a part of the third group with the index value of 5.935, which almost twice exceeded the average index value of this group in the give period. In 2015, the region dropped in the ranking by 11 positions and moved to group IV, "delta regions", with the index value below the average of this group. By 2016, Novosibirsk region regained its position in the group of "gamma regions", after having improved its position by 5 points compared with the previous period. At the same time, it still lagged behind the average indicator level for the group 1.6 times.

Thus, we can rank the regions according to the intensity of changes in their ranking positions for the period 2014–2016. Regions that improved their positions in 2016 compared to 2015 are presented in Table 6, regions that moved down the rankings in 2016 compared to 2015 are presented in Table 7.

Compared with 2015, fifteen regions improved their positions in 2016 by more than 10 points. As it can be seen from Table 5, five regions moved to the group with a higher value of the index of ID, from "delta regions" to "gamma regions". The Republic of Sakha (Yakutia) rose in

Table 6

Regions with a significant change in their ranking positions in 2015–2016 (improved positions, fragment)

No.	Region	2015		2016		2015–2016	
		Rank	Group	Rank	Group	Rank change	Group change
1	Republic of Sakha (Yakutia)	48	IV	11	III	37	+1
2	Kursk region	42	IV	12	III	30	+1
3	Tyumen region without autonomous districts	34	IV	8	III	26	+1
4	Kabardino-Balkaria	73	IV	51	IV	22	0
5	Republic of Crimea	83	IV	62	IV	21	0
6	Republic of Karelia	49	IV	30	IV	19	0
7	Tver region	31	IV	14	III	17	+1
8	Udmurtia	64	IV	48	IV	16	0
9	Belgorod region	35	IV	20	IV	15	0
10	Vologda region	59	IV	45	IV	14	0
11	Komi Republic	56	IV	42	IV	14	0
12	Omsk region	47	IV	35	IV	12	0
13	Khanty-Mansi Autonomous Okrug – Ugra	44	IV	32	IV	12	0
14	Khabarovsk region	36	IV	25	IV	11	0
15	Ulyanovsk region	21	IV	10	III	11	+1

Table 7

Regions with a significant change of their ranking positions in 2015–2016 (lost positions, fragment)

No.	Region	2015		2016		2015–2016	
		Rank	Group	Rank	Group	Rank change	Group change
1	Rostov region	11	III	21	IV	–10	–1
2	Perm region	8	II	18	III	–10	–1
3	Kemerovo region	50	IV	61	IV	–11	0
4	Kostroma region	61	IV	73	IV	–11	0
5	Samara Region	17	III	31	IV	–15	–1
6	Tambov Region	32	IV	47	IV	–15	0
7	Vladimir region	18	IV	34	IV	–16	0
8	Karachay-Cherkess Republic	62	IV	79	IV	–16	0
9	Pskov region	63	IV	81	IV	–18	0
10	Caliningrad region	12	III	40	IV	–22	–1
11	Orenburg region	25	IV	55	IV	–30	0
12	Penza region	16	III	52	IV	–36	–1
13	Magadan Region	13	III	58	IV	–46	–1
14	Sakhalin region	19	IV	83	IV	–65	0

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the ranking by 37 points: in 2016 it ranked 11th and in the previous year, 48th by achieving significant improvements in all areas: socio-economic area, production and technology, investment, R&D, human resources for R&D, and funding. The transition of Kursk region to the group of medium innovators is explained by a significant increase in indicators characterizing production and technology, investment and funding for R&D as well as the factors shaping the innovative potential and innovative activity of the region. Tyumen region closes the top three leading regions in 2016 ranking. It moved to the 8th position from the 34th in the previous period due to its improved performance in R&D, human resources for R&D and funding, which is directly related to the growth in indicators of innovative environment – innovative potential and innovative activity.

Table 6 shows 14 regions and the change in their ranking positions in 2016 compared to 2015, which was more than 10 points. Sakhalin region did not leave the group of "delta regions" in 2016 and led the top three outsider regions with a significant loss of 65 positions. From the 19th place in the 2015 ranking, in 2016, it dropped to the 83rd place due to a very low level of innovative activity and low rates of research and investment activity. Penza region closes the top three, it dropped from the 36th place to the 52nd in 2016. The decline in production and technology, investment activity and R&D funding, affected the indicators of innovative activity in the region, which resulted in the region's joining the group of weak innovators.

At *the fourth level*, we are going to divide regions according to the values of the final indices in innovative categories and areas of implementation. This level allows us to analyze the relationship between innovative development and the factors of external and internal environment as well as the relationship between the areas of implementation of innovation activities.

Thus, the fields reflect the direct relationship between innovative development and innovative potential in 2016 (Figure 6) and between innovative development and funding for R&D in 2016 (Figure 7).

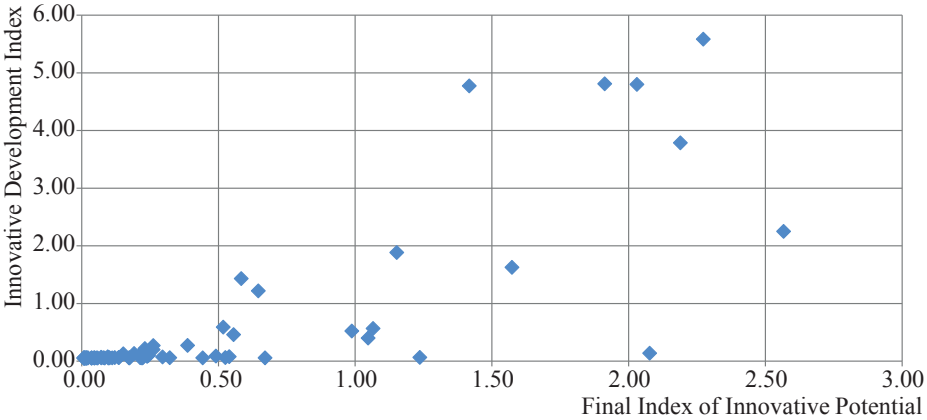

Figure 6. *The field of dependence between innovative development and innovative potential of regions in 2016*

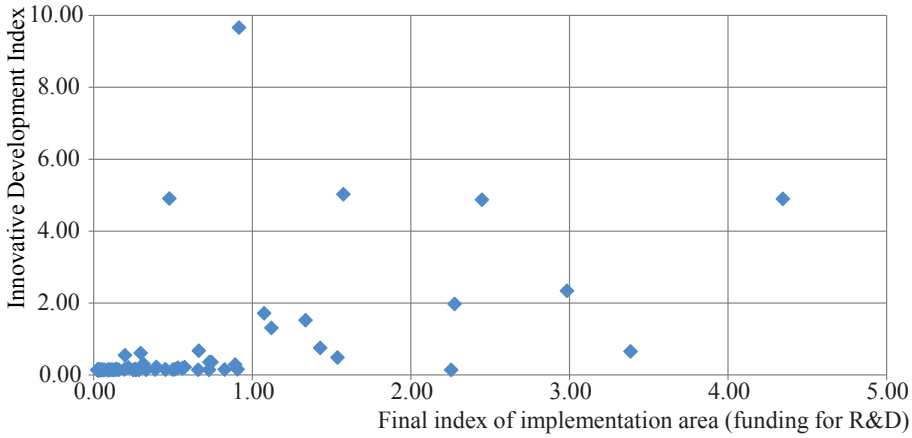

Figure 7. *Field of dependence between innovative development and funding for R&D for 2016*

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At *the fifth level*, we are going to draw a profile of a region depending on its innovative development. The innovative profile relies on the results of region-specific assessment, which allow us not only to reveal the change in the integral index of ID, but also the impact of final indices. The dynamics of changes in the final indices according to innovative categories and implementation areas is presented in Figures 8–9.

The dynamics of the values of region-specific indices, which form the final indices according to implementation areas and innovative categories, are shown in Figure 10 ("Socio-economic area") and Figure 11 ("Innovative climate").

A similar presentation has the dynamics of region-specific indices in the following areas of implementation: production and technology, investment activity, R&D, human resources and funding for R&D.

A similar presentation has the dynamics of region-specific indices in the categories "potential" and "activity".

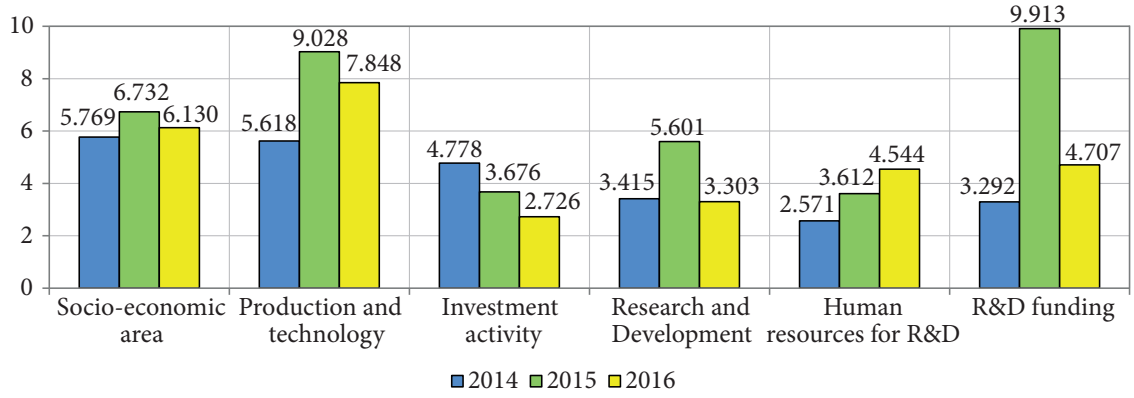

Figure 8. *Dynamics of the values of the final indices by areas of implementation for 2014–2016*

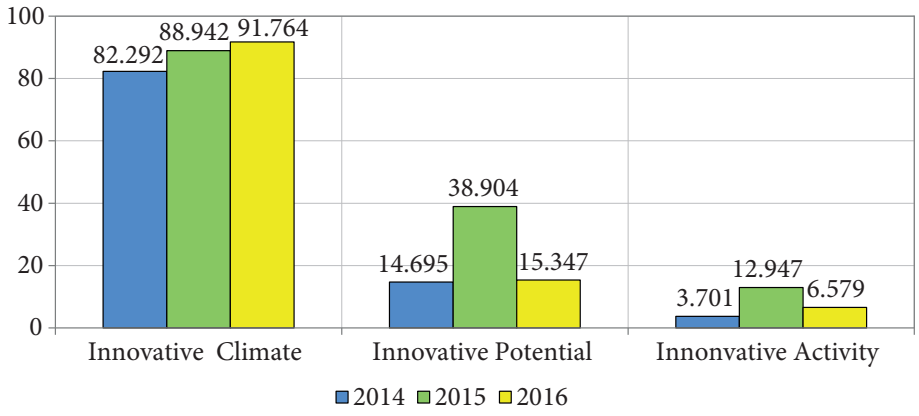

Figure 9. *Dynamics of the values of final indices by innovative categories for 2014–2016*

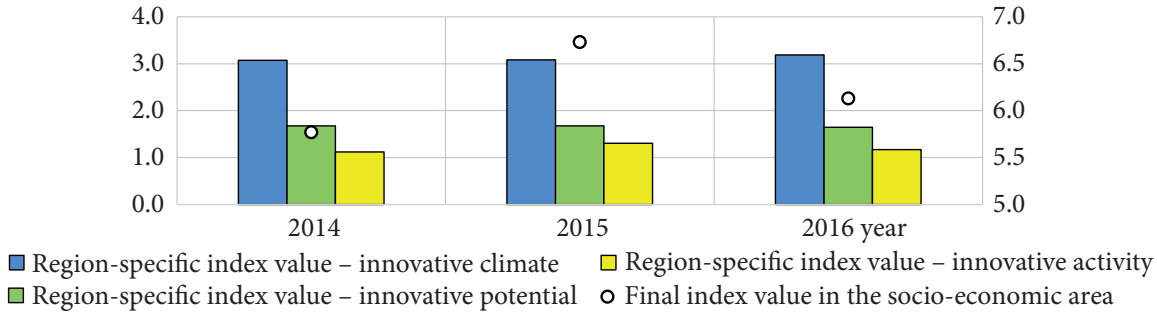

Figure 10. *Dynamics of the values of region-specific indices in the socio-economic area for 2014–2016*

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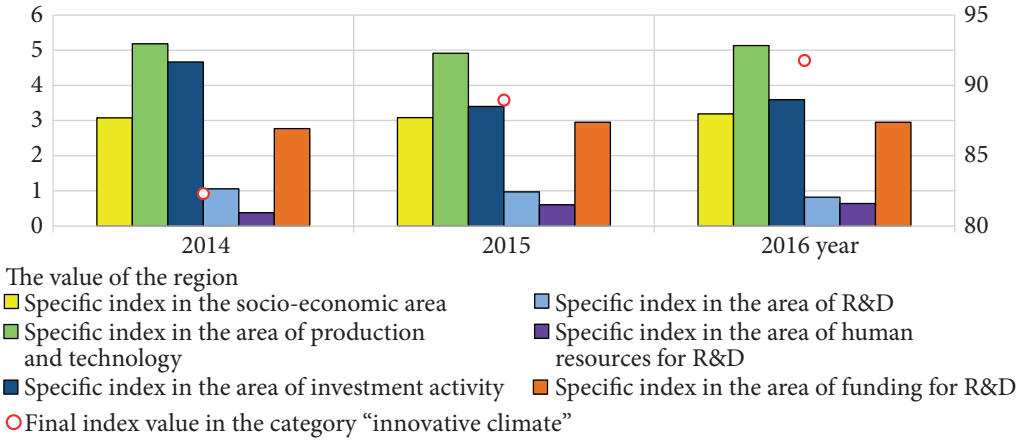

Figure 11. *Dynamics of the values of region-specific indices in the category "innovative climate" for 2014–2016*

Analysis of the results at this level allows us to rank regions according to the final indices – innovative climate, innovative potential and innovative activity in the regions. Similarly, it is possible to rank regions according to the level of development of the implementation areas of innovation activities. Thus, we can make an overall assessment of regions' innovative development. The integral index of ID is calculated on the basis of final indices of innovative categories and implementation areas, and final indices are calculated on the basis of region-specific ones. The latter can be also used to create a profile for each region. The innovative profile of a region reflects the results of the analysis of its innovative environment and show the region's strengths and weaknesses, growth drivers and resources. Therefore, profiling can be useful to devise recommendations and guidelines for further innovative development of the region.

Conclusion

In this research, we were trying to address the problem of the lack of a generally accepted conceptual and terminological apparatus for studying innovation as well as a toolkit for a comprehensive assessment of innovative development.

The proposed methodology is suitable for assessment of innovative development of territories taking into account such characteristics as innovative environment and innovation activities. The methodology comprises a set of indices including the integral index and region-specific indices; criteria for ranking regions according to their level of innovative development and further classification of regions according to their ranking positions; fields and matrixes of regions' distribution according to their innovative development; fields of dependence that show the relationship between innovative development and different categories of innovative environment (external and internal factors); and tools for creating individual profiles of regions.

A limitation of this study is the use of official statistics in calculations: these data are published with a time lag, which may affect the picture we get when assessing the regions' innovative development.

The results described in this article may be further used for studying innovation potential of Russian regions and devising strategies and policies for enhancing innovation in these regions and in the whole country. Further research in this area may involve creation of profiles of innovative development for specific regions, highlighting their strengths and weaknesses. Moreover, the proposed assessment toolkit may be applied in the context of other countries.

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