



DEVELOPMENT OF NEW FORMS OF SPATIAL-INTERACTION NETWORKING: RESEARCH AND EDUCATIONAL CENTERS

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ABSTRACT

Background: The article considers the features, types, and forms of the spatial interaction network that arise during forming and functioning of world-class scientific and educational centers. **Aim:** The authors determine development scenarios of new forms of spatial-interaction network, which involve interaction within the framework of a research and educational center, and the development of regional, interregional spatial interaction network between research and educational centers in priority areas of the development of the science and technology complex of Russia. **Results:** A presented model of the spatial interaction network within the framework of research and educational centers assumes the active participation of society in the innovative activities of research and educational centers through social networks and public associations. The features of regional and interregional spatial-interaction networks are considered, and the effectiveness of these spatial network collaborations is evaluated. **Conclusion:** A proposed model of the spatial interaction network of research and educational centers consists of three main blocks of the spatial interaction network of research and educational centers which contribute to the development of a single innovation space and the spread of innovations in the country.

Keywords: Innovative structures. Network structures. Research and educational centers. Spatial-interaction network. Socio-economic system.



DESENVOLVIMENTO DE NOVAS FORMAS DE REDE DE INTERAÇÃO ESPACIAL: CENTROS EDUCACIONAIS E DE PESQUISA

RESUMO

Antecedentes: O artigo considera as características, tipos e formas da rede de interação espacial que surgem durante a formação e funcionamento de centros científicos e educacionais de classe mundial. **Objetivo:** Os autores determinam cenários de desenvolvimento de novas formas de rede de interação espacial, que envolvem interação no âmbito de um centro de pesquisa e educação, e o desenvolvimento de rede de interação espacial regional e inter-regional entre centros de pesquisa e educação em áreas prioritárias do desenvolvimento do complexo de ciência e tecnologia da Rússia. **Resultados:** Um modelo apresentado de rede de interação espacial no âmbito dos centros de pesquisa e educação pressupõe a participação ativa da sociedade nas atividades inovadoras dos centros de pesquisa e educação por meio de redes sociais e associações públicas. As características das redes de interação espacial regionais e inter-regionais são consideradas, e a eficácia dessas colaborações de redes espaciais é avaliada. **Conclusão:** Uma proposta de modelo de rede de interação espacial de centros de pesquisa e educação consiste em três blocos principais da rede de interação espacial de centros de pesquisa e educação que contribuem para o desenvolvimento de um único espaço de inovação e a disseminação de inovações no país.

Palavras-chave: Estruturas inovadoras. Estruturas de rede. Centros de pesquisa e educação. Rede de interação espacial. Sistema sócio-econômico.

1. INTRODUCTION

Today, the spatial interaction network is of great importance for developing economic cooperation taking into account the specifics and individual characteristics of the particular territory. This type of collaboration is an effective form of interaction since it is based on the principle of cooperation, that is, it is mutually beneficial for all subjects (Camagni, 2017).

The relationships and communications between the subjects of socio-economic systems that have developed over a long period, today, represent a variety of horizontally and vertically integrated participants with common goals and aspirations. Such integration results from formal and informal network connections that influence the further development of territories (Inshakov & Frolov, 2007).

It should be noted that the existing territorial associations belong to a certain type of functioning and are identical in terms of the regional environment (Kocheshkova, 2014). Identifying the features of existing connections and their promising paths in various (new) forms of spatial-interaction networks is an urgent research area.



Participants of spatial-interaction networks actively cooperate in different spheres and directions, constantly use each other's experience, have innovative solutions, and act as a driving force (Sandberg & Gatewood, 1991; Katz, 1991). The degree of involvement in the so-called network interactions is also important and determining the role of each participant to ensure effective links without rupturing the network structure. Such interactions with a certain level of quality and efficiency allow forming integral functional forms of spatial-interaction networks. A technopolis, a cluster, and an industrial district can be distinguished as an example of such forms. The authors believe that under certain conditions, research and educational centers (REC) can act as a new form of spatial-interaction network.

There are more than 50 research and educational centers in the USA that are engaged in research, education, and knowledge transfer.

The authors (Sandberg & Gatewood, 1991) argue that research and educational centers play a key role as reliable structures for cooperation between the scientific community and business structures in the course of achieving mutually beneficial goals. In particular, according to these authors, business structures are characterized by a constant balancing in the focus of research between theoretical developments and applied research (responding to specific application needs for customers or interested parties). They suggest that the determinants of this balance should be further investigated, taking into account the random influence of the resource provision of centers and their management (Katz, 1991). In the article "The institution and infrastructure of entrepreneurship" (Katz, 1991), the author recognizes research and educational centers as those structures that implement "a model of assisting research organizations in working with business according to business and academic goals". It is expected that this connecting role of research and educational centers and their special importance for business development will bring a positive effect in all world economies in terms of growth, job creation, and regional development (Audretsch, Keilbach, & Lehmann, 2006; Martinez-Moyano, 2006).

In the Russian Federation, research and educational centers represent a relatively new form of cooperative interaction in the field of business, science, and education. According to the Decree of the President of the Russian Federation dated May 7, 2018, "On National Goals and Strategic Objectives of the Russian Federation through to 2024" (Katukov, Malygin, & Smorodinskaya, 2012), the state aims to create at least 15 world-class research and educational centers. These centers involve cooperation between universities and scientific institutions with organizations of the real sector.



According to this, the main tools and parameters for creating research and educational centers were determined within the framework of the national project "Science" (Savchenko, Pavlova, & Zhuravleva, 2020) and the Decree of the Government of the Russian Federation of 30.04.2019 No. 537 "On measures of state support for world-class research and educational centers based on the integration of educational institutions of higher education and scientific organizations, and their interaction with organizations operating in the real sector of the economy" (Koroleva, Vershinin, & Grishakina, 2019).

According to this Decree, in 2020, the Perm Territory, Belgorod, Kemerovo, Nizhny Novgorod, and Tyumen regions were determined (on a non-competitive basis) as having world-class research and educational centers. To date, 10 research and educational centers have been organized in various regions of the Russian Federation. According to the Ministry of Education and Science of Russia, research and educational centers can be called the "Technological web" of the country, designed to ensure territorial cohesion for the regions to develop intellectually, technologically, economically, etc.

The creation of research and educational centers implies a new level of cooperation between all universities in the region, their fundamental integration with research organizations, which can strengthen the research activities of universities and improve the quality of education. Research and educational centers created taking into account the socio-cultural and historical context should perform the function of developing regions and creating regional ecosystems in which global business projects can be created (Martinez-Moyano, 2006; Azagra-Caro, Archontakis, & Yegros-Yegros, 2007).

The existing system of stimulating scientific research is more focused on the stage of developing innovations, rather than on their practical implementation. The most effective tool can be special regional programs aimed at financing research projects that are initially developed for specific enterprises that should work together with research organizations. Research organizations cannot receive an appropriate grant if its fulfillment does not provide for the implementation of the results obtained, and the enterprise cannot receive funds to support innovative changes if it does not cooperate with a specific research organization. This initiates a need to search for opportunities for effective interaction between the state and business structures.

Until now, research and educational centers have increasingly been considered only as an organizational mechanism created by regional entities (government authorities, businesses, universities, and scientific organizations) to implement common high-tech projects. The authors believe that such a formal, superficial understanding of the functions



of research and educational centers is unacceptable, since it contradicts their main mission, namely, to accelerate the technological development of the region or territory. The regional specifics of research and educational centers should contribute to the unification to solve the problems that stand in the way of improving the competitiveness of the country, and finding new opportunities for the spatial-interaction network.

2. METHODS

The research basis was the systematization of scientific works of Russian and foreign scientists in the field of the spatial development of the territory, the development of world-class research and educational centers, etc.

The methodological framework of the research is based on the laws and principles of dialectics, cause-and-effect relationships, comparative and statistical analysis, economic and mathematical methods, and the method of expert assessments of the methodology of system analysis of interrelated processes of spatial-interaction network.

Experts can formulate a decent response to political, economic, social, and other challenges, because, as participants in the process, they have a premonition to take exact preventive measures and are ready to consciously use the resources at their disposal (Lavrinenko et al., 2019).

Networks are widely used for simulating the interacting components of complex systems arising in the economy (Gitman et al., 2012). Networks are often described in terms of local properties, such as vertex degree, or local clustering coefficients, as well as global properties. At the same time, certain mesoscale properties are constantly observed in real networks, which often reveal important structural information of the underlying complex systems.

The spatial interaction network model presented in the article within the framework of the research and educational center is developed based on the theory of a four-stage spiral model which combines the system of education, business, the state, and society. A four-stage spiral model represents a single space for transferring innovations between business and science with the support of the state and the participation of civil society (Carayannis, 2016; Chernova & Klimuk, 2019). A four-stage spiral model is considered by many scientists (Carayannis, 2016; Chernova & Klimuk, 2019; Antonov & Pomogaeva, 2019, etc.).



This model is an improved theory of the triple helix, which means continuous cooperation of the main agents of the economy, namely, the state, business, and science in the framework of forming the cluster integration structures.

A four-stage spiral of innovation connects social ecology, the production of third-type knowledge, and innovation. Its most important system-forming element, in addition to the active human factor, is the knowledge resource, which, due to the circulation between social subsystems, known as knowledge circulation, turns into innovations and know-how, implemented in society and the economy (Katukov, Malygin & Smorodinskaya, 2012).

The construction of a spatial network model within the framework of the present study is based on the networking interaction of participants.

Evaluating the effectiveness of the spatial interaction network of research and educational centers was carried out using an expert evaluation method.

3. RESULTS AND DISCUSSION

Over the past 20 years, the role of business in stimulating global economic growth, creating jobs and regional development has been increasingly recognized. Research organizations are an important tool for promoting regional economy and social development through their three missions, namely, education, research, and business support. For example, empirical data show how knowledge transfer activities benefit regional development in terms of entrepreneurial activity (Benoit & Marsh, 2009), competitiveness, and access to financial markets for knowledge-intensive firms (Boardman & Gray, 2010).

According to (Albarra'n et al., 2010), the growth of academic infrastructures, such as research centers and basic university chairs, reflects the institutionalization of business research, which makes progress beyond individual initiative and carries out the progressive accumulation of knowledge.

The author (Finkle, 2005) focuses on the difference between ranked and non-ranked research and education centers in the United States and suggests that research and education centers are an important alternative means of ensuring the sustainability of universities. They reveal that research and education centers that occupy the first place in the U.S. News and the World Report have significantly larger resources and staff, students, secured chairs, as well as more comprehensive postgraduate courses.

Authors (Finkle, 2005; Bowers & Alon, 2010) examine the differences between American and non-American research and educational centers, finding several significant



differences. Thus, the directors of American centers, as a rule, have an MBA degree, are associated with gifted chairs and perceive their center as excellent in terms of research; the same significant importance in these centers is determined by international partners; representatives of the business community with extensive experience are invited to work together.

The form of the spatial interaction network represents a dynamic set of "constellations of value" (Gritsenko, Gumenyuk, & Belov, 2013) representatives of various institutional spheres (business, research, and educational institutions, public authorities, public associations, other types of non-profit organizations), integrated horizontally and vertically, and united by attributive similarities and common individual aspirations. At that, formal and non-formal stable network links contribute to a positive impact on the transformation and spatial development of the territory.

Forming branched multi-level networks is a very powerful and effective tool for the development of the territory, allowing to some extent leveling out its natural or socio-economic disadvantages and at the same time strengthening the existing advantages. The effective spatial interaction network contributes to the progressive change of the spatial structure both within the research and educational centers, as well as between them.

The present article considers two scenarios for the development of new forms of spatial-interaction networks. The first scenario involves interaction within the framework of a research and educational center, which allows identifying the forms and degree of interaction between the participants of research and educational centers. The second scenario assumes the development of an interregional (regional, monoregional) spatial interaction network of world-class research and educational centers.

"The REC is a system that can ensure the commercialization of knowledge accumulated by the existing network of scientific and university research and development centers" (Savchenko, Pavlova, & Zhuravleva, 2020).

In the authors' opinion, the model of the research and educational center should be fundamentally revised from the sequence of "university – scientific organization – the real sector of the economy" to "government – business – science – society", that is, along with the main elements, it is necessary to include in the model society, public associations with their initiatives, and the possibility of involving in the activities of research and educational centers. Society should become the connecting link, a kind of driving force of spatial-interaction networks between both economic entities and legal entities, and the end-user. The development, and most importantly, the commercialization and distribution of innovative



products and solutions is a key task of business, which acts as a central element of spatial-interaction networks, initiating and consolidating ties.

A four-stage spiral model assumes the active participation of society in the innovation process with the assistance of social networks. Society puts forward ideas for innovations, discusses innovative ideas planned for implementation, and increases the information orientation of innovative development in general. Through public involvement, manufacturers and scientific institutions will know which innovations are better perceived in the market that reduces the percentage of risks of closing venture innovation projects.

A four-stage spiral is part of the plan to form a smart specialization of the regions in the context of the Europe-2020 strategy, as well as to implement an effective strategy to improve the country's competitiveness.

It should be noted that the degree of interaction between government – business – science – society depends on the openness and readiness for constructive cooperation of participants. Inter-company interactions tend to build a linear hierarchical system of interacting elements involved in complementary production processes. The inter-organizational connectivity of participants, representing various institutional spheres, can cover the widest range of relationships, including subjects' collaboration and quasi-integration. Understanding the relationship between the types and forms of spatial-interaction networks allows reducing the probability of discrepancies present when implementing existing methodological approaches for the delimitation and subsequent demarcation of spatial-interaction networks.

Interaction between the university, society, business, and the state include the following areas:

- organizing joint research activities of industrial and scientific organizations of the region;
- conducting joint scientific, technical, and technological developments;
- providing services for the organization of scientific and practical events on innovative topics;
- providing consulting services, etc.

In general, one can state that the implementation of a four-stage spiral model contributes to the creation of conditions for obtaining synergetic interaction effects (Fig. 1) (Antonov & Pomogaeva, 2019).



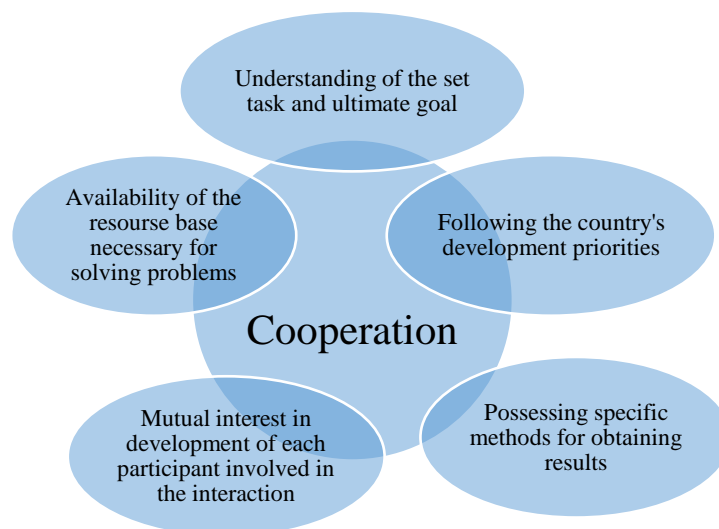


Figure 1. Conditions for obtaining synergetic effects when implementing a four-stage spiral model of industrial development (Antonov & Pomogaeva, 2019).

Note that in general, this model of functioning has something in common with the organization of system interactions of scientific and educational institutions, business, and society in the leading universities of the world. Problems of effective interaction of science, education, society, and industrial business are studied the most comprehensively and systematically in the United States, and Western Europe, where the concept of a new form of university – an entrepreneurial university – was proposed.

Thus, at the Newcastle University (Northern England), an organizational and managerial restructuring was carried out, pursuing as one of the aspects the professionalization of the university's interaction with the business to provide services for firms and establish the university's mission – to be the main driver of the economic development of the region. For this purpose, special departments were created at the university to ensure the commercialization of research outcomes (Audretsch, Hulsbeck, & Lehman, 2012; Junteng & Benson, 2019).

Cambridge University is also aimed at the commercialization of know-how, and cooperation with industrial enterprises (for example, Microsoft, Hitachi, Toshiba, Rolls-Royce, etc.). The first business incubator was established at the University in 1987, which houses start-up high-tech companies.

At the University of Twente (Holland), entrepreneurial activity is implemented according to the "bottom-up" model – from the faculty of management which generates new ideas and developing startup companies. In Bulgaria, university-based entrepreneurship centers are being created at Plovdiv Technical University, Sofia Forestry University, Gabrov Technical University, etc.

The experience of these universities can be used when creating network relationships of the research and educational center participants within the framework of the implementation of a four-stage spiral concept.

As a result of purposeful network interactions of "power – business – science – society", a certain institutional environment is formed with its own set of internal rules and laws regulating relations between subjects. The dominant goal of interaction between the participants allows determining the basic competitive advantages that the interacting structures seek to acquire.

The proposed model of the spatial interaction network within the research and educational center is shown in Figure 2.

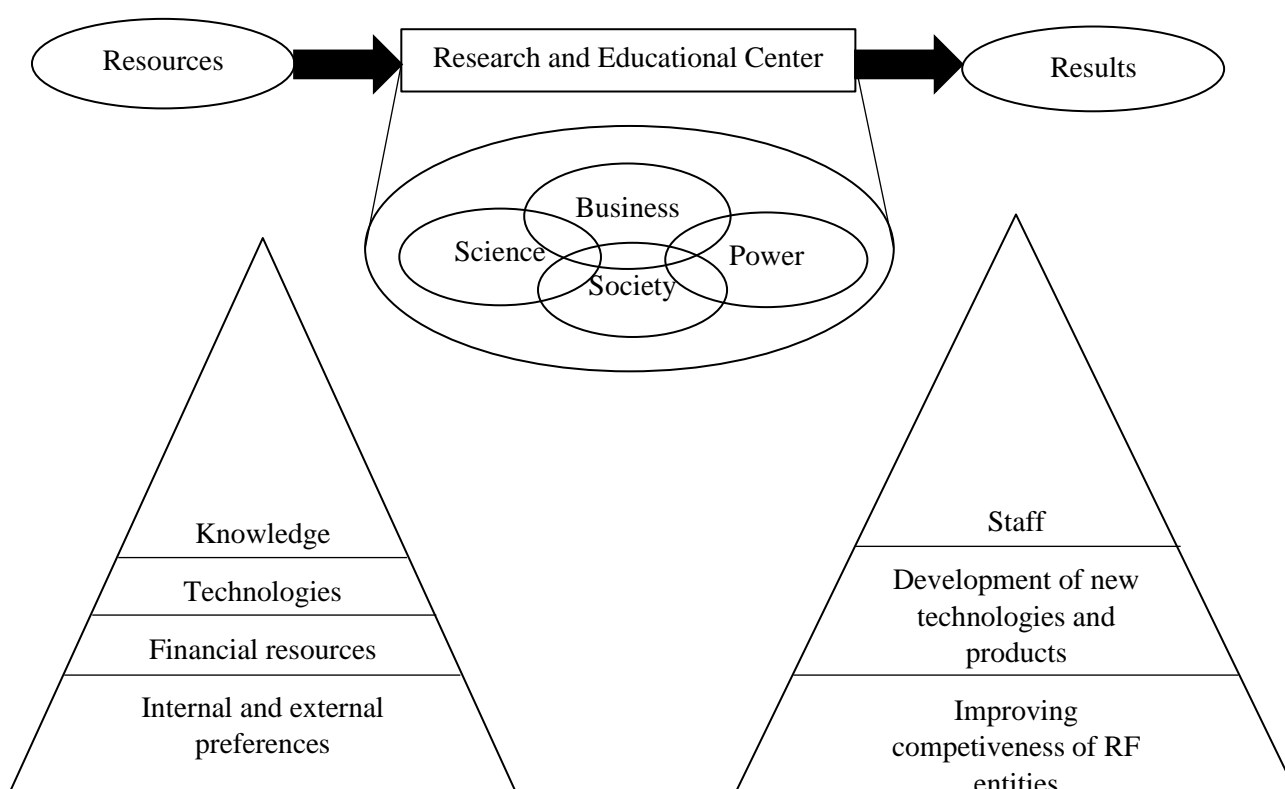


Figure 2. The model of the spatial interaction network within the REC

The synergetic component of the interaction of two, three, and even four participants makes the entire interaction process more intense and vivid.

The interaction between business and science is primarily related to the need to meet the demand for qualified personnel of the appropriate training profile. In this regard, the business conducts a dialogue on the content of the educational curricula; requests targeted training; independently participates in the training of specialists through the creation of basic chairs, resource centers, and in-house platforms for students' practical training. Besides, business is actively working to implement the scientific and technological potential of

universities and other research and educational institutions. The business finances scientific research of a fundamental and applied nature, the production of prototypes, laboratory testing, as well as establishes university-based in-house laboratories with the involvement of academic staff in the implementation of long-term projects. Besides, the business is also involved in the joint use of material, technical, and laboratory facilities.

Business structures provide commercialization and technology transfer through the use of the intellectual deliverables; conclusion of license agreements; purchase of patents; creation of joint start-up projects and small innovative enterprises (Krevsky, Glotova, & Matyukin, 2013).

This model assumes the active involvement of society in the innovative activities of research and educational centers through social networks (Babu & Singh, 1998).

The role of society is manifested in the creation and activity of various public organizations (parties, associations, etc.), as well as the mass media. The functions of the society can be attributed to the actions of individuals aimed at creating and implementing certain attitudes concerning the life of both the country in general and individual regions. A balanced relationship between the state, business, science, and society is necessary; otherwise innovative processes will be carried out inefficiently.

Society puts forward ideas for innovations, discusses innovative ideas put forward for implementation, increases the information-based orientation of innovative development in general. Through public involvement, business, science, and the government will better know which innovations are better perceived in the market. This will reduce the percentage of risks of closing venture innovation projects.

Preferences for participants of research and educational centers imply simplification of procedures, removal of administrative barriers, provision of preferential access to facilities, special tax treatment, and other measures provided for by current legislation and relations between participants.

The system of long-term relations between state bodies, subjects of the private sector of the economy, and scientific organizations contribute to the effective implementation of high-tech investment projects. Discussion of projects with the participation of the society helps to reduce risks and identify promising areas of innovative development.

The interaction of economic entities with state authorities and management bodies is aimed at developing consolidated decisions on the necessary measures to support entrepreneurial, investment, and innovation activity, as well as to promote export and internationalization, modernize fixed assets, and the production process. State infrastructure



projects for the creation of industrial zones, scientific and technological parks (including technoparks in the field of information, medicine, and biotechnologies), business incubators, technology transfer centers, exhibition and conference centers, etc. are of high importance. A common form of solving socially significant tasks is a public-private partnership. The position of the state as a mediator in the relations between business and society is expressed in providing legal regulation of labor relations; developing and implementing technological, environmental, and other standards; performing functions of monitoring compliance with established rules and regulations; supporting non-governmental economic organizations, assisting to their economic activity, etc.

The activity of research and educational centers involves conducting world-class applied scientific research and development, obtaining competitive technologies and products, and their subsequent commercialization, as well as training personnel to solve scientific and technological problems aimed at breakthrough development in priority areas, and improving the competitiveness of the economies of the constituent entities of the Russian Federation.

Innovative development of regions is one of the main challenges of the state. The solution to this problem can be regional and interregional spatial-interaction networks.

The spatial interaction network of research and educational centers is characterized by the processes of direct and indirect influence on each other and their network environment, in which each of the interacting parties acts as a cause and consequence of the simultaneous feedback effect of the opposite side. The mutual conditionality of research and educational centers, generated by their involvement in the spatial-interaction network, contribute to the distribution of roles between them and ensures the filling of so-called structural holes – ruptures in the network structure.

The spatial interaction network of research and educational centers includes three main blocks:

Block 1. Developing human resources:

- training, retraining, and advanced training of specialists in priority and promising areas of science and technology, based on scientific research and effective use of innovative potential;
- conducting fundamental scientific research, carrying out research activities, and performing work based on contracts with customers;



- joint participation in scientific grants;
- scientific and methodological support and improvement of the educational process quality in managerial specialties;
- conducting competitions of scientific works of students, postgraduates, and young scientists on the problems of management theory and its applications, organizing and holding conferences, meetings, symposiums, seminars, schools, and other scientific events;
- carrying out publishing activities, issuing and distributing monographs, collections, brochures, preprints, textbooks, scientific and technical, scientific and methodological, and teaching aids;
- organizing internships and training (based on master's, postgraduate, and doctoral courses) of young researchers, coordinating the interaction with Council of Young Scientists and Specialists, etc.

Block 2. Developing scientific cooperation:

- participating in the implementation of federal and regional scientific programs and projects, in the development of scientific forecasts, and conducting scientific and technical expertise;
- providing scientific and methodological support of regional administrations and universities on the problems of socio-economic development of territories, etc.

Block 3. Developing scientific and industrial cooperation:

- developing innovative structures (technoparks, business incubators, innovation centers);
- developing information resources (Internet portals, academic databases, Internet conferences);
- developing and implementing innovative technologies, etc.

The selected blocks include the most significant areas of spatial interaction network development within the framework of research and educational centers, which allow taking into account the diversity of connections and their socio-economic effect.

Shaping high-quality human capital is a primary factor in the innovative development of regions. Professional development of personnel based on research and educational centers will contribute to increasing the level of innovative development of the regions. At



the moment, in most regions of the Russian Federation, some problems seriously hinder the innovative development of regions. These are limited opportunities for effective use of innovative labor potential and an insufficiently quality educational system. To solve these problems, it is necessary to stimulate the spatial interaction network between research and educational centers and vocational education institutions of the regions.

World-class research and educational center can be established based on the resources of both a single largest university in the region and several universities at once. The second option seems more preferable, because, firstly, it allows using a wider and significant material and personnel resources, and, secondly, it promotes the exchange of experience and knowledge among the teaching staff of training organizations involved in cooperation, thereby increasing the level of human capital development in the region.

Currently, several research and educational centers are functioning at universities in various regions in Russia. However, their relations with the business are undeveloped, and there is no large-scale demand for their services. A REC that can develop such relations, should conduct research on the needs of potential clients in the field of innovation and human capital development, and focus on them, have a clear strategy for its performance, and a system for promoting its services. Besides, a broad range of services for human capital development at enterprises can be provided by a training organization established based on a large multidisciplinary university. The activities of most of the currently existing RECs on the contrary are narrowly focused due to the narrow specialization of the universities where they are based. The need of the economy for structures, engaged in the development of human capital in organizations systematically and on a large scale has not been satisfied, and this niche has yet to be occupied by those universities that will be able to develop an appropriate strategy.

Russian world-class research and educational centers strive to develop interregional cooperation, which will contribute not only to research collaborations but also to the development of communication, based on a research and educational center for regional business structures when implementing large-scale innovative projects.

The system to assess world-class research and educational center being developed in Russia to confirm the status of such a center should take into account the presence of effective collaborations capable of solving large-scale scientific and technological tasks. These interactions should be with both Russian and foreign world-class research and educational centers.



The collaborative nature of research and educational centers consists in the spatial interaction network of all research and educational centers of the country, leading to reinforcing and complementary effects.

In such collaborations, participants of the research and educational center enjoy new opportunities and various advantages, such as:

- participating in various project activities from a comprehensive scientific and technical program of a full innovation cycle to gaining the status of world-class research and educational centers with state accreditation and monitoring of higher education;
- developing and implementing comprehensive research and engineering programs;
- ensuring legal protection of intellectual property rights; ownership and protection of objects, both received and transferred to the management, including abroad;
- commercializing the received intellectual property, including marketing research, and searching for partners to promote products to specific markets, including external ones.

Spatial interaction network implies going beyond transactional connections, increasing the importance of non-commercial interdependencies and interpersonal relationships (Granovetter, 2009). The involvement of various research and educational centers in the spatial interaction network processes determines the breadth and variability of combinations of relational connections formed between network participants (Table 1).

Table 1. Spatial interaction network forms of world-class research and educational centers

No	Forms of interaction	Types of interaction
1	Collaboration, provision, joint participation	Involvement in the design, development, and production processes
2	Training	The exchange of information, communication of knowledge
3	Strategic partnership	The coherence and coordination of actions with respect to internal processes and the external environment
4	Assistance, aiding, reciprocity	Focus on the implementation of mutual support, not involving a direct commercial benefit
5	Competition, cooperation	Rivalry within the frameworks of the individual stages of the innovation process and the struggle for resources
6	Contingence	The correlation between operational activities and strategic planning relative to the individual and network-wide development trajectory

An example of the international experience of the spatial interaction network can be an inter-university research center established based on the Catholic University (Leuven, Belgium), which is an inter-university research center, responsible for the commercialization of university know-how through licensing or the establishment of new enterprises.

Interregional spatial interaction network of research and educational centers is actively developing in the Russian Federation. Vivid examples of such interaction can be



called the interregional REC "Engineering of the Future", which has become the attraction center of scientific schools of the Samara, Tambov, Ulyanovsk, and Penza regions, as well as the Republic of Mordovia, and the largest industrial enterprises, such as Rostech and Roscosmos state corporations, and OJSC Russian Railways.

The REC "Innovative Solutions in Agribusiness" interacts with universities, such as the Ural State Agrarian University, Lomonosov Moscow State University, Astrakhan State University, and others. This research and educational center includes more than 30 universities and research organizations from various regions of the Russian Federation. Joint projects, such as biodegradable packaging, the development of technologies to eliminate odors from pig-breeding complexes, and food technologies are being implemented based on this research and educational center, and others.

A world-class research and educational center "Russian Arctic: New Materials, Technologies, and Research Methods" has been established based on the research and educational capacities of three Arctic entities, namely, the Murmansk Region, the Arkhangelsk Region, and the Nenets Autonomous District. The core of this REC has become the Northern (Arctic) Federal University in Arkhangelsk. The basic participants of the REC from the Murmansk Region are the Kola Scientific Center of the Russian Academy of Sciences, Moscow State Technical University, and the Polar Branch of the Russian Federal Research Institute Of Fisheries and Oceanography (VNIRO). In addition to the three Arctic entities, the research and educational center includes leading universities and academic centers of the Republics of Komi and Karelia.

The Ural Interregional world-class research and educational center "Advanced Production Technologies and Materials" cooperates within the framework of interregional spatial interaction network with several universities, such as Kurgan State University, Chelyabinsk State University, etc.

The interaction of the country's leading universities and industrial partners will allow achieving the main goal, namely, to move to a fundamentally new standard of living in the regions.

Figure 3 shows interregional cooperation within the framework of the research and educational center.



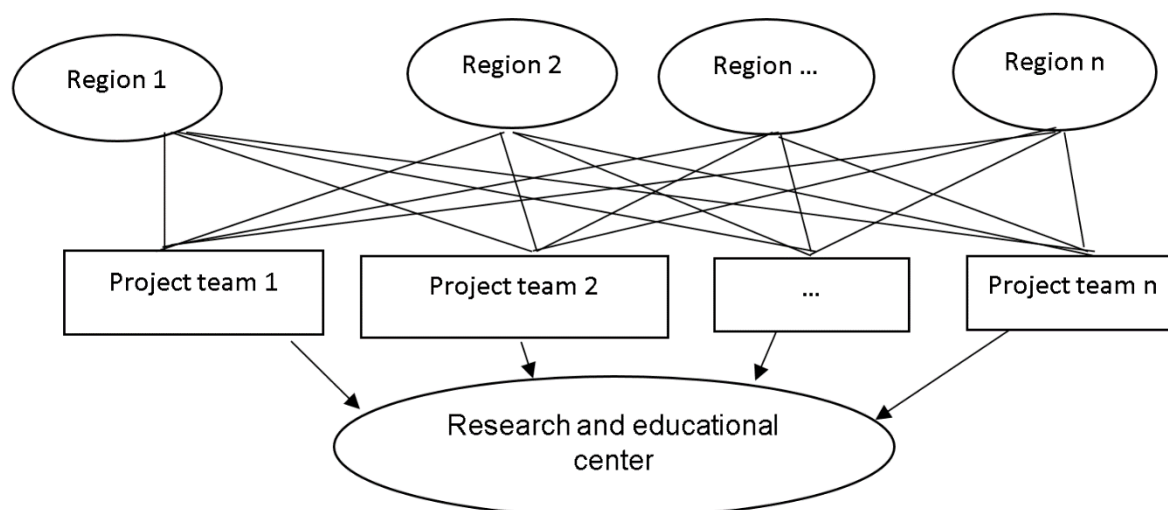


Figure 3. Interregional interaction of world-class research and educational center

Interregional cooperation involves the creation of interregional project teams. The financing is carried out taking into account the attraction of funds from the regional budgets, and the attraction of industrial partners and investors.

Collaboration with foreign partners is an important feature of interregional cooperation within the framework of international research and educational center. Thus, the REC "Engineering of the Future" interacts with the Belarusian State Agricultural Academy, the National Academy of Sciences, and the State University of the Republic of Belarus.

The Russian Federation makes a significant intellectual, organizational, and financial contribution to the implementation of the most important international research projects, such as the Large Hadron Collider of the European Organization for Nuclear Research (CERN), the European X-Ray Free-Electron Laser (XFEL), the Facility for Antiproton and Ion Research in Europe (FAIR), the European Synchrotron Radiation Facility (ESRF), and the International Thermonuclear Experimental Reactor (ITER). In many of these projects, Russia is a key participant.

It is undeniable that the effect of the spatial interaction network within the framework of world-class research and educational centers is almost always positive. The forecast of growth in the performance indicators of the research and educational center "Innovative Solutions in Agribusiness" caused by the influence of effective interregional spatial interaction network with Voronezh State University until 2024 is considered below (Table 2).

Table 2. The forecast of growth in the performance indicators of the research and educational center "Innovative Solutions in Agribusiness" caused by the influence of effective interregional spatial interaction network with Voronezh State University until 2024

Name of the research and education center	Performance indicators	Years			
		2021	2022	2023	2024
Innovative Solutions in Agribusiness	Number of patents for inventions	+10%	+15%	+20%	+25%
	Increase in high-tech output	+6%	+13%	+20%	+29%
	Proportion of researchers under 39 years of age	+15%	+23%	+30%	+39%
	Proportion enterprises involved in innovative activities	+15%	+23%	+32%	+43%

As can be seen from Table 2, the growth of performance indicators until 2024 is from 25 to 43%, which indicates the high efficiency of the planned cooperation with Voronezh State University.

Activities within the framework of research and educational centers will have a positive impact not only on the scientific and technological but also on the socio-economic development of all subjects that are part of it. Besides, joint efforts will result in significant socio-economic effects, including an increase in the number of researchers and the consolidation of young people in the regions, an increase in the intensity of cooperation with corporations, as well as the growth of the gross regional product of the regions participating in the center to levels significantly higher than the pre-pandemic values. When developing the objectives of the research and educational centers, it is necessary to focus on the search for growth points within each region.

4. CONCLUSIONS

The existing variety of spatial interaction network forms, formed taking into account the specifics of the territorial socio-economic system of the region, reflects the dynamic variety of links that are transformed under the impact of a wide range of factors and conditions.

The implementation of the model of research and educational center based on power – business – science – society interaction contributes to the popularization of the ideas of high-tech innovative projects, which allows attracting public opinion and get feedback. Making the results of scientific research public at conferences and economic forums within

the framework of the spatial interaction network of research and educational centers, in turn, will create a single innovation space that will promote the spread of innovations in the country.

It is the spatial interaction network of research and educational centers that have an excellent knowledge base, a set of competencies, and the employment sector but are complementary in the context of individual elements of the innovation process. This interaction is the most significant source of breakthrough innovations, forming the inalienable competitive advantages of the network's stakeholders and the territorial wherewithal of the region.

The development of new forms of the spatial interaction network of research and educational centers will allow them to reach a new level, and will also contribute to the innovative development of the regions.

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