Byvshev et al.
Journal of Innovation and Entrepreneurship (2022) 11:65
https://doi.org/10.1186/s13731-022-00257-w

Journal of Innovation and Entrepreneurship

RESEARCH Open Access

Methodology for assessing the effectiveness of regional infrastructure facilities to support scientific, technical and innovation activities in the context of the synergy effect: analysis, formation and study

Vladimir Byvshev[1,2], Kristina Parfenteva[3*], Irina Panteleeva[4,5], Danil Uskov[1,2] and Vadim Demin[2,6]

*Correspondence: Kristina.Parfe@yandex.ru

[1] Department of Economic and Financial Security, Siberian Federal University, Krasnoyarsk, Russian Federation
[2] Department of Organization and Support of Competitions, Krasnoyarsk Regional Fund for Support of Scientific and Technical Activities, Krasnoyarsk, Russian Federation
[3] Organizational and Analytical Department, Krasnoyarsk Regional Fund for Support of Scientific and Technical Activities, Krasnoyarsk, Russian Federation
[4] Department of Advertising and Socio-Cultural Activities, Siberian Federal University, Krasnoyarsk, Russian Federation
[5] Krasnoyarsk Regional Fund for Support of Scientific and Technical Activities, Krasnoyarsk, Russian Federation
[6] Department of Artificial Intelligence Systems, Siberian Federal University, Krasnoyarsk, Russian Federation

Abstract
The objective of the study is to develop a method for the evaluation of efficiency of the regional infrastructure facilities for the support of scientific, research, technical and innovation activities. This paper presents an analysis of the methods currently used in Russia and abroad, identifying their advantages and disadvantages. Based on the analysis, the author suggests a list of parameters characterizing the given domain, and develops a system for the integrated parameter calculation; a list of the regions is provided with the potential for the most objective efficiency evaluation and testing of the developed method; conclusions are made based on the demonstrated calculations. As a result, the developed method is considered effective and promising. Regardless of the composite index currently being in the stability zone, some of its components may lie in the catastrophic risk zone, posing potential threats to the further innovative development of the subject. At the same time, it is found out that an important role in the efficient functioning of the infrastructure supporting the scientific, research, technical and innovation activities belongs to the legislative environment and the closed innovative cycle (synergy effect).

Keywords: Infrastructure for support of scientific, Research, Technical and innovation activities, Regional economy, Evaluation methods, Innovation activity

Introduction
Active implementation of innovations capable of ensuring the development of knowledge-based economy is a priority of the state policy of the Russian Federation, but the innovative development at the national level appears impossible without well-balanced regional development. One of the factors impeding the innovative development is uneven spatial development of the Russian Federation and increasing regional differentiation. For this reason, an important role is assigned to the formation and development of a regional infrastructure for the support of scientific, research, technical and innovation

activity, expected to eliminate the present imbalances through the creation of favorable conditions for the development and further implementation of innovations (Colombelli et al., 2020; Filipishyna et al., 2018; Firsova et al., 2020; Rezk et al., 2015, 2016; Veselovsky et al., 2019; Zollo et al., 2011).

Once the required infrastructure is formed, one cannot expect immediate and effective output or quick solution of the existing problems. The studies show that if the support infrastructure functions efficiently, the result can be seen only in 5 years, provided that the terms of implementation of the related innovation activity plans are met and proper communication with the innovation market members is present (Ascani et al., 2020; Bezpalov et al., 2019; Kiškis et al., 2016; Laužikas et al., 2016; Parrilli et al., 2020).

For the infrastructure to function efficiently and fulfill the assigned functions, its activity needs to be evaluated in order to correct the underperforming processes. Such evaluation may be carried out using specialized methods. Let us review some methodological approaches to such evaluation, currently used across the globe.

Current practices analysis

In the USA, a composite innovation index is calculated for American counties (Based Economy. U. S. Economic Development Administration). The index consists of four blocks with different weight factors: human capital (30%), economic dynamics (30%), productivity and employment (30%), as well as welfare (10%). The index covers both the resources for innovation activity and its outcomes (Statsamerica, 2009).

The Adam Smith International method (ASI) consists of five stages (1. Evaluation of infrastructure creation costs, 2. Process evaluation, 3. Output evaluation, 4. Results evaluation, 5. Impact evaluation). At the costs stage, the amount of investment required, for instance, for the infrastructure hardware compliant with a list of applicable standards, is evaluated. The process stage assumes the achievement of target indices by the infrastructure's support for the scientific, research, technical and innovation activity. At the output stage, the innovation companies' satisfaction with the infrastructure is analyzed. The main results of such infrastructure's functioning may include diffusion of technologies, R&D quality improvement, etc. The final stage is impact, a vivid parameter of which is the degree of integration in the international markets (Assets publishing service, 2012).

Another method for the innovative development evaluation used in the EU is European Innovation Scoreboard based on a system of 29 indices; later, it served as a basis for the creation of the Regional Innovation Scoreboard of 16 indices. Both systems comprise three index blocks: innovative development factors, companies' activity and innovation activity results. According to the evaluation, the European Union regions can be divided into five types: innovation leaders, strong innovators, moderate innovators, medium innovators and modest innovators (Kudriavtseva, 2012).

The methods for the evaluation of the regional support infrastructure for the scientific, research, technical and innovation activity of Russian researchers are exclusively limited to the analysis of innovative development in the region. Such a tendency may be related to some problems which may occur in choosing the required indices due to the large number of infrastructure facilities in the regions and impossibility of applying identical parameters capable of evaluating the activity of such objects appropriately. At the same time, one should not ignore the fact that the innovative process in the region, as a rule, is carried out in a certain innovation climate, which is greatly determined by the functioning of the regional infrastructure. Based on this statement, we may conclude that its evaluation must be inseparable from the evaluation of the innovative process it underlies.

From the point of view of consistency of its classification, systematization and evaluation of the components of the support infrastructure for scientific, research, technical and innovation activity in the region, as well as the selection of indices that characterize the state and efficiency of its functioning, the method of Panshin and Kashitsyna appears to be the most complete one (Pan'shin & Kashitsyna, 2009). According to the authors, besides providing for a comprehensive study of the development level of the support infrastructure for scientific, research, technical and innovation activity, it is universally applicable to the majority of the Russian regions. The present study forms an integrated index differentiated by the types of elements of the support infrastructure for the scientific, research, technical and innovation activity.

Summarizing the review of the existing methods, we may remark that their authors evaluated both the innovation activity of a region as a whole and the indices that indicate the efficiency of the support infrastructure performance. However, there is a risk of problems in finding sources of data due to the absence of open access to such data. Apart from that, one may notice that there is a lack of indices characterizing the structure of the support infrastructure for scientific, research, technical and innovation activity, as well as regional regulatory legal documents for the domain of innovations.

Methods and approaches

Having reviewed the foreign and Russian approaches to evaluating the regional support infrastructure for scientific, research, technical and innovation activity, it is hereby suggested that an integrated methodology should be developed that would encompass the advantages of the methods described above, at the same time compensating for their drawbacks. The developed methodology will feature the following advantages:

- integrity—comprehensive demonstration of the efficiency of functioning of the support infrastructure for scientific, research, technical and innovation activity, with regard to the synergy effect caused by the operation of the entire infrastructure not considered by the reviewed methods;
- sufficiency—the evaluation system is limited with a required number of parameters capable of fully characterizing the condition and efficiency of the support infrastructure for scientific, research, technical and innovation activity, including its regulatory and legal component not considered by the reviewed methods;
- information support—the evaluation is based on open and accessible statistic data;
- practical applicability—the evaluation system can be not only applied within the given study, but used by regional authorities in their continuous work on correcting the strategic, regulatory, legal documentation and improving the regional innovation policy mechanisms (Ruiga et al., 2019).

At the first stage, the system of parameters for evaluating the efficiency of the support infrastructure for scientific, research, technical and innovation activity is formed, and

Table 1 Parameters for evaluating the support infrastructure for scientific, research, technical and innovation activity in the region by differentiated aspects

Parameter	Threshold value	Threshold value source	Data source
1. Regulatory legal support			
Strategic planning document developed in the goal-setting process	0/1	Original value	Open sources
Availability of a strategic planning document developed in the programming process (State Programs of the constituent entities of the Russian Federation)	0/1	Original value	
Availability of a special legislative act of the constituent entity of the Russian Federation	0/1	Original value	
2. Infrastructure support			
Availability of a set of elements of the support infrastructure for scientific, research, technical and innovation activity in the region	At least 2	Original computation	Open sources
Share of the facilities of the support infrastructure for scientific, research, technical and innovation activity in the total number of organizations engaged in scientific research and development (optimality of infrastructure availability), %	60–75%	Original computation	
3. Potential of the region in the science and innovation domain			
Ratio of the federal education expenditures to GRP, %	At least 5	I.P. Savelyeva	Open sources
Share of college graduate employees in economy, %	At least 40	Original computation	
Share of scientific research and development personnel in the total employed population, %	At least 2	Original computation	
Share of researchers with an academic degree in the total scientific research and development personnel, %	At least 13.6	Original computation	
Innovation activity of organizations, %	At least 12.5	O.I. Mityakova, S.N. Mityakov	
4. Commercialization and effectiveness of scientific and innovation activity in the region			
Intensity of technological innovation expenditures, %	At least 3.2	O.I. Mityakova, S.N. Mityakov	Open sources
Share of domestic current fundamental research expenditures in total current expenditures, %	At least 17.5	Original computation	
Share of domestic current scientific development expenditures in total current expenditures, %	At least 67.5	Original computation	
Share of domestic current expenditures for applied research in total current expenditures, %	At least 15	Original computation	
Ratio of the volume of dispatched innovative products and technological innovation expenditures, times	At least 5	V.K. Senchagov	
Share of developed top production technologies in total volume of used top production technologies, %	At least 1	Original computation	
Inventing activity factor (number of patent applications submitted to Rospatent per 10 thousand people)	At least 5	O.I. Mityakova, S.N. Mityakov	

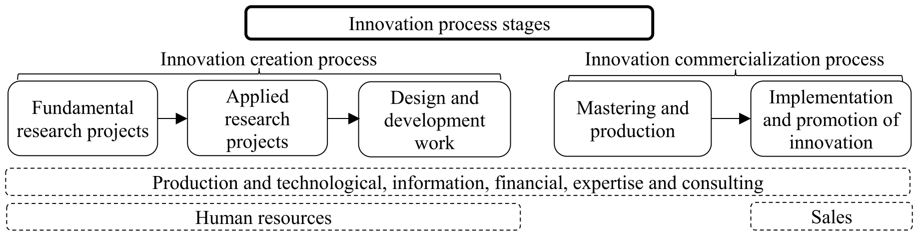

Fig. 1 Innovation process stages

the parameters are grouped by aspects. The parameter groups and their threshold values presented in Table 1 are suggested to be used as applicable aspects.

The regulatory documents foreseen by the first group of parameters lay the foundation for the regional innovation development and operation efficiency of the support infrastructure, as they improve the environment for further integration of scientific and production processes. The regulatory legal support in science and innovation domain shall be focused not only on the execution of special regulatory legal acts, but also their actualization, which is caused by the complex nature of science and innovation domain (Bondarev & Turina, 2011). The specificity of determining the reference values for this parameter group depends on the presence or absence of an up-to-date document. Depending on that, it may be equal to one or zero (if unavailable in the region).

The group of infrastructure availability parameters is based on the comprehensiveness of the facilities of the support infrastructure for scientific, research, technical and innovation activity in the region. This is explained by the fact that an infrastructure must be a single whole, which is achieved by the integration of all the elements required for the implementation of a complete innovation process. Therefore, the absence of one necessary element in the region will indicate a “gap” in the service range at a given stage of the innovation process, and the absence of full support for the implementation of innovative projects by its objects (Dalekin, 2018; Koroleva & Ermoshina, 2014).

The infrastructure availability of the regional support infrastructure for scientific, research, technical and innovation activity is evaluated with a focus on the logic of the innovation process, as stable regional development requires the innovation initiatives to be supported at all of its stages. For this reason, it is reasonable to classify the infrastructure elements by their belonging to the five stages of the innovation process (Fig. 1) (Ivashchenko & Denisova, 2022).

The specificity of evaluating the availability of the support infrastructure for scientific, research, technical and innovation activity in the region is the determination of reference values for each of its elements. Thus, in case of availability of the objects incorporated into it, such element of the support infrastructure for scientific, research, technical and innovation activity is assigned a reference value equal to one. If any element of the infrastructure is unavailable in the region, the reference value equals to zero (Fig. 2).

If all the elements are available in the region, it is, therefore, concluded that the support infrastructure for scientific, research, technical and innovation activity really is a whole system that offers support to the innovation activity subjects on all levels of the innovation process. This way, the synergy effect takes place, and such region is assigned another extra point in the computation of individual parameters

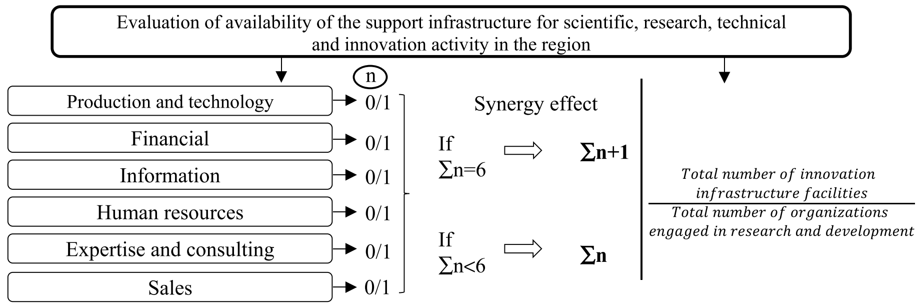

Fig. 2 Evaluation of availability of the support infrastructure for scientific, research, technical and innovation activity in the region

in this subgroup. The effect manifests itself in the growing operation efficiency of the regional support infrastructure for scientific, research, technical and innovation activity in the process of interaction, integration of each of its elements into a well-balanced system for the achievement of a common goal. In this way, it may also signify a dramatic growth and enhancement of the innovation development level in the region (Ivanova, 2019).

Due to the differentiation of the RF constituent entities by many of the factors listed above, the sufficiency and optimality of the available infrastructure facilities in the region shall be evaluated with a relative parameter (Fig. 2), equal to the ratio of the number of infrastructure facilities to the total number of organizations engaged in the research and development domain.

In the creation of innovations, the region's potential parameter group is based on the statistic characteristics of the staffing and human capital of the region, as well as the financial investment into education made by the state. The staffing and human capital is the key factor that promotes the development of the science and innovation potential, as it is people, not machines or investments, who generate the ideas for innovations and scientific discoveries. Of special importance is the establishment of long-term relationship between the government authorities and researchers. The studies show that the territories where the greatest number of innovations are implemented feature a higher innovation staffing potential (Bell et al., 2019; Khuchbarov, 2015; Kremer, 2020; Semenov, 2007).

The group of commercialization and effectiveness parameters of the scientific and innovation activity of the region reveals the parameters of financing the science and innovations, activeness in the innovation and top technology development, as well as in further innovative product manufacture. The parameters are selected due to their usability to evaluate the functioning of the science and innovation spheres in the region.

For the fourth group of parameters, the threshold values are computed by the calculation of mean values for the total number of the regions of the Russian Federation (Loginov, 2015). However, in the present research, the regions with a stably low and continuously deteriorating innovation development level were not included into the calculation not to understate the threshold values.

Therefore, the threshold values were determined based on the statistical data of the regions with higher rating according to the regional innovation development-focused rating agencies, such as RIA Rating (Official Website of The Rating Agency "RIA Rating"), Association of Innovative Regions of Russia (Official Website of Association of Innovative Regions of Russia), Expert RA (Official Website of The Rating Agency "Expert RA"), as well as statistic studies of knowledge-based economy carried out by Science and Research University Higher School of Economics (Gokhberg et al., 2020). To collect objective results, the data collected in the 5-year period from 2014 to 2018 in 15 innovation-development regions were reviewed.

After the selection of the required parameters and reference values for them, at the second stage of the study, the individual indicators for the evaluation of the support infrastructure for scientific, research, technical and innovation activities shall be computed using formulas (1, 2).

During the individual parameter computation at the second stage of work, the parameters were standardized (Mityakov & Mityakov, 2014; Mityakov, 2018). The standardization function may expand the dynamic range of result visualization. As there are two threshold values applied to the selected parameters, which are "not more than" and "not less than", one of the available options of the function for the "not less than" ratio is the function in formula (1):

$$I^r = \frac{1}{n}\sum_{i=1}^{n} \begin{cases} 2^{\left(1-\frac{x_i^r}{a_i^r}\right)/\ln\frac{10}{3}}, \text{если } \frac{x_i^r}{a_i^r} > 1; \\ 2^{-\log_{10/3}\frac{x_i^r}{a_i^r}}, \text{если } \frac{x_i^r}{a_i^r} \le 1, \end{cases} \tag{1}$$

Therefore, for the "not more than" type of ratio, the function from formula (2) is applied:

$$I^r = \frac{1}{n}\sum_{i=1}^{n} \begin{cases} 2^{\left(1-\frac{x_i^r}{a_i^r}\right)/\ln\frac{10}{3}}, \text{если } \frac{x_i^r}{a_i^r} < 1; \\ 2^{-\log_{10/3}\frac{x_i^r}{a_i^r}}, \text{если } \frac{x_i^r}{a_i^r} \ge 1, \end{cases} \tag{2}$$

where I^r is a particular indicator for a group of parameters; n is a number of parameters in a given group; x_i^r is a value of the ith parameter in region r; a_i^r is a threshold value of the ith parameter in region r.

At the third stage, based on the computed particular indicators, the generalized index of the activity of the support infrastructure for scientific, research, technical and innovation activity, is computed using formula (3) as a weighed sum of the standardized particular indicators.

$$\mathrm{IR}^r = \sum_{i=1}^{n} \frac{k^r}{p} \times I^r, \tag{3}$$

where IR^r is a generalized index for the support infrastructure for scientific, research, technical and innovation activity in region r; $\frac{k^r}{p}$ is the weight factor of particular indicators; k^r is the number of parameters included into each group; p is the total number of parameters for all groups; I^r is the same as in formula (1).

Table 2 Interpretation of indicators' values by risk grade

Interval	Interpretation
$I^r(\mathrm{IR}^r) \leq 0.25$	Catastrophic risk zone
$0.25 < I^r(\mathrm{IR}^r) \leq 0.5$	Critical risk zone
$0.5 < I^r(\mathrm{IR}^r) \leq 0.75$	Significant risk zone
$0.75 < I^r(\mathrm{IR}^r) \leq 1$	Moderate risk zone
$I^r(\mathrm{IR}^r) > 1$	Stability zone

At the fourth stage, the values of the particular indicators and indices evaluating the performance of the support infrastructure for scientific, research, technical and innovation activity, are compared to the standardized values presented in Table 2.

A distinctive features of the developed method is the availability and accessibility of all parameters included into the computation system, consideration of both quantitative and qualitative indicators, such as the regulatory legal support of innovation activity, and consideration of the synergy effect caused by the comprehensive operation of the support infrastructure.

Results and discussion

For the verification of the method for the evaluation of activity of the facilities of the support infrastructure for scientific, research, technical, innovation activity, the regions were selected based on ranking the regions by their overall indices. The first group holds the leader region and the regions with the total index value different from that of the leading region's by not more than 20%. The second group includes the regions inferior to the leader by more than 20% but less than 40%. The interval in the third group is 41–60%, and in the fourth, it exceeds 60%. Then, regions from each group were selected to compute the score of the support infrastructure for scientific, research, technical and innovation activity of the region by the differentiated aspects (Table 3).

The regions included into the first group and selected for the method testing are the city of Moscow, the city of Saint Petersburg and the Republic of Tatarstan. Let us analyze the results of the efficiency evaluation of the support infrastructure for scientific, research, technical and innovation activity in the given regions.

From Table 3, we may conclude, that the generalized index for the support infrastructure for scientific, research, technical and innovation activity of the city of Moscow was in the stable zone, which means that its functions in quite an efficient manner. However, in some groups of parameters, significant differences were discovered. The lowered index of the regulatory and legal parameters group can be explained by the suspension of the Law No. 22 of June 06, 2012 "On scientific, technical and innovation activity in the city of Moscow", and the Decree of the Government of Moscow No. 513-PP of June 26, 2007 "On the development strategy of the city of Moscow for the period until 2025", according to which, one of the tasks set for the achievement of the strategic goal of increasing competitiveness and innovation development in the region was the efficient operation of the support infrastructure for

Table 3 Computation of the parameters for evaluating the support infrastructure for scientific, research, technical and innovation activity in the region by differentiated aspects

Region	Year									
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Individual indicators of regulatory legal support										
Moscow	0.667	0.667	1.000	1.000	1.000	0.667	0.333	0.333	0.333	0.333
Saint Petersburg	0.667	0.667	0.667	0.667	0.667	1.000	1.000	1.000	1.000	1.000
Republic of Tatarstan	0.667	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Krasnoyarsk Territory	0.333	0.333	0.667	0.667	0.667	1.000	1.000	1.000	1.000	1.000
Perm Territory	0.333	0.333	0.667	0.667	1.000	1.000	1.000	1.000	1.000	1.000
Volgograd Oblast	0.667	0.667	0.667	0.667	0.667	1.000	1.000	1.000	1.000	1.000
Republic of Sakha (Yakutia)	0.667	0.667	0.667	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Bryansk Oblast	1.000	1.000	1.000	1.000	0.667	1.000	1.000	1.000	1.000	1.000
Individual indicators of infrastructure support										
Moscow	1.847	1.851	1.855	1.873	1.855	1.872	1.848	1.852	1.853	1.856
Saint Petersburg	1.831	1.838	1.835	1.840	1.843	1.848	1.851	1.852	1.854	1.854
Republic of Tatarstan	1.846	1.849	1.870	1.866	1.867	1.853	1.853	1.851	1.847	1.852
Krasnoyarsk Territory	1.838	1.848	1.874	1.870	1.866	1.866	1.841	1.840	1.844	1.835
Perm Territory	1.847	1.872	1.874	1.847	1.873	1.851	1.840	1.845	1.846	1.847
Volgograd Oblast	1.856	1.853	1.850	1.874	1.848	1.838	1.833	1.840	1.850	1.851
Republic of Sakha (Yakutia)	1.831	1.839	1.851	1.839	1.845	1.857	1.870	1.857	1.862	1.872
Bryansk Oblast	1.837	1.862	1.863	1.843	1.843	1.846	1.832	1.842	1.832	1.826
Individual indicators of innovation creation potential in the region										
Moscow	1.025	1.000	1.047	1.048	1.033	1.020	1.014	0.982	0.955	1.043
Saint Petersburg	1.025	0.991	1.024	1.024	1.015	1.032	0.991	0.964	0.980	1.038
Republic of Tatarstan	0.798	0.798	0.834	0.850	0.881	0.900	0.873	0.885	0.891	0.909
Krasnoyarsk Territory	0.813	0.752	0.764	0.775	0.800	0.775	0.765	0.741	0.730	0.762
Perm Territory	0.845	0.824	0.748	0.778	0.767	0.774	0.759	0.723	0.697	0.746
Volgograd Oblast	0.723	0.714	0.687	0.684	0.711	0.685	0.680	0.638	0.620	0.667
Republic of Sakha (Yakutia)	0.877	0.910	0.918	0.916	0.950	0.958	0.923	0.924	0.917	0.923
Bryansk Oblast	0.653	0.666	0.669	0.663	0.695	0.685	0.733	0.694	0.674	0.727
Individual indicators of commercialization and effectiveness of the innovation activity in the region										
Moscow	0.921	1.029	1.078	1.120	1.150	1.145	1.121	1.107	1.014	1.054
Saint Petersburg	1.073	1.102	1.124	1.131	1.137	1.130	1.069	1.083	1.068	1.058
Republic of Tatarstan	0.858	0.902	0.861	0.925	0.908	0.964	0.976	0.968	0.954	0.940
Krasnoyarsk Territory	0.765	0.708	0.832	0.894	0.898	0.838	0.768	0.794	0.745	0.815
Perm Territory	0.735	0.842	0.801	0.769	0.812	0.813	0.801	0.857	0.861	0.820
Volgograd Oblast	0.794	0.782	0.712	0.622	0.602	0.644	0.680	0.662	0.700	0.668
Republic of Sakha (Yakutia)	0.610	0.580	0.640	0.654	0.737	0.714	0.617	0.739	0.629	0.756
Bryansk Oblast	0.908	0.818	0.838	0.860	0.806	0.850	0.875	0.874	0.829	0.731
Generalized indices for the support infrastructure for scientific, research, technical and innovation activity in the region										
Moscow	1.213	1.246	1.320	1.340	1.341	1.295	1.230	1.221	1.185	1.216
Saint Petersburg	1.259	1.264	1.277	1.281	1.282	1.332	1.305	1.305	1.303	1.311
Republic of Tatarstan	1.149	1.212	1.212	1.235	1.188	1.254	1.252	1.251	1.246	1.247
Krasnoyarsk Territory	1.070	1.043	1.143	1.164	1.169	1.192	1.158	1.162	1.145	1.171
Perm Territory	1.070	1.109	1.129	1.116	1.184	1.178	1.168	1.181	1.178	1.174
Volgograd Oblast	1.116	1.109	1.080	1.058	1.047	1.101	1.110	1.098	1.111	1.110
Republic of Sakha (Yakutia)	1.076	1.075	1.101	1.149	1.185	1.182	1.147	1.184	1.148	1.195
Bryansk Oblast	1.182	1.163	1.171	1.170	1.110	1.172	1.185	1.180	1.158	1.133

scientific, research, technical and innovation activity. According to the city mayor, the project was developed in collaboration with the research community of the Higher School of Economics in 2011, but the city development was ahead of the document development pace.

At the same time, regardless of the absence of some regulatory legal acts, there representatives of each of the elements of the support infrastructure for scientific, research, technical and innovation activity are present and developing in the city, thereby providing the synergy effect. Apart from that, it is also possible to consider the quantitative distribution of the infrastructure facilities by element types (Table 4).

Despite good support of all the innovation cycle stages, the city of Moscow lacks optimality of infrastructure availability; the optimal value is 1. (Official Website of NIAC MIIRIS). Reviewing the computed data, one can notice that the major number of facilities were evaluated by their human resources and production-technological infrastructure. The city of Moscow is a real leader in the number of top educational institutions, including higher education institutions and research organizations.

Let us study the parameters of Saint Petersburg from Table 3. Similar to Moscow, the operation efficiency of the support infrastructure for scientific, research, technical and innovation activity has been stable throughout the decade.

Since 2014, the regulatory legal support of science and innovation domains in the city has included the entire range of documents underlying the innovation activity as a whole and maintaining the support infrastructure for scientific, research, technical and innovation activity. Therefore, it is possible to note that the enactment of the related decrees caused the rise in the generalized index in 2014 compared with the previous year's value.

Reviewing the infrastructure availability (Table 4), it is worth noticing that there is a full range of infrastructural elements in the territory of the city, which proves the availability of the full innovation process cycle.

However, considering the ratio of the number of facilities of the support infrastructure for scientific, research, technical and innovation activity to the number of organizations involved in research and development activities, one may conclude that it is not optimal, being, on the average, 9% below the established reference value (Table 4). For this reason, there is a need to increase the number of facilities of the support infrastructure for scientific, research, technical and innovation activity in order to correct the ratio.

The fourth group parameters are dramatically decreasing in 2015. It was caused by the excessive technological innovation expenditures for the actual production volume, which may mean, according to the specialists, low technology transfer efficiency (Bondarenko et al., 2018; Mityakov, 2018).

Furthermore, let us consider the Republic of Tatarstan; according to Table 3, the efficiency of its facilities of the support infrastructure for scientific, research, technical and innovation activity appears relatively stable, though it is necessary to focus on some of the parameter groups.

The low value of the particular regulatory legal support availability indicator in 2009 was caused, first of all, by a "gap" in the special legislative act of the Republic due to the presence of its draft. At the same time, the Republic runs the State Program "Economic Development and Innovation Economy of the Republic of Tatarstan for 2014–2021", which, among other goals, aims at creating the right environment for the

Table 4 Distribution of the facilities of the support infrastructure for scientific, research, technical and innovation activity by elements

Element	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Moscow										
Financial	15	17	23	25	31	32	33	33	36	36
Production and technology	90	100	114	126	133	142	153	167	184	191
Information	8	8	8	8	8	8	8	8	8	8
Expertise and consulting	17	18	19	21	22	23	24	25	25	25
Human resources	264	268	256	248	223	227	203	179	161	153
Sales	5	7	6	8	8	9	10	9	11	10
Infrastructure availability level	0.927	0.959	0.982	1.110	0.985	1.103	0.933	0.961	0.969	0.992
St. Petersburg										
Financial	4	5	5	5	5	5	5	5	5	5
Production and technology	39	40	44	44	45	52	58	66	71	71
Information	1	1	1	1	1	1	1	1	1	1
Expertise and consulting	6	7	7	8	8	8	9	9	9	9
Human resources	89	90	84	82	77	77	76	71	66	66
Sales	5	6	6	7	7	7	8	8	8	8
Infrastructure availability level	0.815	0.866	0.848	0.879	0.904	0.934	0.960	0.964	0.977	0.979
Republic of Tatarstan										
Financial	1	1	1	2	3	3	3	3	3	3
Production and technology	12	15	15	20	25	30	32	30	34	34
Information	15	15	15	18	18	18	18	18	18	18
Expertise and consulting	6	6	6	10	11	12	15	16	16	17
Human resources	14	14	14	17	17	17	17	17	17	17
Sales	1	1	2	3	2	3	3	3	4	5
Infrastructure availability level	0.923	0.946	1.087	1.059	1.070	0.971	0.974	0.954	0.930	0.962
Krasnoyarsk Territory										
Financial	2	2	2	3	3	3	3	3	3	3
Production and technology	9	10	13	14	15	16	16	17	17	17
Information	3	3	3	3	3	3	3	3	3	3
Expertise and consulting	1	1	1	1	1	1	1	1	1	1
Human resources	10	12	12	11	11	10	10	9	8	8
Sales	1	1	1	1	2	2	2	2	2	2
Infrastructure availability level	0.863	0.938	1.119	1.093	1.061	1.061	0.886	0.879	0.908	0.846
Perm Territory										
Financial	2	3	3	3	3	3	3	3	3	3
Production and technology	7	8	11	11	12	13	13	15	15	16
Information	1	1	1	1	1	1	1	1	1	1
Expertise and consulting	3	3	3	4	4	4	4	4	4	4
Human resources	13	16	16	16	16	12	12	11	10	10
Sales	1	1	1	1	1	1	1	1	1	1
Infrastructure availability level	0.932	1.105	1.116	0.932	1.113	0.960	0.878	0.916	0.924	0.931
Volgograd Oblast										
Financial	1	1	1	1	1	1	1	1	2	2
Production and technology	4	5	5	5	5	6	6	7	7	7
Information	1	1	1	1	1	1	1	1	1	1
Expertise and consulting	1	1	1	1	1	1	1	1	1	1
Human resources	15	16	15	15	16	13	13	12	12	12
Sales	1	1	1	1	1	1	1	0	1	1
Infrastructure availability level	0.995	0.972	0.949	1.118	0.934	0.867	0.830	0.878	0.947	0.959

Table 4 (continued)

Element	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Republic of Sakha (Yakutia)										
Financial	1	1	2	2	2	2	2	2	2	2
Production and technology	8	8	9	11	11	12	13	15	17	19
Information	1	1	1	1	1	1	1	1	1	1
Expertise and consulting	1	1	1	1	1	1	1	1	1	1
Human resources	7	9	9	6	7	7	7	7	7	7
Sales	1	1	1	1	1	1	1	1	1	1
Infrastructure availability level	0.818	0.870	0.957	0.875	0.917	1.000	1.087	1.000	1.036	1.107
Bryansk Oblast										
Financial	1	1	3	3	3	3	3	3	3	3
Production and technology	2	2	4	6	6	6	7	7	8	9
Information	1	1	1	1	1	1	1	1	1	1
Expertise and consulting	1	2	2	3	3	3	3	3	3	3
Human resources	5	5	5	5	5	5	5	5	5	5
Sales	1	1	1	1	1	1	1	1	1	1
Infrastructure availability level	0.856	1.034	1.043	0.898	0.898	0.922	0.823	0.895	0.824	0.779

efficient functioning of the innovation economy, including the functioning of the support infrastructure for scientific, research, technical and innovation activity.

The Republic has the entire set of infrastructure elements, which indicates proper infrastructure availability for the complete innovation process cycle (Table 4).

The greatest number of facilities was found in the information element. The Republic of Tatarstan is the leader of the Russian Federation in the number of Technology and Innovation Support Centers, which inventors and research fellows may use for free to search information in the closed Rospatent databases. Moreover, Innopolis, a special economic zone of technical and implementation type, has been founded in Tatarstan. This project is unique in creating a good environment for the comfortable accommodation and work for the young IT specialists in the same area with the necessary social infrastructure, and offering a range of benefits and preferences.

It should be noted that the human resources element of the infrastructure has been in the moderate risk zone throughout the studied period. Such a tendency is caused, first of all, by the low number of specialists engaged in scientific research and development; however, regardless of the failure to fulfill the reference parameter value, the Republic of Tatarstan is one of the leaders in innovation development with a stable growth in the invention activity and a big number of the developed top production technologies.

The next analyzed region is the Krasnoyarsk Territory. Based on the data in Table 3, the generalized index of the support infrastructure for scientific, research, technical and innovation activity of the Krasnoyarsk Territory underwent some changes, which means that the reasons for such changes need to be revealed.

The regulatory legal support, being the foundation for the development and operation of the support infrastructure for scientific, research, technical and innovation activity is noted to be developing in a stagewise manner. For instance, in 2009–2010, there were no strategic planning documents at the regional level; neither was there a

State Program for this domain in 2009–2013. However, in 2011 and 2014, the situation changed through the enactment of the Law of the Krasnoyarsk Territory No.13-6629 of December 01, 2011 "On Scientific, Research, Technical and Innovation Activity in the Krasnoyarsk Territory", and the establishment of the State Program of the Krasnoyarsk Territory "Development of Investment Activity, Small and Medium-Sized Businesses" for 2014–2030.

Studying the availability of the proper number of facilities of the support infrastructure for scientific, research, technical and innovation activity in the given element (Table 4), it was discovered that at the present moment, this branch of support is not developing effectively enough. Since the beginning of the State Program execution, no significant increase in the number of infrastructure facilities has occurred, and the optimality of the infrastructure availability has also been unstable.

Among the problems of the region, it is also possible to notice a low share of the personnel engaged in scientific research and development. One of the reasons of the negative tendencies described above is the insufficiency of action and lack of governmental support for the scientific, research, technical and innovation activity in the Krasnoyarsk Territory, which is also expressed in the program document of the region. For this reason, there is a need for creating new and developing the current support infrastructure facilities, as well as for increasing the level of integration and interaction between science and business.

Throughout the studied period, the generalized index of the support infrastructure for scientific, research, technical and innovation activity of the Perm Territory has been in the moderate risk zone (Table 3).

Similar to that of the Krasnoyarsk Territory, the regulatory and legal support here has been developing in a stage-wise manner. For instance, in 2009 and 2010, there was no necessary strategic planning document. Besides, in 2009–2012, there were no governmental programs in the studied domain either. However, they were enacted in 2011 and 2013. Thus, the state subprogram of the State Program "Economic Development and Innovation Economy" determines one of its tasks for the achievement of the set goal as the development of a proper support infrastructure for scientific, research, technical and innovation activity to promote accelerated creation and development of innovative enterprises.

Since 2013, there has been a rise in the number of production and technological element facilities of the support infrastructure for scientific, research, technical and innovation activity in the Perm Territory (Table 4).

Throughout the decade, the fourth group performance has been in the significant and moderate risk zones. The Perm Territory experiences an obvious deficit of research personnel, including research fellows with academic degrees; for efficient operation of the innovation system, the region needs twice more than it currently has. It directly indicates the need for the development of the human resources in the support infrastructure for scientific, research, technical and innovation activity of the Territory to increase the numbers of highly qualified staff. Apart from that, another problem is a lack of budget required for taking the major measures aimed at the promotion of the innovation development of the region.

Studying the Volgograd Oblast, one may notice that its generalized index is within the significant and moderate risk zones. For 4 years, from 2009 to 2013, the region had no State Program. However, enacted in 2014, it has been adhered to until today. The document highlights the lack of budget and infrastructure for the implementation of the innovative projects of the innovation activity subjects. Let us consider the elements of the support infrastructure for scientific, research, technical and innovation activity of the region comprehensively (Table 4).

Among all the regions studied above, the optimality index of the infrastructure availability in the Volgograd Oblast is the lowest, far behind the threshold value. For this reason, it appears necessary to create additional infrastructure facilities to make the right environment for the enhancement of the innovation development in the region; is also causes parameter groups 3 and 4 in the region to fall to the significant and moderate risk zones.

In the infrastructure development level, the Republic of Sakha (Yakutia) is similar to the region shown above, but, unlike that of the Volgograd Oblast, the generalized index of the support infrastructure for scientific, research, technical and innovative activity of the Republic stands in the stability zone. Let us analyze the factors that could cause such an outcome.

Thus, analyzing the regulatory legal support, it is worth mentioning the absence of any State Program for the research, technical and innovation development of the Republic of Sakha from 2009 to 2011; it was developed in 2012, as in other regions, aimed at promoting the innovation and technological development and forming a competitive economy through the development of regional support infrastructure for scientific, research, technical and innovation activity. The main elements of the support infrastructure for scientific, research, technical and innovation activity of the Republic of Sakha (Yakutia) are presented in Table 4.

Starting from 2014, there has been a rise in the number of facilities in the production and technological element of the support infrastructure, which proves the availability of a set of actions to enhance the development of the region.

Studying the indicators of the innovation creation potential groups, one may notice that all of them were in the moderate risk zone, close to stability. This is explained by the fact that the state education expenditures to GRP ratio in the Republic is sufficient, and there is a high share of researchers with an academic degree. However, one can also notice a low share of personnel engaged in research and development. This may be related to the actual profile of the Republic focused on the mining industry, which constitutes over 50% in the GRP structure. For this reason, there is a low invention activity factor as well as a low share of innovative products, works and services.

The last region to be analyzed was the Bryansk Oblast. Reviewing the generalized score of the support infrastructure for scientific, research, technical and innovation activity, it is found that all of them are in the stability zone. Let us outline the major factors.

The Oblast has the complete necessary regulatory and legal base that creates foundation for the innovation development and operation of the support infrastructure for scientific, research, technical and innovation activity. Therefore, in this regard, the region stands in the stability zone.

It has all types of the support infrastructure elements, and, therefore, a complete innovation cycle. Based on Table 4, we may conclude that throughout several years, there have been no changes in the dominating majority of elements, except for the production and technological one. At the same time, there is a staffing problem caused by a low number of people engaged in research and development; however, the share of innovative products and well-developed top production technologies in the total technologies currently used by industries is high. Therefore, it may be assumed that the elements of the support infrastructure for scientific, research, technical and innovation activity that are represented at a greater ratio to one innovative enterprise than they are in other regions, generate a positive result in the innovative economy development.

Conclusions

A high value of the total integral index does not always signify absence of problems in some parameter groups; a region being a leader in the integral index may be inferior to an average region in some parameters. For this reason, comprehensive analysis and effective innovation development practice selection requires considering every parameter group separately.

As a result of the test carried out, we may notice the effectiveness of the method for determination of bottlenecks in the composition and efficiency of the support infrastructure for scientific, research, technical and innovation activity. The applied method may be used to form a general integral index and to analyse the efficiency of infrastructure functioning in some particular parameters. Separation of the regulatory and legal support parameters into one group allowed to identify the bottlenecks and gaps (almost in all analyzed regions) in the regional legislation that hold back the innovation progress. The synergy effect of the support infrastructure makes it possible to take into consideration such parameters as the closed innovation cycle and the way of innovation support at different stages of technological transfer in various regions. Remarkably, a big number of support infrastructure facilities does not always mean efficient operation.

Abbreviations

R&D	Research and development
EU	The European Union
NIAC MIIRIS	National Information and Analytical Center for Monitoring the Innovative Infrastructure of Scientific and Technical Activities and Regional Innovation Systems
GRP	Gross Regional Product
RA	Rating Agency

Acknowledgements
Not applicable.

Author contributions
All authors read and approved the final manuscript.

Funding
The study was supported by the Russian Science Foundation grant No. 22-78-00011, https://rscf.ru/project/22-78-00011/.

Availability of data and materials
All data generated or analysed during this study are included in this published article.

Declarations

Competing interests
The authors declare that they have no competing interests to declare.

Received: 18 November 2021 Accepted: 16 November 2022
Published online: 30 November 2022

References

Adam Smith International [Electronic resource]: Measuring and Maximising Value for Money in Infrastructure Programmes. (2012). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/194319/measure-maximize-VfM-infrastructure.pdf

Ascani, A., Bettarelli, L., Resmini, L., Balland, P. (2020). Global networks, local specialisation and regional patterns of innovation, Research Policy, 49 (8).

Bell, A., Chetty, R., Jaravel, X., Petkova, N., & Reenen, J. V. (2019). Who Becomes an Inventor in America? *The Importance of Exposure to Innovation, the Quarterly Journal of Economics, 134*(2), 647–713. https://doi.org/10.1093/qje/qjy028

Bezpalov, V. V., Fedyunin, D. V., Solopova, N. A., Avtonomova, S. A., & Lochan, S. A. (2019). A model for managing the innovation-driven development of a regional industrial complex. *Entrepreneurship and Sustainability Issues, 6*(4), 1884–1896. https://doi.org/10.9770/jesi.2019.6.4(24)

Bondarenko, V. V., Chakaev, R. R., Leskina, O. N., Tanina, M. A., Yudina, V. A., & Kharitonova, T. V. (2018). The role of regional development institutions in enhancing the innovation potential of the constituent entities of the Russian Federation. *Regional Economics: Theory and Practice, 16*(1), 83–100. https://doi.org/10.24891/re.16.1.83

Bondarev, S. A., & Turina, VYu. (2011). Regulatory support innovation in the Russian Federation. *Vestnik Saratov State Technical University, 2*(60), 345–349.

Colombelli, A., Grilli, L., Minola, T., & Mrkajic, B. (2020). To what extent do young innovative companies take advantage of policy support to enact innovation appropriation mechanisms? *Research Policy, 49*, 1–17.

Crossing the next regional frontier [Electronic resource]. Information and Analytics Linking Regional Competitiveness to Investment in a Knowledge – Based Economy. U. S. Economic Development Administration, 2009. Available at: http://www.statsamerica.org/innovation.

Dalekin, P.I. (2018). Improvement of Standard Legal Support of Innovative Activity in The Russian Federation. Proceedings of Voronezh State University. Series: Law, 3(34), 51–61. Available at: http://www.vestnik.vsu.ru/pdf/pravo/2018/03/2018-03-03.pdf

Filipishyna, L., Bessonova, S., & Venckeviciute, G. (2018). Integral assessment of developmental stability: Cases of Lithuania and Ukraine. *Entrepreneurship and Sustainability Issues, 6*(1), 87–99. https://doi.org/10.9770/jesi.2018.6.1(7)

Firsova, A. A., Makarova, E. L., & Tugusheva, R. R. (2020). Institutional management elaboration through cognitive modeling of the balanced sustainable development of regional innovation systems. *Journal of Open Innovation: Technology, Market, and Complexity, 6*(2), 32. https://doi.org/10.3390/joitmc6020032

Gokhberg, L. M., et al. (2020). The Rating of Innovative Development of The Constituent Territories of The Russian Federation: Analytical Report. National Research University Higher School of Economics, 6, 264 p. Available at: https://www.hse.ru/primarydata/rir2019

Ivanova, I., Strand, O., & Leydesdorff, L. (2019). The synergy and cycle values in regional innovation systems: The case of Norway. *Foresight and STI Governance, 13*(1), 48–61. https://doi.org/10.17323/2500-2597.2019.1.48.61

Ivashchenko, N. P., Denisova, S. A. Innovation Process and Forms of Innovation Commercialisation. Academic Material. [Electronic resource]. Available at: http://www.msu.ru/projects/amv/doc/h6_1_6_1_nom3_2.pdf

Khuchbarov, A. U. (2015). Human Capital as A Factor of Regional Development. Humanities, Social-economic and Social Sciences, 10, 72–75. Available at: https://www.online-science.ru/m/products/economi_sciense/gid3166/pg0/

Kiškis, M., Limba, T., & Gulevičiūtė, G. (2016). Business value of intellectual property in biotech SMEs: Case studies of Lithuanian and Arizona's (US) firms. *Entrepreneurship and Sustainability Issues, 4*(2), 221–234. https://doi.org/10.9770/jesi.2016.4.2(11)

Koroleva, L. P., & Ermoshina, T. V. (2014). Innovation infrastructure: Composition and place in the innovation system of the economy. *Innovations, 12*(194), 59–61.

Kremer, M. (2020). Experimentation, Innovation, and Economics. *American Economic Review, 110*(7), 1974–1994. https://doi.org/10.1257/aer.110.7.1974

Kudriavtseva, S. S. (2012). Comparative Analysis of Innovative Development of The European Union Countries and Russia (Based on the European Innovation Scoreboard Methodology)—Problems of Raw Economies. *Bulletin of Kazan Technological University, 15*(19), 204–208.

Kumar, I., Nolan, Ch., Cordes, S., Conover, J., Rogers, C., Strange, R., Galloway, H., Morrison, Ed, Drabenstott, M., Waldorf, B. (2009). Crossing the Next Regional Frontier: Information and Analytics Linking Regional Competitiveness to Investment in a Knowledge-Based Economy. Available at: https://www.researchgate.net/publication/277142742_Crossing_the_Next_Regional_Frontier_Information_and_Analytics_Linking_Regional_Competitiveness_to_Investment_in_a_Knowledge-Based_Economy

Laužikas, M., Miliūtė, A., Tranavičius, L., & Kičiatovas, E. (2016). Service innovation commercialization factors in the fast food industry. *Entrepreneurship and Sustainability Issues, 4*(2), 108–128. https://doi.org/10.9770/jesi.2016.4.2(1)

Loginov K. K. (2015). Analysis of Indicators of Regional Economic Safety. The Russian Automobile and Highway Industry Journal, 2(42), 132–139. Available at: https://vestnik.sibadi.org/jour/article/view/136/134

Mityakov, E. S. (2018). Development of Methodology and Tools for Monitoring the Economic Security of Russian Regions (Thesis for the Degree of the Doctor of Economics), Nizhny Novgorod, 360 p. Available at: https://search.rsl.ru/ru/record/01009944030

Mityakov, E.S., Mityakov, S.N. (2014). Adaptive approach to calculation of the generalized index of economic security. Modern Problems of Science and Education, 2, 415–421. Available at: https://www.elibrary.ru/item.asp?id=21471412

Official Website of Association of Innovative Regions of Russia [Electronic resource]. Available at: https://i-regions.org/

Official Website of The Rating Agency "Expert RA" [Electronic resource]. Available at: https://www.raexpert.ru

Official Website of The Rating Agency "RIA Rating" [Electronic resource]. Available at: https://riarating.ru
Pan'shin, I.V., Kashitsyna T.N. (2009). Improving the methodology for the component assessment of the level of the regional innovation infrastructure development. Regional Economics: Theory and Practice, 30(123), 43–53. Available at: https://www.elibrary.ru/item.asp?id=12854823
Parrilli, M. D., Balavac, M., & Radicic, D. (2020). Business innovation modes and their impact on innovation outputs: Regional variations and the nature of innovation across EU regions. *Research Policy*. https://doi.org/10.1016/j.respol.2020.104047
Rezk, M. A., Ibrahim, H. H., Radwan, A., et al. (2016). Innovation magnitude of manufacturing industry in Egypt with particular focus on SMEs. *Entrepreneurship and Sustainability Issues, 3*(4), 307–318. https://doi.org/10.9770/jesi.2016.3.4(1)
Rezk, M. A., Ibrahim, H. H., Tvaronavičienė, M., et al. (2015). Measuring Innovations in Egypt: Case of Industry. *Entrepreneurship and Sustainability Issues, 3*(1), 47–55. https://doi.org/10.9770/jesi.2015.3.1(4)
Ruiga, I. R., Byvshev, V. I., Panteleeva, I. A. (2019). Evaluation of Efficiency of Regional Innovation Infrastructure: Formation of Methodological Principles and Performance Indicators. Innovative Development of Economy, 2(50), 62–71. Available at: https://ineconomic.ru/en/node/1864
Semenov, E. V. (2007). Human Capital in Science. International Organisations Research Journal, 2(4), 24–39. Available at: https://www.hse.ru/en/mag/nohead/vmo/2007-2-4/26975518.html
Veselovsky, M. Y., Izmailova, M. A., Lobacheva, E. N., Pilipenko, P. P., & Rybina, G. A. (2019). Strategic management of innovation development: Insights into a role of economic policy. *Entrepreneurship and Sustainability Issues, 7*(2), 1296–1307. https://doi.org/10.9770/jesi.2019.7.2(34)
Website of the National Information and Analytical Center for Monitoring the Innovative Infrastructure of Scientific and Technical Activities and Regional Innovation Systems [Electronic resource]. Available at: http://www.miiris.ru
Zollo, G., Autorino, G., De Crescenzo, E., et al. (2011). A Gap Analysis of Regional Innovation Systems (ris) With Medium-Low Innovative Capabilities: The Case of Campania Region (Italy), 8th ESU Conference on Entrepreneurship, 1–21. Available at: https://idus.us.es/handle/11441/57776

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.