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Assessment of Socio-Economic Efficiency of the Scientific and Educational Complex: Approach and System of Indicators

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Abstract. The article is devoted to the current topic of choosing the optimal organizational option of multilateral integration of the scientific and educational sphere, business and the state in the process of globalization of the world economy. The authors justify the format of formation of scientific and educational complex on the basis of network interaction, which allows to obtain the greatest synergistic effect. In order to justify the effective network interaction of the scientific and educational complex, an analysis of existing methods of assessing the efficiency of its functioning was carried out and an author's system of performance indicators and its assessment was proposed in accordance with the general purpose of the integration mechanism and the specific purpose of each interaction subject. The model contains a system of heterogeneous indicators reflecting the principles of formation of a scientific and educational complex on the basis of network interaction, which allows, along with an evaluation task, to determine, using factor models, further directions of inter-network relations of subjects in order to better understand the current processes and identify problem areas of coordination of their innovative activity.

Keywords. Scientific and educational complex, integration, network, socio-economic efficiency, evaluation, innovation

1. Introduction

The post-industrial mode of social reproduction provides for the necessary conditions for socio-economic progress. These include the transfer of scientific results to stimulate innovation in the business environment, and the transformation of R&D results into products and services for sustainable economic growth.

Commercialization of scientific knowledge allows business to significantly reduce the innovation cycle, rationally distribute costs and risks, increase revenues and profitability. This is achieved not only through a linear, unidirectional process of transfer of scientific achievements, but also through active interaction with the

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scientific and educational sphere, where the State has a role both in financial support and in creating incentives and the necessary infrastructure for the development and coordination of partnerships among all stakeholders. At the same time, regulatory instruments adapt to changing conditions, such as the transition to the paradigm of "open innovation", digitalization of activities, and the development of global networks. Today, there are a variety of forms to assist in the above-mentioned tasks. However, the types of coordination of linkages based on vertical subordination and traditional market with price signals have lost their effectiveness in the conditions of the economy of network relations [1]. Therefore, in both scientific and practical terms, the largest number of questions is caused by the formation and functioning of the scientific and educational complex (SEC) using the foundations of network interaction, which unites the spheres of science, education and business into a single whole, for the implementation of educational, research and innovation activities [2].

2. Materials and Methods

Research in the field of integration processes of scientific and educational sphere, business and the state, as well as introduction and commercialization of scientific knowledge is devoted to a rather large volume of foreign works. This issue is most reflected in the scientific works of American (Bailey, Baker, Betz, Carayannis, Frank, Kim, Leslie, Nowotny, Tamacy) [3, 4], English (Ash, Brunch, Pettinger) [5], Canadian (Austin, Chan, Tudiver) [3], Japanese (Kitamura, Moriya) [3], German (Betz, Monks) [6], Netherlands (Bleiklie, Craciunoiu, Henkel) [3], Greek (Grigoroudis) [7] and Romanian (Stăiculescu, Richiţeanu-Năstase, Dobrea) [8] researchers.

Studies of domestic scientists Boeva [9], Yesina [10], Islakayeva [11], Kartashova [12], Katkova [13], Cleeva [14], Malina [15], Shadoba [13], Shirko [12] are devoted to the problems of choosing the optimal form of interaction between the subjects of the innovative economy at the regional level.

In the scientific works of Akhtenhagen and Ryugg-Stürm [16], Huggins [17] it is noted that in conditions of innovative economy the network method considers social and economic space as a set of interconnected systems. Network connections are a determining condition of interaction, between the same integration subjects, and between subjects with different affiliation to hierarchical systems.

High-tech innovations, which are the basis for the development of the innovative economy, are increasingly being created jointly [18]. Therefore, the mechanism of integration of the scientific and educational sphere and business should be aimed at creating cost-effective conditions for generation of knowledge for their further dissemination and use. However, at a time when highly developed countries are intensifying integration processes that provide synergistic effects, the inconsistency of the goals of the spheres of science and education, as well as the real sector of the economy, leads to a real threat of backwardness, both science and education, and technological development of companies of individual entities and Russia as a whole [10]. Networking is the best way to ensure quality collaboration among actors with different capacities and interests. The network method provides dynamic balance when the combination of entities in the form of SEC, on the one hand, has a sufficiently clear structure, and on the other hand, it has flexibility and openness, which allows for the joint generation of innovations.

3. Theoretical Aspects

The necessity and importance of the NOC is determined by its role in sustainable development and improving Russia's competitiveness in the context of building a model of economic growth based on innovation. The authors propose and justify the principles of formation of SEC on the basis of network interaction of subjects (Figure 1), which include:

1. Common goals – the target principle that determines the degree of coordination of interests of subjects, coordination of their activities, distribution and exchange of resources. Despite the fact that scientists generate new ideas, in most cases they do not have the managerial experience and management abilities necessary to bring R&D to commercial success [19], and according to Isaac Kirzner's business theory entrepreneurs are constantly in search and assessment of new opportunities for business. It is this process, called entrepreneurial discovery, that should be guided by the State, focusing not on sectors, but on activities that can form the basis of a smart specialization strategy [7].
2. Spatial localization – justified by research on national and regional innovation systems [20] and cluster studies [21].
3. Infrastructure – is intended to create conditions for deepening network interactions and developing interactions between actors.
4. Network communication – the SEC is presented as a set of interconnected network nodes between which communication is based. Entry into the complex, on the one hand, is carried out on the basis of the ability of the subject to effective network communication. On the other hand, it guarantees information support to all subjects of interaction. It is on the basis of network communication that information and knowledge are generated in SEC – the main resources for creating innovations.
5. Network inter-firm cooperation – contributes to the formation of a joint competitive advantage, i.e. the network can act as a source of special rent – income, which cannot be obtained within the framework of the operation of an individual entity (the effect of emergence).
6. Resource dependency – determines the legitimacy of borrowed resources and introduces an element of trust, turning external resources for each subject of interaction into internal resources.

Figure 1. Key principles of SEC based on the network interaction of subjects.

Given that the institutional environment of SEC is a multiple set of interoperable entities based on a network, there is a need for a system of common and private performance indicators and evaluations.

4. Results

The development of a generalized system of indicators is based on the analysis of economic literature and existing methods of assessing the social and economic efficiency of network interaction between subjects [22, 23, 24]. Summarizing the results of the study of the available works of scientists, the following general and private shortcomings of the presented methods can be distinguished:

- do not reflect full diagnostics of problems of network interaction development based on the stages of innovation cycle;
- include only a certain set of effects, largely defined and dependent on the kind and characteristics of network interaction, thus lacking complexity and versatility;
- the implication of the nature of the assessment, without justifying the relationship between the characteristics of the network interaction and the performance of its functioning;
- considers only the educational component of the assessment of the development of the economic space of the region [22];
- considers peculiarities of analysis of efficiency of organizations of associated (network) entrepreneurship [24];
- considers the peculiarities of analysis of network interaction efficiency provided that the university acts as a meta-center [23].

Since none of the considered methods is universal, the authors propose, on the basis of generalization, a list of indicators of socio-economic efficiency of SEC formation and functioning, determined by the general goal of the integration mechanism and the specific goal of each interaction subject (Table 1).

Table 1. Indicators of socio-economic efficiency of the functioning of the SEC.

SEC performance indicators	SEC subject			
	S*	E*	B*	St*
I Economic				
International publication activities, units	K1	W1		
Inventive activity coefficient, units	K2	W2		
Technology exports per researcher, rubles/person	K3			EG1
Number of international patents, units	K4			EG2
Research and development organizations, units	K5			EG3
Research and development costs, rubles	K6			
Number of advanced production technologies created, units	K7			
The share of financial resources of business partners in the university, %		W3		
Increasing revenues from the implementation of educational projects, rubles		W4		
Amount of funds raised, rubles		W5		
Volume of innovative goods and services, rubles			P1	EG4
An export of high-tech products, rubles			P2	EG5
The costs of private business on R&D, rubles			P3	
Business costs for technological innovations, rubles			P4	

SEC performance indicators	SEC subject			
	S*	E*	B*	St*
An innovative activity of business on domestic innovations, units			P5	EG6
Capital participation of companies in the development of SIC infrastructure, %			P6	EG7
The share of innovative products in the total volume of products shipped, %			P7	EG8
The number of used advanced production technologies, units				EG9
Growth rate of average industry profitability, %			P8	EG10
Labor productivity growth, %			P9	EG11
The volume of attracted investments, rubles			P10	
Financing the leading research institutes, rubles				EG12
Growth of tax deductions to the budget, %				EG13
II Social				
An income level per employee, rubles	K8	W6		
Creating direct and indirect infrastructure facilities, units	K9	W7	P11	EG14
The volume of scientific emigration, people	K10			EG15
Number of personnel employed in R&D, people	K11			
Establishing faculties for training in universities, units		W8	P12	
Targets for direct contracts, people			P13	
Creating new jobs, units			P14	EG16
Growth rate of average wages, %			P15	EG17
An employment dynamic in enterprises, %				EG18
The amount of social payments from the integrated structure, rubles				EG19
The influx of young professionals in the scientific and educational sphere, %	K12	W9		EG20

** Legend: S – science, E – education, B – business, St – state.*

The model of the scorecard, graphically shown in Figure 2, largely represents the level of integration process, depending on the commonality of goals, division and cooperation of labor, network communication and emerging resource dependency. Accordingly, based on the general and specific purpose of the subjects and the network structure in the form of SEC, it is possible to both add highly specialized indicators and eliminate excess ones.

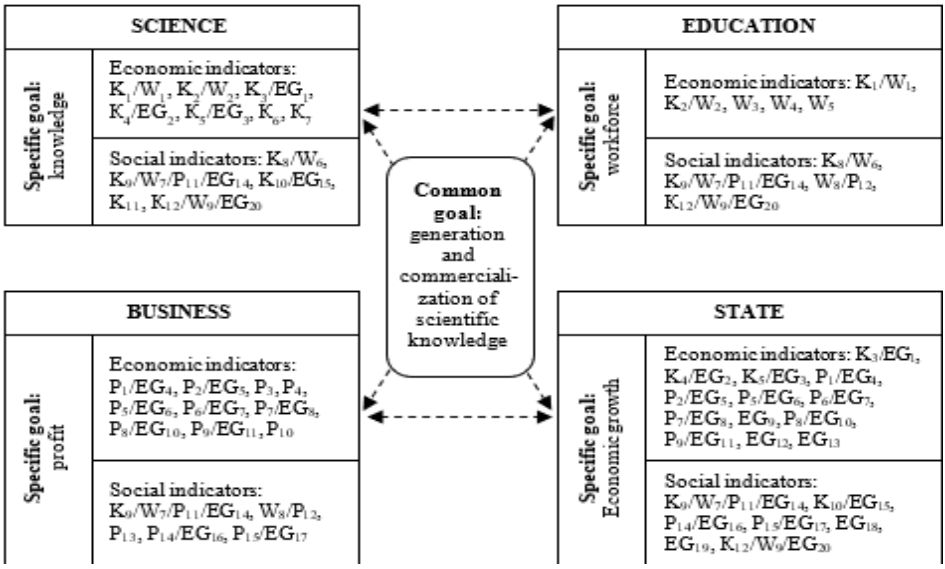

Figure 2. Model of the system of indicators of assessment of socio-economic effectiveness of SEC.

The following indicators of the proposed system of indicators were formed only on the basis of official data sources of the Federal Service of State Statistics of the Russian Federation, the Ministry of Science and Higher Education of the Russian Federation, as well as strategic planning documents, which set targets for interaction between the scientific and educational sphere, business and the State (Table 2).

Table 2. Indicators of socio-economic efficiency of SEC on the example of Krasnoyarsk Krai [25, 26].

SEC performance indicators	SEC subject			
	S	E	B	St
I Economic				
International publication activities, units	734			
Inventive activity coefficient, units	0,99			
Technology exports per researcher, thousands of rubles/person	74			74
Number of international patents, units	15			15
Research and development organizations, units	69			69
Research and development costs, billions of rubles	16,1			
Number of advanced production technologies created, units	31			
The share of financial resources of business partners in the university, %		6,5		
Increasing revenues from the implementation of educational projects, millions of rubles		36		
Amount of funds raised, millions of rubles		27		
Volume of innovative goods and services, billions of rubles			63,1	
An export of high-tech products, millions of rubles			129,49	
The costs of private business on R&D, millions of rubles			760,0	
Business costs for technological innovations, millions of rubles			360,9	
An innovative activity of business on domestic innovations, units			1 110	
Capital participation of companies in the development of SIC infrastructure, %			4,2	
The share of innovative products in the total volume of products shipped, %			3,3	
The number of used advanced production technologies, units				3 787
Growth rate of average industry profitability, %			90,5	
Labor productivity growth, %			99,8	
The volume of attracted investments, billions of rubles			424,7	
Financing the leading research institutes, millions of rubles				424,0
Growth of tax deductions to the budget, %				109,8
II Social				
An income level per employee, thousands of rubles	56,5	38,2		
Creating direct and indirect infrastructure facilities, units		4		
The volume of scientific emigration, people	14			14
Number of personnel employed in R&D, thousands of people	8,1			
Establishing faculties for training in universities, units		3		
Targets for direct contracts, thousands of people			1,5	
Creating new jobs, thousands of units			7,2	
Growth rate of average wages, %			106,9	
An employment dynamic in enterprises, %				1,4
The amount of social payments from the integrated structure, millions of rubles				230,0
The influx of young professionals in the scientific and educational sphere, %	0,5	0,7		0,2

Testing of the system of indicators of assessment of socio-economic efficiency of SEC on the example of Krasnoyarsk Krai [25, 26] shows their simultaneous heterogeneity (quantitative and qualitative) and commonality for all actors. Consideration of quantitative indicators reflecting the state of SEC resources and qualitative indicators characterizing the efficiency of SEC resources use in dynamics will allow to determine, using factor models, the influence of network characteristics

on the activities of its subjects, further directions of inter-network relations in the form of SEC, to understand in greater depth the current processes and to identify problem areas of interaction.

5. Conclusion

According to the authors, the formation and functioning of an integration structure in the form of an SEC using the foundations of network interaction is an effective way to ensure the growth of the economy through innovation. The network method of building relations between the scientific and educational sphere and business in the form of SEC with the active participation of the state, allows, considering interests, to create conditions for their interaction as equal partners.

The proposed system of indicators for measuring the socio-economic effectiveness of the activity of the SEC is characterized by the identification and structuring of general and specific indicators in relation to the main groups of participants, which allows to obtain the appropriate information base for making a reasonable decision on the participation of the SEC in the sustainable development of the regions of Russia on the following components [27]:

- as a promising sector of the economy, with a high share of employment in enterprises producing knowledge-intensive products;
- as a producer of innovation that increases the competitiveness of enterprises;
- as a factor ensuring growth on the basis of SEC innovative enterprises;
- as a factor of competitiveness, contributing to the inflow of highly skilled labor into the economy.

In addition to the assessment task, further study of the importance of the impact of individual indicators will allow to carry out a reasonable analysis (using factor models) of the reasons that prevented the realization of the potential of the SEC in terms of solving problems of coordination of innovative activity of the scientific and educational sphere and business to ensure the sustainable development of the territory of the region as a whole.

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