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The Effect of the Entrepreneurial Ecosystem of Universities on the Innovative Activity in Russian Regions

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Abstract: The entrepreneurial ecosystem of universities is frequently recognized to have a key influence on the innovative activity of the related regions. However, these relationships have not been explored in the scientific literature regarding Russia. Therefore, the current study aims to determine and identify the contours of the entrepreneurial ecosystem of domestic universities in terms of the innovative activity of subjects in Russian regions. The methodological toolkit covers methods for information processing such as monographic desk research, hierarchical cluster and correlation analyses, and comparative analysis. Applying a hierarchical cluster analysis, we grouped universities according to the level of entrepreneurial activity with the allocation of the average value in order to determine the existing correlations and elucidate the problems in involving university innovations in the ratings of innovative activity of regions. The results contribute to the development of existing approaches toward the study of the entrepreneurial ecosystems of universities through a deeper understanding of their role in stimulating the innovative activity of regions and transformation processes.

Keywords: innovative activity; entrepreneurial ecosystem; interaction contours; innovative component; hierarchical cluster analysis; rating



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1. Introduction

Currently, the development of national economies has to deal with fast changes in the external environment. It requires meeting future challenges with the efficient use of the available resource capabilities of the system. It is extremely important to strengthen the impact of university entrepreneurial activity on the innovative activity of regions by building the interactions between education, science, and business.

In Russia, there is high competition in the market of educational services, which is combined with reduced direct funding from the state budget. Therefore, the priorities for the functioning of higher education institutions require modification to meet the challenges of the socioeconomic system. The best practices of the world's leading universities highlight entrepreneurial activity as a key factor in their dynamic and successful development, capable of providing an adequate response to the threats and opportunities of the external environment. In this context, understanding the essence of an entrepreneurial university as a form of “education–science–business” integration within the framework of the creation and development of multilevel entrepreneurial ecosystems is of particular importance for the promotion of innovative activity in regions, among other things. From this viewpoint, all areas of a university's activities that characterize its major resources and contribute to the transfer of research outputs to objects of intellectual property, commercial products, and economic development together contribute to forming an entrepreneurial university that is a growth point for an ecosystem.

So far, the relationship between the evolution of entrepreneurial ecosystems and the priorities of universities in terms of creating opportunities for their interaction and

influence on the innovative activity of regions is not studied in detail. Therefore, in this study, we aim to narrow this gap using an approach that consists of analyzing the contours of the influence of the entrepreneurial ecosystems of universities in regions in Russia and identifying their interconnections. As the objects of our study, universities with a technical profile in the Povolgie region of Russia were chosen, which are most equipped to develop innovations and participate in the innovative processes of the domestic regions.

Currently, the Russian practice is dominated by studies that consider the innovative activities of the domestic regions and their underlying factors. However, the following problems are not addressed regarding the influence of the entrepreneurial ecosystem of universities on the innovative activity of regions in Russia: (i) methodological approaches have not been developed for clarifying the indicators of innovative activity of the regions and generating the entrepreneurial ecosystem of universities and (ii) domestic universities have low efficiency in terms of innovation activities.

This research is based on a complex application of complementary, cluster, and ecosystem approaches to identify the areas for intensifying innovative activity in regions. To this end, the following analyses were performed: (1) A content analysis was carried out regarding the definition of “entrepreneurial university” using two scientific databases, namely Scopus and the Russian Citation Index (RCI). Such an analysis was considered due to the need to (i) quantify the publication activity among Russian and international researchers in terms of this terminology in order to consider the degree of unidirectional/opposite views, (ii) identify the level of elaboration of theoretical and practical issues in scientific research, and (iii) consider approaches and distinctive features in understanding the essence of an entrepreneurial university among domestic and international researchers. (2) The contours of the influence of the entrepreneurial ecosystem of universities were analyzed in terms of the innovative activity of the Russian regions. (3) The need to increase the innovative activity of the regions was validated based on the ecosystem approach and the development of entrepreneurial activities of universities. These analyses underline the structure of this study.

Thus, the approach proposed in this study expands the study of entrepreneurial ecosystems of universities through a deeper understanding of their role in creating and stimulating opportunities for transformational processes in Russian regions. The hypothesis of the study is that one of the major directions toward enhancing the innovative activity of a region should be the entrepreneurial ecosystem of universities in that region. As a result, an effective and dynamic “flow” of innovative development, from the sphere of science to the real sector of the economy, could be ensured, which would directly promote the level of innovative activity of regions and their socioeconomic development. The limitation of scientific research is still the insufficiency of analytical, statistical, and empirical data characterizing the efficiency of the entrepreneurial ecosystems of universities.

2. Literature Review

The emergence of new requirements for universities is a natural response to the challenges of the current stage of economic development for universities to be primarily directed toward advancement in their transition to the next technological paradigm. Particularly, this results in emerging universities that are actively involved in rather new entrepreneurial activities. In the mid-1980s, for the first time, publications in the United States (Etzkowitz 1983) followed by other countries (Van Dierdonck and Debackere 1988; Hisrich and Smilor 1988) considered the fundamentals and development of entrepreneurial educational organizations. Furthermore, the concept of an entrepreneurial university has been well articulated and advanced in numerous studies (see, for instance, Golubev 2010; Konstantinov and Filonovich 2007; Röpke 1998; Kauffeld-Monz and Fritsch 2013; Bae et al. 2014; and Nabi et al. 2017). Among others, we should highlight the seminal research dealing with the transformation of classical universities into entrepreneurial ones (Clark 1998; Isenberg 2010, 2011; Fernández-Nogueira et al. 2018). In this context, Clark (1998) put forward and elaborated a hypothesis according to which universities can implement

entrepreneurial activities without compromising the “traditional university values” such as an educational process and scientific research. At the same time, a university started to be considered as an ecosystem that includes clusters, platforms, incubators, and networks, thus creating the basis for developing entrepreneurship in different regions (Mazzei 2018). For these reasons, some authors think that the growth of the entrepreneurial potential in the university allows one to identify the university not just within an ecosystem (Adner 2017; Jacobides et al. 2015) but rather within an entrepreneurial ecosystem (Fuster et al. 2019).

Interest in entrepreneurial ecosystems has increased enormously in recent years (Spigel and Harrison 2018; Ritala and Gustafsson 2018; Barnard et al. 2019; Colombelli et al. 2022; Corazza and Saluto 2021). This trend is noted both by researchers (Venkataraman 2004; Cohen 2006; Abreu et al. 2016; Hoffman 2020; Uslu et al. 2019; Fischer et al. 2022) and politicians, as well as international and national organizations. For example, Fritsch et al. (2018) investigated Eisenberg’s ideas about the entrepreneurial ecosystem with a research scope focused on highlighting its major components. In general, the World Economic Forum defined the essence of the entrepreneurial system as a set of “inter-related components that determine the opportunities and rates of creation and scaling of new sustainable businesses by entrepreneurs” (World Economic Forum 2014). Stam (2015) went even further and proposed a synthetic model of such a system. However, questions remain that are outside the scope of research performed thus far on the identification of the factors that affect the elaboration of entrepreneurial ecosystems.

In some works by domestic authors, the entrepreneurial ecosystem of universities in Russia is noted to be mainly focused on increasing the number and survival of startups created by university students (Korotkov and Zobnina 2019). However, this view is rather limited, in our opinion, for the development of entrepreneurial activities of universities. Shapovalov et al. (2020) considered the university ecosystem as a space for a set of subjects attributed to an educational process, where their interaction with an external environment is realized. As a result, the individual personality traits of a social entrepreneur are revealed. Here, an important feature of the environment of socioentrepreneurial education as a system is that the student is considered a subject of the educational process and therefore is also a system. Thus, the student in the ecosystem of socioentrepreneurial education shows the active nature of knowledge, which is ultimately expressed in the mutual influence between the subject and the environment.

By 2025, a significant proportion of value chains, according to the forecasts of McKinsey specialists (McKinsey & Company 2022), will unite into several dozen ecosystems, which do not exhibit clearly defined borders among their individual sectors. The developed connections could be revealed only by monitoring the activity of the entrepreneurial ecosystem of universities and assessing their impact on the rating indicators of regional R&D and the country as a whole. The Russian Ministry of Science and Higher Education annually reviews 1286 higher educational institutions in order to assess the efficiency of their activities. It is ordinarily conducted by evaluating more than 70 indicators in the following areas (Information and Analytical Materials Based on the Results of Monitoring the Activities of Educational Institutions of Higher Education (2022)):

- Educational activities (15 indicators);
- Research activities (16 indicators);
- International collaboration (13 indicators);
- Financial and economic activities (8 indicators);
- Staffing (5 indicators).

The assessment includes two sections: (i) indicators reflecting the role of the university in the system of personnel training for the region and (ii) additional indicators for its extended characteristics. The major target for monitoring is “preparing information and analytical materials about educational institutions of higher education and their branches based on performance indicators” (Portal of Federal State Educational Standards of Higher Education (2023)), which, in our opinion, does not reflect the real efficiency of universities,

their entrepreneurial potential, or market rating but only demonstrates the actual value of university performance indicators.

Regarding the concept of entrepreneurial universities, two major approaches could be distinguished, in our opinion, as follows:

- (1) Entrepreneurial universities are elements of the “triple helix” model that provide interaction for science (universities), business, and the state; universities play a leading role in this model (Etzkowitz et al. 2019; Budyldina 2018; Thursby and Thursby 2002; Ulhøi et al. 2012).
- (2) Entrepreneurial universities commercialize scientific advances at the international level and transition to an innovative development model (Astebro and Bazzazian 2011; Gianiodis et al. 2016; Meissner 2017).

As noted above, the term “entrepreneurial university” was introduced in 1998 by B. Clark, who highlighted its features in his book *Creating Entrepreneurial Universities*, as summarized in Figure 1.

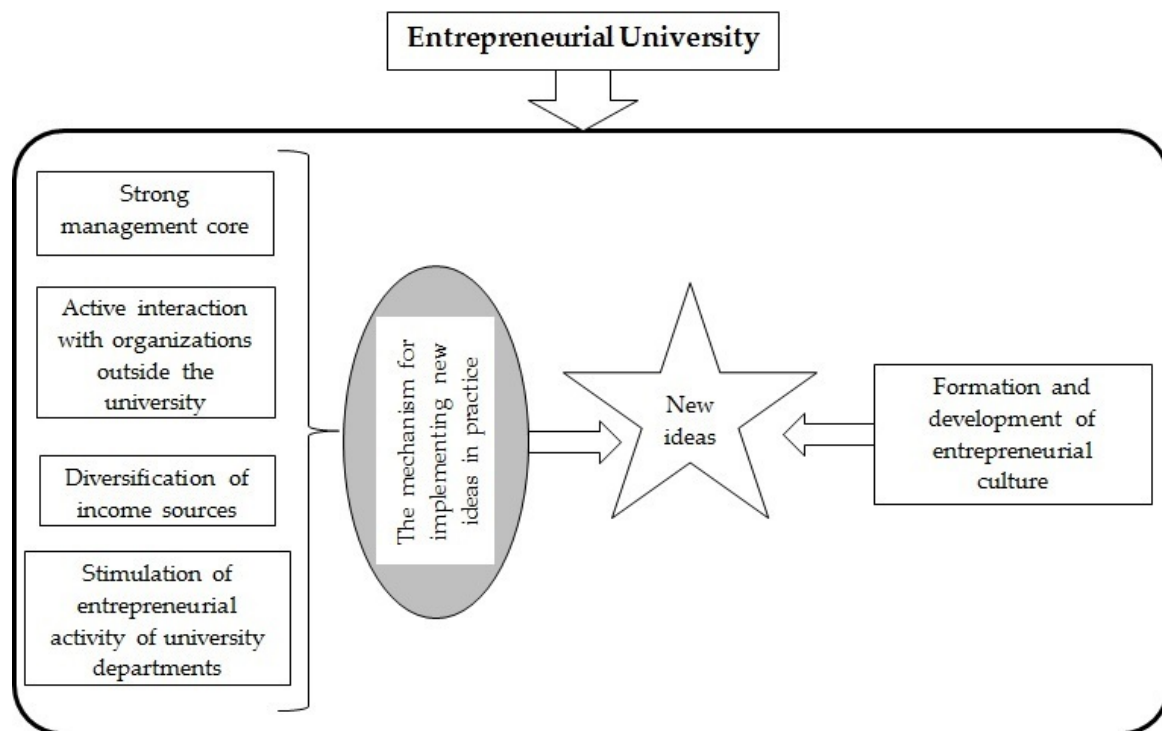


Figure 1. Characteristics of an entrepreneurial university.

As can be seen from Figure 1, there are five basic features that classify the university as an entrepreneurial one. The presence of a strong managing “core”, capable of independently directing the development of the university and quickly and adequately responding to emerging changes, makes it possible to respond to external challenges. The second indicator reflects the presence of subdivisions with highly professional employees, which firstly leads to the development of external associations to transfer knowledge, attract new sources of financing, interact with industry, and develop continuing education and intellectual property; and, secondly, facilitates the interaction of interdisciplinary project-oriented research centers in universities and the external environment. The diversification of income sources, as a hallmark of an entrepreneurial university, is important in the context of declining budgetary funding and reflects the ability of the university to expand its funding base through grants, legal entities, regional funding, charitable foundations, royalties from the use of intellectual property licenses, and income from the provision of paid services. Stimulating the entrepreneurial activity of departments enables their transformation into entrepreneurial units that interact with the external environment, implement the results of

scientific research, attract additional sources of income, and lead to the acceptance of new values by employees.

The abovementioned features together form a mechanism for implementing new developments via the integration of an entrepreneurial culture with university-wide activities, as well as the dissemination and sustainable consolidation of ideas. In terms of the characteristics inherent in entrepreneurial universities, their areas of activity are education and research, which are accompanied by a transfer of knowledge that underlies the need for interaction with the external environment. Consequently, the activities of an entrepreneurial university must meet the needs of the market in educational services, high-tech developments, and labor (Lankin et al. 2011). According to some domestic authors (Andryushkevich and Denisova 2014; Buniak 2016; Podborodnikova 2019; Yudkevich 2014), entrepreneurial universities in Russia are characterized by a reduced dependence on state institutions; susceptibility to global trends; flexibility; adaptive management structure; integration of education, science, and business; interaction with investors; the training of competitive specialists for entrepreneurial and innovative thinking; the development of infrastructure adapted for research and entrepreneurial activities (development centers, technology parks, business incubators, etc.); an effective system for the motivation and stimulation of scientific and teaching staff; a focus not only on fundamental science but also on applied research; competitive and selective selection of students; a high degree of information openness; and the organization of scientific communities and business environment in the region (or scientific, technical, and economic realms surrounding the university).

Thus, the distinctive function of entrepreneurial universities is highlighted in the literature (Digital/McKinsey 2017) as the commercialization of R&D outputs, which is defined in a sequence as follows: Universities conduct scientific research, the result of which is new knowledge. Then, the commercial attractiveness of the invention is assessed by formalizing an intellectual property to be claimed through patenting. Finally, a business plan is detailed to promote the product and the corresponding licenses. One can agree with the opinion that entrepreneurial universities should function as commercial organizations, while university staff and students should behave and think like entrepreneurs. Moreover, universities should be closely linked to the region and support local businesses. However, the mechanisms of the triple helix used in the development of Russian universities are still in their infancy. In our opinion, to accelerate this process and advance their competitiveness, an effective rating assessment is required.

The history of university rankings goes back to 1997, when universities were assessed by the *Asia Week* magazine. In 2003, the staff of Shanghai University compiled the Academic Ranking of World Universities (ARWU) according to 13 criteria, which reflect “the academic mobility of students and teachers, the number of international scholarship programs, the efficiency of scientific research, the citation of scientific articles, the quality of educational services, etc.” (Primina 2018; Lin and Chen 2021). In 2004, Britain began to annually publish a list of the world’s top universities, titled “The Times Higher Education”, and since 2010, they have been reporting the reputation rating of world universities (World Reputation Rankings) and the ranking of the world’s leading universities (World University Rankings) (Velitchenko 2020; Bowman and Bastedo 2011). Currently, one of the commonly recognized rankings is the ranking of 500 leading world universities regarding Poverty Reduction Strategy Papers (PRSPs), according to criteria that reflect the volume of research activity calculated by taking the number of published scientific articles. Because many national policies necessitate the presence of universities in such rankings, there is permanent competition between universities according to the criteria involved. Therefore, the indicators that assess the results of scientific activity are extremely important. For example, objective data such as the number of inventions, patent applications, granted patents, active licenses, the number of scientists, etc., could be included in such an analysis.

3. Methodology

In the course of this study, a complex analysis was employed to cover a number of aspects related to forming the objective key indicators in order to characterize the scientific and entrepreneurial potential of universities. Furthermore, a system analysis was performed which allowed us to investigate the relationship and interdependence of the indicators and identify the opportunities of the entrepreneurial ecosystem of the university within the international knowledge environment. The concept of the rational behavior of market actors was considered to formulate the indicators of entrepreneurial activity in universities according to best practices. To evaluate the contribution of scientists to the practice in formulating the indicators and criteria for their evaluation, we used the method of monographic desk research. The comparative analysis conducted allowed us to assess the degree to which the problem of entrepreneurship formation can be solved in Russia relative to the international context. The method of hierarchical cluster analysis was employed to obtain a comprehensive assessment and grouping of universities according to the level of their innovative activity in Russian regions, while correlation analysis was carried out to identify the relationship between university rankings and innovative activities in these regions.

The experimental case study was the entrepreneurial ecosystem of technical universities in the Povolgie region of Russia.

To comprehensively assess the entrepreneurial ecosystem of universities, we proposed a methodology taking into account the indicators in the major areas of their activities. In our opinion, this approach could allow one to quantitatively determine (i) the efficiency of universities in implementing the opportunities and available resources for entrepreneurial activities, and (ii) their ability to move into the category of an entrepreneurial university. The state-of-the-art concepts indicate that the entrepreneurial ecosystem of universities should be considered within the framework of the basic university activities, namely their educational, research, financial, and economic endeavors. Therefore, the indicators in the rating assessment were combined into three blocks according to the functions and areas of activities. These blocks are listed in Table 1, considering the Russian university practice.

All the indicators for evaluating the entrepreneurial ecosystem of universities were determined using the index method with coefficients, which allowed us to rate universities both in single directions and integrally. For each block, the average indicators were derived by estimating a final output rating as follows:

$$I = \sqrt[3]{0.45I_e \cdot 0.35I_r \cdot 0.2I_{fr}},$$

where I_e , I_r , and I_{fr} are the final coefficients of the rating related to educational activity, scientific activity, and financial/economic results; and the coefficients of 0.45, 0.35, and 0.2 are weighting coefficients that were revealed using an expert assessment as the major qualitative method. As experts, qualified specialists and university scientists were considered.

The overall university's rank was determined using hierarchical cluster analysis, in which universities were grouped into the following three categories:

- Low, if the university rank was less than the average;
- Average, if the university rank was equal to the average;
- High, if the university rank was greater than the average.

The method of hierarchical cluster analysis was chosen for grouping universities because it has no restrictions on the number of selected indicators. Additionally, it allowed us to obtain real results of university classification based on a multivariate assessment of a set of initial data, including situations when the distribution of random variables deviated from a normal (Gaussian) value. The grouping of universities using this method was

carried out by considering a matrix in which the raw values belong to the indicators of the indexes given in Table 1 as follows:

$$I = \begin{pmatrix} I_{e1} & I_{e2} & \dots & I_{ej} & I_{r1} & I_{r2} & \dots & I_{rj} & I_{fr1} & I_{fr2} & \dots & I_{frj} \end{pmatrix}$$

Such an approach facilitates the grouping of universities with not only ranking levels but also the identification of the reserves for developing the efficiency of the entrepreneurial ecosystem of universities in the region.

Table 1. Ranking matrix for the estimation of the entrepreneurial ecosystem of universities.

Activity Areas in University	Functions	Indicators
Educational process	- Teaching according to entrepreneurial-type programs; - Promoting appearing and developing spin-off companies; - Assisting regional development; - Inter-regional and international cooperation.	$I_{e1} = \frac{Q_{1t}}{Q_1}$ Q_{1t} —the number of undergraduate students admitted to the first year of full-time education in higher education programs under sponsorship by companies; Q_1 —the total number of students admitted to the first year of full-time study in higher education programs.
		$I_{e2} = \frac{Q_{ol}}{Q_l}$ Q_{ol} —the number of trainees who improved their qualifications or underwent professional retraining from third-party organizations; Q_l —the total number of trainees who improved their qualifications or underwent professional retraining.
		$I_{e3} = \frac{Q_{tt}}{Q_t}$ Q_{tt} —the number of students studying under the sponsorship of companies in engineering and technical areas of higher education; Q_t —the total number of students enrolled in engineering and technical areas of higher education.
		$I_{e4} = \frac{Q_{fs}}{Q}$ Q_{fs} —number of foreign students enrolled in higher education programs; Q —the total number of students enrolled in higher education programs.
		$I_{e5} = \frac{Q_{fg}}{Q_g}$ Q_{fg} —the number of foreign students who graduated from the university in higher education programs; Q_g —the number of students who graduated from the university in higher education programs.
		$I_{e6} = \frac{Q_{sa}}{Q_s}$ Q_{sa} —the number of full-time students who have studied abroad for at least a semester in higher education programs; Q_s —total number of full-time students who completed higher education programs.
		$I_{e7} = \frac{Q_f}{Q_t}$ Q_f —the number of scientific/teaching staff from abroad; Q_t —the total number of scientific/teaching staff.
		$I_{e8} = \frac{Q_{phdf}}{Q_{phd}}$ Q_{phdf} —the number of PhD students coming from abroad; Q_{phd} —the total number of PhD students.

Table 1. Cont.

Activity Areas in University	Functions	Indicators
Research activities	- Knowledge generation;	$I_{r1} = \frac{V_{oi}}{V_{ui}}$
	- Promoting installing and developing spin-off companies;	V_{oi} —the volume of income from in-house R&D; V_{ui} —university income from R&D.
	- Promoting regional development;	$I_{r2} = \frac{V_{ia}}{V}$
	- International cooperation.	V_{ia} —the amount of income generated from using the results of the intellectual activity of the university; V —university income.
Financial and economic results	- Implementing the educational process according to entrepreneurial-type programs;	$I_{fr1} = \frac{V_{R\&D}}{V}$
		$I_{fr2} = \frac{V_{R\&Df}}{V_{R\&D}}$
		$V_{R\&D}$ —the amount of funds received from foreign legal entities and individuals for performing R&D.
		$I_{fr3} = \frac{V_{fm}}{V_m}$
	- Knowledge generation;	V_{fm} —the amount of funds received from foreign legal entities and individuals for educational activities;
		V_m —the total amount of funds received from educational activities.
		$I_{fr4} = \frac{V_{iga}}{V_{ti}}$
		V_{iga} —the amount of funds from income-generating activities; V_{ti} —the amount of income from all types of financial support.
	- Promoting and appearing and developing spin-off companies;	$I_{fr5} = \frac{V_{ef}}{V}$
	- Assisting with regional development;	V_{ef} —the amount of income derived from non-budgetary sources.
	- International cooperation.	$I_{fr6} = \frac{V_{iea}}{V_m}$
		V_{iea} —the amount of income derived from non-budgetary sources regarding educational activities.
		$I_{fr7} = \frac{V_{ie}}{V_{ird}}$
		V_{ie} —the amount of income from non-budgetary sources regarding R&D; V_{ird} —the total amount of income from R&D.

4. Results

4.1. University Entrepreneurial Ecosystem

The literature analysis shows that there is still no unified, generally accepted, approach for defining the essence of the concept of “entrepreneurial university” despite its widespread use. This rather complicates the development of practical recommendations for the transformation of universities into entrepreneurial ones. Many authors also do not consider the fact that the development of entrepreneurial activities of such universities in all areas—educational, scientific, international cooperation, etc.—extends beyond the horizon of research, which highlights the practical need for creating an entrepreneurial ecosystem of universities. However, only the emergence of such ecosystems will make it possible to properly ensure the association of universities with an external environment. Accordingly, there is no unified system of indicators for assessing the entrepreneurial ecosystem of universities that could allow one to evaluate their rating and control the pace of development as an economic agent. Thus, in our opinion, an entrepreneurial university as a core of the ecosystem should be understood as a university in which teaching is performed in areas of interest in the labor market, taking into account the prospects for the innovative development of the economy, and scientific/technology research is conducted that has a commercialized output while actively interacting with the environment considering the regional, state, and global economy to gain a profit.

Based on this approach, the following major functions of the entrepreneurial university were identified:

- The implementation of entrepreneurial-type programs in an educational process, including innovative methods of student and postgrad teaching, the participation of students in research projects, and training and retraining specialists according to the requests of companies;
- Knowledge generation (scientific research, business incubators, technology parks, and spin-offs);
- The commercialization of scientific outputs (technology transfer centers);
- The promotion of the formation and development of companies (training of specialists, small businesses, and strategic partnerships with companies in the industry and the financial sector);
- The facilitation of regional development (training specialists for the regional economy, the integration and implementation of federal and regional programs, and interaction with local authorities on entrepreneurship development) (D'Este and Patel 2007; Salomaa 2019);
- International cooperation in education and research.

Altogether, the functioning of an entrepreneurial university is implemented in three areas of activity: educational, research, and financial and economic areas. In general terms, the contours for the interaction of an entrepreneurial university with the external environment are shown in Figure 2, as part of the corresponding ecosystem.

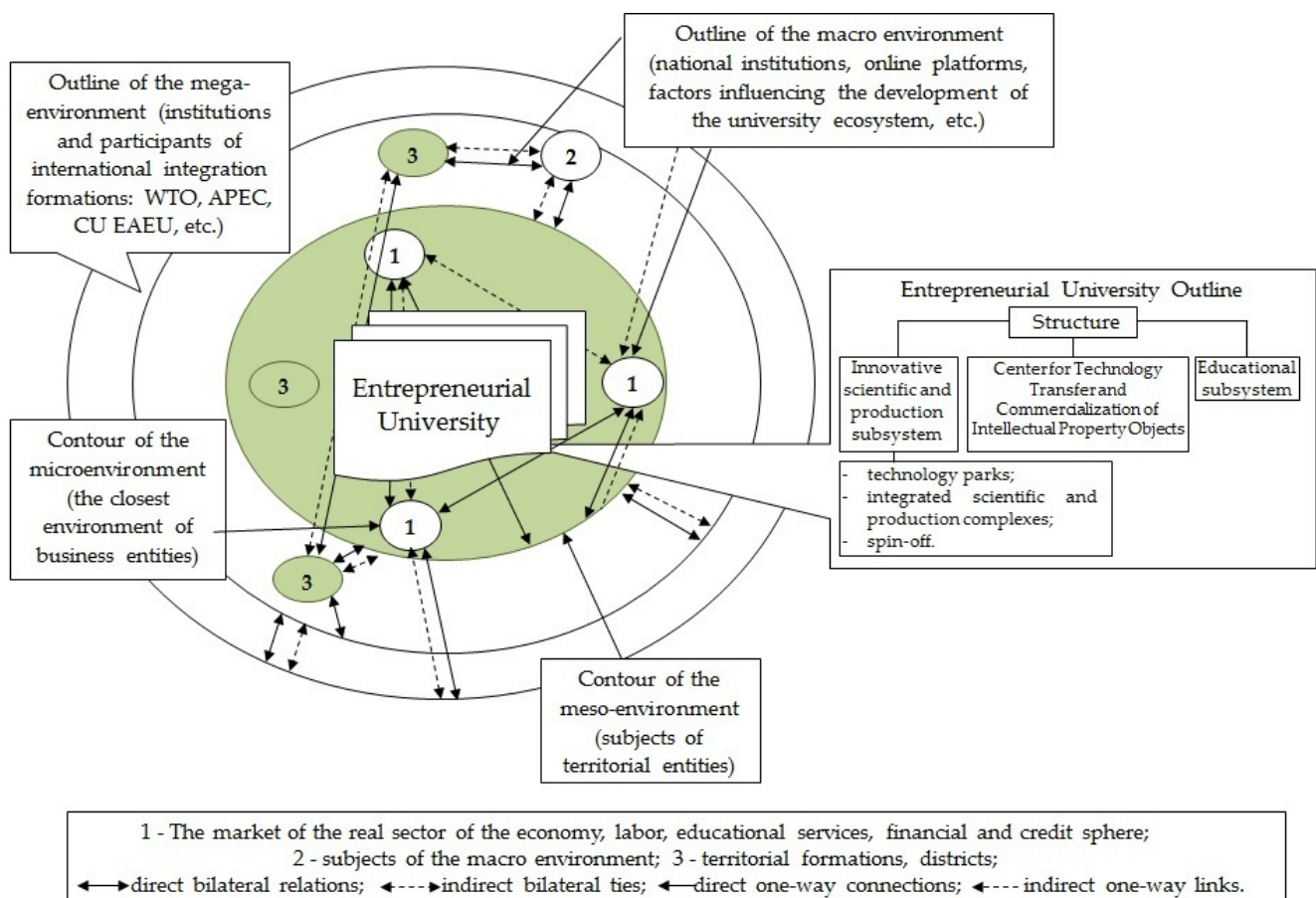


Figure 2. Contours of interaction between the entrepreneurial ecosystem of universities and the external environment.

In Russia, the entrepreneurial ecosystem of universities is still not so developed to be considered in the triple helix paradigm. We may note some university entrepreneurial ecosystems existing in large cities; however, many continue to maintain traditional ties

while introducing only elements of entrepreneurship. In our opinion, this situation is a result of several factors:

- A continued dependence of universities on primary funding from the federal budget;
- The instability of economic development;
- An insufficient interaction between universities and businesses in the framework of training and scientific/applied research;
- Problems in the commercialization of the results of innovation activity;
- A lack of developed infrastructure for a technology transfer;
- A weak entrepreneurial culture in universities;
- A lack of consideration of the basic elements to form the upper level of infrastructure;
- The insufficient activity of large businesses in technological innovations.

4.2. Validation of the Methodology

The proposed methodology was validated using the examples of 17 technical universities located in the Povolgie area of Russia, and the results were found to be quite consistent with the entrepreneurial model: They perform the educational process, participate in research grants to advance R&D, and create new technologies that have market potential. Many of these universities have technoparks as a part of their structure. For the purpose of this study, open access sources containing information on the activities of these universities during 2017–2021 were considered. The results of the rating assessment of the surveyed universities are given in Table 2.

Table 2. Rating assessment of the entrepreneurial ecosystem of universities in the Povolgie region of Russia.

University	2017	2018	2019	2020	2021
Nizhny Novgorod State Engineering and Economic University (NGIEI)	0.0647	0.0693	0.0622	0.0769	0.0771
Nizhny Novgorod State University of Architecture and Civil Engineering (NNGASU)	0.0989	0.0989	0.0465	0.0888	0.0836
Nizhny Novgorod State Technical University n.a. R.E. Alekseev (NNSTU n.a. R.E. Alekseev)	0.0863	0.0836	0.0787	0.0872	0.0880
Penza State Technological University (PenzGTU)	0.0695	0.0218	0.0771	0.0907	0.0915
Penza State University of Architecture and Construction (PGUAS)	0.0889	0.0704	0.0800	0.0727	0.0749
Perm National Research Polytechnic University (PNRPU)	0.0917	0.0945	0.0954	0.0902	0.0986
Perm State Agro—Technological University (PSATU)	0.0569	0.1387	0.0891	0.0869	0.0751
Ufa State Aviation Technical University (USATU)	0.0775	0.0900	0.0823	0.0941	0.0929
Ufa State Petroleum Technological University (USPTU)	0.0906	0.0865	0.0811	0.0890	0.0872
Volga State University of Technology (VSUT)	0.0861	0.0934	0.0908	0.0901	0.08011
Kazan State University of Architecture and Engineering (KSUAE)	0.1060	0.1073	0.1047	0.0994	0.1007
Kazan National Research Technical University named after A.N. Tupolev—KAI (KNRTU-KAI)	0.0838	0.0769	0.0908	0.0778	0.0780
Kazan National Research Technological University (KNRTU)	0.1023	0.0832	0.1229	0.0858	0.0937
Samara State Technical University (SamSTU)	0.0887	0.0922	0.0852	0.0699	0.0891
Yuri Gagarin State Technical University of Saratov (SSTU)	0.0820	0.0764	0.0732	0.0795	0.0658
Kalashnikov Izhevsk State Technical University (Kalashnikov ISTU)	0.0900	0.1197	0.0968	0.0956	0.0897
Ulyanovsk State Technical University (ULSTU)	0.1035	0.0922	0.0981	0.0987	0.1002

The results of the grouping carried out using hierarchical cluster analysis are shown in Figure 3.



Figure 3. Rating assessment of the entrepreneurial ecosystem of universities in the Povolgie region of Russia at various years during the 2017–2021 period.

Considering the data in Figure 3, we may highlight some findings. In 2017, 9 of the 17 universities had a rating above the average, compared with 8 universities in 2021. It should be noted that the results of research and out-of-budget activities had a major impact on the ranking of universities. The most favorable conditions for developing the entrepreneurial ecosystem of universities were in 2019 and 2020, but the remote format of activities in 2021 led to a decline in the ratings of universities. For comparison, the share of high-rank universities in the total number of surveyed universities was 52.9% in 2017 and even increased to 58.8% in 2019 and 2020, whereas it was only 35.29% in 2021. The maximum increase in the rating was observed at the PenzGTU, with a gain of 31.7%, increasing its ranking from low to high; for instance, the university had the lowest rating in 2018. A maximum rating reduction was observed in SSTU, by 19.4 %, which went down from the average level in 2017 to a low level in 2021.

Figure 4 shows a summary of changes in ranks among the universities under study from 2017 to 2021. The most remarkable growth was observed for PenzGTU, due to a large gain in educational activities: its rating of educational activities increased by more than 4 times, while the rating of its research activities increased by more than 3.5 times.

The results obtained for the surveyed universities made it possible to finally assess the development of the entrepreneurial ecosystem of universities in the Povolgie region. For this purpose, we grouped the universities in the various areas of the Povolgie region according to the index for the development of the entrepreneurial ecosystem. The data are presented in Figure 5. The best development was observed in the Republic of Tatarstan, while the Perm region deteriorated. However, the general trend indicates the development of the entrepreneurial ecosystem in the Povolgie region as a whole, although there was certain unevenness across its various regions.

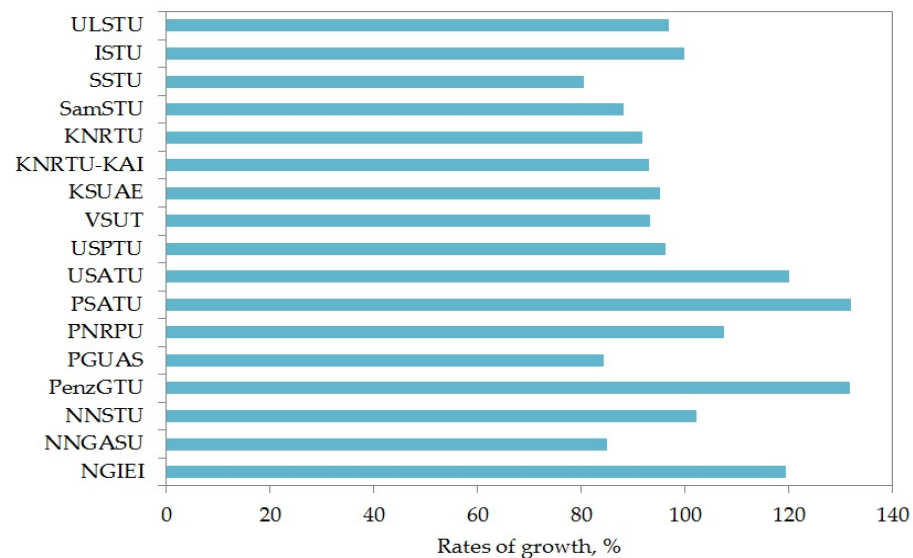


Figure 4. The change in the ratings of universities in the Povolgie region of Russia in 2021 in relation to those observed in 2017 (taken as 100%).

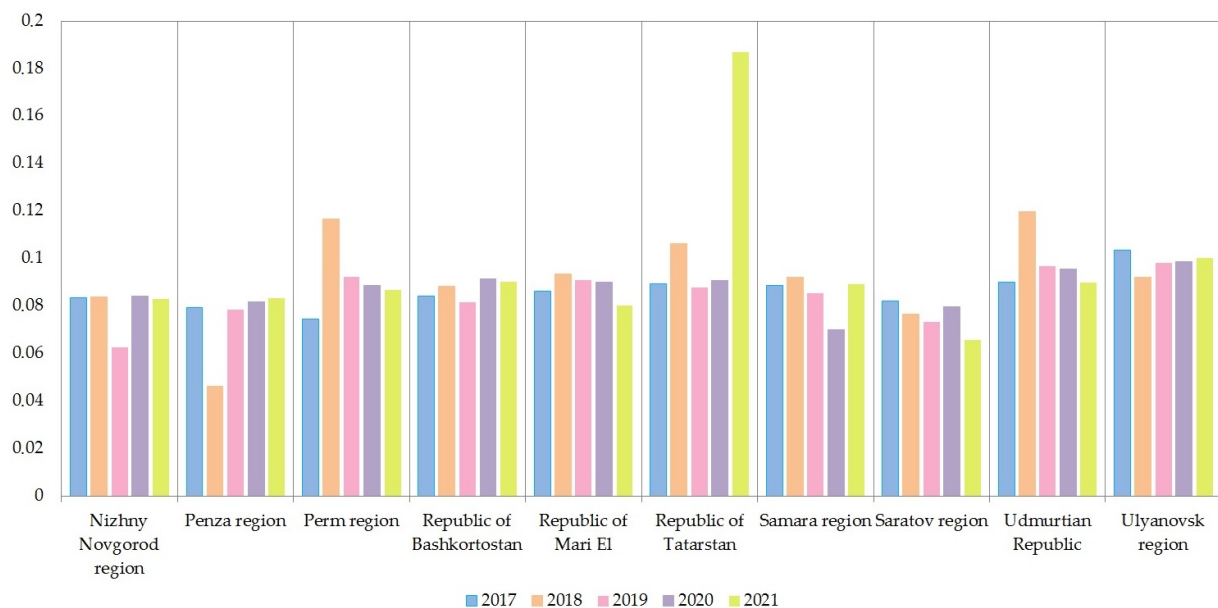


Figure 5. The index of the entrepreneurial ecosystem of universities across various regions in Povolgie (Russia).

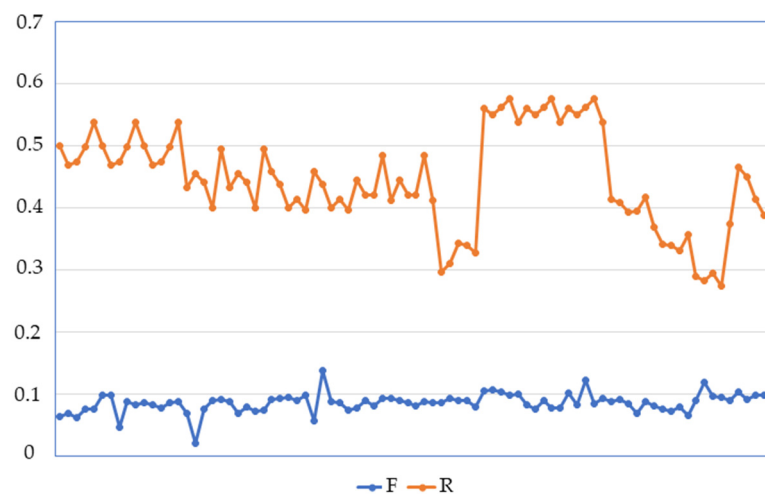
4.3. Assessing the Influence of the Contour of the Entrepreneurial Ecosystem of Universities on the Innovative Activity of the Regions in Povolgie (Russia)

We analyzed the inter-relationship and impact of the entrepreneurial ecosystem of universities on the innovative activity of the regions using the method of correlation analysis. Methodological approaches for assessing the rating of innovative activities of regions are presented in the *Rating of Innovative Development of Subjects of the Russian Federation* (2021) and the *National Research University Higher School of Economics* (2019). As a criterion for the level of regional development, the index of innovative activity of the region (IIAR) developed by the Higher School of Economics (Russia) was adopted. This index is built on the basis of 53 quantitative and qualitative indicators that characterize (1) the socioeconomic conditions of a region's innovative activity, (2) its scientific and technical potential, (3) the level of innovation and export activity, and (4) the quality of innovation policies. These indexes are summarized in Table 3.

Table 3. Index of innovative activity of the regions (IIAR) in Povolgie (Russia).

The Povolgie Regions of Russia	2017	2018	2019	2020	2021
Nizhny Novgorod region	0.50	0.48	0.47	0.50	0.54
Penza region	0.43	0.46	0.44	0.40	0.50
Perm region	0.43	0.39	0.37	0.40	0.50
Republic of Bashkortostan	0.44	0.42	0.42	0.49	0.41
Republic of Mari El	0.30	0.31	0.34	0.34	0.33
Republic of Tatarstan	0.56	0.55	0.56	0.58	0.54
Samara region	0.41	0.41	0.39	0.40	0.42
Saratov region	0.37	0.35	0.34	0.33	0.36
Udmurtian Republic	0.29	0.32	0.29	0.28	0.38
Ulyanovsk region	0.47	0.45	0.41	0.39	0.39

Correlation analysis makes it possible to visually identify the forms of connections between the level of development of the entrepreneurial ecosystem of universities, denoted as a factor feature (F), and IIAR, considered a result feature (R). For this purpose, a correlation plane was built as a set of points with F and R values, which allowed us to put forward a hypothesis for the general population about the linear nature of the relationship between F and R values (Figure 6).

**Figure 6.** Dependence of the entrepreneurial ecosystem of universities (F) and the level of innovative activity in the regions (R) of Povolgie.

The developed function allows for the estimation of both the specific and general impacts of the entrepreneurial ecosystem of universities on innovative activities in regions of Povolgie. Still, it is worth noting that using multiple linear regression might lead to a multicollinearity effect, i.e., the emergence of linear relationships between variables due to their high correlation. This reduces the accuracy of the estimated regression parameters and may yield regression coefficients that cannot be used for interpreting the degree of influence. Therefore, the exogenous indicators selected as a result of the correlation analysis were checked for multicollinearity to exclude the mutual influence of exogenous variables.

The parameters of the linear regression were estimated via the least squares method. Here, the first regression coefficient shows the predicted IIAR level but only if $R(X) = 0$ is close to the sampled values. The second regression coefficient characterizes the average value of IIAR as a result of changing (increasing/decreasing) the magnitude of the development of the entrepreneurial ecosystem of universities. Thus, we conducted a paired linear

regression analysis based on empirical data with the noted parameters, and the extent of the dependence was assessed using the empirical correlation ratio. The data are presented in Table 4.

Table 4. Empirical regression equations between the development rating of the entrepreneurial ecosystem and IIAR in Povolgie (Russia).

Year	Regression Equation	Empirical Correlation
2017	$R = 0.03158 F + 0.07205$	0.18802
2018	$R = 0.06537 F + 0.11670$	0.20273
2019	$R = 0.03709 F + 0.06939$	0.16884
2020	$R = -0.00134 F + 0.08726$	0
2021	$R = 0.01152 F + 0.08103$	0.08854

These calculations indicate a lack of a unified relationship between the ratings of the entrepreneurial ecosystem of universities and IIAR in Povolgie. At the same time, in every year, except for 2020, there was a direct relationship between the indicators under consideration. The empirical correlation ratio had the highest value in 2018 but remained at a rather insignificant level. We suggest that this is primarily attributed to the level of socioeconomic development of the regions under study.

The correlation dependence between the rating of the entrepreneurial ecosystem and IIAR across the regions of Povolgie also did not exhibit an unambiguous direction, which is clearly seen in Figure 7. The largest impact of the entrepreneurial ecosystem on innovation activities was observed in the Samara region (0.68) and the Republic of Bashkortostan (0.29). A negative correlation between these two indicators was observed for the Perm, Penza, Ulyanovsk, and Saratov regions, as well as for the Udmurtian Republic. In other regions of Povolgie, there was a positive dependence, with the average value equal to 0.10835. Still, the negative relationship between the development of the entrepreneurial ecosystem of universities and the innovative activities of the regions of Povolgie in 2020 is associated, in our opinion, with a decline in economic development indicators due to the COVID-19 pandemic, when universities operated under a remote format, and many enterprises were suspended or even terminated their activities.

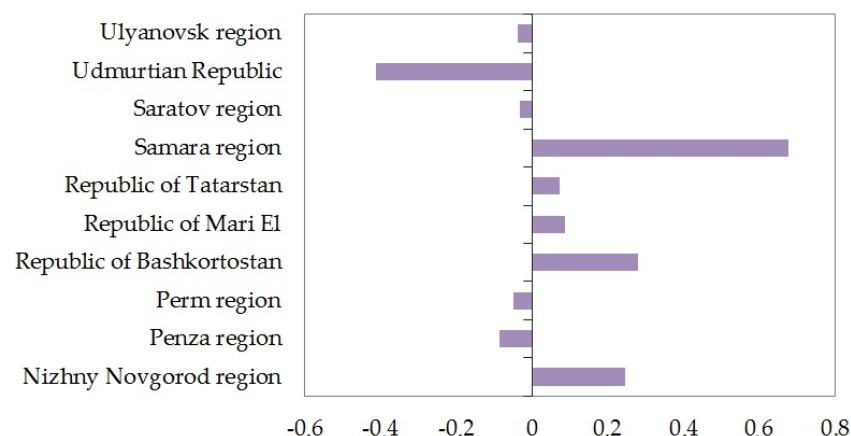


Figure 7. Correlation dependence between the ratings of the entrepreneurial ecosystem and IIAR in Povolgie (Russia) during 2017–2021.

As a result, there was a decrease in the volume of the gross regional product and the innovative activities of enterprises and organizations. This is reflected in the curves shown in Figure 8.

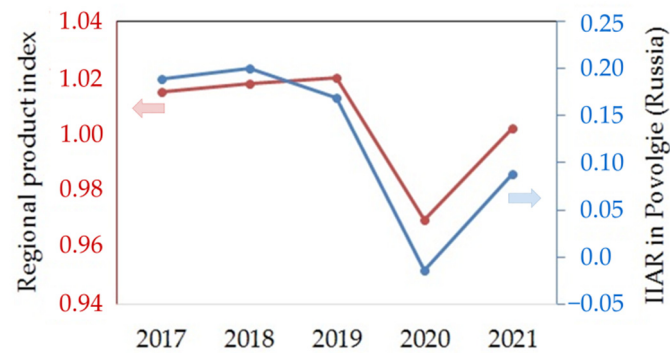


Figure 8. The gross regional product index and IIAR in Povolgie (Russia) during 2017–2021.

5. Discussion

The results of the conducted research indicate a rather low level of development of the entrepreneurial ecosystem of universities and its insignificant impact on the innovative activity of the regions in Povolgie (Russia). In our opinion, one of the reasons is the shortcomings of the existing methods for assessing the innovative activities of regions, which account only for the information provided by enterprises to statistical authorities but do not utilize the results of research and innovation activities of universities. However, many local universities, as shown here, carry out innovations; introduce their results into educational, administrative, and managerial activities; successfully develop technology parks; and interact with enterprises.

A contradiction is that the indicators taken in the global innovation index (GII) consider the results of universities, while they are not counted when assessing innovative activities in Russian practice. However, the products and services produced by universities play a significant role in the innovative activities of regions and local markets of labor, goods, and services, including educational services, small innovative enterprises, and start-ups.

Still, many domestic and foreign experts note the low efficiency of innovation activities of domestic universities in Russia. This is ordinarily explained due to the lack of entrepreneurial thinking among scientists–inventors, the existing gaps in the innovation commercialization chain, and the lack of key elements in the innovation ecosystem of universities (Efremova and Romanova 2020). Therefore, attempts to commercialize technologies have not yet been crowned with tangible success. As rightly noted in another research (Kiseleva et al. 2022), the level of regional development in Russia varies greatly. Moscow, St. Petersburg, and Tatarstan are leaders in the ratings of innovative development of regions, which account for about 57% of the total volume of innovative goods shipped and innovative works and services carried out, while the remaining 76 regions account for only 43% of the results of innovative activities. This indicates a need for further analytical research to identify the factors for the development of entrepreneurial ecosystems in regions as an element of the growth of innovative activities.

Many studies agree that innovations are the major instrument for increasing the competitiveness of regions and the country as a whole. Therefore, to advance the level of socioeconomic development and promote innovative activities and competitiveness among regions, it is necessary to develop a reasonable strategy that allows one to achieve a long-term effect. In turn, this necessitates the facilitation of new methods and tools to build regional strategies that take into account quantitative and qualitative assessments of a dynamically changing environment and the current challenges. Despite a growing number of studies regarding the innovative activities of regions and rating assessments of universities, methodological approaches using indicators that properly reflect the innovative activities of regions in Russia and the development of the entrepreneurial ecosystem of universities are still insufficiently developed. Some studies devoted to this problem note that universities should make a significant contribution to the development of regional and local innovations (Cervantes 2017). However, it is not enough only to increase the innovative activities of a region; other components must be also taken into account. These include the investment

climate, a regulatory framework, and an infrastructure for innovations (Cuaresma et al. 2013). The most comprehensive approach involves the assessment of the various aspects of regional innovation systems, which could be carried out by employing the triple helix concept for the analysis and evaluation of the existing strategies (Etzkowitz and Zhou 2017). However, this concept does not sufficiently take into account the impact of demand on the creation and implementation of new knowledge, technologies, and products. To a certain extent, the extrapolation of the three-tier model to a four-tier one could help in eliminating this issue (Volodin et al. 2020) as an integral approach for the assessment of the results obtained at the regional level and the development of effective mechanisms for introducing innovations.

Improving the monitoring and evaluation system at the regional level requires employing multilevel methods that consider chronological and spatial dynamics. The current study proposes a comprehensive assessment of the entrepreneurial ecosystem of universities that is universal in nature because a significant portion of the indicators were considered while taking into account international standards. This method can be used for regions with varying degrees of economic activity in order to identify “bottlenecks” in promoting their innovative activity. The complex nature of the developed methodology involves an assessment in three directions, which reflect the components of the activities of universities from different perspectives. Each block was evaluated from a quantitative and qualitative standpoint by particular criteria, resulting in a complex value for calculation. The weakness of the proposed methodological approach is the absence of a unified scale for assessing the level of development of the entrepreneurial ecosystem of universities for all regions in terms of innovations because it is based on the values of weight coefficients. Weight coefficients are individual for each region and were determined using an expert method. In addition, the results of the study are presented for only 10 out of the 89 regions of Russia, which indicates the need for further analysis and assessment of the association of the entrepreneurial ecosystem of universities with innovative development in other regions.

6. Conclusions

Following the objective of this study, we determined and analyzed the degree of influence of the contours of the entrepreneurial ecosystem of universities on the innovative activities of subjects of economic development, taking the example of the Povolgie region in Russia. This allowed us to demonstrate the relationship between the degree of development of the entrepreneurial ecosystem of universities and the innovative activities of the corresponding regions in Povolgie.

Our study shows that the major features of an entrepreneurial university are the dissemination of knowledge, the generation of knowledge, the promotion of education and development of companies, regional development, and international cooperation in order to adequately commercialize the complex of “education–science–entrepreneurship”. The entrepreneurial ecosystem of universities lies at the core of the region’s innovative activities. Promoting the entrepreneurial potential of universities is impossible without a quality training process, a high level of qualification and competitiveness of graduates, the stimulation of innovations, and the development of new forms of educational and scientific activities covering all levels of management.

The rating assessment of the entrepreneurial ecosystem of universities was based on multilevel hierarchical and integrated indicators using quantitative and qualitative methods. The identification of weighted criteria, established for each region accounting for its socioeconomic development, would help to improve the verification of the rating. Their use will allow one to consider regional factors, as well as the individual characteristics of each area of university activities. In our opinion, such an approach facilitates the identification of weaknesses and strengths of a university within the framework of its entrepreneurial and innovative activities and determines the vector of its further development to positively influence the functioning of socioeconomic systems.

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