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Innovative Development in Northern Russia Assessed by Triple Helix Model

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Abstract. This paper considers issues related to assessing the level of innovative development in the northern regions of Russia. A comparative assessment of the level of innovative development in seven regions of the Far North of Russia (FNR) for 2017 was carried out based on statistical data from the composite integrated index. A version of the Triple Helix (TH) econometric model served as the foundation for the assessment. This article presents the analytical results according to three elements of the TH model: the effectiveness of research and development (science), the effectiveness of innovation (industry), and budget expenditure on science and innovation (government). Regional innovative profiles were built during the analysis, which helped identify the strengths and weaknesses of the influence of science, business, and government on the development of innovative activities in the region. The results of such ratings make it possible to assess the comparative advantages and disadvantages of specific regions for further analysis. The data can be used in program documents on the region's innovative development. The methodology proposed for an innovation activity rating can help predict the main development trends of the entire territory of the Far North. Finally, it can be applied to other regions and countries if relevant statistical information is available.

Keywords: Indicators; Innovative development of the region; Rating; Russia, far north; Subject

1. Introduction

The present development of economies in many countries, including Russia, is based on innovative development and the actual task of assessing of assessing a country's innovative regional development (IDR).

Continuous monitoring of IDR indicators is necessary for making various organizational and managerial decisions by local executive authorities on the development of the innovative economy of a territory.

Assessing a region's innovation potential based on the continuous monitoring of changes in its indicators becomes a necessary tool. This helps determine the level of development in the innovation part of the regional economy.

Currently, there are a number of research papers on quantitative measurements of the (Leydesdorff and Park, 2014; Mêgnigbêto, 2018; Nurutdinova and Dmitrieva, 2018) and according to high-tech industries (Leydesdorff et al., 2015). One research paper (Istomina

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et al., 2018) on the TH model presents an econometric analysis of the quantitative relationship between innovation activity indicators based on statistics by the Federal Service for State Statistics (Rosstat). As the literary review of the works of foreign and domestic researchers shows, there are currently no practical tools for quantifying the IDR level based on the theoretical TH model, except for the simulation model of relations between TH actors (Ivanova and Leydesdorff, 2014).

At present, the main organizations that regularly carry out IDR ratings include the Association of Innovation Development of Russian Regions (Rating of Innovation Development of Russian Regions, 2018) and the National Research University "Higher School of Economics" (HSE) (Russian Regional Innovation Scoreboard, 2020).

To assess the level of IDR, the main problem is the lack of a scientifically substantiated number of indicators in the innovation sphere, approximately 15–20 indicators (Lisina, 2012).

The development of the TH model in the region requires a quantitative assessment of actor interaction in innovation. Due to the complexity of the analyzed processes, there is no unambiguous approach to assessing the processes occurring in the TH model (Popodko and Nagaeva, 2019).

In this regard, in contrast to existing methods and based on the TH model (Etzkowitz, 2003; Etzkowitz and Leydesdorff, 2003; Chacko, L., 2019), Egorov developed a methodology for the quantitative assessment of IDR by a minimum number of key indicators in the field of scientific and innovative activity (Egorov et al., 2019; Berawi, M.A. 2016; Berawi, M.A., 2021; Shichkov, A. et al., 2019). The main advantage of the methodology compared with other methods is the use of data from official statistical sources, which excludes the subjectivity of an expert assessment of the calculation results.

The assessment of the level of innovative development is carried out for northern countries of the world located to the north of the Arctic Circle and includes the zone of the Far North. These also include both countries of the European part (Denmark, Iceland, Norway, Finland, Sweden, and Russia) and countries of North America (Canada and the USA). Despite the fact that the countries of northern Europe occupy 20% of the entire northern territory of the globe, their combined population is small and accounts for only 4% of all those living in this part of the world (Northern territories in the all-Russian, 2012; Vasiliev and Selin, 2012; European Commission. Regional Innovation Scoreboard, 2019).

According to Bloomberg's annual Innovation Index in 2020, the leading economies are Germany, South Korea, Singapore, Switzerland, and Sweden (Table 1).

In recent years, Russia has consistently ranked 25^{th}–27^{th}, although in 2016, it occupied 12^{th} place according to this rating.

Table 1 Innovative economies rating for northern countries

Country	2020	2019	2018	2017	2016
Sweden	5	7	2	2	3
Finland	7	3	7	5	7
Denmark	8	11	8	8	9
USA	9	8	11	9	8
Norway	17	17	15	14	14
Canada	22	20	22	20	19
Iceland	23	23	24	25	28
Russia	26	27	25	26	12

Source: Innovative economies rating, 2020

Currently, there are eight regions whose territories are fully part of the Far North of Russia (next FNR): the Murmansk and Magadan regions, the Republic of Sakha (Yakutia), Kamchatka Territory, and four autonomous areas: the Nenets Autonomous Area, Khanty-Mansi Autonomous Area, Yamalo-Nenets Autonomous Area, and Chukotka Autonomous Area (list of areas qualified as the regions of the Far North).

Thus, the above discussion determines the relevance of this research, the object of which is the innovative development of a region's economy. The aim of this study was to quantify and analyze the level of innovative development of regions based on the TH model.

The scientific novelty of the work lies in using the author's econometric TH model to assess the contribution and identify the strengths and weaknesses of the influence of the scientific and education system, business, and the state on the innovative development of the region according to their minimum key statistical indicators in the field of innovation.

2. Methods

In the Russian Regional Innovation Index (RRII) sub-indexes, the National Research University Higher School of Economics (HSE) applies the following designations for composite indicators of the three main elements of the TH econometric model (Russian Regional Innovation Scoreboard, 2020).

Research and development effectiveness (SEdC) includes the following indicators (A):

A1. The number of articles published in peer-reviewed journals indexed by Web of Science per 10 researchers (the number per 10 researchers).

A2. The number of patent applications for inventions filed with the Federal Service for Intellectual Property (Rospatent) by national applicants per the number of employed aged 15–72 years (the number per one million people).

A3. The number of advanced manufacturing technologies developed in the region per the number of employed aged 15–72 years (the number per one million people).

Innovation performance (industry) (B):

B1. The share of innovative goods, works, and services in the total volume of goods shipped, works performed, and services provided (percent).

B2. The share of reintroduced or technologically sophisticated innovative goods, works, and services that are new to the market in the total volume of goods shipped, works performed, and services provided (percent).

B3. The share of organizations that rated the reduction in costs for materials and energy as the main benefit of innovations among other organizations involved in technological innovations (percent).

Budget costs for science and innovation (government) (C):

C1. The share of budgetary appropriations for civil science from the consolidated budget funds of the subject of the Russian Federation, among other consolidated budget expenses of the subject (percent).

C2. The share of federal budget funds in total expenses for technological innovation (percent).

C3. The share of budget funds of the subject of the Russian Federation and local budgets in the total cost of technological innovation (percent).

Figure 1 shows the econometric model for performing an integral assessment of the level of innovative development in a region according to the three above-mentioned indicators based on the TH model.

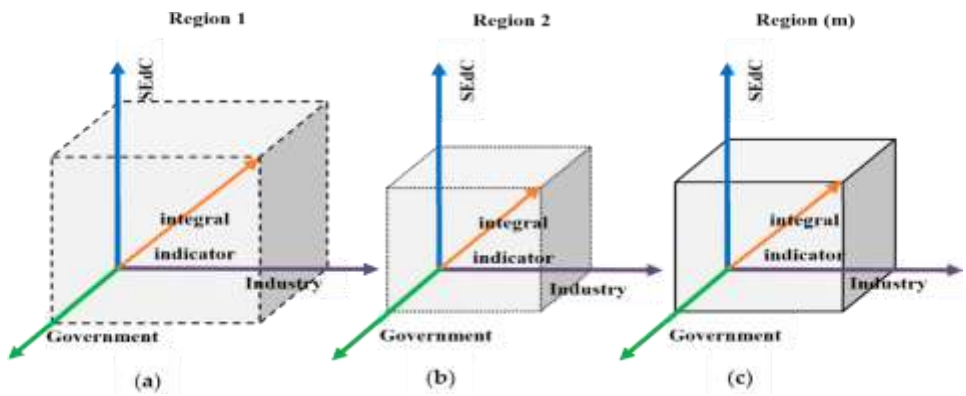

Figure 1 The econometric model for an integrated assessment of the level of innovative development in a region based on the TH model.

Within the TH model, the integrated index IDR (Kj) is determined by the following equation:

$$Kj = \sqrt{(I_j^{gov})^2 + (I_j^{SEdC})^2 + (I_j^{ind})^2} \quad (1)$$

where I_j^{gov} is the assessment of the impact of state projects on the innovative development of the *j*-th region;
I_j^{SEdC} is the assessment of the impact of the science and education complex on the innovative development of the *j*-th region; and
I_j^{ind} is an assessment of the impact of industries on the innovative development of the *j*-th region.

The main advantages of the proposed research methodology and the difference from other methods are the possibilities of excluding the subjectivity of expert assessments through the use of indicators given in official statistical sources in the field of science and innovation, as well as the proposed tools based on the TH model, which allows the assessment of the contribution of each participant of the triad to the overall innovative development of the region.

3. Results and Discussion

Figure 2a shows the results of normalized values from the IDR of the FNR rating based on HSE methodology according to 53 indicators, while Figure 2b shows the results based on the developed TH model methodology.

As it follows from the figures above, the results of the calculations show the difference in leadership: according to the HSE method, Murmansk Region is number one, while according to the TH model, Yamal-Nenets Autonomous Area is the leader. In both calculations, Yakutia is in third place. The difference in the regions' positions comes mainly as a result of the different number of indicators used for the rating assessments: the HSE methodology applies 53 indicators, and the TH model applies only nine.

When analyzing the corresponding results for the three RRII sub-indexes, it can be seen that the regional leaders vary. For example, in the TH element, "*productivity of research and development*," the leaders are Yamalo-Nenets Autonomous Area, Kamchatka Territory, and Yakutia (Figure 3). Yamalo-Nenets Autonomous Area is at the top, mainly due to a relatively high result in the "development of advanced manufacturing technologies" indicator; the region is ranked 10th among 85 subjects of the Russian Federation. Accordingly, Kamchatka Territory performs well in "*developing advanced manufacturing technologies*" (31st) and "publishing activity of researchers" (33rd). The researchers of the Republic of

Sakha (Yakutia) also show a high rate of publishing activity with a 13th position.

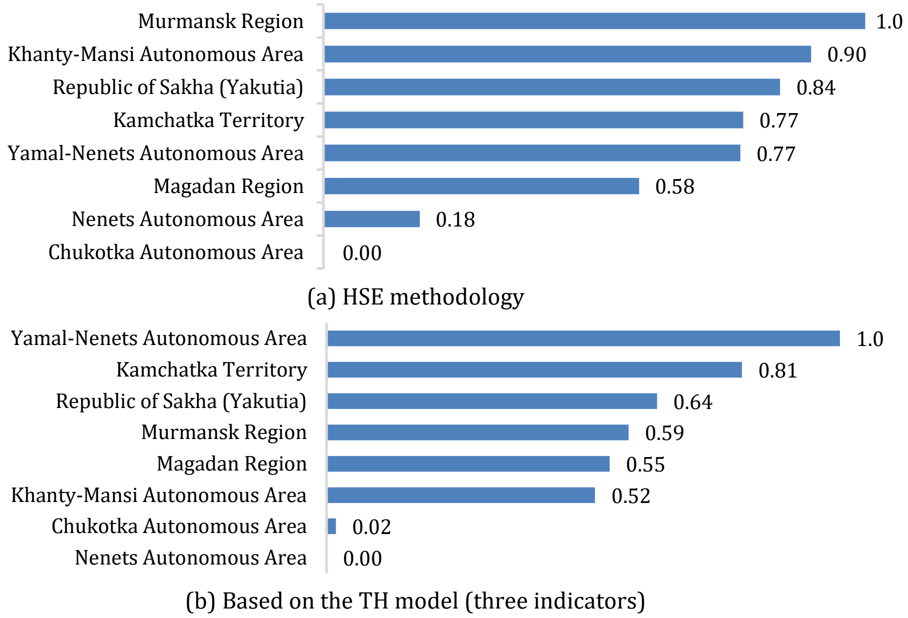

Figure 2 FNR regions' innovative development ratings

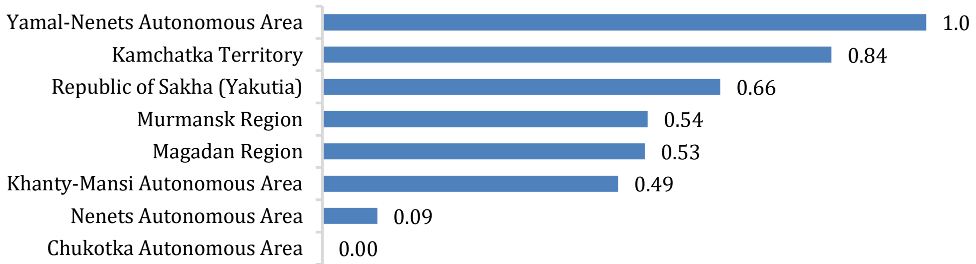

Figure 3 Rating of FNR regions according to the research and development efficiency (science) indicator

According to the "effectiveness of business innovation," the leaders in the rating are Khanty-Mansi Autonomous Area and Magadan and Murmansk Regions; this is mainly due to their high share of organizations that have reduced material and energy costs as a result of innovation (ranked 3rd, 4th, and 9th in the Russian Federation, respectively) (Figure 4).

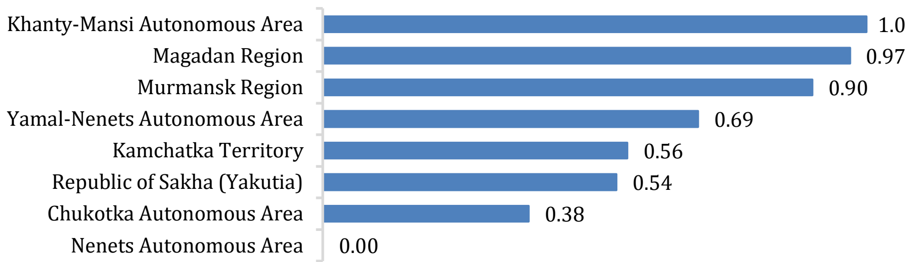

Figure 4 Rating of FNR regions according to the "innovative performance (business)" indicator

The indicator "budgetary expenses for science and innovations" comprehensively reflects a region's position in terms of the quality of its regional innovation policy. The policy refers to the efforts of local authorities to provide financial support and develop innovation activity in the region. Figure 5 shows that, according to this indicator, there is a significant gap between the positions of the three leaders and the other regions. For example, the Republic of Sakha (Yakutia) ranks 13th among the other subjects of the Russian Federation, and 18th when it comes to the share of the regional budgetary funds the expenditure on technological innovation. The Yamal-Nenets Autonomous Area and Murmansk Region occupy 7th and 16th places, respectively.

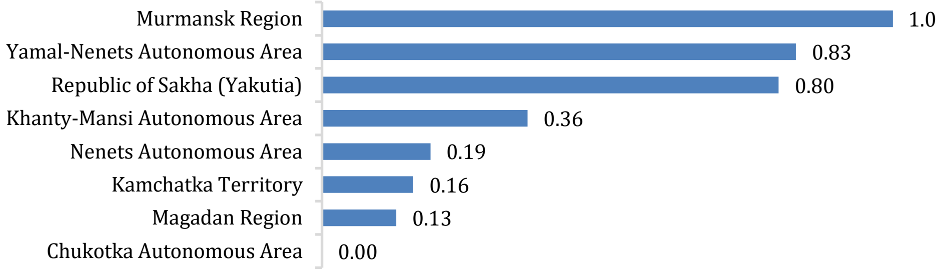

Figure 5 Rating of FNR regions according to the "budgetary expenses for science and innovations (state)" indicator

Based on Equation 1, the share of contribution (influence) of each Triple Spiral partner to the overall innovative development of the *j*-th region is estimated by the ratio:

$$R_j = (I/I_j)^2 \times 100 \quad (2)$$

Figure 6 shows the distribution of the impact of science, business, and government o the overall innovative development of the FNR regions. It is clear that the leadership of Yamal-Nenets Autonomous Area (see Figure 2) comes as a result of the approximately even level of the TH partners' indicators (39%, 28%, and 33%, respectively). The Kamchatka Territory shows a high level of science contribution (53%) and a low level of state support (10%) in innovative development in the region. It should be pointed out that relatively high indicators of the efforts of regional executive bodies to support innovation in Yakutia (40%) and the Murmansk Region (41%) do not result in significant practical results in the development of business in the sphere of innovation. This is mainly due to the fact that the developed and adopted legislative legal acts in the fields of scientific, technical, and innovation policy of the region affect the development of the innovation process with a certain time lag.

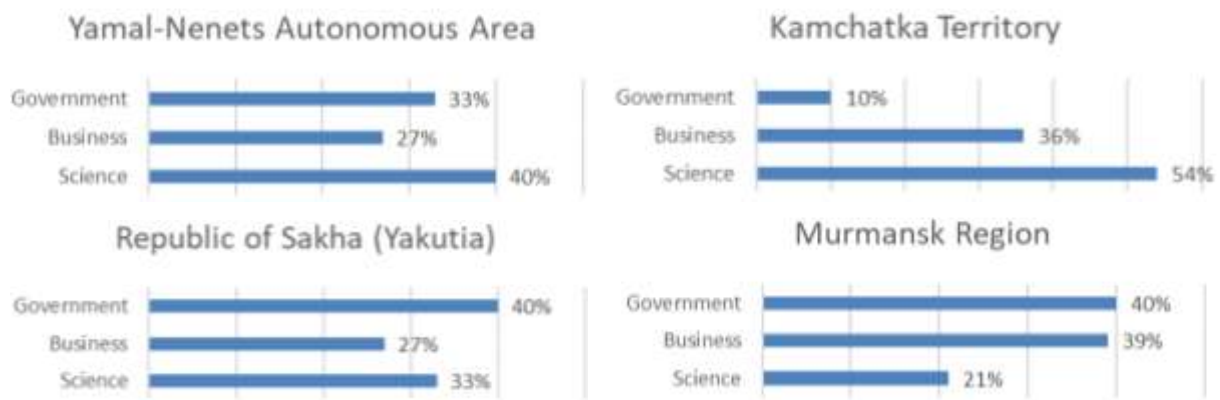

Figure 6 The share of the TH partners' contributions to the overall innovative development of the FNR regions

To identify the strengths and weaknesses of the influence of science, business, and government on the innovative development of the region, it is necessary to conduct a more detailed analysis of the following key indicators of the TH partners, science, business, and government, in the field of innovation.

Indicators for science:

– The publication activity of researchers (A1);
– Patent activity (A2);
– The development of advanced manufacturing technologies (A3).

Indicators for business:

– The share of innovative products (B1);
– The share of innovative products new to the market (B2);
– The proportion of organizations that have reduced material and energy costs as a result of innovation (B3).

Indicators for government:

– The share of allocation for science in the regional budget (C1);
– The share of the federal budgetary funds in expenditure on technological innovation (C2);
– The share of the regional budget funds in the expenditure on technological innovation (C3).

As an example, Figure 7 shows the innovation profile of two arctic regions built on the normalized values (from 0 to 1) of the above indicators.

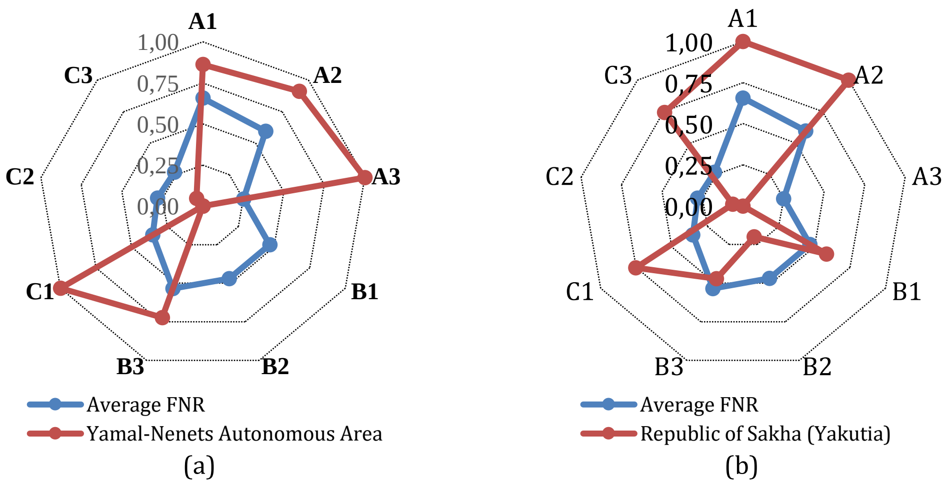

Figure 7 Innovation profile of regions

As can be seen from Figure 7, the results of scientific research and development (sub-index A) have a strong influence on the innovative development of both regions, although Yakutia does not develop advanced manufacturing technologies. These regions also have a significant share of financial allocations for science from their local budgets (C1), and its value is much higher than the normalized average value for FNR (0.35). In addition, one of the strengths of innovation activity in the Yamal-Nenets Autonomous Area is indicator B3 (the share of organizations that have reduced material and energy costs as a result of innovation), while in Yakutia it will be indicator C3 (the share of the regional budget in the cost of technological innovation). The weaknesses of both regions under consideration are indicators B1, B2, and C2 (YaNAA) and indicators A3, B2, and C2 (Yakutia).

In general, rating assessments of the innovative development for each region are very useful. It helps to evaluate the comparative advantages and disadvantages of regions for further analysis in the program documents for innovative development.

It should be noted that the above research methodology, in addition to the regional level, can also be used at the level of various technological clusters. In future research, it is also necessary to consider modern conditions of the digital transformation of the economy in the regions of Russia (Babkin et al., 2017; Bharadwaj et al., 2013; Chaniasa et al.,2019; Jin ., et al, 2020; Kostin & Uporova, 2018; Schepinin et al, 2018).

4. Conclusions

The study demonstrates a significant difference between FNR regions in terms of innovative development. Five FNR regions show higher values for the composite innovation index than the average (0.26). The values vary by region, from 0.05 (Nenets Autonomous Area) to 0.46 (Yamal-Nenets Autonomous Area). Different positions of regions are also shown in the individual sub-indexes' ratings. Creating innovative profiles clearly points out the strengths and weaknesses of the influence of science, business, and local authorities on the region's innovative development.

The results obtained will fulfil the information needs of the regional authorities that make and implement decisions in the field of innovation policy. The ratings will allow manufacturers to consider regional specifics when implementing and using various innovative projects and developments. In addition, it will help citizens to evaluate the performance of executive bodies in the regions.

Thus, based on the studies carried out, the following results were obtained: (1) Based on the econometric model of the TH, there is a significant difference in the Arctic regions in terms of their innovative development; (2) The share of the TH partners' contribution to the overall innovative development of the Arctic regions of Russia was determined, and the strengths and weaknesses of the influence of science, business, and local authorities on the innovative development of the region were identified; (3) The results of the rating assessments will allow regional authorities and manufacturing enterprises to fully incorporate the regional specifics when implementing and using various innovative projects and developments in their activities; and (4) The proposed methodology for the rating of innovation activities in the regions will allow the prediction of the main trends in the development of the Far North.

It should be noted that the above research methodology can be used for other regions and countries of the world, provided that relevant statistical information in the field of innovation is available.

Further research on this topic will be aimed at studying the impact of the results of innovative activities on improving the livelihoods of the population in the regions in the context of the digital transformation of industries and the social sphere.

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