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"Triple Helix" Model for Recourse-Based Regions

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Exhaustion of non-renewable mineral resources determines sustainable socio-economic development of resource-based regions. However, mineral resource abundance is an essential competitive advantage that can be used for innovative development of regional economies. At the first stage of creating innovative economy, pilot innovation projects can be implemented in mining industry, and then in manufacturing and service sectors of economy. For this, an effective model of innovative activity in a resource-based region should be developed. In this article we consider the "triple helix" model.

The purpose of this article is to assess the potential for innovative development of a resource-based region through the "triple helix" model. We have studied the Krasnoyarsk Krai as a typical resource-based region.

The use of the "triple helix" model results in a change in the roles of actors in innovation process. Universities play a major role and become entrepreneurial universities. The entrepreneurial university aims to create and implement innovations through technology transfer to industry. At the same time, the government becomes an equal partner of innovation process, and a customer for the development of advanced production technologies.

Effective implementation of the "triple helix" model requires quantitative assessment at a regional level. For this, we suggest a system of indicators and methodology for assessing the level of innovative development for a resource-based region. This methodology is our contribution to the theory of innovative development.

Keywords: resource-based region, innovative development, assessment methods, "triple helix" model, entrepreneurial university.

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Introduction

Resource-based economy cannot be considered sustainable. The reasons are dependence on the world prices for mineral resources, cyclical nature of mineral resource extraction, monopoly of large mining companies appropriating rental income, and great environmental damage. However, the main problem for resource-based regions is the mineral resources exhaustion, so the period of positive economic growth is limited.

Nevertheless, natural resource abundance is a competitive advantage for regions. We argue that this advantage should be exploited and non-renewable natural resources should be converted into renewable assets. Thus, reproducible economic potential should be created during the development of mineral deposits.

Unlike natural resource-based development, an innovative economy is based on renewable factors such as innovations and knowledge (Smith, 2000). These factors ensure long-term sustainable socio-economic development (Bergek et al., 2008). Therefore, resource-based and innovative development should be combined to ensure sustainable economic growth.

The purpose of this study is to assess the possibilities of innovative development for resource-based regions.

In literature, the “triple helix” model based on the interaction between the government, industry and universities is considered as the most effective way of organising innovation processes in a region (Etzkowitz, 2008).

In the “triple helix” model, the role of academic research increases. Universities become the leading element of innovation process. Most of research is applied and interdisciplinary (Bozeman, 2000). Innovations are regulated by the needs of industry, rather than the government (Freeman, 2013). Actors of the innovation (government, university and industry) perform functions of each other. Universities take initiative in creating innovations and their commercialisation, industry performs government functions in financing engineering innovations, and creates innovative products and technologies (Thune, Gulbrandsen, 2014).

Undisputed advantages of the “triple helix” model are the increase in diversity of innovative products, reduction in risks and costs of creating new innovative products and technologies and increase in economic efficiency through the interaction between three actors of innovation (Katunkov et al., 2012).

The rest of the article is organised as follows. Section 2 reviews the theory on the "triple helix" model. Section 3 focuses on the data and current situation of the Krasnoyarsk Krai. Section 4 presents methods and results. Section 5 concludes and provides avenues for future research.

Theory of the "triple helix" model

Despite the importance of enhancing innovation at a regional level through the "triple helix" model, little attention is paid to this issue in literature. Most authors consider the mechanism for implementing the "triple helix" model at a national level (Kolesnikova, Peteneva, 2017). However, the implementation of the "triple helix" model for regions in Russia has a number of specific features.

Scientific research in regions is mainly carried out by institutions of the Russian Academy of Sciences, while universities provide education. In spite of the fact that the integration of academic institutes and universities has been recently increasing, the integration process is slow (Labunskaya, 2014).

Several ministries coordinate research activities. The actions of these ministries are often inconsistent. There are frequent cases of research and development duplication resulting in the inefficient use of funds allocated to innovative projects. At the same time, there is a significant shortage of funds for research and development in regions (Dezhina, Kiseleva, 2008).

Most companies in regions demonstrate a low level of innovative activity and do not spend their funds on development and innovations. The interaction between regional industry, academic institutions and universities is weak. We cannot observe the "triple helix model" being formed in regions.

Regional government has little control as regards to the industry innovation. There is no system of public support and stimulation of industry innovative activities at a regional level (Pakhomova, 2012).

Regional innovation infrastructure which should contribute to enhancing the innovation is poorly developed and inefficient. However, it is the regional government that should coordinate the implementation of the "triple helix" model in a region (Labunskaya, 2014).

The main activities of the regional government to stimulate innovation are:

- setting priorities for innovation activities in a region, choosing effective innovative projects and programs in collaboration with the Russian Academy of Sciences and universities;

• supporting development of innovative enterprises organized by universities, academic institutions and industry which produce new innovative products and technologies;

• promoting and advertising new innovative products;

• supporting and developing regional scientific organizations and universities;

• developing mechanisms to stimulate innovation in a region through a system of tax incentives and a developed system of innovation investment institutions.

Thus, the organisation of innovative activities at a regional level in accordance with the “triple helix” model requires a change in the role of the regional government which should become an active actor and partner of innovation (Smorodinskaya, 2011). Table 1 presents the traditional and new roles of the innovation actors in a region.

Table 1. Traditional and new roles of the actors of innovation in the “triple helix” model

Actors	Traditional roles	New roles
Research universities (academic institutes)	To provide education	Centre for the creation of new knowledge and innovation. Leading element of the innovation
Regional government	To fund, coordinate and regulate innovation process	A partner in the innovation
Industry	To organize production	An active participant, investor and consumer of innovations

Source: compiled by the authors.

The main difference between the “triple helix” model and the existing model of innovative activity organisation in a region is the dominant role of universities.

The main role of academic research is to create fundamental and applied innovations while the main role of universities is to provide education. Combining the functions of research organisation and education provider enhances the importance of universities in innovation process (Magro, Wilson, 2013). Research universities establish new companies that implement innovations and create institutional conditions for enhancing innovation and effective development of national innovation systems (spin-off companies, start-ups, industry incubators, technology parks, technopolises, etc.). Universities are focused on the practical implementation of innovations, and are actively involved in technology transfer to industry (Colyvas et al., 2002). The main focus in creating knowledge as a product is on young people who study at universities.

It creates a kind of stock of new knowledge that turns into innovation. Therefore, the bulk of resources should be allocated to generating innovations by young researchers. In this case, the university becomes the main element of innovation process, creating scientific and technological knowledge or innovation. As a result, the traditional roles of the innovation actors change. Thus, the relations between the university and industry are built in a new way. The industry becomes a customer of innovation and provides the main funding for research and development. For example, in the United States, private sector provides up to 75 % of research costs, and 100 largest international corporations account for 90 % of this amount (Dezhina, Kiseleva, 2008).

The relationship between the government and universities about priority setting, funding and monitoring is changing. The government becomes a partner of research organised by research universities, and therefore cannot directly intervene in their activities. Moreover, the government acts as an innovation customer and can finance innovative projects that are implemented in its interests.

The changing role of universities in the “triple helix” model resulted in the introduction of the “entrepreneurial university” concept. The term “entrepreneurial university” was first used by Etzkowitz, who considered university as an effective tool for enhancing innovation (Etzkowitz, Leydesdorff, 2000). According to Clark, “the main feature of the entrepreneurial university is its willingness to commercialize knowledge” (Clark, 2001). Entrepreneurial activity at the university should be system-forming and should involve its research and educational areas. In this case, entrepreneurship should become valuable for university professors and students who should be actively involved in the implementation of various commercial projects (Meyer-Krahmer, Schmoch, 1998). In other words, the university forms a new understanding of the university mission according to which entrepreneurial attitude to academic activities should dominate (Zucker et al., 2002).

Another author of the entrepreneurial university concept, Ropke believes that the entrepreneurial university should work closely with the government to help address emerging issues and demonstrate entrepreneurial behaviour in a market. All university managers, professors and students should be involved in innovation production (Ropke, 1998).

Etzkowitz identifies three successive stages of the entrepreneurial university development. At the first stage, the university develops a strategic vision and determines the possibility of implementing its research priorities. At the second stage, the university takes an active part in the commercialisation of intellectual property resulting from the activities of its professors, employees and students. At the third stage, the university actively cooperates with the industry and public companies to transfer knowledge and technology (Etzkowitz, Leydesdorff, 2000). Konstantinov and Filonovich argue that the implementation of entrepreneurial university concept under conditions of limited financial and material resources requires significant organizational changes in the organization of scientific and educational activities. These changes will allow the university to overcome existing barriers with society and become a popular organization (Konstantinov, Filonovich, 2007).

The most detailed definition of the entrepreneurial university is given by Grudzinsky. Entrepreneurial university is: 1) an organisation whose activity is based on targeted innovations and which is capable to work under the conditions of risk and dynamic demand; 2) an effective organisation which is engaged in profitable activities and relies primarily on its own capabilities; 3) a liberal organisation with flexible network construction; 4) an organisation in which the key factors are people and their competence; 5) an organisation whose management delegates the rights and responsibilities to performers as much as possible; 6) an organisation which is customer oriented and can respond timely and flexibly to changes in their requirements (Grudzinskiy, 2003).

Thus, the implementation of the "triple helix" model in resource-based regions changes the university role (Schartinger et al., 2008). At its core, the university should become entrepreneurial university (Table 2).

Table 2. Comparison of the traditional and entrepreneurial university functions

Roles	Traditional university	Entrepreneurial university
Main activities	the main activity is an educational activity the secondary activity is a scientific activity	the combination of three types of activities — educational, scientific and entrepreneurial
Sources of financing	budget financing	- budget financing; – income from industry activities
Participation in innovation	mediated	- centre of innovation; – the main actor of the "triple helix" model
Relationship with industry	weak	close
Relationship with government	works according to public plans	considers government as a partner in innovation

Source: compiled by the authors.

Data

We consider the possibility for implementing the "triple helix" model in the Krasnoyarsk Krai, since the natural resource use impedes its economic development. Thus, in 2013, the growth rate of the gross regional product (GRP) of the Krasnoyarsk Krai was 102.9 %, in 2016, it was only 101.5 %.

In the Krasnoyarsk Krai a linear model of innovation organisation is used and the bulk of funding for research comes from the budget. In 2017, the volume of budget financing for domestic research costs in the Krasnoyarsk Krai amounted to 87.6 %. The share of scientific organisations funds in the total funding was 7 %. The share of industry funds was 4.7 % and the share of funds of universities, non-profit sector and foreign organisations in the aggregate was 0.7 %. The share of research funding on the basis of competitive distribution of funds (grants and other types of competitive financing) was only 3.6 % while about half of these funds (1.7 %) was allocated as subsidies. During the period of 2015–2017, domestic costs of research increased by 159.4 % and amounted to almost 16 billion rubles.

Scientific ideas that can be implemented as innovations in the region were initiated by scientific organisations, universities and research departments of industrial enterprises. During the period of 2015–2017, the number of research organisations increased by 14 %.

The productivity of scientific and research organisations can be measured by the number of developed advanced manufacturing technologies organised by groups:

- new for Russia;
- fundamentally new;
- including patent purity.

With a general increase in the number of advanced manufacturing technologies developed in Russia, only a small number of them are fundamentally new.

The number of developed advanced manufacturing technologies in the Krasnoyarsk Krai is relatively low, while the number of used advanced manufacturing technologies is growing at a high rate. During the period of 2013–2017, the number of used advanced manufacturing technologies increased 1.6 times and amounted to 3,787. However, the applied manufacturing technologies are updated infrequently. In 2017, the share of the technologies introduced six or more years ago in the total number of production technologies was 57 %. A negative innovation trend in the Krasnoyarsk Krai is the growing number of advanced manufacturing technologies purchased abroad. During the period of 2013–2017, the number of advanced manufacturing technologies purchased in Russia increased by 1.2 times, while the number of foreign technologies grew by 2.3 times. This policy is characteristic of large mining companies that purchase innovations abroad to ensure their competitive advantage in the world markets.

The regional government does not have a significant impact on company innovation and the innovative development strategy of the Krasnoyarsk Krai does not take into account the resource specialisation of the region. As result, the innovative activity in the region is low, especially in the non-resource sector. Fig. 1 shows the decrease in the number of filed patent applications and the number of received patents during the period of 2013–2017.

Fig. 2 shows the decrease in the share of enterprises and organisations implementing innovation.

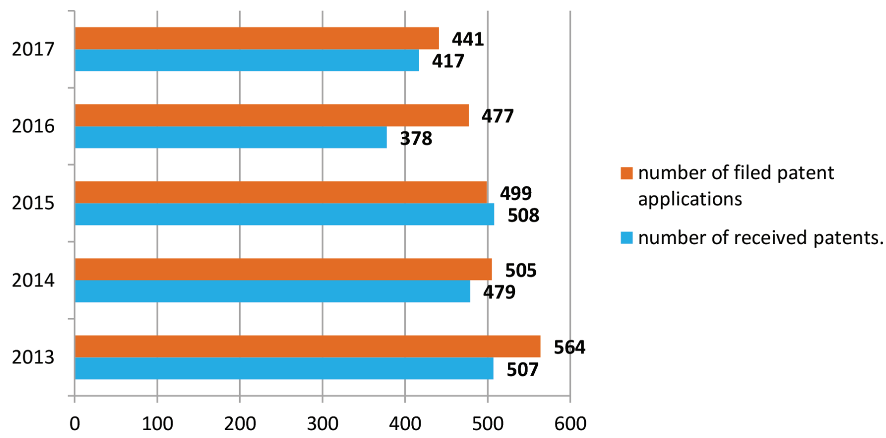

Fig. 1. The number of filed patent applications and received patents

Organisational and marketing innovations are important. However, it is technological innovations that determine the level of industry technical development. With the implementation of the linear model of innovative development, there is a significant reduction in financing the costs of technological innovation in the Krasnoyarsk Krai (Fig. 3).

Fig. 3 shows the increase in financing the costs of technological innovations from budgets (primarily from the Federal budget) with the significant reduction in financing from funds of enterprises. In 2013, the amount of financing technological innovations from funds of enterprises was 2.2 times higher than the amount of funding from the Federal budget, but in 2017, the situation was reversed. Thus, the innovative activity of enterprises decreases and this trend leads to a reduction in the financing development and introduction of technological innovations.

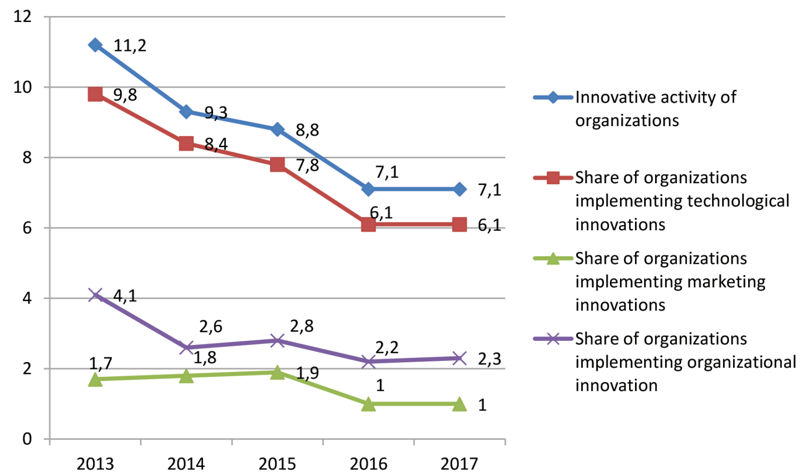

Fig. 2. Indicators of innovation activity in%

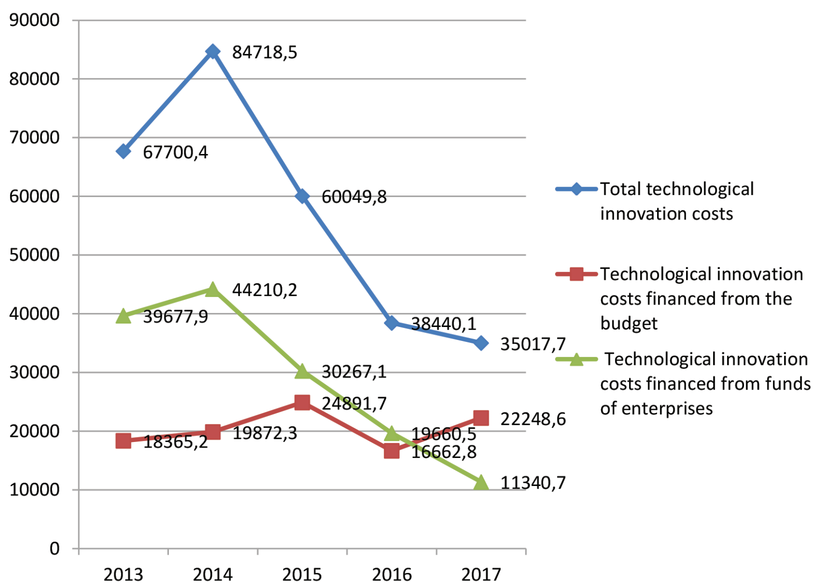

Fig. 3. The cost of technological innovation in million rubles

Low innovative activity of enterprises and organisations in the region results in decreasing the share of innovative products, works, and services in the total volume of goods, works and services (Fig. 4).

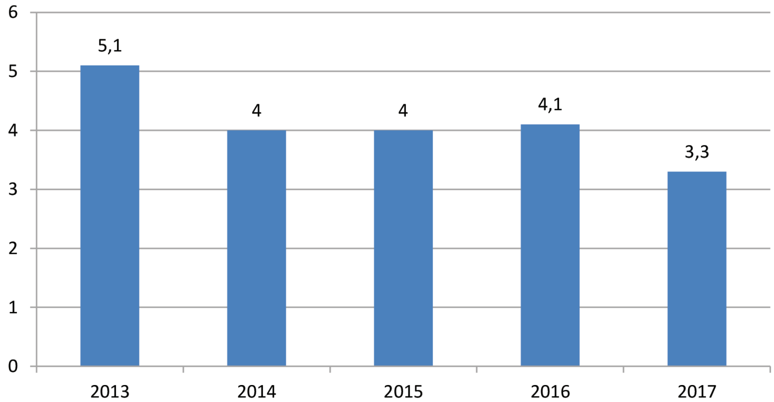

Fig. 4. The share of innovative products, works, services
in the total volume of goods, work and services in%

The results of the analysis demonstrate the need to identify obstacles in the organisation of innovative activity. For this, the implementation of the "triple helix" model should be quantified and bottlenecks that hinder its implementation should be identified.

Methods and results of the study

The development of the "triple helix" model in a region requires a quantitative assessment of the actor interaction in innovation. Due to the complexity of the analysed processes, there is no unambiguous approach to the assessment of the processes occurring in the "triple helix" model.

Egorov proposes a simplified method of rapid assessment (Egorov, 2018). He uses such indicators as received patents to measure activity of academic research, volume of produced innovative products to assess the activity of industry, and the funding amount of research from the regional budget to measure the activity of government. The integrated index of regional innovative development according to the "triple helix" model is presented as expression:

$$I = \sqrt{I_1^2 + I_2^2 + I_3^2}, \quad (1)$$

where I_1 — the number of received patents for inventions, utility models and industrial designs per 1,000 people of the economically active population; I_2 — the share of innovative products, works and services in the total volume of goods, work and services; I_3 — the percentage of public research spending in the total expenditures of the regional budget (Egorov, 2018).

Dezhina and Kiseleva suggest a more complex assessment methodology. In this methodology, the interaction between three actors in innovation is measured through bibliometric analysis, for which all articles where the first address belongs to “academic research” domain are chosen. Then the authors select the articles in which the second address relates to “industry” and the third address relates to “government” (Dezhina, Kiseleva, 2008). However, this methodology is very difficult to use at a regional level.

Leonova and Shinkevich propose a system of indicators for estimating innovative interactions in the “triple helix” model in regions (Leonova, Shinkevich, 2015). These authors use such indicators as the share of research and developments (R & D) costs in the GRP, the share of scientific and technical services and R&D in the GRP and innovative territorial clusters to estimate the government performance. The activities of universities (academic research) are measured by the following indicators: the funding amount of technology parks in the field of high technologies and the funding amount of innovation territorial clusters. To assess the innovative activity of industry, Leonova and Shinkevich (2015) suggest using such indicators as the share of investment in equipment or fixed capital in the GRP and the number of applied advanced technologies per 1,000 enterprises. We believe that the difficulty of applying this indicator system is that the information on some indicators (in particular, on the financing of technology parks and clusters) is not available.

Given the experience gained in assessing activities of the actors in the “triple helix” model at a regional level, we suggest the following system of indicators (Table 3).

Table 3. Indicators for assessing the interaction between the actors of the “triple helix” model at a regional level

Actor	Indicators
University (academic institutes)	Number of organizations currying out research and development
	Domestic costs for research and development by sources of financing, million rubles
	Number of received patents for inventions and utility models
	Number of developed advanced production technologies
Industry structures	Number of used advanced production technologies
	Innovative activity of organisations,%
	Share of innovative products, works and services in the total volume of goods, works and services,%
Regional government	Share of the regional budget in financing the cost of technological innovations,%

Source: compiled by the authors.

We can obtain the data for the proposed indicators in the official statistics. To estimate the level of innovative development in a region, we suggest an integrated indicator. To form this indicator, we first compare the actual value of the indicator with the benchmark value:

$$In = \frac{X\ actual}{X\ benchmark}, \quad (2)$$

where *In* is the value of the innovative development index for the n — indicator.

$$K = \frac{\sum_n^m In}{m} * 100\%, \quad (3)$$

K is the integrated index of the innovative development of a region, m — the number of indicators for assessing the innovative development of a region.

As a benchmark value of the innovative development indicators, we propose to use the values of these indicators in the “benchmark” (in terms of innovation development) region of Russia. The benchmark region is the Republic of Tatarstan, which ranks first among Russian regions in terms of innovative development in 2017 (*Indikatory innovatsionnoi deiatel’nosti*.., 2018).

In Table 4, we suggest a scale of the integrated index values for estimating the level of the innovative development for regions according to the “triple helix” model.

Table 4. Scale for estimating the level of innovative development

Value of integrated index	Level of innovative development
	high
0.84–0.75	average
0.74–0.65	low
0.64–0.45	very low
0.44	critically low

Using this method, we estimated the level of the innovative development for the Krasnoyarsk Krai according to the “triple helix” model. Table 5 shows the results of this estimation.

Table 5. Estimation of the level of innovative development for the Krasnoyarsk Krai (as of 2016)

Indicators	Krasnoyarsk Krai (actual value)	The Republic of Tatarstan (benchmark value)	The ratio of actual and benchmark value
Academic research:			
• number of organisations currying out research and developments;	73	113	0.65
• domestic costs for research and developments by sources of financing, million rubles;	16,939.8	12,569.5	1.35
• number of received patents for inventions and utility models;	364	1,034	0.35
• number of developed advanced production technologies	35	64	0.55
Industry structures:			
• number of used advanced production technologies;	3,751	7,465	0.5
• innovation activity of enterprises,%;	7.1	21.3	0.33
• share of innovative products, works and services in the total volume of goods, works and services,%	4.1	25.2	0.16
Regional government:			
• share of the regional budget in financing the cost of technological innovations,%	0.01	0.09	0.1
The integrated index of innovative development of the region			0.5

Sources: Calculations of authors using data from site https://www.gks.ru/folder/11186

Table 5 shows that the level of innovative development according to the "triple helix" model in the Krasnoyarsk Krai is very low.

Thus, this method allows us to assess the level of innovative development and develop measures to enhance innovation in the region. Given the results of assessment, we can conclude that the regional government is the "weak link" in implementation of the "triple helix" model for the Krasnoyarsk Krai.

Conclusion

Resource-based regions use the linear model for organising innovation activity. The weak interaction between large mining companies and academic institutes or universities is due to the industry orientation to purchase innovations and high technologies abroad. Such policy reduces the costs of mining companies for research. However, it does not ensure the use of "breakthrough" innovations and therefore significantly reduces the possibility for innovative development.

We suggest that a change in the current situation requires the development and implementation of new strategy to stimulate innovative activity given the specifics of resource-based regions. In addition to legislative support for innovative entrepreneurship, this strategy should include measures to stimulate the relationship between industry and universities and to enhance the role of the regional government.

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Модель «тройной спирали» для регионов ресурсного типа

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Поиск путей устойчивого социально-экономического развития ресурсных регионов обусловлен исчерпаемым характером добычи минерально-сырьевых ресурсов. Однако богатая минерально-сырьевая база может рассматриваться как неоспоримое конкурентное преимущество, которое может быть использовано для развития инновационной экономики региона. Это обусловлено тем, что на начальном этапе формирования инновационной экономики пилотные инновационные проекты могут реализоваться в добыче полезных ископаемых, а в дальнейшем — в обрабатывающих и обслуживающих (сервисных) отраслях экономики. Для этого необходимо предложить эффективную модель организации инновационной деятельности в ресурсном регионе, одной из которых является модель «тройной спирали». Таким образом, целью данного исследования служит оценка возможностей инновационного развития экономики ресурсного региона на основе модели «тройной спирали». Объектом исследования выступает Красноярский край как типичный регион экономики сырьевого типа.

Применение модели «тройной спирали» определяет необходимость изменения роли участников инновационного процесса. Основная роль здесь отводится университетам (науке), которые становятся предпринимательскими университетами. Задачей предпринимательских университетов является создание и практическое внедрение инноваций на основе трансфера технологий с бизнесом. При этом государство становится равноправным партнером инновационного процесса, а также заказчиком разработки передовых производственных технологий.

Эффективное внедрение модели «тройной спирали» определяет необходимость количественного измерения уровня ее реализации на региональном уровне. Для этого авторами предложены система показателей и методика оценки уровня инновационного развития ресурсного региона, что можно рассматривать как новизну исследования.

Ключевые слова: ресурсный регион, инновационное развитие, методика оценки, модель «тройной спирали», предпринимательский университет.

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