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Regional Patent Policy Analysis in Russia




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Abstract

Introduction. The article studies patent activity in the regions of Russia. The relevance of the research in this area is determined by the importance of the innovation component in economic growth, as well as by the established targets in the Concept of Technological Development of the Russian Federation for the period up to 2030. The aim of the study is to identify possible types and directions of patent policy for different groups of Russian regions on the basis of patent activity factors.

Materials and Methods. The empirical material for the analysis includes data from the World Intellectual Property Organization (WIPO) and the Federal State Statistics Service (FSSS) for 2012–2021. We use linear regression to identify the key factors affecting the patent activity of the regions. The method of hierarchical clustering allowed us to identify groups of regions according to their patent activity.

Results. The linear regression showed the statistically significant dependence of regional patent activity on I-activity level of organizations, the number of active fixed broadband Internet subscribers per 100 population and the average of internal costs for research and development per 1 organization in the region. The hierarchical clustering distinguished 5 clusters of regions: “The Leader”, “Innovation centers”, “Regions of high manufacturability”, “Old R&D regions” and “Regions-outsiders”. The authors also formulate definitions of the regional patent policy and the national patent policy and present typologies of state patent policy.

Discussions and Conclusions. Based on empirical and theoretical analysis, recommendations on further directions for the development of active patent policies were given to groups of regions. The results of the study can be applied in the development and implementation of scientific and technological regional development strategies, and will also be useful to specialists and government officials involved in regulating patent activity in the regions.

Keywords: regional economy, innovation economy, patent activity, innovation activity, state patent policy, regional patent policy

Conflict of interests. The authors declare no conflict of interest.

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Анализ региональной патентной политики в России

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Аннотация
Введение. Актуальность исследования в области патентной активности в российских регионах обусловливается значимостью инновационной составляющей экономического роста, а также установленными целевыми показателями в Концепции технологического развития Российской Федерации до 2030 г. Цель исследования – определить возможные виды и направления патентной политики для различных групп регионов России с учетом факторов патентной активности.
Материалы и методы. Эмпирической базой для анализа послужили данные Всемирной организации интеллектуальной собственности и Федеральной службы государственной статистики за 2012–2021 гг. Использована линейная регрессия для выявления ключевых факторов, влияющих на региональную патентную активность. Метод иерархической кластеризации позволил выделить группы регионов по их патентной активности.
Результаты исследования. Линейная регрессия показала статистически значимую зависимость региональной патентной активности от уровня И-активности организаций, количества активных абонентов фиксированного широкополосного доступа к сети Интернет на 100 чел. населения и среднего значения внутренних затрат на исследования и разработки на 1 организацию в регионе. Методом иерархической кластеризации выделено 5 кластеров регионов: «Лидер», «Инновационные центры», «Регионы высокой технологичности», «Старые научно-исследовательские регионы» и «Регионы-аутсайдеры». Сформулированы определения региональной патентной политики и национальной патентной политики, представлены типологии государственной патентной политики.
Обсуждение и заключение. На основе эмпирического и теоретического анализа группам регионов были даны рекомендации по дальнейшим направлениям развития активной патентной политики. Результаты исследования могут быть использованы при разработке и реализации стратегий научно-технического развития регионов, а также будут полезны специалистам и государственным служащим, занимающимся регулированием патентной деятельности в регионах.

Ключевые слова: региональная экономика, инновационная экономика, патентная активность, инновационная активность, государственная патентная политика, региональная патентная политика.

Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов.

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Introduction. Ensuring long-term economic growth in the modern world is almost impossible without introducing innovations. Today there are many innovative development indices and ratings of countries and regions. Ratings of regional innovative development are being actively created in Russia; among the most famous are: the Rating of Innovative Regions of Russia by the Association of Innovative Regions of Russia[1] and the Russian Regional Innovation Scoreboard by the National Research University Higher School of Economics[2].

One of the key indicators of regional innovative development is their patent activity. Ensuring innovative development of the economy is extremely important for

[1] [Rating of Innovative Regions: For Monitoring and Management Purposes: Version 2015-1.0. 2015]. (In Russ.) Available at: https://i-regions.org/upload/iblock/b19/file_47.pdf (accessed 25.10.2023).

[2] Abdrakhmanova G., Demidkina O., Demyanova A., et al. Digital Economy Indicators in the Russian Federation: 2022. Data Book. Moscow: HSE; 2023. Available at: https://www.hse.ru/data/2023/08/08/2069278693/Digital_Economy_Indicators_2022_EN.pdf (accessed 25.10.2023).

the Russian Federation [1; 2]. To achieve the target indicators of the Concept of Technological Development by 2030[3] (in particular, an increase in the number of patent applications by 2.4 times), efforts and measures are required not only at the federal but also at the regional level. However, high results of socio-economic indicators and, especially, innovative development indicators are not common in most regions of the Russian Federation.

In this article, the authors undertake to analyze the parameter of regional patent activity as an indicator of the innovative development of the region. The purpose of the study is to determine possible types and directions of patent policy for different groups of regions in the Russian Federation based on factors of patent activity. In accordance to this purpose, we:

1) determine trends in national and regional patent activity of the Russian Federation over the past 10 years;

2) based on correlation and regression analysis, identify the key factors that determined regional patent activity in 2021;

3) using the clustering method, distinguish regions by patent activity and other parameters of innovative development.

According to the Federal Service for Intellectual Property of the Russian Federation (the Rospatent)[4] and W. Strielkowski [3], digital transformation contributes to an increase in the number of applications in electronic form. In this study, we test whether digitalization has an impact on patent activity in general. Therefore, the authors hypothesize that digitalization should have a positive effect on regional patent activity.

Based on the theoretical provisions of D. Romer's model of economic growth, namely the production function of knowledge, the authors put forward the hypothesis that human capital has a decisive role in regional patent activity.

The authors also believe that the number of technology organizations in the region should have a positive effect on regional patent activity.

Another hypothesis is the positive dependence of the regional patent activity on the average internal costs for research and development per 1 organization in the region.

Literature Review. The methodological basis of the study are articles devoted to regional patent activity in Russia over the past 10 years, including studies by M. A. Nikonova [4], J. A. Gadzhiev [5], Y. L. Domnich [6], L. Aldieri, M. Kotsemir, & C. P. Vinci [7], etc. Most of these articles are rather descriptive and only report statistical indicators and some trends in patent activity in the regions, mainly until 2019. S. Zemtsov, A. Muradov, I. Wade and V. Barinova attempted to build a regression model only to determine which of the two parameters (human capital or research and development (R&D) costs) has a more important impact on patent activity in the region [8]. An attempt to construct a regression was also made in the study of T. D. Degtyareva [9], however, the constructed model also uses only two parameters – the number of patents for inventions and the number of patents for utility models. In addition, both studies

[3] [Concept of Technological Development for the Period until 2030. Government of Russia, 20 May 2022]. (In Russ.) Available at: http://static.government.ru/media/files/KlJ6A00A1K5t8Aw93NfRG6P8OIbBp18F.pdf (accessed 25.10.2023).

[4] [Digital Transformation Contributes to an Increase in the Number of Applications in Electronic Form. Rospatent: Federal Service for Intellectual Property, 4 Apr. 2023]. (In Russ.) Available at: https://rospatent.gov.ru/ru/news/cifrovaya-transformaciya-04042023 (accessed 25.10.2023).

use data only up to 2015, without taking into account subsequent further recovery and crisis changes in the Russian economy. These constructed regression models do not take into account other parameters that may affect regional patent activity.

We admit the study of I. E. Ilina, N. I. Zolotykh and I. V. Bitkina, where an attempt was made to construct an index of the regional patent activity based on four groups of parameters: patents, technologies, infrastructure, and stuff [10]. Despite the deep theoretical development of the construction index logic, the study did not attempt to construct a regression (or correlation) analysis, therefore, there may be multicollinearity among the variables.

An important theoretical basis for the current article is developments in the field of innovation strategy and regional innovation policy by Russian and international economists [11–13]. In addition, in domestic studies in the 2000s, attempts were made to conceptualize patent policy within the framework of political economy and the institutional approach. In particular, the type of patent policy focused on classical universities in the system of regional innovation policy was described [14], and institutional conditions were analyzed as a factor influencing the formation of regional innovation policy[5]. These studies formed the basis for the author's development of the typology of patent policy, as well as the formulation of definitions of terms.

Many research projects attempted to create an index of regional innovative development [15; 16]. These developments allowed us to correctly identify potential variables that may influence patent activity in the region. For instance, M. G. Karelina used different indicators related to the research and educational sphere to construct an index of innovative development of the region based on three groups of parameters: innovation potential, innovation climate, and innovation performance [17].

The study is also based on the Knowledge Production Function (KPF) models, which describe the relationship between R&D costs, human capital, and innovation results. Basic ideas about the production function of knowledge are associated with the papers of Paul Romer, Zvi Griliches and Adam Jaffe in the 1980s[6].

Thus, at the time of preparing the article current review and analysis of regional patent policy in Russia is not fully presented and requires more in-depth statistical and theoretical analysis using clustering and regression analysis methods.

Materials and Methods. In this paper, the authors use translations of the Russian Federation constituent entities according to ISO 3166-2:RU which defines codes for some of the names of the Russian principal subdivisions. The data for analysis was taken for the period 2012–2021, therefore 85 regions are included in the statistics (and before 2014 – 83 regions).

Patent activity is the level of development of a country's innovative activity in the context of registered patents and applications for patents from the subjects of the country, as well as foreign residents. The fact is that not every patent is a commercial success. Therefore, for this study, the indicators of the coefficient of inventive activity

[5] Valieva O.V. [The Influence of Institutional Conditions on the Formation of Regional Innovation Policy. Dissertation. Ph.D. Econ. Sciences: 08.00.05]. Novosibirsk: IEOPP SB RAS; 2009. (In Russ.) Available at: http://www.econom.nsc.ru/ieie/news/zashiti/avtoref/apr09/valieva.pdf (accessed 25.07.2023).

[6] Romer P.M. Endogenous Technological Change. *Journal of Political Economy*. 1989;98(5):71–102. https://doi.org/10.1086/261725

(for regression analysis) and the FSSS data on issued patents in the regions are used. In this article, the coefficient of inventive activity refers to the number of issued patents per 10,000 people in the region [5, p. 65]:

$$Inventive\ Activity\ Coefficient = number\ of\ granted\ patents / \left(\frac{population}{10000} \right).$$

In general, the article uses the FSSS statistical collection “Regions of Russia. Socio-economic indicators” for the periods 2012–2022. We decided to analyze and pay attention to this specific period due to the changed economic situation in Russia after the 2014 crisis, when sanctions against Russia were introduced. Data for 2012 and 2013 allow us to look at the situation before significant structural changes in the country’s economy, and the field of 2014 allows us to track the dynamics of how the economic situation could influence the development of patent activity in the regions.

In this article, the analysis of patent activity in the regions of Russia will be based on indicators of patents for inventions and utility models, since the number of patents for industrial designs is insignificant and does not have a strong impact on the total volume of patents.

The article is based on methods of statistical data analysis. To determine the key factors of regional patent activity, the authors use a multiple regression model. The method of hierarchical clustering is used to identify groups of regions. Taking into account the economic situation in 2021–2022 (coronavirus crisis), as well as the fact that data for 2022 is the most current at the time of writing, the authors use data for 2022 to carry out the specified statistical methods of analysis.

Results. *Analysis of the Russian Regional Patent Activity Dynamics (2012–2021).* In the period from 2012–2021, there is a dynamic (trend) of a decrease in regional patent activity according to the Russian average. This is also accompanied by a decrease in patent applications in the regions (see Fig. 1).

The largest number of patents was issued in 2014 – 35,332 patents, and the largest number of patent applications was in 2013 – 42,354 applications. Moreover, in 2021, 28,442 patent applications were filed, of which 21,745 were approved (76.45% approval rate).

In general, the dynamics of the Russian patent activity are similar to European dynamics but have more acute dynamics: the declines in 2014, 2016, 2019 and 2020 are more significant than in Europe as a whole (see Fig. 2)[7]. At the same time, in 2017 and 2021, a recovery in patent activity was observed throughout the world and in Europe, but in Russia, there were serious drops in these years (−12.1% and −12.8%). We assume that such dynamics are associated with the slower adaptation and recovery of Russian technology companies after the crises of 2014–2016 and the coronavirus pandemic in 2020.

According to analytical statements of the Rospatent, the greatest blow during the crisis came from a decrease in patent activity among individual entrepreneurs[8].

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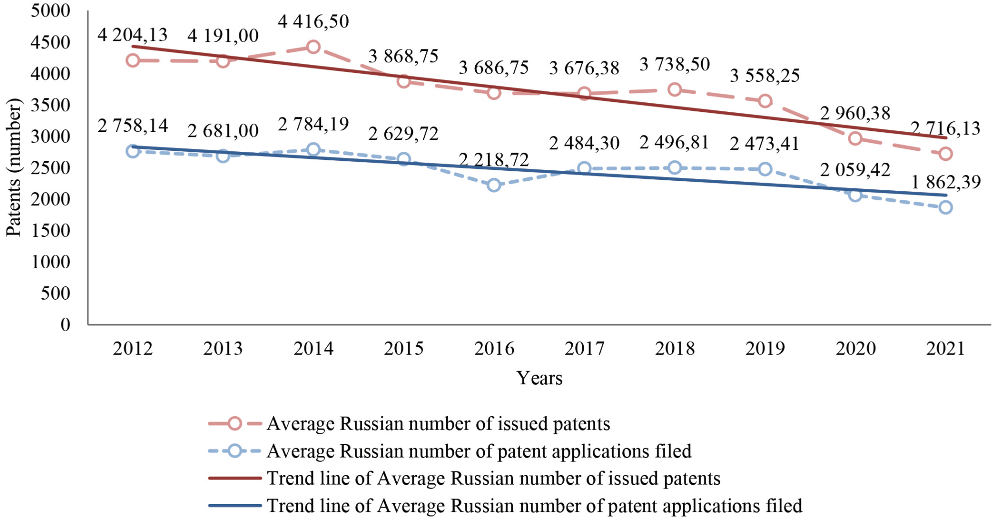
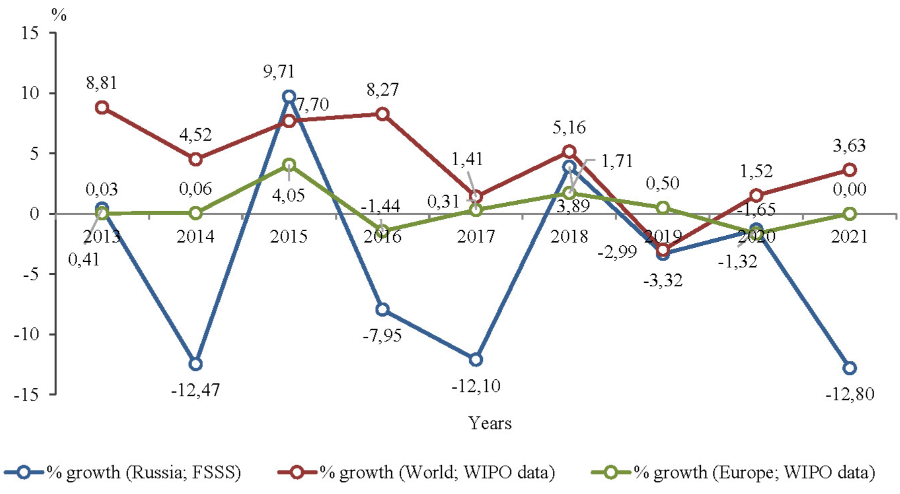
[7] WIPO IP Statistics Data Center. WIPO. Available at: https://clck.ru/3ADqCj (accessed 25.10.2023).

[8] [Trademarks in Price. *Kommersant*, 13 Jan. 2022]. (In Russ.) Available at: https://www.kommersant.ru/doc/5158278 (accessed 25.10.2023).

Thus, in 2021, the number of applications from legal entities increased by 1.2%, while individuals submitted 45.9% less than last year. It is mainly due to this that sharp reductions in patent activity in Russia occur.



F i g. 1. Average Russian regional patent activity (2012–2021)[9]

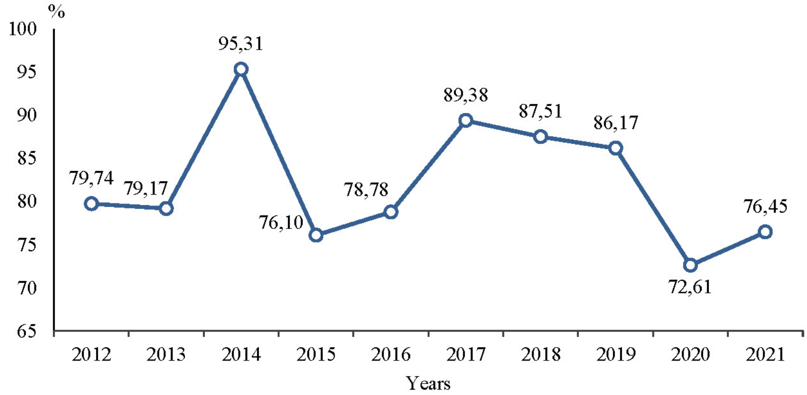


F i g. 2. Patent application activity comparison (2013–2021), %[10]

At the same time, the dynamics of the approval rate do not have an obvious trend (see Fig. 3). The highest percentage of patent applications approval was in 2014 (95% of patents were approved), as well as in 2017 (89%).

[9] Source: Calculated by the authors based on data from The Federal State Statistics Service (2022). (In Russ.) Available at: https://rosstat.gov.ru/folder/210/document/13204 (accessed 25.10.2023).

[10] Source: Calculated by the authors based on data from The Federal State Statistics Service (2022). (In Russ.) Available at: https://rosstat.gov.ru/folder/210/document/13204; World Intellectual Property Organization data (2023). Available at: https://clck.ru/3ADqCj (accessed 25.10.2023).



F i g. 3. Approval rate of patent applications in Russia (2012–2021), %[11]

The absolute leader in patent activity is the Central Federal District: it accounts for almost half of all patents issued in Russia. At the same time, we note that over the past three years, the share of the Central Federal District decreased by almost 3% (compared to 2012), and the share of the Northwestern Federal District increased by 3% (to 12.58%). The second place in terms of contribution to the total number of patents issued in Russia is occupied by the Volga Federal District, which also slightly increased its share.

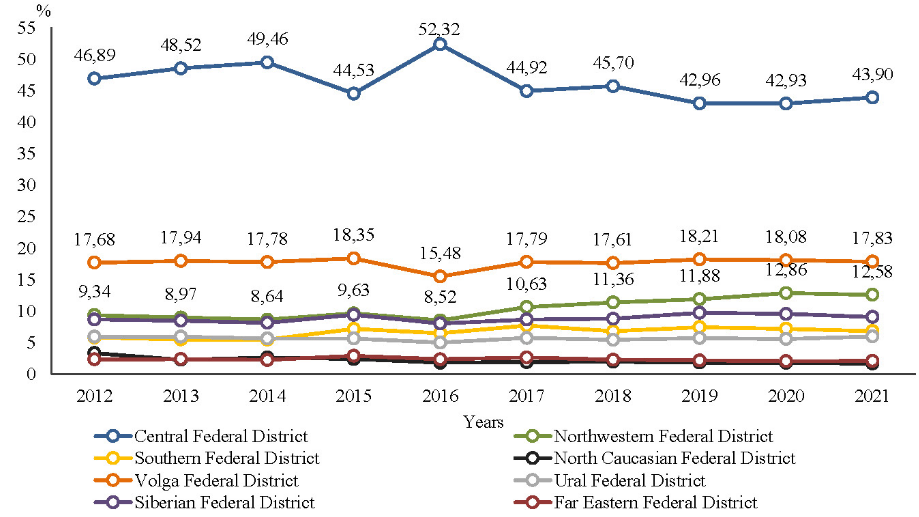
It is also worth noting the drop in issued patents in the North Caucasian Federal District, both in absolute and relative values – the share decreased from 3.32% to 1.67%, and the total number of issued patents from 1118 to 363 patents (almost in 3 times) – this is the most significant drop among federal districts in 10 years. The greatest decline in this federal district was demonstrated by the Republic of Dagestan: from 630 to 44 issued patents. At the same time, the reduction was mainly due to patents for inventions (and not for utility models), which dominated the structure of patent activity in the region. We attribute this to time lags associated with the ineffective work of the regional office of the Rospatent, since in 2014, 2015, 2018, and 2020 the number of issued patents was greater than patent applications (see Fig. 4).

The shares of the remaining federal districts were approximately at the same level for 10 years: Southern Federal District ~6–7%, Ural Federal District ~6%, Siberian Federal District 8.5–9%, Far Eastern Federal District ~2% (see Fig. 4).

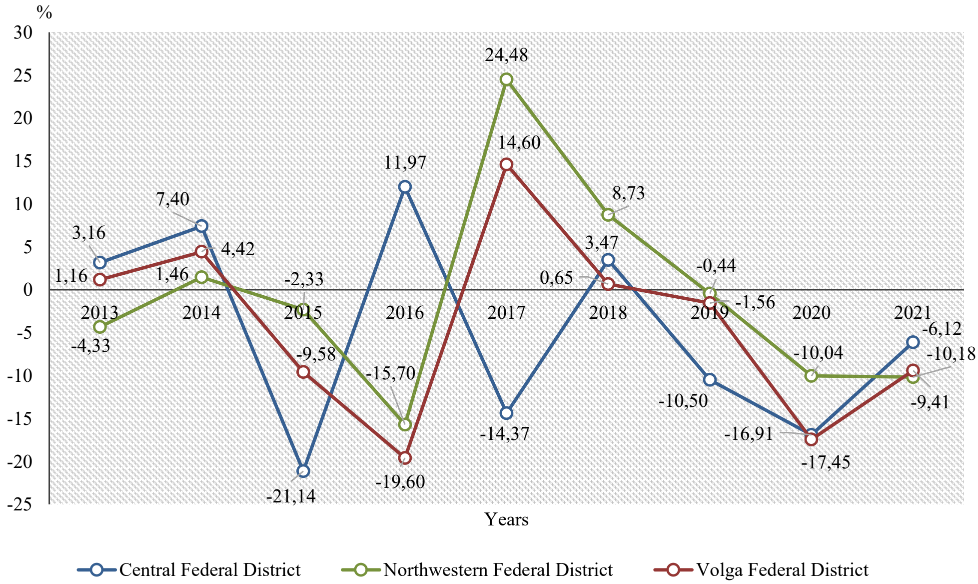
The greatest decline in patent issuance in federal districts was observed in 2016, 2020, and 2021: on average −15.22%, −17.3% and −9.17%, respectively (see Fig. 5). It was during these years that crisis phenomena in the economy and stagnation were observed, which affected patent activity in the regions.

Determination of the regional patent activity factors based on the regression model results. Before the regression model construction, the authors cleared the data of externalities. Thus, out of 85 regions, 78 regions remained to build the regression model. First of all, regions where data on patent activity is not provided (Nenets Autonomous District and Chukotka Autonomous District) and where the Inventive Activity Coefficient is below 10% (Republic of Adygea, Altai Republic, Republic of Ingushetia) were deleted. The top externalities (St. Petersburg and Moscow) were also crossed out, since these regions are not only statistically unsuitable for econometric analysis.

[11] Source: Calculated by the authors based on data from The Federal State Statistics Service (2022). (In Russ.) Available at: https://rosstat.gov.ru/folder/210/document/13204 (accessed 25.10.2023).



F i g. 4. Share of federal districts in all Russian patent activity (2012–2021), %[12]



F i g. 5. Dynamics of growth in the issuance of patents in federal districts (2012–2021), %[13]

Most often, the number of employees with higher education or the number of researchers per 1 resident of the region is used as an indicator of the human capital level. The authors of the article also propose to use as a metric of human capital in the personnel aspect – the number of bachelors and masters enrolled in higher educational institutions in the region in period *n*. According to the authors, this indicator is

[12] Source: Calculated by the authors based on data from The Federal State Statistics Service (2022). (In Russ.) Available at: https://rosstat.gov.ru/folder/210/document/13204 (accessed 25.10.2023).
[13] Source: Calculated by the authors based on data from The Federal State Statistics Service (2022). (In Russ.) Available at: https://rosstat.gov.ru/folder/210/document/13204 (accessed 25.10.2023).

more reliable, since it reflects the educational and personnel aspects of human capital. An indicator of 6 years is used as a time lag (i.e. data for 2015). During this time the applicant is just going through the stages of bachelor's and master's education.

To focus on quality human capital, special indicators have been developed: "high-quality workforce in research&science" (HQWRS) and "potentially high-quality workforce" (PHQW) adjusted for the regional Human Development Index (HDI) (however, there is no high correlation between the HDI itself and patent activity: $r \approx 0{,}2$)[14]. These formulas are presented below:

$$HQWRS = researchers \times HDI,$$

$$PHQW = students_{2015\,year} \times HDI,$$

where *researchers* – the number of researchers per 1 resident of the region; $students_{2012\,year}$ – the number of accepted undergraduate, specialist and master's degree students per 1 resident in 2015.

First of all, the authors create a correlation matrix to test hypotheses about the presence of a correlation between the designated variables:

1) the share of organizations carrying out technological innovations (I-activity level);
2) the percentage of scientific activity (science) in the GRP;
3) average internal costs for research and development per 1 organization in the region;
4) high-quality workforce in research&science (HQWRS) per 1 citizen;
5) the number of active fixed broadband Internet subscribers per 100 population;
6) the number of personal computers per 100 employees;
7) potentially high-quality workforce per 1 citizen (PHQW);
8) the percentage of employed people with higher education.

The constructed correlation matrix showed a connection between patent activity and:

1) the share of organizations carrying out technological innovations (I-activity level);
2) the percentage of scientific activity (science) in the GRP;
3) the average internal costs for research and development per 1 organization in the region;
4) high-quality workforce in research&science (HQWRS) per 1 citizen;
5) the number of active fixed broadband Internet subscribers per 100 population;
6) potentially high-quality workforce per 1 citizen (PHQW).

The correlation analysis discovered multicollinearity between the variables "% of scientific activity (science) in the GRP", "average internal costs for research and development per 1 organization in the region" and "High-quality workforce in research&science per 1 citizen" (HQWRS) (see Appendices 1[15]). The method of maximum correlation with the dependent variable was used to remove the variable "High-quality workforce in research&science per 1 citizen" (HQWRS) from the future regression model. It was decided to use the variables "% of scientific activity (science) in the GRP" and "average internal costs for scientific research and development per

[14] Human Development Index in Russia: Regional Differences. Analytical Note. Analytical Center for the Government of the Russian Federation, Dec. 2021. (In Russ.) Available at: https://ac.gov.ru/uploads/2-Publications/analitika/2022/_2021_long.pdf (accessed 25.10.2023).

[15] Appendices 1. https://doi.org/10.15507/2413-1407.127.032.202402.250

1 organization in the region" for constructing the regression, since they have almost the same correlation with the dependent one.

To further specify the model, we took the natural logarithm of the variables (ln) and constructed a correlation matrix with the remaining variables (see Appendices 2[16]). Thus, we improve the correlation of independent variables with the coefficient of inventive activity.

After constructing a regression model with the remaining variables, it was found that the indicator "% of scientific activity (science) in the GRP" is not statistically significant, since its p-value is not less than 0.05 (see Table 1). In this case, we exclude these variables from the regression model.

T a b l e 1. **Table of coefficients of the regression model No. 1[17]**

	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Srd. Error	Beta		
(Constant)	−1.369	1.096		−1.249	**.216**
ln_GRP_science	.035	.155	.028	.223	**.824**
ln_I_activity	.399	.166	.224	2.399	.019
ln_PHQW	.298	.133	.183	2.236	.029
ln_Internet	.737	.186	.383	3.970	.000
ln_ average_R&D_costs	.139	.055	.293	2.540	.013

Note: Dependent variable: ln_coefficient_image_active.

In the final multiple regression model, the variables "Potentially high-quality workforce per 1 citizen", and "average internal costs for scientific research and development per 1 organization in the region" are statistically significant because their p-values are less than 0.05 (see Table 2–4).

T a b l e 2. **Table of coefficients of the regression model No. 2**

	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Srd. Error	Beta		
(Constant)	−1.348	1.084		−1.244	**.218**
ln_I_activity	.400	.165	.225	2.424	.018
ln_PHQW	.300	.132	.185	2.274	.026
ln_Internet	.756	.165	.393	4.581	.000
ln_ average_R&D_costs	.148	.040	.311	3.718	.000

Note: Dependent variable: ln_coefficient_image_active.

T a b l e 3. **Summary of the regression model**

Model	R	R-square	Adjusted R-square	Std. Error of the Estimates	Durbin-Watson
1	.856[a]	.733	.703	.39149	1.764

Note: Dependent variable: ln_coefficient_image_active.

[16] Appendices 2. https://doi.org/10.15507/2413-1407.127.032.202402.251

[17] Source: Tables 1–4 calculated by the authors based on data from The Federal State Statistics Service (2022). (In Russ.) Available at: https://rosstat.gov.ru/folder/210/document/13204 (accessed 25.10.2023).

T a b l e 4. **ANOVA for the regression model**

Models		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.729	4	4.682	30.551	.000*
	Residuals	10.115	66	.153		
	Total	28.844	70			

Notes: Dependent variable: ln_coefficient_image_active.
* Predictors: (const) ln_GRP_scince, ln_PHQW, ln_Internet, ln_I_activity.

The data were also tested for autocorrelation by the Durbin – Watson test. In the resulting model, the Durbin – Watson reading is in the range $1.743 < DW < (4 - 1.743)$, therefore, the hypothesis of the absence of residuals' autocorrelation is accepted (see Table 3).

Therefore, the following multiple linear regression model was created:

$$\ln\left(y_{patent_{activity}}\right) = 0,4 \times \ln(x_1) + 0,3 \times \ln(x_2) + 0,756 \times \ln(x_3) + 0,148 \times \ln(x_4) + \varepsilon,$$

where $y_{patent\_activity}$ – coefficient of regional patent activity; x_1 – I-activity level of organizations; x_2 – PHQW; x_3 – the number of active fixed broadband Internet subscribers per 100 population; x_4 – average internal costs for research and development per 1 organization in the region (see Table 2 and Table 4).

The resulting regression model has good explanatory power ($R^2 \approx 0.733$) i.e. explains more than 70% of cases (observations) (see Table 3).

We also decided to test the correlation between the Digitalization Index, calculated by the HSE based on the share of organizations using digital technologies in the total number of organizations[18]. In this case, the Pearson correlation was significant ($r \approx 0.416$). Therefore, the hypothesis about the impact of the regional digitalization on patent activity can be confirmed. Still, we admit that this hypothesis needs a more comprehensive verification through complex special indices.

We proved that regional patent activity is influenced by both "Potentially high-quality workforce per 1 citizen" and "average internal costs for research and development per 1 organization in the region".

Based on the result obtained, the hypothesis that the number of technological organizations in the region has a positive effect on regional patent activity was refuted. This is due to several factors, one of the key ones, according to the authors, is the difference in the quality of innovative technical organizations.

The hypothesis of a positive strong relationship between regional patent activity and average internal costs for research and development per 1 organization in the region was also confirmed. This suggests that the organizations' budget policy in the development of science and innovation is important for patent activity and, as a result, the innovative development of the region.

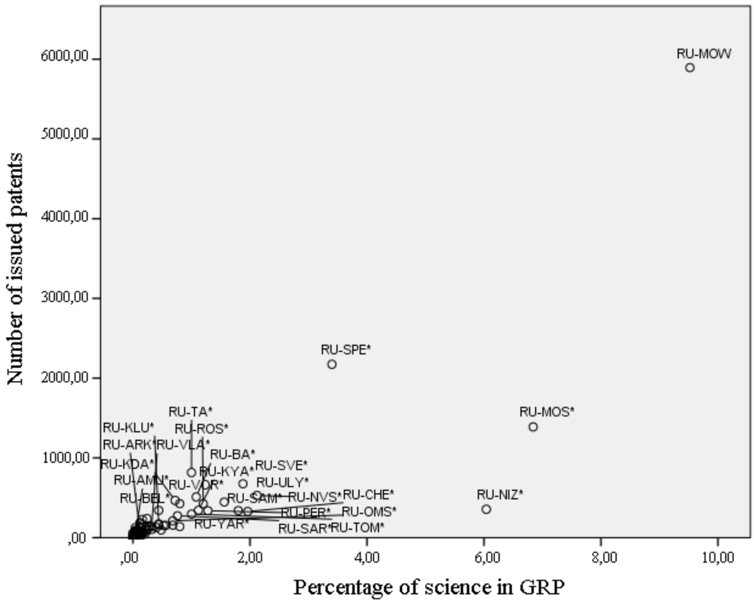
Moreover, the influence of "% employed with higher education" on the patent activity was not confirmed. The authors believe that such situation is connected with a generally high prevalence of low-quality higher education in Russia even in regions with low urbanization.

[18] Abdrakhmanova G., Demidkina O., Demyanova A., et al. Digital Economy Indicators in the Russian Federation.

The hypothesis based on D. Romer's economic growth model that human capital plays a decisive role in patent activity was confirmed. We assume that for developed regions (Moscow autonomous city, Saint-Petersburg autonomous city, Moscow administrative region), human capital may be more important than average internal costs for research and development per 1 organization in the region [8]. However, based on the constructed regression model, it can be seen that for most regions, the costs of organizations for scientific and research activities have a greater impact on patent activity.

Clustering: identifying groups of regions by their patent activity. Since we have determined variables influencing on regional patent activity, we can identify clusters of regions taking into account these variables and regional patent activity.

First, we look at the data in terms of their patent activity and % of scientific activity in the GRP structure using a scatter diagram (see Fig. 6). We found that Moscow autonomous city, Saint-Petersburg autonomous city, Moscow administrative region and Nizhny Novgorod administrative region stand out among the other regions. Also, with a detailed visual analysis of the graph, we can note that the Sverdlovsk administrative region, Novosibirsk administrative region, Voronezh administrative region and Tyumen administrative region also stand out slightly in terms of % of scientific activity in the GRP structure.



F i g. 6. Regional patent activity (Patents) and percentage of internal companies' costs for research and development in GRP[19]

Obviously, two variables are not enough to identify clusters in more detail. Therefore, the variables for clustering were chosen:

1) the number of patents issued in the region;

2) the share of organizations that carried out technological innovations (I-activity level);

[19] Source: compiled by the authors.

3) the percentage of scientific activity (science) in the structure of GRP;

4) the number of scientists and researchers per 1 citizen.

For cluster analysis, the authors use data standardization across variables to equalize the significance of the parameters. Centroid clustering with Euclidean square distance was used as a clustering method. Clustering results are presented in tables and graphs (see Appendices 3[20]). Therefore, we can identify the following clusters:

1. *The Leader*: Moscow autonomous city;
2. *Innovation centers*: Saint-Petersburg autonomous city, Moscow administrative region, Nizhny Novgorod administrative region;
3. *Regions of high manufacturability*: Republic of Tatarstan, Rostov administrative region, Republic of Mordovia, Chuvash Republic;
4. *Old R&D regions*: Novosibirsk administrative region, Tyumen administrative region, Kaluga administrative region, Tomsk administrative region, Voronezh administrative region, Sverdlovsk administrative region, Republic of Bashkortostan, Samara administrative region, Chelyabinsk administrative region, Yaroslavl administrative region, Vladimir administrative region, Perm administrative territory, Penza administrative region, Tula administrative region, Omsk administrative region, Ulyanovsk administrative region, Ivanovo administrative region;
5. *Regions-outsiders*: Altai republic, Altay administrative territory, Amur administrative region, Arkhangelsk administrative region, Astrakhan administrative region, Belgorod administrative region, Bryansk administrative region, Chechen Republic, Chukotka autonomous district, Irkutsk administrative region, Jewish autonomous region, Kabardino-Balkar republic, Kaliningrad administrative region, Kamchatka administrative territory, Karachay-Cherkess republic, Kemerovo administrative region. Khabarovsk administrative territory, Khanty-Mansi autonomous district, Kirov administrative region, Komi Republic, Kostroma administrative region, Krasnodar administrative territory, Krasnoyarsk administrative territory, Kurgan administrative region, Kursk administrative region, Leningrad administrative region, Lipetsk administrative region, Magadan administrative region, Mari El Republic, Murmansk administrative region, Nenets autonomous district, Novgorod administrative region, Orenburg administrative region, Orlov administrative region, Primorsk administrative territory, Pskov administrative region, Republic of Adygea, Republic of Buryatia, Republic of Crimea, Republic of Dagestan, Republic of Ingushetia, Republic of Kalmykia, Republic of Karelia, Republic of Khakassia, Republic of North Ossetia–Alania, Republic of Sakha (Yakutia), Republic of Tuva, Ryazan administrative region, Sakhalin administrative region, Saratov administrative region, Sevastopol autonomous city, Smolensk administrative region, Stavropol administrative territory, Tambov administrative region, Tver administrative region, Udmurt Republic, Vologda administrative region, Vologograd administrative region, Yamalo-Nenets autonomous district, Zabaykalsky administrative territory.

Discussion and Conclusion. As we noted earlier, the results of the region's innovative activity depend on the regional patent policy. At the time of preparing this article, a definition of this term has not been finally formed in Russian scientific articles. Most studies deal either with regional innovation policy in general [18] or

[20] Appendices 3. https://doi.org/10.15507/2413-1407.127.032.202402.254

with the patent policy of individual organizations (most often universities and firms), sometimes the term "patent policy" appears in the context of the national patent policy in a particular country, but also remains without a clear definition [19]. At the same time, it should be noted that the economic and political economic aspects and strategies of the state patent policy have been deeply theorized in international studies. Thus, in the papers[21] at the microeconomic level, within the framework of the optimal patent theory, various strategies of patent policy in the market were modeled, including redirection to technological change of firms' choices toward a more socially efficient mix of products and processes. In addition, a significant part of researches is devoted to modeling the impact of national patent policy on economic growth [20; 21]. Nevertheless, most of these foreign studies also do not have a clear definition of the term "state patent policy" and especially "regional patent policy". For this reason, in this study, we attempt to formulate the authors' definitions of the terms "regional patent policy" and "state patent policy".

By *the regional patent policy*, the authors of the article understand strategic actions and decisions applied at the regional level, aimed at managing and developing the patent system, as well as stimulating innovation and patent activity in this region.

The regional patent policy depends on the priorities and principles laid down in national (state) patent policy. In turn, *the national patent policy* refers to the system of norms, rules and measures adopted and regulated by the government to manage patents and intellectual property to stimulate innovation, protect the inventors' rights (their intellectual property) and ensure the public interest.

The authors of the article also propose to distinguish different types of state patent policy. Thus, we propose the following typology of state patent policy:

– *Centralized* and *decentralized*;

– *Incentive* (emphasis on financial incentives for inventions; simplification and acceleration of patenting procedures) and *conservative/protective* (emphasis on protecting property rights, compliance with regulatory standards);

– by relying on stakeholders (by type of agent support): *oriented on research institutes* [14; 22; 23], *business/corporate-oriented* (support for large corporations and industrial giants), *startup-oriented* (individual entrepreneurs and small businesses);

– *Active* (active state intervention through financing) and *passive* (the state is limited to creating legislative norms and structures without active financial support);

– by global scale: *global/international* (international agreements and standards), *national* (creation of national legislation and national support measures) and *regional*;

– *"statist" type* (the state can assign rights to all inventions obtained as a result of research at the expense of public funds, and inventions cannot be patented, and inventors cannot claim rights to them) and *"partnership"* type (rights to inventions obtained as a result of conducting research at the expense of public funds, may belong to the organization that did it, and the state receives a free non-exclusive license to use it) [24].

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[21] Gallini N.T. Patent Policy and Costly Imitation. *The RAND Journal of Economics*. 1992;23(1):52–63. https://doi.org/10.2307/2555432; Vaughan F.L. Patent Policy. *The American Economic Review*. 1948;38(2):215–234. https://doi.org/10.2307/1910493

Thus, based on the factors influencing on regional patent activity (regression analysis results) and the identified clusters (clustering results) for each group of regions of the Russian Federation we can highlight its priorities in regional patent policy.

Thereby, for the *"Innovation centers"* group, the directions of regional patent policy are related to ensuring sustainable growth of patent activity and improving the quality of the patents themselves for their greater commercialization. For the *"Leader"*, it is important to define goals for the future and promising directions of innovation policy. These two clusters may consider the option of a protective regional patent policy, since it may improve the quality of registered patents.

An active and stimulating patent policy should be common to the other three groups: financial support and stimulation of registration of large companies and inventions in their regions, and not their outflow to the "innovation centers" group.

For the *"Regions of high manufacturability"* group, it is important to increase patent activity, the quality of patents and their commercialization, which will contribute to the innovative development and economic growth of the regions of this group. Thus, the growth of scientific activity in the structure of the GRP and an increase in funding will allow these regions to break into the group of "innovation centers". The closest to achieving this result is the Republic of Tatarstan.

The group *"Old R&D regions"* mainly concentrates on regions with old science cities and research institute centers (Novosibirsk administrative region, Samara administrative region, Sverdlovsk administrative region, Tomsk administrative region, etc.). As the direct heirs to the planned Soviet economy, where a statist type of patent policy was implemented, these regions are hard enough to move to a partnership type (model) of patent policy. Obviously, these regions also face the type of patent policy oriented towards research institutes. Modernization of research institutes, determination of priorities for research activities, and additional funding from the federal center will unlock the potential of many regions of this cluster and increase investment attractiveness for registering patents and companies.

"Outsiders" are the largest group of regions. These are regions facing such problems as: low investment attractiveness, the presence of formal and informal bureaucratic barriers to patent registration, relatively low levels of socio-economic development in general, proximity to "leaders" and "innovation centers", etc. Based on the specialization of the region, it is important for this group to correctly determine and formalize the regional patent policy.

All regions cannot be potential innovation centers due to regional division of labor and specialization. The presence of an "outsiders" cluster is a natural situation in the economy of any country. However, in Russia, the absolute majority of regions (61 regions) found themselves in this group, with a huge gap even from the regions of the "Old R&D regions" cluster. This highlights the significance for many regions of this cluster to create or radically revise the innovation development strategy and the regional patent policy: determination of need for effective mechanisms to support patent activity, transition to an active patent policy.

This is especially important since many regions of this cluster either do not have a regulatory framework for planning innovative development in the region (for example, strategies for innovative development or a section for innovative development in the overall strategy for socio-economic development) (e.g. Omsk administrative region, Astrakhan administrative region, Kaliningrad administrative region, Oryol region, Sevastopol, Pskov region, Novgorod region, Karachay-Cherkess Republic, Republic of Kalmykia, Jewish Autonomous Region, Republic of Adygea, Altai Republic, Nenets autonomous district, Chukotka autonomous district, etc.) or their regulatory framework is not sufficiently ramified (e.g. Smolensk administrative region, Yamalo-Nenets autonomous district, Republic of Dagestan, Republic of Khakassia, Kamchatka administrative territory, etc.)[22].

We assume that at the initial stage of patent policy formation in these regions, the startup-oriented type can increase patent activity in general. However, this patent policy type can lead to the flow of patented utility models and inventions to the large companies located in the "Innovation centers" cluster due to the low socio-economic indicators of the "Regions-outsiders". This may cause issues in the future innovative development and investment attractiveness of these regions.

The statistical analysis of time series demonstrates high inequality among regions in terms of patent activity: 4 leading regions (Moscow autonomous city, Saint-Petersburg autonomous city, Moscow administrative region, Republic of Tatarstan, Sverdlovsk administrative region) issue more patents than the remaining 81 regions (10949 and 10780), at the same time, most regions (66 regions) in terms of patent activity do not reach the Russian average level (255 patents). This indicates that innovation and technological activity is concentrated in several developed regions and is almost completely absent in economically backward regions of the Russian Federation [25; 26]. We also found a relatively stable downward trend in both issued patents and patent applications over the past 10 years. At the same time, the approval rate of patent applications over the past 10 years does not have a clear trend toward growth or decline.

Based on the results of the regression analysis, we were able to refute and confirm several hypotheses about the influence of indicators on regional patent activity. Thus, we were able to statistically confirm the hypothesis, based on the theoretical principles of Romer's economic growth model, that human capital has a decisive influence on patent activity. In addition, it was revealed that an increase in internal spending by organizations on research and development also leads to an increase in patent activity in the region. The share of technological organizations in the region (the I-activity level) has a statistically significant positive impact on regional patent activity.

We were also able to confirm the hypothesis about the impact of digitalization on the growth of patent activity in the region. We also tested the correlation between the Digitalization Index, calculated by the HSE based on the share of organizations using digital technologies in the total number of organizations[23]. In this case, the Pearson correlation was significant ($r \approx 0.416$). Therefore, the hypothesis about the impact of regional digitalization on patent activity can be confirmed. However, the authors admit the importance of a more detailed analysis of this hypothesis in future research projects and studies.

[22] Abashkin V., Abdrakhmanova G., Bredikhin S., Gokhberg L. [Russian Regional Innovation Scoreboard. Issue 7]. Moscow: HSE University; 2021. p. 56–58. (In Russ.) Available at: https://www.hse.ru/mirror/pubs/share/492403134.pdf (accessed 08.08.2023).

[23] Abdrakhmanova G., Demidkina O., Demyanova A., et al. Digital Economy Indicators in the Russian Federation.

In this study, we also theorized and conceptualized issues of regional and state patent policy: the authors' definitions of these concepts and typology were proposed. Thus, the authors define *the regional patent policy* as strategic actions and decisions applied at the regional level, aimed at managing and developing the patent system, as well as stimulating innovation and patent activity in this region. *The national patent policy* is determined through a system of norms, rules and measures adopted and regulated by the government to manage patents and intellectual property in order to stimulate innovation, protect the rights of inventors (their intellectual property) and ensure the public interest.

Moreover, we cluster regions of Russia by patent activity: The Leader, Innovation centers, Regions of high manufacturability, Old R&D regions, and Regions-outsiders. Applying the regional patent policy concept, we identified for each cluster the main directions and possible types of regional patent policy. Thus, for the "The Leader" and "Innovation centers" clusters, a scenario of a restraining (protective) regional patent policy is possible, since it will improve the quality of registered patents. An active and stimulating patent policy should be common to the rest of the clusters: financial support and stimulation of registration of large companies and inventions in their regions, and not their outflow to the "Innovation centers" group. For the "Outsiders" cluster, it is extremely important to create a regulatory framework for planning innovative development in the region: strategies for innovative development, strategies for digital development of the region, or a section of innovative development in the overall strategy of socio-economic development. The danger for this cluster of using a startup-oriented patent policy is emphasized due to the risks of patents being bought out by large companies in developed regions of Russia due to the low socio-economic indicators of outsider regions

In conclusion, the overconcentration of regional patent activity in 4 subjects of the federation raises the issue of finding solutions to this problem for the regions- outsiders. In this context, further research and systematization in the field of the theory of national and, in particular, regional patent policy in line with not only the normative (legal) approach, but also from the point of view of modern political economy, acquire particular significance.

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