Ю. В. Данейкин, О. П. Иванова, В. А. Трифонов

Вклад университета в развитие региона: экосистемный подход

Проблема и цель. Оценка вклада университетов в социально-экономическое развитие регионов, технологический и инновационный прогресс промышленности – актуальные вопросы современной повестки модернизации высшего образования в Российской Федерации. Авторы предлагают методику оценки вклада университетов в региональное развитие с позиций экосистемного подхода, позволяющую перенастраивать программы развития акторов региональной экосистемы «Образование – Наука – Промышленность» в целях достижения задач технологического прогресса и социально-экономического развития региона.

Методы исследования. При определении показателей с использованием экосистемной концепции учитывали, что исходными компонентами для работы каждого актора региональной экосистемы «Образование – Наука – Промышленность» являются результаты деятельности одной из этих составляющих. При использовании системной теории при определении групп показателей выделили процессные, средовые и проектные составляющие региональной экосистемы «Образование – Наука – Промышленность».

Результаты. Сформированы восемь блоков подсистем показателей вклада вуза в региональное развитие: в интеграционные, инвестиционные процессы и технологическое развитие региона, инновационное развитие региона, демографическое развитие региона, рынок труда региона, социальное развитие региона, интеллектуальный потенциал региона, инфраструктуру региона, экономику региона. Обособлены показатели эффективности (результативности) университета («внутренняя» результативность университета) и показатели вклада университета в развитие региона. Показатели разделены на краткосрочные (позволяющие оценить вклад университета как эффект от деятельности университета, проявляющийся в течение 1-2 лет) и долгосрочные (позволяющие оценить вклад университета как эффект от деятельности университета, проявляющийся через 5-7 лет). Показатели дифференцированы по группам (приоритет 1, приоритет 2, приоритет 3) с учетом тесноты связи индикатора и показателя вклада вуза в региональное развитие.

В заключении показаны возможности практического использования методики для анализа результативности функционирования вуза в регионе и корректировки программ развития университетов в региональной экосистеме, в том числе при оценке эффективности реализации программы «Приоритет 2030».

Ключевые слова: университет, регион, развитие региона, экосистема «Образование – Наука – Промышленность», экосистемный подход, системная теория, вклад университета в развитие региона

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University contribution to the development of the region: ecosystem approach

Problem and purpose. Assessment of the contribution of universities to the socio-economic development of regions, technological and innovative progress of industry are topical issues of the modern agenda for the modernization of higher education in the Russian Federation. The authors propose a methodology for assessing the contribution of universities to regional development from the standpoint of the ecosystem approach, which makes it possible to reconfigure the development programs of the actors of the regional ecosystem "Education – Science – Industry" in order to achieve the tasks of technological progress and socio-economic development of the region.

Research methods. When determining indicators using the ecosystem concept, it was taken into account that the initial components for the work of each actor of the regional ecosystem "Education – Science – Industry" are the results of the activity of one of these components. When using the system theory in determining the groups of indicators, the process, environmental and design components of the regional ecosystem "Education – Science – Industry" were identified.

Results. Eight blocks of subsystems of indicators of the university's contribution to regional development have been formed: in integration, investment processes and technological development of the region, innovative development of the region, demographic development of the region, labor market of the region, social development of the region, intellectual potential of the region, infrastructure of the region, economy of the region. The indicators of the efficiency (effectiveness) of the university ("internal" efficiency of the university) and the indicators of the university's contribution to the development of the region are distinguished. The indicators are divided into short-term (allowing to evaluate the university's contribution as the effect of the university's activities, which manifests itself within 1-2 years) and long-term (allowing to evaluate the university's contribution as the effect from the university's activities, which manifests itself in 5-7 years). The indicators are differentiated by groups (priority 1, priority 2, priority 3) taking into account the close relationship between the indicator and the indicator of the university's contribution to regional development.

In the conclusion, the possibilities of practical use of the methodology for analyzing the performance of the university in the region and adjusting the programs for the development of universities in the regional ecosystem, including when assessing the effectiveness of the implementation of the Priority 2030 program, are shown.

Keywords: university, region, regional development, ecosystem "Education – Science – Industry", ecosystem approach, systems theory, university contribution to the development of the region

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Introduction

Russian universities have entered the era of modernization of models of interaction with scientific organizations, industrial partners, and government bodies. So, in particular, the Priority 2030 program, launched in June 2021, is aimed at the integration and cooperation of scientific, educational organizations, industrial companies, the demand for the results of their interaction in the real sector of the economy of the country and regions.

Ensuring the systemic balance and sustainable development of the socio-economic system of the region is facilitated by the effective inclusion of the university in regional processes. Universities can play the role of collaborators in planning and economic development of regions [1]. However, the definition of "points" for the application of the university's forces in regional development depends not only on identifying the key problems of the region and analyzing the existing labor market. The contribution of universities to the development of territories depends both on the model of interaction between the university and the region and on the role that the university plays as an actor in the regional ecosystem "Education – Science – Industry".

The purpose of this article is to present a methodology for assessing the contribution of universities to regional development from the standpoint of the ecosystem approach. To achieve the goal, the existing approaches to assessing the contribution of universities to the development of territories are considered, the ecosystem approach and the provisions of the system theory are used to identify groups of indicators.

Review of methodologies for assessing the impact of universities on regional development

Researchers point out that universities are the economic, social, cultural resource of the city due to tax revenues, the development of the educational and cultural environment [2; 3]. Universities perform city-forming, city-developing and city-preserving functions [4-6]. Scientists note that the contribution of universities is also determined by their market initiatives in the territory of their residence [7]. Universities are becoming key agents of the intraregional concentration of knowledge dissemination [8], in the process of knowledge creation and diffusion, they contribute to the development of the region [9].

Approaches to assessing the contribution of universities to regional development are mainly based on identifying several groups of criteria. P. Pellenbarg [10] examines the blocks of economic from the effects of the university's impact on the region: university revenues and expenses, the development of the labor market, assistance in the creation of new firms, the commercialization of knowledge, employment at the university. The ACE methodology is aimed at assessing the economic impact of the university on the region [11], includes criteria: the number of jobs created by the university, the cost of goods produced with the participation of the university, the amount of taxes paid by the university, the number of new enterprises in the region created with the participation of the university. In [12], the university is considered as a source of the economic base of the region (university revenues, living expenses of visiting students, etc.). The model for assessing the contribution of the university to the development of the region, highlighting

the importance of the competencies of specialists receiving higher education, makes it possible to determine the tax income of the territory from the higher wages of university graduates [13]. The analysis of the innovative research contribution of the university to the development of the territory is based on the assessment of the number of inventions, patents, new spin-out or spin-off companies, the publication frequency of articles by teachers, the position of the university in the rankings [14]. In the OECD assessment model [15], the blocks of the contribution of higher education to the development of innovation, human capital, socio-cultural development, and preservation of the environment are highlighted. Similar groups of indicators are proposed by scientists of the Higher School of Economics [16]: contribution to socio-economic development, human capital development, innovative development of the region. On the basis of the investment principle of comparison "with a project" and "without a project" in [17] it is proposed to assess the role of the university in regional progress.

In general, the review of approaches to the analysis of the contribution of universities to regional development allows us to state that the methods either focus on the specific role of the university (for example, in the innovative development of the region), or use the grouping of criteria on the basis of "economy", "competence", "innovation" and so on. At the same time, universities are considered separately from other subjects of the territories. And in modern conditions of transformation of the role of universities, including in their interaction with business, society, it seems necessary to use the ecosystem approach, the study of universities in their collaboration with other subjects of the region. The ecosystem approach becomes the basis for the strategic integrated management of economic systems to ensure their preservation and sustainable development [18], is considered as a concept that describes the mutual influence of economic agents, their relationship with the environment [19]. The effects of the functioning of the university in the region depend on its role and functions in the "Education – Science – Industry" ecosystem of the region.

The role of the university in the "Education – Science – Industry" ecosystem of the region

The ecosystem is viewed as: a set of autonomous organizations that produce complementary components of value, which build a certain structure of relations without vertical integration [20; 21], a network of firms offering related products and services [22-24], "a complex of uncontrolled hierarchically organizations localized in space, business processes, innovation projects and infrastructural systems interacting with each other in the course of creation and circulation of material and symbolic goods and a firm, or a platform that includes both the manufacturer and third-party participants, creating and assigning new value through innovation" [26], "a set of actors with varying degrees of multilateral, non-general complementarity, which are not fully controlled by the hierarchy" [20].

Significant characteristics of ecosystems: complementarity and coordination of enterprises in different industries without a management hierarchy, joint specialization [22], higher efficiency of coordination of interrelated but autonomous organizations [27].

It should be noted that the literature investigates various types of ecosystems, including educational [28] (for example, ecosystems that promote social or cultural innovation and development, ecosystems that support technological innovation and the development of teams of technology entrepreneurs and developers, etc.), regional entrepreneurial

ecosystems [29], business ecosystems (enterprise interactions with customers and suppliers) [30], technological ecosystems (a set of interconnected technologies and interdependent technological advances that influence evolution) [31; 32].

We consider the regional ecosystem "Education – Science – Industry" as an innovative and technological one, localized within one region, the actors of which, in interaction, create values for the region. These values are expressed in innovative solutions, new technologies, personnel training for the development of industrial enterprises and overcoming the socio-economic problems of the region. The selection of just such an ecosystem is due, in particular, to the fact that the problem of ensuring the innovative and technological development of industrial complexes in the Russian Federation requires a solution. It has become more complicated in the context of the forced transition to the policy of import substitution. Even with the implementation of state measures to stimulate the innovative activity of economic entities, the crisis in the industry of the Russian Federation continues. The change in the paradigm of global technological development, the emergence of the sixth technological order necessitate the creation of conditions for ensuring the competitiveness of domestic industry in world markets. However, there is no synergistic effect from the measures of the state, which has determined the list of priority directions for the development of science, technology, technology and critical technologies and the actions of the enterprises themselves. The industry of the Russian Federation has problems in the field of innovation. With the support of the state, in recent years, technoparks, technology transfer centers, industrial (industrial) parks, business incubators, centers for the collective use of equipment, special economic zones, technopolises, innovative scientific and technological centers, etc. have been created in the Russian Federation. However, practice shows that these objects need both the coordination of joint activities and the assessment of their effectiveness. Therefore, the role of universities is important as a driver, initiator of the creation and development of integration formations in industry, and infrastructure facilities for their scientific and innovative support.

On the other hand, the new program for the development of universities "Priority 2030" involves strengthening the contribution of scientific and educational organizations to the socio-economic development of the regions. The activation of the participation of the actors of the "Education" and "Science" systems in the development of industrial complexes, innovation infrastructure, contributing to the technological modernization of industries is in demand. Consideration of regional ecosystems "Education – Science – Industry" as an object of research, as well as an assessment of the role of the university – the actor "Education" and "Science" – is aimed at solving the problem of ensuring the functioning of regional integration industrial structures, in particular, innovative scientific and technological centers.

Consideration of the university as an actor of the regional ecosystem "Education – Science – Industry" allows one not only to highlight the key and significant for a particular region "points" of application of the efforts of universities, but also to form a system of criteria for assessing the contribution of the university in overcoming technological imbalances in the development of the national economy, in social – economic development of territories, in the conversion of the results of intellectual activity of the scientific and educational sector into products (goods, works, services) of the real sector of the economy. Within the framework of this article, we presented a methodology for assessing the contribution of the university to the development of the socio-economic system of the region, including the formation of industrial complexes, in particular, innovative scientific and technological centers (STCs), based on the ecosystem concept.

Results

The purpose of the methodology for assessing the contribution of the university to the development of the region is analytical (presentation of a map of the university's contribution to regional development), strategic (using the results obtained to reconfigure the development programs of the actors of the regional ecosystem "Education – Science – Industry" in order to achieve the tasks of technological progress and socio-economic development region).

When determining the indicators, we proceeded from the ecosystem approach and took into account that the initial components for the work of each actor of the regional ecosystem "Education – Science – Industry" are the results of the activity of one of these components. When determining the groups of indicators, we identified (taking into account the system theory) process, environmental and design components of the regional ecosystem "Education – Science – Industry".

The object components of the regional ecosystem "Education – Science – Industry" are the actors "Education", "Science", "Industry".

The actors of the "Education" component in our study are organizations of general, secondary and secondary specialized education, universities. The process component of the actor in the regional ecosystem "Education - Science - Industry": preparation, accumulation, storage and dissemination of knowledge, personnel training, the formation of human capital for the implementation of innovative activities, the formation of an effective system for monitoring and forecasting the needs of the actor of the Industry component in personnel, including those with unique competencies, expanding the volume and improving the quality of training specialists for employment of graduates in the subjects of the actor of the component "Industry", the development of organizational mechanisms for cooperation of ecosystem participants in the field of education, the introduction and development of modern educational methods and technologies, including a project-based approach to learning, the implementation of educational programs aimed at the formation of new competencies of the 21st century, the development of a system of continuous education, retraining and advanced training of scientific, engineering and technical and managerial personnel, development of a system of additional education for children, ensuring the formation of motivation students, the development of the circle movement, the creation of a network of centers for youth innovative creativity, children's technology parks, specialized school classes, the holding of Olympiads for schoolchildren on the topic of innovative entrepreneurship, innovation management, the function of an intermediary in the innovation system, the initiation of joint research, participation in the creation of new science-intensive enterprises, ensuring communication with external systems, transfer of innovations between entities. The key role of universities in creating innovative ecosystems, new knowledge-intensive enterprises and conducting joint research with industry is emphasized in [33; 34]. Universities make an indirect contribution to the activities of industrial structures [35].

The actors of the "Science" component are universities, scientific institutes, research institutes, design and engineering organizations for the development and modernization of industrial products, companies engaged in R&D. The process component of the actor in the regional ecosystem "Education – Science – Industry": scientific substantiation of the

main directions of long-term scientific and technological policy, an inventory of available scientific groundwork in the field of fundamental and applied science, achievements of scientific and technological progress in the country and abroad, development of a program of fundamental and exploratory research for the "Industry" actor, collection and examination of scientific information, scientific and methodological support of the "Education" actor, research, technological developments for the production process, development of new products, engineering, development or implementation of new digital solutions, information systems for the production process, consultations on production, organizational and financial issues, issues of building production and business processes, long-term forecast of technology development and market situation.

Actors of the "Industry" component are a set of companies, enterprises (firms) for the production, repair and modernization of industrial products, including those united in clusters, integrated companies, and other forms of association. The process component of the actor in the regional ecosystem "Education – Science – Industry": the formation of a request for research and development, for personnel training, participation in the conduct and financing of R&D, the introduction of innovations and new technologies in production, the formation of a request for personnel and research, production of products.

Processes taking place in the regional ecosystem "Education – Science – Industry": integration, investment processes, technological, innovative, demographic, economic development of the region.

The environmental components of the regional ecosystem "Education – Science – Industry": the labor market, the demographic structure of the population of the region, society, the infrastructure of the region, the intellectual potential of the region.

Design components of the regional ecosystem "Education – Science – Industry": projects for the creation of industrial complexes, innovative scientific and technological centers (STCs), scientific and educational centers, clusters of enterprises, innovations.

When forming the system of indicators, we proceeded from the practice of structuring criteria into blocks (groups). However, in contrast to common approaches to stratification of indicators, we have identified other blocks (determined based on the process, design, environmental components of the regional ecosystem "Education – Science – Industry"), which are ranked according to their importance for the region.

A priori ranking was carried out: experts (economists, representatives of enterprises, STCs, authorities of the Novgorod region) were asked to arrange groups (blocks) of indicators, as well as to supplement the list (if, according to the expert, it is incomplete). The group that has (in the opinion of the expert) a more significant influence on regional development is given the first place, the rest are arranged in descending order. The results of ranking according to the degree of influence of the contribution to regional development is the contribution to:

1. integration, investment processes and technological development of the region,
2. innovative development of the region,
3. demographic development of the region,
4. labor market of the region,
5. social development of the region,
6. the intellectual potential of the region,
7. infrastructure of the region,
8. the economy of the region.

Thus, 8 blocks – subsystems of indicators – are allocated:

- integration-investment-technological, which assesses the influence of the university on the integration processes in the region, the creation of clusters, innovative scientific and technological centers, networks of enterprises and organizations, the formation of an ecosystem "Education – Science – Industry", attracting investments and technological development of industries;
- innovative, which assesses the influence of the university on the growth of production of innovative goods and services, the introduction of innovations into the activities of enterprises and organizations in the region;
- demographic, which assesses the impact of the university's activities on the age and sex composition of the region's population;
- personnel, which examines the impact of the university on the labor market in the region;
- social, which analyzes the impact of the university's activities on the quality of life of the population of the region in general and students in particular;
- intellectual, which examines the influence of the university's activities on the structure of education in the region;
- infrastructural, in which the influence of the university's activities on the development of infrastructure in the region, including the university campus, is investigated;
- economic, which analyzes the impact of the university's activities on the regional economy, budget revenues.

In addition, the presented division of indicators into groups is due to the following. It is recognized that the university in the region is able to become the initiator and engine of cooperation between the participants of the "Education – Science – Industry" ecosystem. The technological and innovative development of the region, which determines the increase in investment in the economy of the region, depends on the scientific and innovative potential of the university, its ability to interest scientific institutions and industrial enterprises in joint research. The growth in labor productivity as a result of the technological and innovative development of industry is able to compensate for the decline in the working-age population in the regions of the Russian Federation. The fact is that statistical data indicate that the Russian labor market in the coming years will face a shortage of labor resources, which are shrinking due to an aging population and demographic decline. By 2035, the reduction in the working-age population may amount to 3.1 million people*. Attraction of young people to the region by the university can improve the demographic structure of the population. According to the forecast of Rosstat, the number of citizens under the age of 16 will decrease: the optimistic scenario assumes a decrease by almost 3 million – to 24.6 million people, which will amount to 16.1% of the population by 2036. In the pessimistic version of the forecast, the reduction will amount to 7.3 million people (4.2%), having decreased from 27.4 million to 20.1 million people (14.5% of the population). Rosstat believes that the most likely decline is by 5 million people over 15 years, from 27.4 million to 22.4 million (15.6% of the population).

The aging of the population also determines the importance for the region of the role of the university in the development of the labor market and the social development of the region. It is not only about increasing the share of employed at the university in the total number of employed in the region, providing continuous education, training and retraining of older people for the needs of the labor market. In this case, the indicators

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* Cadre are key. Is the Russian labor market ready to reduce the able-bodied population // <https://tass.ru/obschestvo/7007706>;
Economically active and able-bodied population // <https://rosinfostat.ru/ekonomicheskii-aktivnoe-naselenie/>

of the university's contribution to the development of the region can be the satisfaction of the need for personnel for industry, health care, and education in the region. To assess the contribution of the university to the social development of the region, we propose to evaluate not only the ratio of average monthly cash payments to students, graduate students, residents, assistants to the average salary in the regional economy, but also the contribution to the socio-cultural development in the region (the number of social projects implemented by the university), the contribution to development environment, improvement of the ecological situation in the region (the number of environmental projects implemented by the university). Attention to the social and environmental problems of the region, the development and implementation of projects in this area with a wide coverage of the population and media coverage contributes to the improvement of the social well-being of the residents of the region. The number of contracts awarded by the university in the field of medical research and medical services should also be estimated. The effects of the university's activities in these areas can be an improvement in the quality of medical care in the region, attracting investors, and reducing the level of poverty in the region.

The contribution of universities to the development of the infrastructure of the region involves not only the development of the university campus, the creation of spaces on the campus open to residents of the region (stadiums, gyms, libraries, workshops, cinemas), but also the construction of new campus facilities, the implementation of architectural and design projects to improve the campus. This contributes to the involvement of the population of the region in the life of the university, meeting the need for events and facilities for leisure and classes. The result is a solution to the problems of the region in creating, arranging, maintaining spaces for cultural and sports life, improving the image of the region, forming a unique brand for the region. Measurable indicators of the contribution of the university can be the attraction of migrants and those coming to study, migration growth.

Taking into account the fact that the initial components for the work of each actor of the regional ecosystem "Education – Science – Industry" are the results of the activity of one of these components, when determining the indicators for assessing the contribution of the university to regional development, we singled out separately the indicators of efficiency (effectiveness) of the university ("internal" university performance) and indicators of the university's contribution to the development of the region. "Internal" university performance affects regional development. In addition, indicators include short-term (allowing to assess the university's contribution as an effect from the university's activities, which manifests itself within 1-2 years) and long-term (allowing to assess the university's contribution as an effect from the university's activities, which manifests itself in 5-7 years).

So, for example, short-term indicators of efficiency (effectiveness) of the university's activities, affecting the development of integration, investment processes in the region and its technological development:

- The share of students enrolled in the 1st year from other regions, %.
- The ratio of average monthly cash payments to students, graduate students, residents, assistant trainees to the average salary in the region's economy.
- Average earnings of graduates who have completed their studies on educational programs of higher education of the university in relation to the average earnings in the region.
- The contribution of the university to the development of general, secondary vocational education, additional vocational education for schoolchildren in the region (qualitative indicator).

- The share of the university's teaching staff working on a part-time basis in the organizations of secondary vocational education in the region.
- The share of teaching staff involved in the functioning of organizations with highly equipped student places as mentors, tutors, experts.

Long-term indicators of efficiency (effectiveness) of the university's activities, affecting the contribution to the development of integration, investment processes in the region and its technological development:

- The number of universities and research organizations participating in consortia with the university.
- Participation of the university in the creation of clusters, STCs.
- The number of new areas of R&D that have emerged as a result of the activities of the university, alumni and teachers.
- The number of projects (programs) of the university in the framework of the implementation of R&D, corresponding to the current international research agenda in the priority areas of the Strategy for scientific and technological development.
- The number of leading Russian and foreign scientists involved in the implementation of projects.

To assess the contribution of the university to the development of the region in each of the eight subsystems, we have identified one or several key indicators, the positive dynamics of which indicate the positive impact of the university on the regional system (Table 1).

Table 1

Indicators for assessing the contribution of the university to the development of the region

Subsystem	Indicator of the university's contribution to the development of the region
Integration-investment-technological	Increase in developed advanced production technologies in the region, %. Increase in internal current expenditures on research and development by type of expenditure (wages, equipment purchase), %.
Innovative	Increase in the share of products of high-tech and knowledge-intensive industries in the region's GRP, %.
Demographic	Population growth in "student" age, in% of the previous year.
Personnel	Increase in the share of the population with digital skills in the total population aged 15-74, %
Social	Involvement of residents of the region in social projects, % of the previous year Reducing the level of poverty in the region.
Intellectual	Increase in the number of personnel engaged in research and development, % compared to the previous year.
Infrastructure	Migration gain.
Economic	Growth in real incomes of the population, in% of the previous year. GRP per capita

Indicators are highlighted in each subsystem. In the process of selecting and differentiating indicators by groups (priority 1, priority 2, priority 3), the methodology provides for the use of an indicator that makes it possible to determine the closeness of connection (pair correlation coefficient) of the indicator and the indicator of the university's contribution to regional development. Indicators with the highest values of paired correlation coefficients form a block – priority 1, with a less close relationship – priority 2, with a relationship indicator that is significant for analysis, but not high enough – priority 3.

Table 2

Indicators of the subsystem "Integration-investment-technological" for assessing the contribution of the university to regional development

Block	Indicator group	Indicator
Short term	Priority 1	Gross regional product growth.
	Priority 2	Increase in the number of personnel engaged in research and development, including by category: researchers.
		The movement of personnel engaged in research and development (taken from other scientific organizations).
	Priority 3	Increase in the number of new technologies (0-2 UGT).
Long term	Priority 1	Increase in the number of organizations carrying out research and development in the region.
		Increase in the physical volume of investments in fixed assets by type of economic activity
	Priority 2	Increase in the number of advanced production technologies used in the region by groups of advanced production technologies.
		The movement of personnel engaged in research and development (accepted after graduation).
	Priority 3	Change in the level of diversification of the region's economy.
		The movement of personnel engaged in research and development (taken from other scientific organizations).

The generalized indicator of the influence of the university's activities on regional development for the t -th period relative to the indicator taken as the comparison base is calculated for all subsystems using the formula:

$$K'_{inf} = \sqrt[3]{\prod I_j^t},$$

where K_{inf}^t – an integral indicator of the influence of the university's activities on regional development for the t -th period; I_j^t – quantitative assessment of each subsystem of indicators included in the analysis.

Partial generalized indicators (for each group of indicators) are calculated as the geometric mean of the number of influence indicators that form the groups.

Discussion of the results

This research is in line with the study of the features of the spatial and functional localization of regional educational subsystems by Russian scientists [36-38].

The legitimacy of our use of the ecosystem concept to develop a methodology for assessing the contribution of universities to regional development is confirmed by the trend and effectiveness of the application of the provisions of the ecosystem approach in research on the development of universities. So, in particular, in [39] it is proposed to use the ecosystem principles of organizing the provision of higher education services. We agree with the opinion of the authors of the article [39], who indicate the need to design an ecosystem for the development of universities in order to implement the social mission of the university in the region and transform the ecosystem of the region as a whole.

We share the positions of the authors who consider universities as important resources for regional development [2-9]. When forming a methodology for assessing the contribution of a university to regional development, we, as well as a number of researchers [10-12; 15; 16], used the method of grouping indicators. However, unlike other studies, the selection of indicators was based on the ecosystem approach and systems theory. In order for the indicators to cover the maximum number of processes, environments and projects that are most important in the process of mutual influence and co-development of universities and regions, we have identified the process, environmental and design components of the regional ecosystem "Education – Science – Industry". And this determines the scientific novelty and practical value of the proposed approach to assessing the contribution of the university to regional development.

We agree with the approaches of the authors [40], who suggested that the university's contribution to innovative development be based on the analysis of Inputs ("input" – factors of innovative development in the resulting variables) and Outputs ("output" – the results of innovation). The same principle was used by us in determining the indicators of the efficiency (effectiveness) of the university ("internal" efficiency of the university) and indicators of the university's contribution to the development of the region.

It should be noted that the majority of the methods do not offer an integral indicator of the influence of the university on the regional system. For example, the methodology of the OECD Program for Institutional Management in Higher Education [15] for assessing the role of the university in the socio-economic development of regions provides for the analysis of statistics, including data on the socio-economic development of regions, expert polls, analysis of the situation in regions, analysis of demographic and migration processes, their dynamics in a comparative regional perspective.

We agree with the approaches of the authors suggesting, for example, in [16; 41] calculation of integral indicators. So, in [15], the values of indicators in each of the blocks identified by the authors are normalized, weighted and aggregated with the same weights into a subindex characterizing the position of the regions for each of the blocks. In [41], an integral approach to the construction of indicators of the development of the higher education system is proposed, reflecting the increase in the gross regional product obtained as a result of the functioning of the higher education system in the region.

However, in contrast to the works of these scientists and others, whose works we studied, our approach involves obtaining a generalized indicator of the impact of university activities on regional development for a certain period. This makes it possible to compare the roles of universities in regional development, to rank them, to be able to track the dynamics of their influence on the regions.

In addition, unlike those considered in the course of work on the methodology of domestic and foreign developments in this area, the author's approach provides for ranking indicators, their prioritization. In each of the eight subsystems, we have identified one or more of the most important indicators, the positive dynamics of which demonstrates the positive influence of the university on the regional system. The highest priority are those indicators that are closely related to the indicators of the development of the region. This approach seems to us to be methodologically justified, allowing not only to assess the performance indicators of higher education institutions most affecting the region's system, but also to use them when strategizing the development of regional ecosystems.

Thus, a critical analysis of domestic and foreign developments in the field of assessing the role of universities in the development of regions, the use of progressive and

methodologically justified approaches and principles allowed the authors to develop a methodology that is a contribution to the theory of regional development and the economy of education, which has an applied value for use in developing mechanisms improving the efficiency of universities and assessing their impact on the success of the regions.

Improving the methodology for strategizing and assessing the mutual influence of actors of regional ecosystems "Education – Science – Industry" will allow for a more conscious approach to the management and development of these systems, as well as see potential opportunities for cooperation and fixing best practices, their potential transfer to other ecosystems.

The results may be of interest both for scientists, heads of universities, employees of the Ministry of Science and Higher Education, and for those who make decisions on the development and performance assessment of universities, INTCs, RECs, consortia of universities, scientific institutions and enterprises formed as part of the implementation of the "Priority 2030", and defining the strategy and priorities of scientific and technological development of the regions of the Russian Federation.

Conclusion

Thus, we substantiated the need to use the methodology for assessing the contribution of the university to the regional development of the regional ecosystem "Education – Science – Industry" for the formation of a system of indicators. The concept of the regional ecosystem "Education – Science – Industry" is formulated as an innovative and technological one, localized within one region, the actors of which, in interaction, create values for the region. A system of indicators for assessing the contribution of the university to the development of the socio-economic system of the region, including the formation of innovative scientific and technological centers (STC), is presented, which differs from the traditional approach to determining the criteria for the effectiveness of the functioning of universities, a specialized approach that takes into account the special features of regional ecosystems "Education – Science – Industry". In contrast to the common approaches to stratification of indicators, the blocks of indicators are determined based on the process, design, environmental components of the regional ecosystem "Education – Science – Industry", which are ranked according to their importance for the region. In each subsystem (block) of indicators, their priority is determined. The indicators of efficiency (effectiveness) of the university ("internal" efficiency of the university) and indicators that allow assessing the contribution of the university as an effect from the activities of the university, manifested within 1-2 years, and indicators that allow assessing the contribution of the university as an effect from the activities of the university, manifested in 5 -7 years. In addition, a method for calculating a generalized indicator of the university's influence on regional development is shown. The application of the methodology for the assessment will allow universities to improve their development strategies, and the authorities, in integration with universities and business, will adjust regional development programs.

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REFERENCES

1. Boulton G., Breimer D. Universities and Innovation: The Challenge for Europe / League of European Research Universities. LERU. Belgium – 2006 [Electronic resource]. Available at: <https://www.leru.org/publications/universities-andinnovation-the-challenge-for-europe#> (accessed 15 June 2021)
2. Balmasova T.A. "The third mission" of the university — a new vector of development? *Higher education in Russia*, 2016, no. 8-9, pp. 48–55.
3. Bezgodov D.N., Belyaeva O.I. Socio-cultural mission of the university in the context of the development of the region. *Higher education in Russia*, 2016, no. 6, pp. 128–134.
4. Vakhshatyn V. Metafori i metamorfozy universiteta [Metaphors and metamorphoses of the university]. *Kultivator – Cultivator*, 2011, 3. Available at: <http://www.intelros.ru/pdf/Kultivator/3/2.pdf> (accessed 15 June 2021)
5. Reznik G.A., Ponomarenko Yu.S. & Kurdova M.A. *Funktsii vuza: novye vozmozhnosti razvitiya* [Functions of the university: new development opportunities]. *Mir nauki – World of Science*, 2014, 4. Available at: <https://mir-nauki.com/PDF/30PMN414.pdf> (accessed 15 June 2021)
6. Emelyanova I. N. *Strategicheskie prioritety klassicheskogo universiteta. Kontent-analiz missiy* [Strategic priorities of a classical university: mission content analysis]. *Universitetskoye upravlenie: praktika i analiz – University Management: Practice and Analysis*, 2016.
7. Rücker Schaeffer, P., Fischer, B., Queiroz, S. Beyond Education: The Role of Research Universities in Innovation Ecosystems. *Foresight and STI Governance*, 2018, vol. 12, no. 2, pp. 50–61. DOI: 10.17323/2500-2597.2018.2.50.61
8. Fritsch M., Schwirten C. Enterprise-University co-operation and the role of public research institutions in regional innovation systems. *Industry and Innovation*, 2006, vol. 6, no. 1, pp. 69–83.
9. Jiao H., Zhou J., Gao T., Liu X. The more interaction the better? The moderating effect of the interaction between local producers and users of knowledge on the relationship between R&D investment and regional innovation systems. *Technological Forecasting and Social Change*, 2016, vol. 110, pp. 13–20.
10. Pellenbarg P.H. How to calculate the impact of university on the regional economy. A case study of the University of Groningen, The Netherlands, University of Groningen. Regional Quantitative Analysis Research Group: University of Barcelona, 2005.
11. Caffrey J., Isaacs H.H. Estimating the impact of a College or University on the Local Economy. Washington, DC: American Council on Education, 1971.
12. Elliott D.S., Levin S.L., & Meisel J.B. Measuring the economic impact of institutions of higher education. *Research in Higher Education*, 1998, vol. 28, no. 1, pp. 17–33.
13. Bluestone B. UMASS/Boston: An Economic Impact Analysis. Boston: John W. McCormack Institute of Public Affairs. The University of Massachusetts, 1993.
14. The impact of the University of Birmingham (A report for the University of Birmingham), 2013, Oxford Economics. Available at: <http://www.birmingham.ac.uk/Documents/university/economic-impact-of-universityofbirmingham-full-report.pdf> (accessed 15 June 2021)
15. OECD: Higher Education and Regions. GLOBALLY COMPETITIVE, LOCALLY ENGAGED, 2007. Available at: <https://www.oecd.org/edu/imhe/highereducationandregionsgloballycompetitivelocallyengaged.htm> (accessed 15 June 2021)
16. Assessment of the contribution of regional systems of higher education to the socio-economic development of regions of Russia / O.V. Leshukov, D.G. Evseeva, A.D. Gromov, D.P. Platonova; National Research University Higher School of Economics, Institute of Education. Moscow, NRU HSE Publ., 2017. 30 p.
17. Lugom Yu.V. Instrumental Methods for Assessing the Impact of a University on the Economic Development of a Region Based on Investment Theory. *Proceedings of ISA RAS*, 2013, no. 1, vol. 63.
18. Shkarupeta E.V., Bachurin D.N. Conceptual provisions of the ecosystem approach to managing the development of economic systems in the context of digital transformation. *Production organizer*, 2020, vol. 28, no. 3, pp. 7–15. DOI: 10.25987/VSTU.2020.32.34.001
19. Mercan B., Goktas D. Components of Innovation Ecosystems: a Cross-Country Study. *International Research Journal of Finance and Economics*, 2011, no. 76.
20. Jacobides M.G., Cennamo C., Gawer A. Towards a theory of ecosystems. *Strategic Management Journal*, 2018, vol.

- 39, issue 8, pp. 2255–2276. DOI: 10.1002/smj.2904.
21. Kleiner G.B. Socio-economic ecosystems in the light of the systemic paradigm. *System analysis in economics: collection of articles. tr. V Int. scientific-practical conf. - Biennale (November 21-23, 2018) / under total. ed. G.B. Kleiner, S.E. Shchepetova*. Moscow, Prometheus Publ., pp. 5-14.
  22. Jacobides M., Cennamo C., Gawer A. Industries, Ecosystems, Platforms, and Architectures: Rethinking our Strategy Constructs at the Aggregate Level. Working paper, London Business School, 2015.
  23. Adner R. Match your innovation strategy to your innovation ecosystem. *Harvard Business Review*, 2006, vol. 84, no. 4, pp. 98–107.
  24. Iansiti M., Levien R. The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability. Harvard Business School. Press: Boston, MA, 2004.
  25. Socio-economic ecosystems in the light of the systemic paradigm. *Systems analysis in economics – 2018: collection of works of the V International scientific and practical conference - biennale (November 21-23, 2018) / ed. ed. G.B. Kleiner, S.E. Shchepetova*. Moscow, Prometheus Publ., 2018, pp. 5-14.
  26. Autio E., Thomas L.D.W. Innovation ecosystems: implications for innovation management. In the Oxford Handbook of Innovation Management, Dodgson M., Gann D.M., Phillips N. (eds). Oxford University Press: Oxford, UK, 2014.
  27. Ramenskaya L.A. Application of the concept of ecosystems in economic and management research. *Manager*, 2020, vol. 11, no. 4, pp. 16–28. DOI: 10.29141/2218-5003-2020-11-4-2.
  28. Spencer-Keyes D., Luksha P., Cubist D. Educational Ecosystems: Emerging Practices for Future Education. Published by the Moscow School of Management SKOLKOVO and Global Education Futures.
  29. Solodilova N.Z., Malikov R.I., Grishin K.E. Methodological tools for assessing the state of the regional entrepreneurial ecosystem. *Economy of the region*, 2018, vol. 14, no. 4, pp. 1256-126.
  30. Kapoor R., Lee J.M. Coordinating and Competing in Ecosystems: How Organizational Forms Shape New Technology Investments. *Strategic Management Journal*, 2013, vol. 34, no. 3, pp. 274-296.
  31. Adomavicius G., Bockstedt J., Gupta A., Kauffman R.J. Technology roles and paths of influence in an ecosystem model of technology evolution. *Information Technology and Management*, 2007, vol. 8, no. 2, pp. 185–202.
  32. Wareham J., Fox P., Cano G. Technology ecosystem governance. *Organization Science*, 2014, vol. 25, no. 4, pp. 1195–1215.
  33. Benneworth P., Hospers G.J. The new economic geography of old industrial regions: Universities as global-local pipelines. *Environment and Planning*, 2017, vol. 25, no. 6, pp. 779–802.
  34. WEF (2013) Entrepreneurial Ecosystems Around the Globe and Company Growth Dynamics. Geneva: World Economic Forum.
  35. Mowery D.C., Sampat B.N. Universities in National Systems. The Oxford Handbook of Innovation / Eds. J. Fagerberg, D. Mowery, R. Nelson. Oxford: Oxford University Press, 2005, pp. 209–239.
  36. Endovitsky D.A., Treshchevsky Yu.I., Rudnev E.A. Statistical analysis of the spatial and functional localization of educational subsystems in the regions of Russia. *Higher education in Russia*, 2019, vol. 28, no. 3, pp. 75–84. DOI: 10.31992/0869-3617-2019-28-3-75-84
  37. O. V. Perfilieva. Universities and regional development: theoretical analysis and research methodology. *Izvestia of Saratov University. Ser. Economy. Control. Law*, 2014, vol. 14, issue. 3, pp. 479–488.
  38. Kogan E.Ya., Postalyuk N.Yu., Kuteinitsyna T.G. Models of interaction of universities with the economy and social sphere of the region. *Higher education in Russia*, 2019, vol. 28, no. 7, pp. 9–18. DOI: 10.31992/0869-3617-2019-28-7-9-18.
  39. Simchenko N. A., Berkovich M. L. Ecosystem designing for the development of universities in a digital environment. *Perspektivy nauki i obrazovaniya – Perspectives of Science and Education*, 2021, vol. 49, no. 1, pp. 491-505. doi: 10.32744/pse.2021.1.34.
  40. Ogurtsova E.V., Perfilieva O.V., Firsova A.A. Indicators for assessing the contribution of the university to the innovative development of the region. *University management: practice and analysis*, 2017, vol. 21, no. 4, pp. 53-62. DOI: 10.15826/umpa.2017.04.049.
  41. Bolgova E.V. Integral indicator of the development of the higher education system in the economic space of the region. *Modern problems of science and education*, 2014, no. 3, pp. 364-364.

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