

INVENTIVE ACTIVITY OF RESEARCHERS: CROSS-COUNTRY RATINGS

The recent years have seen the intensified studies of the research potential of Russia and its regions not only in terms of the set of major components (human, financial, informational, organizational, logistical) that make up this potential but also from the standpoint of evaluating the productivity and efficiency of researchers. The cross-country analysis uses separate highly aggregative parameters, the values of which are usually not in favor of Russia. However, after an in-depth study of this subject, these assessments do not appear to reflect correctly the real trends of inventive activity in the science and technology sphere of Russia and its regions. In addition, the realization of creative potential by researchers is measured primarily through the systems based on evaluation of their publication activity. The issue of rating the inventive and patent activity of researchers and its products in the cross-country context (especially detailed ratings), as well as its institutional determinants, clearly does not attract sufficient attention. These considerations determined the choice of the subject for this study. Its empirical basis was provided by statistical materials of both Russian and foreign databases recognized by the world scientific community. This study is focused on theory and methodology, as well as on procedures. The goal is to develop the methodological and procedural tools for studying and assessing the inventive activity of researchers, including the procedural support for cross-country comparative assessments. Based on their previous studies, the authors advanced the hypothesis that, amid declining level of available financial resources, continuous reduction in the number of researchers, institutional constraints and contradictions, the inventive activity of Russian researchers largely remains and is implemented in a number of its major parameters on the same level as in advanced countries. Based on the goals and objectives of the study, the authors used a parametric model that identified and evaluated the parameters, methods and indicators ensuring a comprehensive assessment of dynamics in the inventive and patent productivity and efficiency, which allows to achieve a high level of reliability. The methods used by the authors included dialectical and epistemological method, structural and logical method, structural and functional method, decomposition method, method of statistical grouping, and index method. The study involved the transition from traditional analysis with high-level parameters and indicators to analysis with indicators of reasonable detailing. The authors proposed and clarified new key performance indicators grouped by such criteria as inventive activity, patent activity, and efficiency. They substantiated the expediency of using the dialectical combination of process-oriented assessments, performance assessments and vector assessments reflecting the development trends. The results of this study may be considered in the elaboration of management decisions by the relevant entities responsible for science, technology and innovation policies at all levels of government and management.

Keywords: inventive activity of researchers, theoretical and methodological foundations, procedural designs, parametric model, cross-country rating, dialectic and epistemological method, decomposition method, method of statistical groupings, process-oriented assessments, performance assessments

Introduction

Recognizing the priority of innovative development and efficient use of the existing potential across all types of resources and factors is characteristic of the world's leading countries. The creative potential of researchers plays a special role in the system of these resources. It is realized not only in the form of high-quality scientific studies (the assessment of which attracted much attention in recent years), but also through inventive and patent activity, creation of competitive intellectual products. A legitimate concern is often expressed about Russia's low indicators of publishing activity in the global flow of publications, which certainly has some objective reasons (low share of Russian publications in international citation indexes, keeping records of references in English, intensive decline in the number of productive researchers of older generation, etc.) For example, in 2014, Russia's share in the world was 2.11 % of articles and, in early 2016, 2.28 % of articles indexed in the Web of Science¹. The situation is even harder in the area of inventive and patent activity². In 2015, the world's share

¹ Rasshirenie deyatelnosti? [Increasing activity?] In Russian. (2016). Poisk. Ezhenedelnaya gazeta nauchnogo soobshchestva [The Search. Weekly Newspaper of Scientific Community], 7, 2.

² Data of Organization for Economic Cooperation and Development. Retrieved from: <http://www.oecd.org> (date of access: 1/22/2017).

of Russian national applications for inventions was 1.2 % (while the US share of similar applications stood at 18.2 % and, for Japan, it was 15.7 %). There is also a very significant lag in terms of titles of protection issued to Russian national applicants compared to the national applicants from the leading countries of the world: Russia – 2.0 %, USA – 20.6 %, Japan – 21.8 %.

Given that these parameters, as a result of the high level of aggregation, including their causation by the impact of negative patterns of institutional nature prevailing in Russia, cannot objectively reflect the real trends of the actual inventive activity, we conducted a detailed analysis of the dynamics of Russian inventive activity compared to the inventive activity in the OECD countries. We used both traditional and our own criteria while elaborating on the relevant areas for achieving higher and more sustainable results.

Theoretical Basis

The leading theoretical basis of this study is the fundamental theory of social reproduction, the various aspects of which are being developed both by Russian and foreign scientists.

The social reproduction is a multidimensional, complex and contradictory process. By summarizing the methodological foundations of its study, we can identify a number of areas, including single-phase, evolutionary, level-based, structural and functional areas. When analyzing a major component of the research efficiency within the framework of scientific and technological potential reproduction, this study is based primarily on the two last areas, including inventive and patent activity.

The theory of reproduction of scientific, technological, and technical capacities is associated with theories of innovative development, knowledge economy, including the works on intellectual capital, intellectual property, etc.

In accordance with the subject of this study, a special place is held by the materialization theory, the material implementation of scientific knowledge in the reproductive system of “Science—Technology—Economy” proposed by A.I. Anchishkin, who substantiated the necessity of dialectical unity in this system of needs, interests, and motivations of all actors involved [1]. A productive methodology is provided by the research of reproduction relations in science and technology through the mechanism of the interaction between three sectors, including research, production of means of production, production of competitive products [2], macroeconomic scientific and technological transformation, technological modes [3]. The authors conducted their research in line with the comprehensive studies prepared by the leading scientific teams in the area of the scientific and technological renovation of the Russian economy with an in-depth analysis of a wide range of the most relevant issues [4, 5].

Among the basic theories of our study, a special place is held by the intellectual capital theory, the genesis of which is due to the increasing role of intellectual and creative potential of researchers in the scientific and technological transformation of Russian economy and regions. At the same time, there is a certain lack of studies of these key subjects in the system of social reproduction. A significant contribution to fill this gap was made by the conceptual work of A.I. Tatarkin, who identified and substantiated the role of intellectual resources of society as a major driving force of “sustainable extensive and balanced reproduction of national wealth on intensive basis” [6]. Its core component is the creative potential of researchers implemented through mobilization of their abilities and capacities to multiply the professional knowledge and skills in the creation of original and unique intellectual products with both social and sought-after market properties [7]. These unique characteristics of researchers determined the desire of scientists to reflect them in new categories. For example, L.V. Milov and a number of other scientists identify the “ownership of mastery” as a category that reflects the specifics of ownership held by the “carriers of uniquely valuable use values in the area of intellectual work” [8, P. 804]. Some researchers suggest to consider the “creators as a new class of owners” and as “the main resource of innovative economy” [9].

The protection of results of intellectual activity, including inventive activity, is implemented within the relevant regulatory acts. The provisions of these documents do not fully take into account the specifics of complex and contradictory relationship between stakeholders (individuals and legal entities) and distribution of their rights to objects of intellectual property. For example, some specific aspects of intellectual property alienation require to prepare detailed contracts. This is caused primarily by the specific origin of its objects resulting from hard intellectual work conducted mainly by individual researchers, their inseparability from their creators [10].

V.A. Dozortsev, one of the leading experts on intellectual property rights, notes that creativity “is an environment of purely individual activity represented only by living labor embodied in the personality of the author,” and it is necessary to clearly distinguish the labor in terms of “generating the creative results and facilitating such results ... The grounds for the emergence of rights... are provided only by personal contribution, or something new that was made by the creator” [11, P. 282].

The transfer and commercialization of intellectual products in science and technology should be based on the economic criterion of feasibility and effectiveness in order to avoid the loss of this valuable resource.

In theory and practice of intellectual property, one of the major problems is the development of a mechanism for protecting the ownership rights to inventions (industrial property objects), which have a fundamental novelty, high inventive level, and industrial applicability. This is implemented primarily through patents certifying priority, authorship of inventor and his exclusive right to use this product. There is not enough attention to the economic aspects of this mechanism.

In a market economy, the use of intellectual property objects means the ability to generate additional income from a monopoly on new technology, the sale of patents and licenses. In our opinion, this is one of the manifestations of the objective economic law of scarcity, limited resources, which was noticed as early as by David Ricardo, who associated the increase in the cost of goods with their scarcity [12]. Modern works study patenting as a necessary condition for ensuring the monopoly of inventor (with certain restrictions) and the ways for a more active role of patents in stimulating the competition. The patent protection implies a particular strategy for licensing, commercialization, and market circulation of inventions [13, P. 167–212], while the economic essence of patents and their functions found their conceptual reflection in a number of studies [14, 15].

When the invention is involved in commercial circulation, the inventor should find it more beneficial to sell (transfer) the rights (or certain powers) to use such invention in terms of covering direct costs (to create it) and transaction costs (particularly for specifying the property rights), rather than keep the invention secret. However, Russian expert recommends to protect today’s complex intellectual property objects, such as the inventions in the area of nanotechnology (given their specific character, including interdisciplinary nature), in the form of a trade secret or industrial secret [16, P. 12].

In addition, the complexity of the problem of keeping (not keeping) the invention in secret is associated with the modern focus of researchers on the active publishing of their results. The publishing gives rise to protection of these results, but for the most part only for moral rights of the author. There may be problems with recording the property rights to patentable results, such as exclusive (monopoly) right to use the invention, the exclusion of other persons, right to sell licenses, etc., including those associated with the premature publication before submitting the application to the patent office, as well as those related to the use of works without patent protection by competitors. The developed countries (especially, the USA) allow to obtain a preliminary patent, which reduces the above risks. However, in Russia, this type of protection is virtually not used.

As we have already indicated, the monopoly (limited) of the author (creator) of the invention is ensured by the relevant legal norms and certainly meets the interests of the inventor and the interests of organizations, the state, and society as a whole. One of the key business objectives in the area of patent protection is to eliminate illegal use of inventions in order to address, in one way or another, the institutional problem of “free riders.” The creator of the invention should be able to recoup the incurred costs and have incentives, including rent, to continue his intensive and complex activity. The costs of the inventor and other interested agents can be viewed as specific and often unrecoverable investments (for example, due to imperfect legal protection). In addition, the undeveloped market for products of intellectual activity and, consequently, the absence or incompleteness of information on transactions with such complex products give rise to the problem of adequately assessing their market value and, as a result, the problem of getting income and having incentives for the creation of these products. The interests of organizations, state, and society as a whole can also be violated when the inventions (mostly those having good prospects) are appropriated by agents of other countries. They also may be violated in the case of the deficit (absence) of such necessary institutional conditions, as the developed institution of venture capital [17–21].

The general and specific theoretical aspects identified above reveal the essence and main characteristics of the research object and, in our opinion, play a leading role in the development of methodological foundations for its study and implementation.

It should be noted that a lot of attention is paid to procedural aspects, in particular, the assessment of results of the inventive activity, including the intellectual property objects [22–24]. However, there is a lack of works on comparative (rating-based) cross-country assessments of inventive activity of researchers, which are crucial for developing theoretical, methodological, and procedural foundations and adopting science-based management decisions.

Model, Methods, and Indicators of Assessment

The scientists use a varied set of models, methods, and indicators for the assessment of researcher work. Based on the goal and objectives of this study, we selected a parametric model with such parameters (components), methods, and relevant indicators that ensure a comprehensive assessment of inventive activity and the efficiency providing the necessary level of validity. The novelty of the proposed solution is in the transition from the traditional analysis with high-level parameters and indicators to the analysis with indicators of reasonable detailing, including the use of decomposition method, a method of statistical grouping, and index method. We introduced some clarified and new indicators, and made the focus on the dialectics of process-oriented assessments, vector-based assessments (those reflecting specific trends), and effectiveness assessments. Based on this methodology and methods, we monitored and compared key parameters describing the development of inventive activity in Russia and leading countries of the world taking into account the results of our earlier study [25, P. 40–110].

The dynamics in the submission of patent applications by researchers and issuance of patents (by applicant categories) are presented in Table 1.

Table 1

Number of Patent Applications and Issuance of Patents for Inventions in the Russian Federation*

Indicator	Number of patent applications and patents granted by year						
	2000	2004	2006	2008	2010	2012	2015
Applications filed for patents of the Russian Federation	28,688	30,192	37,691	41,849	42,500	44,211	45,517
including by:							
Russian applicants	23,377	22,985	27,884	27,712	28,722	28,701	29,269
Foreign applicants	5,311	7,207	9,807	14,137	13,778	15,510	16,248
Patents granted in the Russian Federation	17,592	23,191	23,299	28,808	30,322	32,880	34,706
including to:							
Russian applicants	14,444	19,123	19,138	22,260	21,627	22,481	22,560
Foreign applicants	3,148	4,068	4,161	6,548	8,695	10,399	12,146
Effective patents of the Russian Federation	144,325	108,721	123,882	147,067	181,904	181,515	230,869

* According to the annual reports of Rospatent. Retrieved from: <http://www.fips.ru>. Date of access: 1/22/2017).

The data in Table 1 are used to calculate the following indicators of inventive and patent activity that are generally accepted in research and practical work:

- Rate of inventive activity;
- Rate of self-sufficiency;
- Rate of dependency.

The data on the dynamics describing the change of these indicators are presented in Figure 1.

We can identify the following key changes of indicators:

— Rate of inventive activity. The rate increased substantially in 2006 (from 1.65 to 1.96) and remained at about the same level until 2013 but, in 2014, it fell sharply (in fact, to the level of 2005). The fall of the indicator in 2014 resulted from decreased number of filed applications (Russia’s population remained virtually unchanged) (Table 1). In 2015, the value of the indicator returned to its 2013 level.

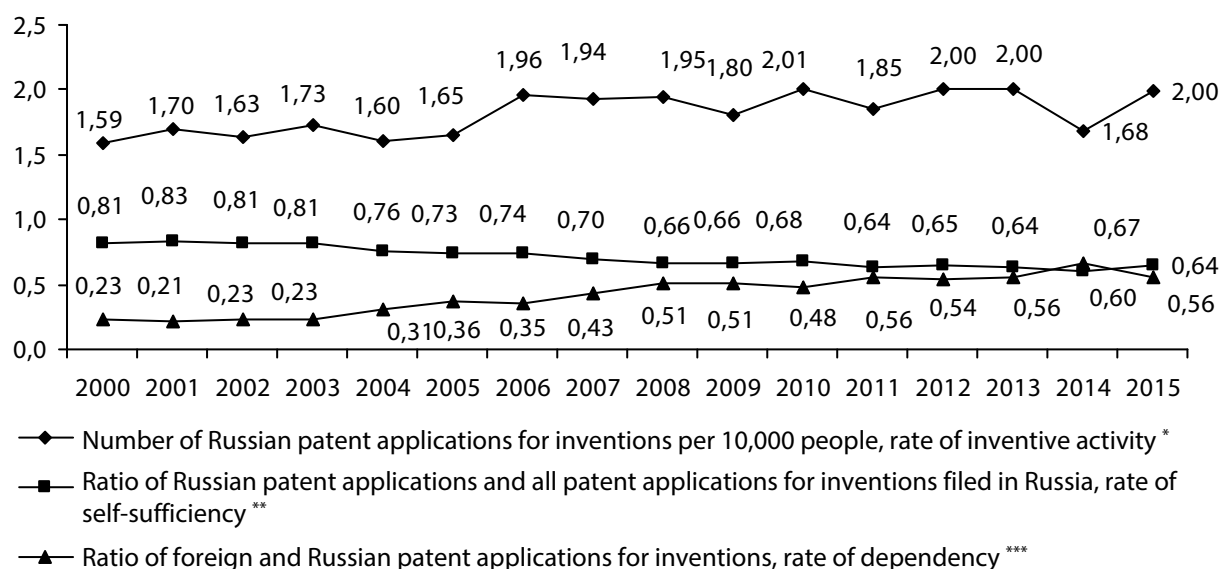


Fig. Indicators of patent activity in the Russian Federation in 2000–2015 (According to the annual report of the Federal Service for Intellectual Property (Rospatent) for 2015. Retrieved from: <http://www.rupto.ru> (date of access: 22/01/2017))

— Rate of self-sufficiency. After a substantial decline in 2000–2007 (mainly due to the stable growth in the number of patent applications filed by foreign applicants), the value of this indicator has remained relatively stable since 2008.

— Rate of dependency. The indicator began to grow in 2004. The most significant increase occurred in 2014: amid the increased number of applications filed by foreign applicants, there was the above-mentioned drop in the number of applications filed by Russian applicants.

In general, the number of applications by foreign applicants increased by about three times in 2015 compared to 2000. The dynamic growth of applications filed by foreign applicants has an objective basis since, in the international practice, filing a patent application in one country is accompanied by several applications in another country.

In terms of patents granted for inventions (Table 1), the share of Russian applicants in the total annual volume of granted patents fell from 82 % in 2000 to 65 % in 2015. In connection with sufficiently long periods of reviewing patent applications in Russia (for the inventions, this period is 12 months from the date of filing)³, the drop in the number of applications filed in 2015 did not affect the number of granted patents. It is also possible to conclude that the number of patents granted annually to foreign applicants is growing with significantly higher dynamics (from 2000 to 2015, it increased by about 3.9 times) than the similar figure for Russian applicants (in the same period, it increased by 1.6 times).

Results of Cross-Country Rating Assessments

For cross-country comparisons, we identified a number of key indicators and grouped them by such criteria as the inventive activity and efficiency, and patent activity and efficiency.

We calculated the indicators based on the data from the World Intellectual Property Organization (WIPO) and UNESCO Institute for Statistics⁴.

Inventive Activity and Efficiency

We identified the following indicators of inventive activity:

— Number of researchers per application (persons). This indicator is proposed for a more accurate cross-country comparison of the efficiency in the inventive activity. It is calculated with a time lag of one year, that is, the number of researchers in the previous year attributable to a single application in the subsequent year. This lag is introduced taking into account the average period of reviewing a patent application for the invention.

³ According to the Federal State Budgetary Institution Federal Institute of Industrial Property. Retrieved from: <http://www1.fips.ru> (date of access: 1/22/2017).

⁴ 7 Data of World Intellectual Property Organization (WIPO) (see <http://www.wipo.int> (date of access: 1/22/2017)) and UNESCO Institute for Statistics (see www.uis.unesco.org; date of access: 1/22/2017)).

- National patent applications per 10,000 people (rate of inventive activity).
- Ratio of national patent applications and all patent applications filed to the national patent office (rate of self-sufficiency).
- Ratio of foreign and national patent applications filed in the country (rate of dependency).
- Ratio of patent applications filed by domestic applicants abroad and in the country (rate of distribution).
- National patent applications per USD 1 million of R&D expenditures (items).

WIPO reports provide data only for two of the indicators that we selected in this group. Thus, WIPO calculates (at purchasing power parity in 2011):

- Patent applications per 1 million people.
- National patent applications per USD 1 million of R&D expenditures. The calculation of this indicator uses a time lag by taking into account the R&D expenditure for the year preceding the statistical data for the number of patent applications, as their registration takes on average 12 months.

We made the following sampling from the array of statistical data:

- Member countries of the Organization for Economic Cooperation and Development (OECD).
- Candidate countries for accession to OECD.
- Participant countries of OECD enhanced engagement program.

In January 2017, 44 countries belonged to these categories, including candidates countries for accession to OECD, such as Russia (in March 2014, the OECD Council postponed activities related to the OECD accession process for the Russian Federation for an indefinite period), Colombia, Latvia, Costa Rica, Lithuania; participants of OECD enhanced engagement program, such as Brazil, India, Indonesia, China, and South Africa. Given the lack of complete data for calculating some of the indicators selected by the authors, Indonesia was excluded from the sample. As a result, the sample included 43 countries.

The results of the analytical comparison of these indicators are presented in Tables 2 and 3. For each indicator, they show five leading and five lagging countries in the study group, as well as the rank of Russia and its nearest neighbors. Similarly, corresponding calculations were made by indicators and countries for 2007 [25], 2009, and 2014. Their use allows to make a comparative cross-country analysis of dynamics and to identify the leading trends and areas of developments.

The rates presented in the table (dependency and self-sufficiency) overlap to some extent, as the same values are actually used in their calculation.

Number of researchers per application. Compared to 2007 and 2009, the top five countries in 2015 are virtually the same, except for China (climbed to the 1st rank), Russia ranked 8th out of 43, which can be viewed as a positive result.

Rate of dependency. Compared to 2009, Russia's rank in 2015 did not change, it ranked 28th (the rate of 0.56 reflects its rank amid such leading countries of the world as the United Kingdom and Norway). In 2007, it ranked 22nd (with the rate value of 0.43). The higher is the rate, the higher is formal "dependency" of the country. However, in our opinion, the analysis should assess it in conjunction with other indicators. Rather than the independence of the country, the low value of this indicator may be a sign that foreign applicants do not consider it necessary to patent the results of their work given the low assessments of copying risks, or they are not present at all on the market of that country.

Rate of self-sufficiency. By this indicator, Russia ranks 28th, similarly as by the rate of dependency.

It should be noted that for calculating of indicators "National patent applications per 10,000 people" and "National patent applications per USD 1 million of R&D expenditures (items)," we used the data on applications filed by residents only to the national patent offices, where they are registered in the first instance (to avoid duplication when calculating the number of applications).

Rate of inventive activity. In 2015, Russia ranked 20th (with the value of the indicator of 2.05); in 2009, it ranked 18th (1.80); in 2007, 17th (1.94). In 2015, the USA appeared among the top five countries for this indicator.

Rate of distribution. By this indicator, Russia ranked 42th in 2015 (in 2009 and 2014 it ranked 34th). However, in absolute terms, the value of this indicator has slightly increased from 0.05 (2009) to 0.14. The very low value of this indicator is the sign of unfavorable situation in Russia (to the predominant extent, this is caused by the lack of funds, as well as by the particular aspects of the legal status held by the Russian defense industry enterprises) in terms of patenting the domestic intellectual property objects abroad. This often leads to the "leak" of intellectual activity results and causes serious problems when concluding international contracts involving these objects and establishing joint ventures.

Cross-Country Rating of Inventive Activity for 2015*

Rank among 43 countries	Number of researchers per application (persons)/country		Ratio of foreign and national patent applications filed in the country (rate of dependency)/country		Ratio of national patent applications and all patent applications filed to the national patent office (rate of self-sufficiency)/country	
	Value of indicator	Country	Value of indicator	Country	Value of indicator	Country
1	1.57	China	0.01	Lithuania	0.99	Latvia
2	2.07	Korea	0.02	Portugal	0.98	Portugal
3	2.64	Japan	0.02 (2009)	Slovenia	0.98 (2011)	Slovenia
4	4.40 (2013)	USA	0.03	Poland	0.97	Poland
5	7.46	Germany	0.04	Greece	0.96	Greece
...						
Country rank is given in brackets after the name	13.72 (2014)	Italy (6)	0.41	Germany (26)	0.71	Germany (26)
	15.12 (2014)	France (7)	0.53	United Kingdom (27)	0.65	United Kingdom (27)
	15.20	Russia (8)	0.56	Russia (28)	0.64	Russia (28)
	16.75	Turkey (9)	0.57	Norway (29)	0.64	Norway (29)
	16.81	Poland (10)	0.76	Ireland (30)	0.57	Ireland (30)
...						
39	64.66	Slovakia	7.43	South Africa	0.12	South Africa Israel
40	69.79	Ireland	7.64	Canada	0.12	Canada
41	85.52	Lithuania	11.49	Australia	0.08	Australia
42	105.25 (2014)	Costa Rica	12.25	Mexico	0.08	Mexico
43	144.10	Estonia	34.35	Costa Rica	0.03	Costa Rica

Note: If there is no data for the value of indicator in 2015, the information is shown for the last available year.

* Calculated by the authors according to the data of WIPO (retrieved from: <http://www.wipo.int>) and UNESCO Institute for Statistics (retrieved from: <http://www.uis.unesco.org>; date of access: 1/22/2017)). Calculated with a lag of one year as the number of resident researchers in the previous year to the number of applications from resident researchers in the current year. The latest available year is indicated in brackets.

It is also necessary to note the ambiguity of situation with this indicator in the leading countries of the world. For example, in 2014, the USA ranked 31st for this indicator (with the value of 0.83); Korea ranked 38th (rate of 0.42), which roughly corresponds to their values in the previous periods. In our view, one of the main reasons may be the strengthening of global trends towards keeping the inventions in the “know-how” mode (especially when entering the open international market), although the “know-how” tool is not without a number of drawbacks. Israel (ranks 1st) has the highest value of the indicator (10.26).

Our analysis shows, that when the Russian authorities view the low value of the indicator describing the ratio of patent applications filed by the Russian applicants abroad and the number of applications filed in Russia as the evidence pointing to the low level of achievements by Russian science, this may be not indisputable. At the same time, in the international practice, the patenting abroad is not only a tool to protect intellectual property objects, but also a means of limiting the ability of competitors to obtain the same or similar achievement.

Cross-Country Rating of Inventive Activity and Efficiency for 2015

Rank among 43 countries	National patent applications per 10,000 people (rate of inventive activity)* / country		Ratio of patent applications filed by domestic applicants abroad and in the country (rate of distribution)* / country		National patent applications per USD 1 million of R&D expenditures (items)** / country	
	Value of indicator	Country	Value of indicator	Country	Value of indicator	Country
1	33.05	Korea	10.26	Israel	2.79 (2014)	China
2	20.39	Japan	5.36	Ireland	2.54 (2014)	Korea
3	10.35	Switzerland	4.73	Canada	1.88 (2014)	Japan
4	9.51	Luxembourg	4.35	Italy	1.15 (2013)	New Zealand
5	8.97	USA	4.19	Switzerland	0.96 (2014)	Russia
...						
Country rank is given in brackets after the name	2.58	New Zealand (18)	—	—	—	—
	2.57	Iceland (19)	—	—	—	—
	2.05	Russia (20)	—	—	—	—
	2.00	Italy (21)	—	—	—	—
	1.80	Ireland (22)	—	—	—	—
...						
39	0.16	South Africa	0.41	Brazil	0.11 (2014)	Australia
40	0.11	Mexico	0.34	Poland	0.10 (2014)	Belgium
41	0.10	India	0.25	Turkey	0.10 (2014)	Estonia
42	0.07	Colombia	0.14	Russia	0.09 (2014)	Ireland
43	0.04	Costa Rica	0.04	China	0.06 (2013)	Costa Rica

Note: Some cells are lined through since there is no need to specify the values of indicator, as Russia ranked in the top five and bottom five countries for these indicators. If there is no data for the value of indicator in 2015, the information is shown for the last available year.

* Calculated by the authors according to the data of WIPO (see <http://www.wipo.int>) and the World Bank (see <http://data.worldbank.org>, date of access: 1/22/2017).

** Calculated by the authors according to the data from UNESCO Institute for Statistics (see <http://stats.uis.unesco.org>) and WIPO (see URL: <http://www.wipo.int>; date of access: 1/22/2017). The rate is calculated with a one year lag for R&D expenditures (number of patent applications for the latest year with available statistics was correlated with R&D expenditures incurred in the previous year), R&D expenditures by purchasing power parity in 2011.

For comparative analysis of patent applications filed by Russian applicants and applicants from a number of leading countries to the European Patent Office, we took a sample of relevant statistical data (Table 4)⁵.

The statistics presented in Table 4 show that Russia is significantly behind the leading countries in terms of the number of patent applications filed to the European Patent Office. Thus, in 2014, it lagged behind Japan and Germany by more than 100 times, and behind the United States by nearly

⁵ OECD data. Retrieved from: <http://www.oecd.org> (date of access: 1/22/2017).

Patent applications filed to the European Patent Office (number)

Country	Number of patent applications filed to the European Patent Office, by year				
	2010	2011	2012	2013	2014
Russia	177	168	185	232	208
Germany	27,354	26,230	27,285	26,576	25,672
USA	39,519	34,987	35,224	33,859	36,686
Japan	21,824	20,568	22,699	22,566	22,111
China	2,049	2,548	3,733	4,059	4,657

200 times. The gap with China was smaller (about 22 times). However, China is much more dynamic in increasing the pace of filing its patent applications (in 2010–2014, their number grew by 2.3 times, while the number of Russian applications increased by 1.3 times.). This means that the lag of Russia behind China is likely to increase.

Overall, we should note that, in terms of the aggregate indicator of patent activity, Russia also lags very significantly behind its own pre-perestroika level. According to experts, in the mid-1970s, the share of Russia in the total number of national patent applications filed for inventions in the world was 25.8 % (for the USA, 14.6 %; for Japan, 30.6 %), while its share in the total number of titles of protection granted in the name of national applicants was 22.8 % (for the USA, 15.1 %; for Japan, 19.3 %) [26]. The experts estimate that, in the 1980s, Russian researchers were registering annually about 2,000 foreign patents and kept in force almost 20,000 such patents with the appropriate support from the state budget [27, P. 116].

At the same time, we observed some positive trends. For example, in 2011 the total number of international patents held by Russia in the form of triadic patents (a patent for the same invention of the same inventor that is simultaneously registered in the European Patent Office (EPO), US Patent and Trademark Office (USPTO), Japan Patent Office (JPO), as well as in the International Patent System (PCT)) increased by about 70 % compared to 2001⁶.

National patent applications per USD 1 million of R&D expenditures. Russia holds one of the leading positions and ranks 5th (rate of 0.96). For comparison, the USA ranks 6th (rate of 0.73, the data for 2013). Of course, this attests to rather high efficiency (in terms of how actively patent applications are filed) of Russian R&D expenditures and intensity of research (amid the low level of financing). At the same time, in 2014, the value of the indicator slightly decreased compared to 2007 (the rate of 1.41) and 2009 (the rate of 1.17). It should be noted that this is a global trend. In 2014, the indicators of two leaders that are ahead of Russia by 2–2.5 times also demonstrated a downward trend compared to 2007. The exception is China (ranks 1st), where the value of the indicator over this period increased by 1.5 times.

Inventive Activity and Efficiency. We identified the following indicators of patent activity and efficiency:

- Number of researchers per granted patent (persons).
- Ratio of patents granted to foreign applicants and local citizens (rate of dependency).
- Ratio of national patents and all patents granted by the country's offices (rate of self-sufficiency).
- Patents granted by the authorities to local citizens per 10,000 people (rate of patent activity).
- Ratio of patents granted to domestic applicants abroad and at home (rate of distribution).
- Patents granted to local citizens per USD 1 million of R&D expenditures (items).

According to key experts [28, P. 10], the patent statistics reflect primarily the data on triadic patents. In this regard, we consider it expedient to point out some differences in weight values of four out of six relevant Russian and foreign indicators that we identified above (except for the second and third indicators). As we have already mentioned, for Russian inventors it is difficult to obtain triadic patents.

For a more accurate and complete assessment describing the efficiency of researcher work, we made a comparative assessment of Russia's position in terms of patent activity and efficiency in the already selected group of countries (Table 5, 6). We calculated the "Number of researchers per granted patent" and "Patents granted to local citizens per USD 1 million of R&D expenditures" with a time lag of three years, with account of the average period for presenting research results in the form of patent

⁶ OECD data. Retrieved from: <http://www.oecd.org> (date of access: 1/22/2017).

applications, reviewing patent applications, and for the procedure of granting patents in national patent offices (according to our estimates based on Russian and foreign experience, it takes about three years). In other words, when calculating the above indicators, we used the data on the number of researchers and R&D expenditures recorded three years earlier.

Table 5

Comparative Cross-Country Characteristics of Patent Activity Indicators for 2015

Rank among 43 countries	Number of resident researchers per granted patent (persons)/country		Ratio of patents granted to foreign applicants and local citizens (rate of dependency)/country		Ratio of national patents and all patents granted by the country's offices (rate of self-sufficiency)/country	
	Value of indicator	Country	Value of indicator	Country	Value of indicator	Country
1	4.14	Korea	0.03	Greece	0.97	Greece
2	4.40	Japan	0.03 (2011)	Slovenia	0.97 (2011)	Slovenia
3	5.33	China	0.05	Latvia	0.95	Latvia
4	8.97	USA	0.07	Poland	0.93	Poland
5	17.48	Italy	0.10	Turkey	0.91	Turkey
...						
Country rank is given in brackets after the name	19.65	Russia (6)	0.52	Slovakia (24)	0.66	Slovakia (24)
	23.46	France (7)	0.53	Luxembourg (25)	0.65	Luxembourg (25)
	24.91	Luxembourg (8)	0.54	Russia (26)	0.65	Russia (26)
	27.87	Poland (9)	0.68	Switzerland (27)	0.60	Switzerland (27)
	27.89	Latvia (10)	0.93	United Kingdom (28)	0.52	United Kingdom (28)
...						
39	324.61	India	11.23	Colombia	0.08	Colombia
40	360.14	Brazil	11.38	New Zealand	0.08	New Zealand
41	615.91	Portugal	13.31	Austria	0.07	Austria
42	752.67	Iceland	21.78	Mexico	0.04	Mexico
43	1 581.00	Costa Rica	129.00	Costa Rica	0.01	Costa Rica

Note: If there is no data for the value of indicator in 2015, the information is shown for the last available year.

* Calculated by the authors according to the data of WIPO (see <http://www.wipo.int>) and UNESCO Institute for Statistics (see <http://www.uis.unesco.org>; date of access: 1/22/2017). The calculation was made with a lag of 3 years (the number of patents granted in the current year is correlated with the number of researchers three years earlier).

Number of researchers per granted patent. By this indicator, Russia climbed from the 9th position in 2007 (7th in 2009) to the 6th position in 2015. China made an outstanding performance and holds the 3rd position (10th in 2007). For Russia, the number of resident researchers per patent application and per granted patent remained consistent during the period under study. In 2015, it was 15.20 researchers per application (Table 2) and 19.65 researchers per granted patent (Table 5). In our view, this allows to conclude that the percentage of national patent applications approved by the Russian patent office was high.

The values of similar indicators among the top five countries vary considerably. The gap between the number of researchers per patent application and the number of researchers per granted patent ranges from 2.0 times (Korea) to 3.4 times (China) (Table 2 and Table 5). The identified trend is also observed in the indicators of national patent applications and patents granted to local citizens per 10,000 people. For Russia, the data remains consistent: 2.05 for patent applications (Table 3) and 1.57

for granted patents (Table 6). For other leading countries, we observed the gap between these indicators as it was with the previous group of indicators (Table 3 and Table 6).

At the same time, the number of Russian researchers per granted patent significantly exceeds the values of the similar indicator of the top four countries.

Rate of dependency and rate of self-sufficiency. By these indicators, in 2015, Russia lost its positions significantly compared to 2007 and fell from the 19th to the 26th. As it has already been shown (Table 1), this occurred following the increase in the number of patents granted to foreign applicants.

The dynamics of patent activity and efficiency in the context of comparative cross-country assessments is presented in Table 6.

Table 6

Comparative Cross-Country Characteristics of Indicators of Patent Activity and Efficiency for 2015

Rank among 43 countries	Patents granted by the authorities to local citizens per 10,000 people (rate of patent activity)* / country		Ratio of patents granted to domestic applicants abroad and at home (rate of distribution)* / country		Patents granted to local citizens per USD 1 million of R&D expenditures (items)** / country	
	Value of indicator	Country	Value of indicator	Country	Value of indicator	Country
1	15.08	Korea	12.00	Costa Rica	1.25	Korea
2	11.56	Japan	7.85	Israel	1.10	Japan
3	4.39	USA	6.06	India	1.03	China
4	1.92	China	5.77	Ireland	0.93	Russia
5	1.76	Luxembourg	5.36	Switzerland	0.78	Luxembourg
6	1.65	France	4.51	Denmark	0.42	Italy
7	1.57	Russia	4.29	Netherlands	0.41	Poland
...						
39	0.03	Mexico	0.36	Turkey	0.04	Portugal
40	0.02	Brazil	0.31	Latvia	0.02 (2014)	India
41	0.02	Colombia	0.23	Poland	0.01	Brazil
42	0.01	India	0.10	Russia	0.01 (2014)	Iceland
43	0.00	Costa Rica	0.06	China	0.00 (2014)	Costa Rica

Note: If there is no data for the value of indicator in 2015, the information is shown for the last available year.

* Calculated by the authors according to the data of WIPO (see <http://www.wipo.int>) and the World Bank (see <http://www.worldbank.org>; date of access: 1/22/2017).

** Calculated by the authors according to the data of WIPO (see <http://www.wipo.int>) and UNESCO Institute for Statistics (see <http://www.uis.unesco.org>; date of access: 1/22/2017). The rate is calculated with a three year lag for R&D expenditures (number of patent applications for the latest year with available statistics was correlated with R&D expenditures incurred three years earlier), R&D expenditures by purchasing power parity in 2011.

Rate of patent activity. In 2015, Russia ranked 7th (rate of 1.57). In this case, the gap with Korea (ranked 1st) was about 10 times, and the gap with the USA (ranked 3rd) was 2.8 times.

Rate of distribution. We observed a position described above by the similar indicator for patent applications (Table 3), as Russia also ranked 42nd (Table 6). As a positive development, we can view its leading position (compared to 2009) versus China and the increase in the value of the rate from 0.03 (2007) to 0.10 (2015).

We have already mentioned one of the main reasons for this position in the rating: it is very costly to obtain and keep in force a foreign patent. For example, experts give the following figures: the costs of patenting one invention in three or four countries (which is appropriate and reflects the international practice) can often exceed \$50,000 even without taking into account the increasing annual fees [16, P. 6].

Patents granted to local citizens per USD 1 million of R&D expenditures. Despite the fact that, in 2015, Russia held a high 4th position, there was some decline in the value of the indicator (in 2009 it ranked

1st). With the rate of 1.03, China moved to the 3d position in 2015 (in 2014, it had a rate of 0.74 and held the 4th position).

While pointing out to unfavorable trends, we should note that many scientists view as a negative phenomenon the very low share of domestic patents, which lead to the conclusion of licensing agreements and assignment agreements. In our opinion, this is not so straightforward. For example, A.N. Kozyrev, a leading researcher on the economics of intellectual property, believes [29, P. 776–778] that information on transactions with intellectual property objects including the terms of transactions for the sale of patents and licenses is insufficiently transparent. In addition, his studies suggest that the percentage of licensed patents is not so high in the developed countries, either.

We share the opinion of A.N. Kozyrev that the low values of this indicator are significantly affected by the specifics of the defense sector, which, as we have already mentioned, has many secret inventions. The conclusion of license agreements and assignment agreements with the representatives of the civil sector is severely restricted. Moreover, Russian economy can be characterized by a low level of demand for and often illegal use of intellectual property, which is rightly pointed out by many scholars and practitioners. In addition, the existing legal regulations including tax regulations are not encouraging the registration of results of intellectual activity as intangible assets even in major Russian companies, which generally does not correspond to the international practice. All this gives rise to a shortage of incentives, reduces the motivation of researchers to engage in intellectual and intense creative activity. The situation is exacerbated by the high cost of registering and keeping patents, especially in foreign countries. For example, the cost of registering a patent in Russia with the assistance of an appropriate expert is about 60,000–90,000 rubles [30, P. 9]. A number of development institutions offer some benefits, but they are not always readily available.

The instability of achievements made by Russian researchers, which is also caused by lack of financial support, is reflected in the relevant Russian and international ratings. For example, according to the study by Bloomberg rating agency⁷, in 2017, Russia fell to the 26th position in the world by Innovation Index (taking into account such factors as patent activity, concentration of researchers, intensity of R&D, amount of public R&D financing) while in 2016 it ranked 12th (having climbed to this position from the 14th held in 2015 and 18th held in 2014). According to the Global Innovation Index of INSEAD, an international business school⁸, in 2016, Russia was only 43rd in the world (in 2014 it was 49th). And by the protection of intellectual property rights, one of the leading indicators of competitiveness assessed by the World Economic Forum, Russia ranked 117th out of 138 countries in 2016 (in 2011 ranked 126th out of 142 countries)⁹.

To complete the presentation of results obtained in our study, it would be expedient to highlight, along with the above findings and recommendations, the key importance of ensuring appropriate institutional environment. The point of view shared by a considerable number of scientists and expressed, for example, by I. Tsapenko, who wrote about the “deplorable state of national patent sphere” caused by the lack of required institutional conditions [31, P. 13] seems to be quite reasonable.

The practice of leading foreign countries demonstrates the priority importance of institutional conditions for the dynamic development of science and technology, and sustainable economic growth. The theoretical synthesis and substantiation of these trends and patterns were provided in the works of leading foreign and Russian researchers. For example, D. North concludes that “technological changes and institutional changes are the major determinants of social and economic development” [32, P. 133], and “technology sets the upper limit of the achievable economic growth” [32, P. 169]. D. North emphasizes the pioneering contribution of K. Marx to studying the relationship of technological development (“productive forces”) with “different aspects of human organization, and especially property rights” (“relations of production” [32, P. 168]. Based on an analysis of extensive empirical material, T. Eggertsson further develops these aspects emphasizing the importance of institutional structures: “... Some political systems create incentives for moving the structural frontier of production possibilities close to technical production frontier, while others don’t” (cited from [33, P. 341]). By

⁷ L. P. Bloomberg. Retrieved from: <https://www.bloomberg.com/news/articles/2017-01-17/sweden-gains-south-korea-reigns-as-world-s-most-innovative-economies> (date of access: 1/22/2017).

⁸ The Global Innovation Index. Retrieved from: <https://www.globalinnovationindex.org/gii-2016-report> (date of access: 1/22/2017).

⁹ Data of Global Competitiveness Report for 2011-2012, 2016-2017. The World Economic Forum. Retrieved from: <http://reports.weforum.org/global-competitiveness-index/competitiveness-rankings/#series=EOSQ052> (date of access: 1/22/2017).

structural frontier of production possibilities T. Eggertsson understood the possibilities “in which the costs are minimized, and the output volume reaches its peak” [33, P. 341]. The leading role of institutional conditions in providing science and technology support for socio-economic development is also substantiated in the works of leading Russian scientists [34].

As rightly acknowledged by A.L. Andreev, the establishment of a special type of environment in the form of “intellectual environment” necessary for the “formation of researchers and academic schools” [35, P. 321] is no less important in mobilizing the institutional conditions, including those required for social and socio-cultural development. As a “primary ... task of effective innovation policy,” the scientist identifies the “formation of innovative social environments that support it,” “innovative self-organization of society” [35, P. 323], and further develops the theory of the “creative class” proposed by R. Florida. [36]. Based on historical practice and empirical studies, A.L. Andreev reached a conclusion on the need for “deliberate social designing,” “growing” of “creative intellectual environments” [35, P. 325].

Conclusion

The main reasons for selecting the goal of this study include the needs of scientific community to monitor the rating of Russian scientific achievements in the global system of science and technology developments, and assess correctness of negative characteristics that are fairly common among the representatives of certain public and administrative authorities with regard to the efficiency and contribution of science and technology to the innovative development of the economy.

Due to the specifics of research work and its results, the potential of inventive activity is a complex subject for studying, assessing, regulating, and managing. Therefore, it is advisable to use different sets (combinations) of models, methods, and assessment indicators.

We proposed our own version of research methodology based on the synthesis of general theory and institutional study areas, including the theories of reproduction of scientific and technical, and scientific and technological capacity, innovative development, knowledge economy, intellectual capital, intellectual resources, and intellectual property.

Based on monitoring the dynamics of inventive and patent activity of Russian and foreign researchers (mainly from leading OECD countries) for a sufficiently extended period of time, we presented the system of their rating assessments. We identified problem areas, especially serious lagging of Russia in terms of patent applications filed in foreign patent offices, support of national patenting abroad, the specific weight of signed license agreements and assignment agreements for domestic patents. The reasons for this are primarily of institutional nature. They include the lack of financial support, incentives, weak development of the relevant infrastructure, which certainly does not allow to fully realize the potential of Russian researchers in the area of inventive and patent activity.

Overall, we can conclude that by a number of key parameters the inventive activity of researchers is maintained and improving. In our view, this may mean the increase of intensity in the research work amid declining volumes of financial support and reduction in the number of researchers across virtually all sectors of science and technology. The study results also indicate the existing problems and contradictions that do not allow to fully realize the potential of researchers in the area of inventive and patent activity. As demonstrated by the results of our contemporary and previous studies, these problems and contradictions are of repetitive nature, that is, they acquire the signs of negative patterns.

The full realization of inventive and patent activity of researchers can be achieved only after mobilizing not only their potential and internal reserves of the scientific and technological community, but also relevant institutions represented by the state authorities in charge of scientific, technological, and innovative development, as well as industrial, commercial, and financial entities. It is necessary to consider the intensification of efforts to create economic and legal conditions, including during the further elaboration of the Long-Term Strategy of Scientific and Technological Development of Russia, the Federal Law “On Scientific, Scientific and Technical, and Innovative Activity in the Russian Federation,” etc. The results can be used in further studies and developments of this complex subject, including the alternative ones, as well as in the teaching of relevant academic subjects.

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Authors

Tatyana Ivanovna Volkova — Doctor of Economics, Head of the Sector of Institutional Economics, Institute of Economics of the Ural Branch of RAS (29, Moskovskaya St., Ekaterinburg, 620014, Russian Federation; e-mail: randall@bk.ru).

Ivan Aleksandrovich Usoltsev — Loan Inspector, Sberbank of Russia (67, Kuybysheva St., Ekaterinburg, 620026, Russian Federation; e-mail: nino34@yandex.ru).