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BUILDING THE INTERACTION MECHANISMS BETWEEN UNIVERSITIES AND ENTERPRISES IN ACCORDANCE WITH TRL-SYSTEM

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Abstract

The article focuses on the analysis of the network and cluster interaction mechanisms between higher educational institutions and representatives of business structures in foreign and national practice. As a result, the significance to involving universities in the processes of innovative development of regions was attached. The prospects and directions of the formation of network and cluster interaction mechanisms between higher educational institutions and representatives of business structures in the regions of Russia with the involvement of elements of the innovation infrastructure in accordance with the technology readiness levels and stages of the product. As part of the studying the processes of interaction between the scientific, educational and business space in the ideology of sustainable and innovative development, the following is used: 1) a systematic approach in considering and systematizing possible forms of inter-firm cooperation, taking into account the use of the technology readiness level scale TRL (Technology Readiness Level); 2) a synergistic approach in the context of networking between higher educational institutions and representatives of the corporate sector; 3) the knowledge triangle concept.

Keywords: Network and cluster interaction, innovation infrastructure, universities, Technology Readiness Level (TRL-system)

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1. Introduction

The processes of economic globalization taking place in the world necessitate the development of new methodological and practical approaches to the formation of various collaborations aimed at increasing the national level of innovative development. In an attempt to increase the efficiency of the functioning of national and regional innovation systems, network types of interaction between representatives of the scientific, educational and business communities are becoming increasingly popular.

In recent years, the Russian Federation has created the necessary legal mechanisms to ensure the conditions for interaction between business and universities. In particular, the Federal Law "On Education in the Russian Federation" defines the main types of integration between territorial entities, which make it possible to talk about the institutionalization of this process. The main forms of interaction between higher educational institutions and business are (Itskovits, 2011; Mangushov, 2017; Samigullina, 2015) : scientific research conducting in educational institutions; experimental development through grants or other sources of funding; involving corporate employees with educational institutions and (or) involving employees of educational institutions with organizations on a contractual basis; creation of specialized scientific laboratories by industrial enterprises in higher educational institutions, etc.

However, despite attempts by state regulation on the issues of strengthening cooperation between entities aimed at developing the national innovation system of the Russian Federation, there is a low efficiency of interaction between universities and business. This is due to the following reasons (Artiomov, 2014; Baskakova et al., 2016; Beloborodova, 2008): poor results of joint activities (not recognizing the potential benefits from cooperation); low level of government support; lack of tax incentives for enterprises-investors in education; poor coordination of educational and scientific activities between partner universities in solving the most pressing scientific and technical problems which companies are facing; lack of completeness of information from organizations about the capabilities of higher education institutions on the one hand and information about the needs and requests of companies on the other; inconsistency of quality and elaboration of innovative projects with the standards of the organization; low demand for domestic innovative developments, including university research and development (R&D); lack of a unified attitude to interaction with partners in the internal environment of a higher educational institution, as an integral part of the development strategy; uncertainty about intellectual property rights; the relative secrecy of the innovative infrastructure of higher education institutions.

2. Problem Statement

The presence of constraining factors determines the formation of a clear algorithm for building the mechanisms of interaction between universities and business structures, taking into account the requirements and the concept of innovative development of enterprises, the stage of development of an innovative product and the possibility of effective use of the university innovation infrastructure.

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3. Research Questions

To solve problems and substantiate the key directions foreseen in the innovative development programs and innovative projects (their readiness for commercialization), large representatives of the corporate sector use a comprehensive assessment system through the technology readiness level (TRL) (Galbraith et al., 2006; Kalashnikova et al., 2019; Petrov et al., 2016).

Using the TRL scale as a tool for managing the innovation process within the framework of cluster interaction will allow:

1) to form a cluster management model based on the knowledge triangle concept;
2) optimize the distribution of budgetary and extra-budgetary funding;
3) to increase the efficiency of using the regional innovation infrastructure;
4) ensure the participation of universities during the whole chain of an innovative product formation.

4. Purpose of the Study

Based on the above, the purpose of the current study is to determine the prospects and directions for the building the mechanisms for network and cluster interaction between higher educational institutions and representatives of business structures in the regions of Russia with the involvement of elements of the innovation infrastructure in accordance with the levels of technology readiness and product stages.

5. Research Methods

The study of the processes of interaction between scientific, educational and business space in the ideology of sustainable innovative development is based on:

1) a systematic approach in considering and systematizing possible forms of inter-firm cooperation, taking into account the use of the technology readiness level scale TRL;
2) a synergistic approach in the context of network interaction between higher educational institutions and representatives of the corporate sector (Ivanova et al., 2019);
3) the knowledge triangle concept based on a systematic approach to managing innovation processes through the ability to mobilize and integrate resources to create a market offer that has value for the consumer, coordinator and participants in the collaboration (network) (Unger & Polt, 2017).

The knowledge triangle concept partly overlaps with such models as the “entrepreneurial university” (Etzkowitz et al., 2008; Foss & Gibson, 2015) and “triple helix” (Etzkowitz & Leydesdorff, 2000).

The knowledge triangle concept is characterized by the following two-way communication channels: science - education, education - innovation, science - innovation. The central role in this model is assigned to stimulating the transfer of knowledge through the use of public-private partnership tools and mechanisms of network (cluster) interaction.

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The analysis of the special literature carried out in the framework of the study made it possible to identify the two most common forms of inter-firm cooperation, allowing in the future to strengthen the position of the corporate sector and increase the level of efficiency of its innovative activities, both at the regional level and at the level of the country as a whole (Etzkowitz et al., 2008; Foss & Gibson, 2015; Unger & Polt, 2017):

1. Free economic zones (FEZ), including technoparks - territories with a special economic status, aimed at accelerating the socio-economic development of the constituent entities of the Russian Federation (special economic zones, zones of territorial development, territories of advanced socio-economic development). Free economic zones are, in fact, geographically concentrated, government-backed agglomerations of internationally competitive enterprises with a number of advantages, including an efficient infrastructure, a favourable business environment, few regulatory restrictions, and a minimum of bureaucracy.
2. Cluster structures are forms of entrepreneurial associations that become catalysts for industrial and innovative activity in the regions by building relationships in this sphere of production due to territorial proximity and functional connectivity. Cluster structures make it possible to accumulate and stimulate production and scientific and technological aspects to the greatest extent, accentuating the flow of possible investments in the industrial and educational sector, and, consequently, to increase the intensity of interaction between the public sector and science and universities, ensuring an increase in the contribution of the corporate sector to R&D and innovation development.

In order to substantiate the key directions provided in the programs of innovative development and identify the stages of implementation of innovative and investment projects carried out by cluster members, it is advisable to use a scale for determining the levels of technology readiness.

The technology readiness level scale (hereinafter referred to as the TRL scale) is a list of manufacturing stages and verification of a development object from an idea to a serial sample. The TRL scale is characterized by levels from 0 - the initial level, to 9 - the mature level of technology readiness (Petrov et al., 2016).

The main stages of manufacturing and verification of the development object are presented in accordance with Table 1.

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Table 1. The main stages of manufacturing and verification of the development object, taking into account the TRL scale (compiled by the authors based on data (Petrov et al., 2016)

No.	Development stage	Brief description
0	Basic research	undirected: determining the feasibility of developing a new technology
1		directed: assessing the impact of new technology
2	Applied research	choice of a technological concept: scientific justification, identification of advantages and feasibility of development, risk assessment
3		development and laboratory testing of key technology elements (proof of concept)
4	Experimental developments	design, development and technological work (development of technical specifications, identification of operational characteristics, prototype)
5		testing of manufactured prototypes, technological processes in real conditions (comparison with laboratory data, building a model for estimating production costs)
6		critical tests to verify the reliability of a prototype
7		factory tests of a pilot industrial sample
8	Pilot production and certification	production of prototypes, their expertise and certification
9	Production	serial product manufacturing, implementation of a technical process

As international experience shows, the main prerequisites for the formation of cluster structures aimed at sustainable innovative development of the territory are:

1) a high level of fiscal capacity for the region, necessary for the implementation of a set of measures aimed at creating a favorable innovation environment;
2) a developed industrial sector, high values of the industrial production index, location on the territory of large, medium-sized small enterprises within the framework of the formation of a value chain;
3) the presence in the region of leading universities and federal research centers.

It is necessary to outline the strategic goal of the cluster, which should be focused on the creation of an innovative territory based on the effective use of the innovative potential of the elements of the economic system in specific areas of industry, contributing to an increase in the competitiveness of the regional economy in the national and foreign markets.

Strategic tasks that need to be solved within the framework of this goal:

1) the formation of an effective model for innovative development of the cluster based on the mechanisms of interaction between state authorities, higher educational institutions and large businesses;
2) determining the directions of scientific and technical activities of the cluster;
3) use of the competitive advantages of foreign models of innovative development;
4) creation of a specialized cluster organization;
5) development of an effective investment and legal system of cooperation between enterprises and universities in joint innovation projects;
6) formation of the innovation infrastructure of the cluster;

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7) elaboration and detailing of the cluster roadmap;
8) determining the role of the cluster in the sustainable innovative development of the region;
9) development of a system for monitoring the effectiveness and efficiency of the cluster.

Based on the current major megatrends (Svechnikova, 2017) of the fourth industrial revolution (3D printing (additive manufacturing); unmanned vehicles; advanced robotics; new materials; the Internet of Things), the following directions of scientific and technical activities of the cluster can be formed: creation of new materials with unique properties; development of additive technologies for the production of materials; introduction of modeling, automation and robotization into the production process; development of resource-saving and environmentally friendly technologies for obtaining raw materials, metals and alloys.

Based on the level of technology readiness, the ratio of budgetary and extra-budgetary funds invested in applied research and experimental development is determined. The size of the share of public funding can be revised upward by the budget funds manager in order to accelerate the progress of a technology toward maturity on the TRL scale.

According to the authors, taking into account the TRL scale, the optimal size of the share of budgetary funds necessary to ensure innovation and investment projects implemented by cluster members can be formed (Table 2).

Table 2. Distribution of funding sources within the cluster model using the TRL scale (compiled by the authors)

Activities	TRL scale levels	Share of budget financing, %	Types of projects
Basic research	TRL-0	100	search
	TRL-1	100	search
Applied research	TRL-2	100	search
	TRL-3	100	search
Experimental developments	TRL-4	80-90	search; complex
	TRL-5	70-80	complex
	TRL-6	50-60	complex
	TRL-7	30-40	Complex
Pilot production and certification	TRL-8	0-20	Complex
Production	TRL-9	0	Complex

The analysis of the technology readiness level is carried out by the manager of budgetary funds allocated within the framework of project financing in accordance with performance indicators. Among the financial instruments of state support for innovation and investment projects within the cluster, the following can be used: special investment contracts, subsidizing interest rates, subsidizing research and development costs, project financing, and targeted loans.

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6. Findings

Based on the use of the TRL scale, it is proposed to form the following list of performance indicators for the implementation of projects within the cluster in the context of sustainable development of the territory (Ruiga et al., 2019a, 2019b):

1) the number of publications and citations of articles in peer-reviewed journals (TRL 0-2);
2) coefficient of inventive activity (TRL 3-7);
3) the share of innovative goods, works, services in the total volume of exports of goods, works, services of industrial enterprises; innovative activity of industrial organizations; percentage of organizations implementing technological innovation (TRL 8-9).

It is assumed that the activities of the cluster are aimed not only at the implementation of innovation and investment projects, but also at the formation of an appropriate innovation infrastructure (a set of technological and industrial infrastructure facilities that ensure both the development of the cluster and the sustainable innovative development of the region). At the same time, it is necessary to understand that the elements of the innovation infrastructure will also ensure the relationship between universities and business. Following the logic of the TRL scale, support for cluster activities can be provided by the following representatives of the innovation infrastructure, presented in accordance with Table 3.

Table 3. Elements of the innovation infrastructure in the activities of the cluster (compiled by the authors)

Activities	TRL scale levels	Elements of innovation infrastructure
Basic research	TRL-0	Higher education institutions, research institutes, scientific foundations
	TRL-1	
Applied research	TRL-2	Scientific foundations, technology transfer center, shared-use center
	TRL-3	
Experimental developments	TRL-4	Scientific funds, shared-use center, specialized regional development institutes, prototyping center, business incubators, venture funds, industrial parks
	TRL-5	
	TRL-6	
	TRL-7	
Pilot production and certification	TRL-8	Certification, standardization and testing centers, special economic zones, industrial and technology parks, specialized regional development institutions
Production	TRL-9	Industrial and technology parks, clusters, special economic zones, priority development areas, specialized regional development institutions

Thus, the model of innovative development of a cluster can be represented as a hierarchical system that includes three levels.

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1. Management level. The specialized organization manages and coordinates the activities of the cluster: forms the key directions, activities, goals and objectives of the cluster functioning, provides methodological, organizational, expert-analytical and information support for its participants.

2. The level of implementation. At this level, there is an interaction between scientific and industrial members of the cluster for the creation and implementation of innovations.

A prerequisite for the cluster functioning is the cooperation of anchor universities and enterprises in the implementation of joint innovative projects. In order to ensure a synergistic effect within the cluster, there is a need for interaction of anchor participants with universities and industrial enterprises of other regions and industries according to the principle of functional dependence.

3. The level of security. The objects of innovation infrastructure provide a favourable climate for the implementation of innovation activities by cluster members. Development at this level implies the creation and improvement of innovative infrastructure facilities in order to increase the attractiveness of the implementation of innovative projects within the cluster.

7. Conclusion

Summarizing the above, it can be concluded that it is necessary to implement institutional transformations in universities on the basis of appropriate tools to stimulate and regulate innovation and investment activities. Thus, the “knowledge triangle” provides support for political decision-making, showing that investments in one of its components have a multiplicative effect not only for other structural elements, but also for the external context, including the modernization of the labour market, stimulating structural changes in the economy, increasing the quality of life of the population (Unger & Polt, 2017). The active participation of universities in the transfer of knowledge is still determined by territorial proximity. Based on this, it is necessary for higher education institutions to use tools for formalizing and organizing the transfer of knowledge in the form of network and cluster structures.

To improve the mechanisms of network and cluster interaction between higher educational institutions and representatives of the corporate sector, in the event of a positive decision on the formation of a cluster, it becomes necessary to organize a subsequent action plan at the regional level:

1. Creation of a scientific and technical cluster: definition and approval of cluster priority activities; creation of a specialized organization cluster; determination of the composition of the Cluster Board; formation of funding sources for the cluster; inclusion of participants in the cluster; development and approval of the cluster strategy.
2. Formation of innovation infrastructure: formation and approval of directions for the development of cluster infrastructure; development and creation of an industrial park within the cluster; cooperation with universities on the creation of small innovative enterprises; development of cooperation with business incubators; cooperation with technology transfer centers at universities.
3. Improvement of legislation: coordination of scientific, educational and innovative tasks of the development of the regional economy within the cluster; elaboration of programs for economic and innovative development of the region; organization of practice-oriented education at

universities participating in the cluster; development of tax mechanisms to support cluster members; development of organizational mechanisms of support for cluster members; formation of a unified cluster policy region.

4. Implementation of specialized events: creation and development of the cluster site; development of cooperation with the media; formation of a database of clusters (based on existing ones); organization and holding of conferences, round tables, seminars; search for potential participants; monitoring the effectiveness of the cluster.

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