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Elaborating a Methodology for Assessing the Impact of Innovation Entrepreneurship on the Development of the Region's Economy

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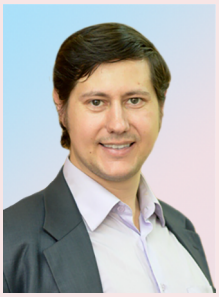

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Abstract. Along with the transition of the Russian economy to innovation development, the role of innovation entrepreneurship as a driver of intensive economic growth has significantly increased. This type of entrepreneurship provides regions with competitive advantages. The purpose of the study is to assess the extent of influence of innovation entrepreneurship on the level of economic development of Russian regions by testing the technique of regression analysis of panel data. In order to achieve this goal, we addressed the following tasks: first, we reviewed scientific papers that investigate the influence of the innovation factor (including innovation entrepreneurship) on the development of the regional economy; second, we selected and scientifically substantiated the choice of statistical indicators that reflect, on the one hand, the development of innovation entrepreneurship and on the other – the development of the economy of Russian regions; third, we analyzed the impact of innovation entrepreneurship on the

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economic development of Russian regions on the basis of the indicators selected and with the use of econometric tools. We applied the following scientific methods: systematization, generalization, study of literature, documents, and results of activities. We should separately highlight the method of mathematical modeling that we used to perform a regression analysis. The following results were obtained: first, on the basis of the review, we found that innovation entrepreneurship has a significant impact on the development of the economy of regions, especially during recession periods; second, the results of the regression analysis allowed us to confirm the hypothesis that innovation entrepreneurship should be considered a significant factor in economic development of Russian regions. We also revealed that in the conditions of the modern domestic economy, the technological component of innovation entrepreneurship (the essence of which is the development of innovative solutions) is the most prominent one.

Key words: innovation entrepreneurship, region, gross regional product, indicator, innovative solution, innovation product, regression analysis, modeling, panel data.

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Introduction

Economic scientists have always paid considerable attention to the problem of identifying factors and finding sources of economic development. A striking example is the protectionist economic policy developed within the framework of mercantilism, the main provisions of which proclaimed the establishment of high import duties, support for national producers, etc. (De Santis, W. Stafford, T. Mann, A. de Montchrestien) (Gadzhiev, 2017; Cwik, 2011).

A. Smith believed that the foundation of economic development within a particular socio-economic system consists in its absolute advantages, that is, factors that ensure the possibility of producing more goods using a constant amount of resources. For example, favorable agro-climatic conditions can be considered as absolute advantages for most agricultural areas. Developing the theory of A. Smith, D. Ricardo introduces the term "comparative advantages". In his opinion, even if the region does not have absolute advantages, this does not mean that the production of any good is not profitable for it. According to D. Ricardo's theory, the time spent on producing a unit of goods is the main condition for ensuring competitiveness in the production process (Fenin, 2017; Shumacher, 2012a, Shumacher, 2012b).

Representatives of institutionalism (W. Hamilton, T. Veblen, J. Galbraith, J. Commons, etc.) assigned a special role in economic development to social institutions. According to J. Keynes, state regulation of the economy (in particular, its influence on aggregate demand) is the basis of its stability and subsequent development, as well as the main tool for overcoming crisis situations. J. Schumpeter, the founder of the Theory of Innovation (The Theory of Economic Development, 1911), believed that innovation is recognized as the dominant factor ensuring the development of an economic system (Kurz, 2007; Bessy, Favereau, 2010; Kovaleva, 2015; Salamova, 2020; Hospers, 2005; Dequech, 2012; Caballero, Soto-Oñate, 2015).

We can find a lot of similar examples in the history of economic teachings. However, we should note that, so far, scientists have not come to a single

conclusion about which factors have the greatest impact on economic development.

With the advent of regionalism and regional economics (the first half of the 20th century), the research into the factors that influence economic development in individual territorial units became most widespread. This was due to the fact that in the conditions of an industrial and post-industrial society, the region became a complex multicomponent system whose structure and specifics were in no way inferior to the state as a whole. In many cases, the development of a State is determined by the development of its individual regions.

It is important to note that in the context of this study we will consider the term "region" from the standpoint of an administrative-territorial approach (G.V. Gutman, V.I. Leskin, A.V. Shvetsov, K. Deutsch, etc.). Thus, the region will be identified with the notion of constituent entity of the federation (or a group of entities, for example, an economic district or a federal district) (Leksin, Shvetsov, 1997; Gutman, 2002). The choice is due to the fact that the data for the regression analysis carried out in the framework of the work are taken for each RF region where the region is an administrative-territorial unit (that is, a constituent entity of the federation).

Relevance of the research. In the context of global resource constraints accompanied by pessimistic forecasts about considerable depletion of natural resources and food reserves, a tense military-political situation, and a number of other circumstances, one of the ways to solve the problem for our country is to develop an innovation-oriented paradigm of socio-economic development. Gradually, Russia should transform from an exporter of raw materials into a technologically advanced power producing a high share of added value (Polyanskaya, Naidenova, 2015).

The modern reproduction system needs to develop and implement innovations at almost all stages – from production to consumption. Old technologies that have exhausted their resource cannot help Russian regions (and Russia as a whole) to cope with competition and achieve their goals. This requires practical implementation of innovation in individual economic processes in the economy of each of RF constituent entities. Innovations act as a key factor in sustainable economic growth, contribute to the creation of a reliable material and non-material basis for the life of the present and future generations.

With the transition to the Fourth Industrial Revolution (sixth technological paradigm) The Russian Federation, like many other countries, has chosen an innovation "path" of development. In this regard, the formation of innovation entrepreneurship, innovation enterprises, etc. has become widespread. This is due to the fact that this type of entrepreneurship plays a key role in the innovation process. The function of implementing the most important stage of the innovation process (namely, the stage of commercialization of innovations) in a market economy is assigned to private innovation companies, which play a decisive role in the process of transferring a novelty into the innovation category. In addition, they participate in the creation of "innovative solutions" along with universities, research institutes, research centers, etc. Possessing financial resources, innovation business entities are able to conduct longitudinal and rather costly scientific research, which is often difficult to do within the framework of scientific organizations that are state-owned (since they are significantly limited by the financing factor) (Burkina, 2020; Oliveira, 2019).

Based on a review of a number of scientific papers (Zhil'nikov, 2014; Burkina, 2020; Kupriyanov et al., 2020; Golova, 2021; Smotritskaya, Chernykh; 2021; Oliveira, 2019; Oswald, 2019), as well as works by representatives of the theory of endogenous economic growth (P. Romer, R. Lucas, G. Grossman, P. Aghion, D. Audretch, A. Rodriguez-Pose, B. Jovanovich, etc.), whose research is the current mainstream in studying the impact of the innovation

factor on the economic development of regions, we can conclude that innovation entrepreneurship provides regions with competitive advantages through the use of qualitatively new means and objects of labor, production of goods with high added value, optimization of a number of production processes, savings on the use of natural resources, development of new market sectors and types of economic activity, creation of new jobs (including high-tech jobs) (Zadumkin, Terebova, 2009; Lucas, 1988; Grossman, Helpman, 1989; Romer, 1990; Rivera-Batiz, Romer, 1991; Romer, 1992; Nelson, Romer, 1996).

Innovation entrepreneurship obviously has a positive impact on the development of the regional economy; the works of both Russian and foreign researchers clearly prove it. Nevertheless, the acute scientific problem still consists in the lack of tools that allow for a comprehensive and objective assessment of the impact of innovation entrepreneurship on the economic development of regions (including an assessment of the degree of such influence).

Within the framework of our work, an attempt is made to solve this scientific problem by applying the methodology of regression analysis of panel data characterizing innovation entrepreneurship. We should note that previously the scientific literature did not use this tool on a wide-scale basis for solving the problem of assessing the impact of innovation business on regional economy. Some studies in which attempts have been made to conduct such an analysis do not consider the specifics of the data that have a panel structure; moreover, the range of indicators characterizing innovation entrepreneurship in these studies is insufficient (Zhil'nikov, 2014; Chelnokova, Sumarokova, 2014). At the same time, when eliminating these "gaps", we think that the choice of the above-mentioned methodology, due to the structure of the values of the indicators selected for analysis, is the most objective in solving the scientific problem we have defined. This assumption forms the basis of the scientific hypothesis of our study. The hypothesis is formulated as follows: the use of regression analysis of panel data will allow us to obtain consistent, statistically significant estimates of indicators characterizing innovation entrepreneurship and comprehensively characterize its impact on the development of the region's economy.

Russian regions will be considered as the object of the study. The subject of the research is innovation entrepreneurship as a driver of economic development of RF regions. It is worth noting that innovation entrepreneurship will be understood not only as small or medium-sized enterprises, but as entrepreneurship in general (including large business).

The purpose of the work is to assess the degree of influence of innovation entrepreneurship on the economic development of Russian regions.

To achieve this goal, it is necessary to address the following tasks:

1. To review scientific papers that examine the impact of innovation, as well as innovation entrepreneurship on the development of the regional economy.

2. To carry out and scientifically substantiate the selection of statistical indicators reflecting, on the one hand, certain aspects of the activity of innovation entrepreneurship, on the other hand, the development of the economy of Russian regions.

3. To analyze the impact of innovation entrepreneurship on the economic development of RF regions on the basis of the selected indicators through the use of econometric tools.

Literature review

Innovations are considered as a significant factor that promotes economic development. A number of scientists (A. Toffler, F. Fukuyama, D. Bell, etc.) believe that the majority of developed countries in the modern world have gained global economic superiority primarily with the help of innovation economy (Toffler, 1986).

Current practice and the works of Russian and foreign scientists prove the dependence of economic growth on the pace of development of scientific and technological progress (research by N.Ya. Tinergen, R. Solow, J. Hicks, etc.). The hypothesis put forward within the framework of the theory of endogenous economic growth about scientific and technological innovations as internal sources of constant growth has allowed us to develop a number of models of long-term economic growth provided, on the one hand, by investments in physical capital (machinery and equipment), on the other hand, by investments in human capital. Models with investments in the knowledge sector deserve special attention (Uskova, 2009; Rivera-Batiz, Romer, 1991; Nelson, Romer; 1996). In addition, according to P. Romer, there is an increasing public return on R&D spending (Romer, 1990).

It is worth noting that the Russian economy has chosen a course toward innovation development. However, innovation infrastructure facilities in Russia the were formed and developed with some lag behind other developed countries.

There are several main stages in the post-Soviet history of innovation. The period that took place in the 1990s is characterized by an almost complete lack of demand for innovations. The state innovation policy existed nominally – in the form of the Decree of the President of the Russian Federation dated April 27, 1992 no. 426 "On urgent measures to preserve the scientific and technological potential of the Russian Federation"[1]. Since at that time the domestic economy was commodity-heavy, representatives of extractive industries (mainly oil and gas corporations) were the main customers of innovations (Gretchenko, Monakhov, 2011).

The next stage (the 2000s) is characterized by a general rise in industrial production and the economy as a whole. Individual sectors began to demand scientific and technological achievements (including the light industry, the food industry, as well as the fuel and energy complex). State innovation policy was implemented through the formation of federal target programs, establishment of special economic zones, science towns and technology parks. The innovation policy was presented in the Letter of the President of the Russian Federation no. Pr-576 dated March 30, 2002 "Fundamentals of the policy of the Russian Federation in the field of science and technology development for the period through to 2010 and beyond"[2]. At this stage, associated with the completion of transition processes, there is a relatively stable situation in the field of innovation research. During the period under consideration, there has been a steady trend of increasing state participation in the innovation process (Gretchenko, Monakhov, 2011).

Among the Russian scientists and economists who dealt with the impact of the innovation factor on the economic development of regions during this period, we would like to highlight L.I. Abalkin, S.Yu. Glazyev and others (Abalkin, 2004; Glazyev, 2008; Glazyev, 2011; Glazyev, 2013a; Glazyev, 2013b). In particular, L.I. Abalkin studied the drivers of national economic development and noted the originality of the market economy model that gives top priority to an innovation approach to solving urgent economic problems (Abalkin, 2004).

The next stage (since the end of the 2000s) is characterized by the inclusion of innovation activities in the list of the main priorities of the country. During this period, the Foundation for the Development of the Center for the Development and Commercialization of New Technology (the Skolkovo Foundation) was established, the Strategy

[1] On urgent measures to preserve the scientific and technological potential of the Russian Federation: Presidential Decree 426, dated April 27, 1992 (amended September 30, 2012). Available at: http://www.consultant.ru/document/cons_doc_LAW_3269/

[2] Fundamentals of the policy of the Russian Federation in the field of science and technology development for the period through to 2010 and beyond: Presidential Letter Pr-576, dated Mach 30, 2002. Available at: http://www.consultant.ru/document/cons_doc_LAW_91403/

for Innovation Development of the Russian Federation for the period through to 2020 was approved, and the implementation of Order no. Pr-22 dated January 4, 2010 (Item 5, Sub-item "b") on the elaboration of innovation development programs (IDPs) was launched (Burkina, 2020). Amendments to legislation aimed at stimulating innovation are currently being discussed. Promoting innovation has been elevated to the status of a national project.

According to I.I. Smotritskaya and S.I. Chernykh (Smotritskaya, Chernykh, 2021), at the present stage, an economic model built on the basis of a continuous process of innovative renewal has no alternative in ensuring sustainable socio-economic development. It is worth noting that this opinion is shared by the majority of foreign and Russian scientists (Aganbegyan et al., 2020; Golova, 2021; Oswald, 2019). Nevertheless, we can encounter "polar" positions. In particular, Yu.V. Simachev and colleagues (Simachev et al., 2021) note that at the nationwide level, a positive relationship between productivity and innovation is not always observed. Some foreign authors (Ramadani et al, 2019) also adhere to this thesis, saying that the importance of innovation for productivity growth increases as we approach the technological frontier. In an economy far from the technological frontier, on the contrary, economic growth is based rather on "physical" factors (fixed capital, labor force, etc.).

According to A.G. Aganbegyan, in order to ensure sustainable development of the domestic economy, it is necessary to provide an annual increase in the high-tech production sector by about 15% in the coming years (Aganbegyan, 2020). In the modern world, with the global nature of producer competition and a sharp acceleration of the pace of scientific and technological development, it is fundamentally possible to achieve this only in line with the innovation paradigm.

I.M. Golova notes that Russia's transition to an innovation development paradigm is an objective necessity in the context of ensuring sustainable competitive growth. Nevertheless, according to the researcher, Russia is currently lagging significantly behind the technological leaders in terms of innovation activity. Russia ranks 48th (between Romania and India) on the Global Innovation Index. In addition, Russia's share in global high-tech exports decreased to 0.35%. The economy's dependence on imports for such crucial items as machine tools and tools is about 90%, which poses a serious threat to the country's socio-economic security, especially in the face of increasing international sanctions (Golova, 2021).

At present, the transition of the Russian economy to the path of innovation development is limited by a large number of factors, including the consequences of the global crisis, as well as sanctions imposed on Russia by a number of foreign states. These reasons have a negative impact on the innovation activities, as well as provoke negative dynamics of industrial growth rates, slowing down the development of infrastructure industries, which seriously restricts institutional and technological changes in the economy and leads to a greater drop in the competitiveness of Russian industry in world markets, including high-tech ones. For the successful development of the Russian economy in the innovative aspect, it remains important to develop measures aimed at modernizing production, industry, and the development of innovative entrepreneurship, the implementation of which will contribute to changing the technological appearance of the territory of the Russian Federation (Yakushev, 2017; Kuznetsova, 2019).

As a rule, microeconomic units – subjects of innovation activity and organizations of innovation infrastructure – become the immediate local "points" of innovation implementation and the realization of relevant investment projects. These are the enterprises, as well as individual entrepreneurs engaged in industries, agriculture, and services.

The private sector (represented by entrepreneurs) is considered one of the key actors in innovation development in regional socio-economic systems. This is due to the fact that entrepreneurship

is a representative of the "real" sector of the economy, which creates a product and sells it on the market. In the context of the transition of the world's largest economies to innovation development, we would like to focus on the role of innovation entrepreneurship in ensuring economic development in regions. We should note that the idea of R. Nelson (one of the founders of the concept of national innovation systems (NIS)) was that private commercial firms are the "heart" of the national innovation systems of large industrialized countries.

Innovation entrepreneurship is an independent activity carried out by entrepreneurs on a systematic basis; this activity is connected not only with the development of innovations, but also their transfer to the category of innovations (Ivanov, 2021). Among the scientists who have been engaged in and are still studying the impact of innovation entrepreneurship on the development of regional economies, representatives of the Harvard School, the Austrian School, and the Modern Russian School of Innovation can be noted. Also we would like to mention the representatives of the theory of endogenous economic growth (Lucas, 1988; Grossman, Helpman, 1989; Romer, 1990; Rivera-Batiz, Romer, 1991; Romer, 1992; Nelson, Romer, 1996).

Drawing an analogy with innovation development, we can say that the history of innovation entrepreneurship development in Russia also has three stages (the 1990s, 2000s, 2010s). Private innovation organizations in Russia emerged back in the first half of the 1990s during the privatization campaign, when small enterprises started to be formed from sectoral research institutes; these enterprises sought to use their own intellectual potential to maintain "viability" in a new economic situation. Their number was gradually decreasing, which was due to the low demand for innovation and the difficulty of entering the market with new products. Nevertheless, since the late 1990s, new innovation organizations have been emerging; they were created to conduct research and development for large companies. Besides, we should note that in 2009 Federal Law 217[3] was adopted, which allows small innovation enterprises to be formed on the basis of universities. Thus, before the adoption of this federal law, most of the innovation enterprises acted as independent companies. The share of state participation was relatively small (Bauman, 2005).

With the adoption of FZ-217, in the first few years alone (from August 2009 to the end of December 2013), about 2,000 small innovation enterprises (SIEs)[4] were established on the basis of 281 Russian universities. It is worth noting that such firms were created not only on the basis of universities, but also research institutes, as well as other institutions of the Russian Academy of Sciences.

The impact of innovation enterprises on the regional economy is considered in the works (Polunin, 2012; Zhilnikov, 2014). According to L.V. Polunin, there is an urgent need to develop a long-term regional innovation policy. In the economic system undergoing a transformation, innovations should take a completely different key place in creating GRP and ensuring the competitiveness of the region's economy. In the work (Zhilnikov, 2014), an attempt was made to perform a correlation analysis aimed at assessing the significance of the impact of innovation activities of enterprises on the economic development of RF constituent entities. In particular, the author selected indicators that characterize, on the one hand, innovation activity (average level of

[3] On amendments to certain legislative acts of the Russian Federation on the creation of economic companies by budgetary scientific and educational institutions for the purpose of practical application (implementation) of the results of intellectual activity: Federal Law 217-FZ, dated August 2, 2009. Available at: http://www.consultant.ru/document/cons_doc_LAW_90201/

[4] Small innovation enterprises: In the conditions of a "barrier environment". Available at: https://akvobr.ru/problemi_razvitiya_malih_innovacionnih_predpriyatii.html

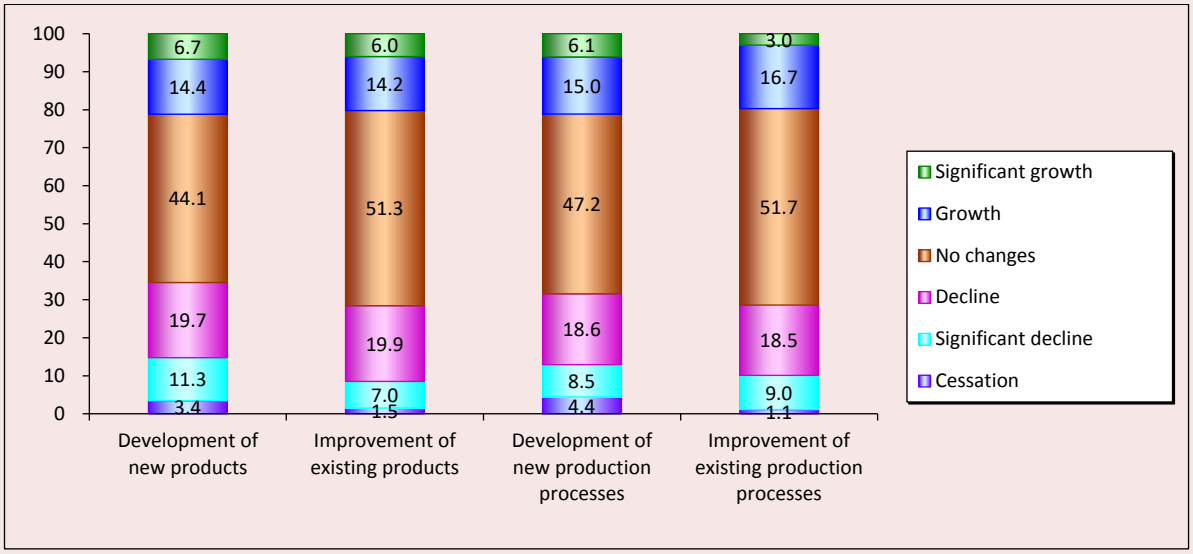
R&D expenditure, average volume of innovative goods, works, services), on the other – economic development of the region (average GRP of the region). The results of multiple correlation analysis allowed the authors to conclude that the innovation activity of enterprises has a significant impact on economic development in the region.

It is worth noting that the role of innovation entrepreneurship has significantly increased during the economic recession observed recently in many countries and caused by various reasons. In particular, this is due to the impact of restrictive measures introduced during the pandemic. In addition, trade wars between countries are actively underway (the United States and countries of Foreign Europe impose economic sanctions against Russia, China, countries of the "Latin American market" (Mexico, Brazil, Argentina)) (Kupriyanov et al., 2020).

Despite all the negative implications of the economic recession, we can firmly state that the current recession creates a favorable "ground" for the development of innovations that are launched through the creative use of existing technologies and competencies. Thanks to non-standard management solutions, many innovation enterprises have profitably integrated into the environment: organizations engaged in the development of robotics have adapted their own technology for medical purposes by introducing it into the process of disinfection of premises. Amazon has launched artificial intelligence technology, which allowed retailers to abandon cash turnover. Diagnostic equipment has also been developed to scan the lungs for virus damage in less than a minute. According to a report of the World Economic Forum, since April 2020, the number of global innovation developments in the field of combating the pandemic has increased threefold (Kupriyanov et al., 2020).

The effects of the COVID-19 pandemic in relation to innovations in a modern high-tech sector were assessed by specialists of the Institute for Statistical Studies and Economics of Knowledge of the National Research University Higher School of Economics (HSE). The analysis was based on the results of a survey of 529 enterprises of high-technology and medium-high-technology industries

Effects of the COVID-19 pandemic: innovation activity (% of the surveyed innovation-active enterprises)



Source: Effects of the COVID-19 pandemic on innovations in the Russian high-tech sector. Website of the HSE Institute for Statistical Studies and Economics of Knowledge. Available at: https://issek.hse.ru/news/473020936.html (accessed: January 21, 2022).

(according to the Eurostat/OECD classification) within the framework of the HSE regular monitoring of innovation activity of enterprises as of end of 2020. The sample is representative by type of economic activity. The results are weighted to reflect the real structure of the Russian economy *(Figure)*.

As we can see in the figure, one fifth (19.5%) of companies took advantage of the crisis to expand their own research and development program. Besides, in 2020, the overall level of innovation activity of organizations in the Russian Federation amounted to 10.8%, which is 1.7 percentage points (p.p.) higher than it was a year earlier (before the onset of the pandemic). The largest growth was demonstrated by such areas as IT (by 10.2% versus 5.5% in 2019), healthcare (8.6% versus 5.3%), software development (13.2% versus 11.1%)[5].

It turns out that the role of innovation enterprises during recession periods is of particular importance, since they are among the first ones to increase their own business activity, which undoubtedly contributes to the "revival" of the economy as a whole. On the one hand, this is due to the fact that innovation enterprises are important actors in scientific and industrial cooperation (Kuznetsova, 2019). In addition, to ensure the stable functioning of innovation companies, firms that are engaged in "servicing" their activities are often involved. For example, these may be firms specializing in the supply of raw materials, equipment repair (including office equipment), outsourcing, etc.

These studies have shown that innovation entrepreneurship can be considered as one of the significant drivers of economic development on the territory. However, it is worth noting that the development of innovation entrepreneurship in the Russian Federation at the present stage tends to slow down. This is evidenced by the negative dynamics of the values of indicators characterizing its effectiveness. In particular, the volume of innovative products has been steadily declining since 2015[6]. Moreover, territorial differentiation in the development of innovation enterprises was noted. This is partly due to the fact that the conditions for conducting innovation activities in the regions vary significantly. As a rule, the concentration of innovation business entities is observed in regions with developed innovation potential, where large scientific and scientific-educational organizations are concentrated, which, in turn, form the basis for innovation business.

Research methodology

In the course of the research, we used theoretical methods (systematization, modeling, generalization) and empirical methods (studying literature, documents and results of activities).

Using the method of systematization, we selected scientific papers that reflect certain aspects of the influence of the innovation factor (including innovation entrepreneurship) on the development of the regional economy; the papers were further studied in detail using the above-mentioned empirical method. Also, systematization helped us to select statistical indicators characterizing both the development of innovation entrepreneurship and the economy of Russian regions.

Since a large amount of analytical and statistical data is provided in the framework of the article, we used the graphical method to make their presentation more clear.

We would like to highlight the method of mathematical modeling, which was also used to build regression models reflecting the relationship between the indicators of development of the regional economy and innovation entrepreneurship. These models were built using Gretl statistical software.

[5] Exacerbation of innovation. The pandemic has intensified the introduction of research and development. Available at: https://www.kommersant.ru/doc/4987473.

[6] Appendix to the collection *Regions of Russia. Socio-Economic Indicators*. Available at: https://rosstat.gov.ru/folder/210/document/47652

Results and discussion

In order to assess the contribution of innovation entrepreneurship in regional economic development, we decided to conduct a regression analysis. This is due to the fact that regression analysis (unlike correlation analysis) allows us not only to establish the presence of a "response" of one variable to another, but also to identify the degree of influence of each regressor on the dependent variable. It is also important to note that within the framework of this work, we tested the methodology of regression analysis of panel data; it was due to the structure of the values of the indicators selected for analysis.

The primary task for the implementation of this analysis is to identify indicators that, on the one hand, reflect certain aspects of innovation entrepreneurship, and on the other hand, the level of economic development of the region.

Since in the framework of regression analysis the dependent variable (region's economic development in our case) should be presented in the singular as the most comprehensive indicator reflecting the level of development of the regional economy, we decided to use the GRP indicator. According to a number of researchers, including (see, for example: Fat'yanov, 2018), it is the GRP indicator that makes it possible to assess the scale and effectiveness of development of regional economies.

Before talking about indicators characterizing the activity of innovation entrepreneurship, we should point out a number of aspects related to the essence of this notion. The approaches to the essence of innovation entrepreneurship that were highlighted in the context of a research conducted at Vologda Research Center of the Russian Academy of Sciences (*technological approach*, according to which the main task of innovation entrepreneurship is to develop novelties; *economic approach,* in which innovation entrepreneurship is considered as an economic entity whose activities are aimed at commercialization of innovations; *comprehensive approach* that combines the provisions of the first two approaches) allow us to determine those statistical indicators that determine the designated type of entrepreneurship most effectively (Ivanov, 2021).

In the framework of this study, we use a comprehensive approach, since it includes both technological and economic components of innovation entrepreneurship thus reflecting the entire multidimensional nature of the concept under consideration.

Conditionally, the indicators that characterize innovation entrepreneurship can be divided into two groups:

1. Indicators characterizing the drivers of innovation entrepreneurship activity:

– the number of organizations that have carried out research and development;

– the share of organizations that implement technological innovations;

– internal R&D costs.

2. Performance indicators of innovation entrepreneurship:

– the volume of innovation goods, works, services;

– developed advanced production technology.

We chose indicators "the number of organizations that have carried out research and development" and "the share of organizations that implement technological innovations" because the specifics of innovation entrepreneurship consists not only in the development of innovative solutions, but also in the creation of an innovative product on their basis; this is reflected in the framework of an integrated approach to defining the essence of the term "innovation entrepreneurship".

The indicator "internal R&D costs" was chosen because it most comprehensively characterizes the costs of innovation activities of enterprises, since it includes not only current costs (for example, employee remuneration, purchase of raw materials to produce innovation goods, etc.), but also capital costs (to purchase equipment, as well), which may indicate the prospects for the development of innovation firms.

The significance of the indicator of the volume of innovation goods, works and services is that it characterizes the effectiveness of innovation entrepreneurship. According to A.A. Rumyantsev, Doctor of Economics, Professor, chief researcher at RAS Institute for Regional Economic Studies, "the volume of innovation goods, works, services in the total volume of goods shipped, works performed, services provided" is an effective indicator of activities to bring research findings to practical use (Rumyantsev, 2018). This opinion is shared by A.A. Abdulvagapova, who considers that "the volume of innovation goods, works and services" is the most important indicator of the effectiveness of small innovation entrepreneurship (Abdulvagapova, 2021).

However, we should note that the abovementioned indicator characterizes the performance effectiveness of organizations engaged in technological innovations to a greater extent. The activity of innovation organizations that conduct R&D is characterized by the indicator "developed advanced production technologies".

The inclusion of only the abovementioned indicators in the regression model will look incorrect, since innovation (including innovation entrepreneurship) is not the only driver of economic development. It would be more correct to consider the impact of innovation entrepreneurship on the regional economy against the background of the main drivers of regional economic growth, corresponding to indicators characterizing the cost of fixed assets, the size of investments in fixed assets, as well as the amount of labor force.

In addition, it is necessary to include an indicator that would most comprehensively characterize the business sector. For this purpose we chose the indicator of turnover of private companies in Russia.

It is worth noting that in a number of statistical collections, including *Innovation Activity Indicators* developed by specialists at the Higher School of Economics[7], one can find a wide range of statistical indicators, including calculated (relative) ones, which characterize certain aspects of activity, as well as the effectiveness of innovation entrepreneurship (for example, "the share of organizations that carried out certain types of innovation activity in the total number of organizations that implemented technological innovations", "the share of costs for certain types of innovation activity in the total amount of costs for technological innovations", "the volume of innovation goods, works, services created with the use of the results of intellectual activity, the rights to which belong to Russian copyright holders", etc.). Nevertheless, these indicators cannot be included in the model, since their values reflect the situation in the Russian Federation as a whole.

It is important to note that the values of the indicators were taken for the period from 2010 to 2019. At that time there was an awareness of the need to build an innovation economy at the state level. In particular, the Skolkovo Foundation was established, an innovation development strategy was developed, etc. (Burkina, 2020). Besides, a study of the statistical population aimed at identifying abnormal behavior (that is, statistical outliers) was conducted. The analysis excluded regions whose values differ several times from the average values in the sample (in particular, Moscow, Saint Petersburg, the Republic of Kalmykia, the Republic of Dagestan, the Jewish Autonomous Oblast).

Moving on to the approximation of the values of the selected indicators we would like to remind that GRP (dependent variable) is a generalizing indicator of regional economic activity that characterizes the process of production of goods and services for end use. Thus, the power approximation corresponding to the Cobb – Douglas production function seems to be the most correct one.

[7] Innovation activity indicators. Available at: https://issek.hse.ru/mirror/pubs/share/397986230.pdf

Table 1. Characteristics of variables for regression analysis

Variable	Unit of measurement	Symbol
Gross regional product*	Million rub.	Y
Cost of fixed assets*	Million rub.	C1
Investments in fixed assets*	Million rub.	C2
Number of workers	Unit	L
Turnover of organizations*	Million rub.	B
Organizations engaged in R&D	Unit	I1
Share of organizations implementing technological innovations	%	I2
Internal R&D costs*	Million rub.	I3
Volume of innovation goods, works, services*	Million rub.	I4
Developed advanced production technology	Unit	I5

* The values of the selected indicators were given in a comparable form (compared to the level of 2019).
Source: Appendix to the collection *Regions of Russia. Socio-Economic Indicators*. Available at: https://rosstat.gov.ru/folder/210/document/47652 (accessed: April 27, 2022).

This function is as follows:

$$Y = A \cdot |Li|^{ai} \cdot |Ci|^{bi}, \quad (1)$$

where A – constant multiplier;

Li – variables corresponding to labor costs as a factor of production;

Ci – variables corresponding to the cost of capital as a factor of production;

ai, bi – elasticity coefficients showing a percentage change in the dependent variable due to a one percent change in the corresponding regressors *(Li, Ci)*.

However, the formula (1) reflects the classical type of production function, where "labor" and "capital" are considered the main factors of production. With the development of economics, factors of economic growth were supplemented with "entrepreneurship" and "innovation".

As part of this work, the production function will take the following form:

$$Y = A \cdot |Li|^{ai} \cdot |Ci|^{bi} \cdot |Bi|^{ci} \cdot |Ii|^{di}, \quad (2)$$

where Bi – variables characterizing the business sector;

Ii – variables characterizing innovation entrepreneurship;

ci, di – elasticity coefficients showing a percentage change in the dependent variable due to a one percent change in the corresponding regressors (*Bi, Ii*).

Thus, we have one dependent variable (let us denote it as "Y") and nine independent variables (*Tab. 1*).

Returning to the question of approximating the values of the presented variables, we note that since the observations were carried out on different grounds for different time periods, the data considered in the context of the analysis were interpreted as panel data. In turn, the panel data analysis technique has a number of advantages over other methods. Thanks to their special structure, panel data help to build more meaningful models and get answers to questions that are not available within models based on spatial (or temporal) data. Moreover, often unobservable factors are correlated with other variables. Within regression models, this means that the unobservable factor is an essential variable in the model and its exclusion leads to biased estimates of the remaining parameters. Panel data models allow for more accurate parameter estimates, even taking into account the presence of multicollinearity between independent variables[8].

A technique for panel data analysis includes three main stages. At the first stage, a pooled model for panel data is being built. The combined model represents a linear regression model that practically does not take into account the panel data structure

[8] Unified model of panel data. Available at: http://www.machinelearning.ru/wiki/index.php?title=%

and does not allow realizing the potential of panel data, including the individual characteristics of the units under consideration.

Next, a fixed effect model is built. This model makes it possible to make a transition in the equation to the time averages. The conditions that are assumed within the framework of the model guarantee the non-bias and consistency of the estimates. This model is quite flexible, because, unlike the previous model, it allows taking into account the individual heterogeneity of objects. However, taking into account flexibility can lead to a loss of significance of estimates (due to an increase in their standard errors).

The final stage is the construction of a random effect model. This model is a compromise between the two previous ones, because it has fewer constraints than the first model, and it helps to get more statistically significant estimates than the second one[9].

Further, based on a number of criteria (including the coefficient of determination, log likelihood, etc.) and statistical tests (a joint test on selected regressors, a robust test, as well as the Hausman and Breusch–Pagan tests), the "best" model is selected.

Let us build models for panel data analysis that are described by the following equation:

$$\ln Y = \ln A + a1 \cdot \ln|C1| + a2 \cdot \ln|C2| + \\ + b \cdot \ln|L| + c \cdot \ln|B| + d1 \cdot \ln|I1| + d2 \cdot \ln|I2| + \\ + d3 \cdot \ln|I3| + d4 \cdot \ln|I4| + d5 \cdot \ln|I5|$$

Table 2. Modeling results

Coefficient values and their significance level	Pooled model	Fixed effect model	Random effect model
const	3.53***	13.67***	6.22***
ln|*C*1|	0.28***	0.01	0.13***
ln|*C*2|	0.25***	-0.01	0.09***
ln|*L*|	0.18***	-0.6**	0.17**
ln|*B*|	0.25***	0.45***	0.40***
ln|*I*1|	0.10**	0.13***	0.14***
ln|*I*2|	0.03**	0.07***	0.06***
ln|*I*3|	-0.03**	0.03	-0.03
ln|*I*4|	-0.03***	-0.01	-0.02**
ln|*I*5|	0.02	0.02**	0.02**
Value of R^2	0.97	0.99	-
Logarithm of likelihood	209.32	576.40	78.59
Results of a joint test on selected regressors (value of p-statistics)	-	5.49265e-23	0.00
Results of a robust test (value of p-statistics)	-	2.55255e-31	-
Results of the Breusch – Pagan test (value of p-statistics)	-	-	6.14028e-95
Results of the Hausmann test (value of p-statistics)	-	-	5.82948e-35

Note:
*** - the variable is statistically significant at the level of 1% or less;
** - the variable is statistically significant at the level of 5%;
* - the variable is statistically significant at the level of 10%.
Own compilation based on the results of regression analysis.

[9] Introduction to panel data analysis. Available at: https://pokrovka11.files.wordpress.com/2011/12/intro_panel.pdf

To do this, we will use Gretl programming environment. We chose this program, because, unlike, for example, Excel environment, Gretl environment allows us to use such an important tool as robust standard errors. This is expressed in the selection of calculation formulas adjusted for heteroscedasticity in the residuals, which significantly increases the accuracy of simulation results. The final values of the estimated coefficients, as well as a number of other indicators characterizing the resulting dependence, are presented in *Table 2*.

The table shows that within the framework of the pooled panel data model, the factor such as the cost of fixed assets of enterprises has the greatest impact on GRP. The second place is occupied by the factors related to investments in fixed assets and the turnover of private companies. The third place is occupied by the number of workers. As for innovation entrepreneurship, its contribution is also noticeable (mainly due to the activities of enterprises engaged in R&D).

According to the fixed effect model, the importance of innovation entrepreneurship for the development of the regional economy is quite high. In particular, in comparison with the previous model, the influence on the resulting variable has increased not only on the part of enterprises engaged in R&D, but also organizations implementing technological innovations (which is of particular importance, since technological innovations are considered as the main result of innovation entrepreneurship). Moreover, in the context of this model, the "return" from the variable characterizing the effectiveness of the technological component of innovation business (that is, from the implementation of R&D) has significantly increased. Nevertheless, the most noticeable effect on the dependent variable in the model with fixed effects is provided by the regressor, which characterizes the business sector (turnover of enterprises). The significance of this regressor (compared to the combined panel data model) has almost doubled. However, we should note that the degree of influence of variables corresponding to indicators characterizing the value of fixed assets, the size of investments in fixed assets, as well as the amount of labor force, has significantly decreased (and has even become negative in some cases). This could be due to the fact that taking into account the individual heterogeneity of objects (which is a characteristic feature of the model with fixed effects) has led to the loss of significance of the data of the variables that characterize them.

As for the random effect model, its results indicate the following: the business sector, as well as the labor factor (the amount of labor force), has the greatest impact on the development of the regional economy. Also, the degree of influence of organizations engaged in R&D is quite high (here it is the highest among all the models presented). In addition, the influence of organizations implementing technological innovations is noticeable. And, finally, the variable characterizing the effectiveness of the technological component of innovation entrepreneurship (developed advanced production technologies) is significant.

Having compared the values of the coefficients of determination (R^2), as well as the values of the logarithms of likelihood, we determined that the fixed effect model is the most "preferable" of the presented models; thus, we should make our choice in favor of this model. Moreover, it is backed by the results of the Hausmann test, the Breusch – Pagan test, the robust test, and the joint test on selected regressors.

However, from our point of view, the results obtained within the framework of this model do not quite objectively reflect the influence of individual regressors on the resulting variable: in particular, taking into account the specifics of the innovation process in modern Russian realities (it is described in more detail in the section "literature review"), it seems doubtful that the significance

of the variables characterizing innovation entrepreneurship is higher than the variables that characterize major drivers of regional economic growth. In our opinion, the results obtained within the framework of the combined panel data model, as well as random effect models, reflect the situation most accurately. Moreover, the values of the coefficients characterizing the drivers of innovation entrepreneurship activity and the effectiveness of such activity are virtually the same in the context of the fixed effect model and the random effect model. Therefore, in this situation, the choice in favor of the random effect model will be more objective.

Comparing the results obtained within the framework of all three models, we can note that the number of organizations engaged in R&D has the greatest impact on GRP (among the factors characterizing innovation entrepreneurship). The influence of organizations implementing technological innovations is 2–3 times less (depending on the model). This can be explained by the fact that in the conditions of the Russian economy, innovation enterprises, for the most part, are engaged in the development of innovation solutions, rather than creating innovation products based on them. The same is evidenced by the values of indicators characterizing the effectiveness of innovation entrepreneurship.

Scientific novelty of the study consists in the transposition of a research technique (regression analysis of panel data) on the subject of research (innovation entrepreneurship), in relation to which this method was previously used "narrowly" (which is due to the lack of completeness in the construction of panel models in the techniques we have studied, and which was solved within the framework of this study). The approbation of the methodology of regression analysis of panel data on the designated subject of research has shown its consistency, which is confirmed by the values of indicators characterizing the quality of the models (even within the framework of the combined panel data model, the value of the determination coefficient was 0.97). And taking into account the fact that the model included indicators that not only characterize innovation entrepreneurship, but also other factors of regional economic development (for example, the business sector without taking into account its "innovation" component), this method can be more widely used in conducting further studies related to assessing the impact of individual drivers of regional economic development.

Practical significance of the study lies in the fact that the results obtained can be used by representatives of regional governments to work out strategies for regional innovation development, including on the basis of innovation entrepreneurship. In particular, the simulation results have shown that with a one percent increase in the number of organizations engaged in R&D the potential growth of GRP in the region can be 0.14%, and with a one-percent increase in the share of organizations implementing technological innovation – by 0.07%. Presidential Decree 204 "On national goals and strategic objectives of the development of the Russian Federation for the period through to 2024", dated May 7, 2018, sets before the RF Government the task to accelerate national technological development and increase the number of organizations implementing technological innovations to 50% of their total number. If the target is achieved by the scheduled date, then the potential growth of GRP only at the expense of organizations implementing technological innovations in the whole country may amount to 3.5%.

We can conclude that our scientific hypothesis has been confirmed: the use of the regression analysis of panel data allowed us to obtain consistent, statistically significant estimates of indicators characterizing innovation entrepreneurship, as well as to produce a comprehensive characterization of the impact of innovation entrepreneurship on the development of the regional

economy (including taking into account the effect of factors that do not directly relate to innovation entrepreneurship, but are still major factors in the development of the regional economy).

Conclusion

Within the framework of the study, we have made a contribution to the development of methodological tools for assessing the impact of innovation entrepreneurship on the development of the regional economy. Unlike other ones, our technique takes into account fixed and random effects, which ensures the completeness of the construction of panel models. The developed technique also allows us to consider the individual heterogeneity of variables. This makes it possible to obtain unbiased estimates.

According to the results of the regression analysis we have assessed the potential contribution of innovation business entities to the development of the regional economy: a one-percent increase in organizations engaged in R&D can potentially ensure the growth of GRP in the region by 0.14%, and a one-percent increase in organizations implementing technological innovations – by 0.07%. Moreover, we have found that in the conditions of the Russian economy, the technological component of innovation entrepreneurship is the most pronounced one (which is confirmed by the results of simulation).

The obtained results can be used for analytical and forecast studies devoted to the analysis of the impact of innovation factors (including innovation entrepreneurship) on the regional economy. In addition, they can be useful to representatives of regional authorities in the development of regional strategies for innovation and scientific and technological development. This will improve the quality of the implemented innovation policy in the Russian regions.

At the subsequent stages of the study we plan to do the following: 1) identify problems and prospects for the development of innovation entrepreneurship in the regions (using methods of sociological research, including questionnaires, expert interviews, case-study); 2) work out a comprehensive mechanism for the development of the economy of Russian regions based on innovation entrepreneurship.

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