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Structural changes and innovation economic development of the Arctic regions of Russia

Sergei A. BEREZIKOV
Institute of Economic Problems G.P.Luzin, Kola Scientific Center of the Russian Academy of Sciences, Apatity, Russia

This article is devoted to problem of assessing relationship of innovative economic development and structural changes in industry of the Arctic regions. Performed analysis showed that change in the structure of industrial production in the Arctic regions from 2010 to 2016 was characterized by significant interregional differences in speed and intensity of transformation processes.

It is shown that one of the key factors that caused structural changes in industry of the Arctic regions of Russia in 2010-2016 was increase in economic role of innovations and change in the pace of innovative processes development. In particular, the results of correlation analysis showed the presence of stable positive links between «science intensity» of economy and transformation of regional industry structure. The presence of a strong positive connection between impact of innovative development factors – an increase in growth rate of innovative goods – and structural changes in industrial production was set. Another factor contributing to structural changes in industry was investment in modernization of production.

It is proved that in order to ensure further sustainable economic growth in regions of the Arctic, a necessary condition should be a substantial increase of «science intensity» in economy, including industries related to mining operations.

***Key words*:** structural variations; structural changes; innovative development; Arctic; industry

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Introduction. Large-scale structural transformations, observed in the modern world, based on innovative technologies of the fifth and sixth ways form a new development paradigm, which is based on innovations that provide progressive structural changes in the economy. At the same time, «existing and inadequate modern structure of distribution of economy sectors and associated uneven economic development of individual territories are additional negative factors that impede economic development of the country» [8, p. 673]. This necessitates a deeper study of processes of innovative development of industry in the Arctic.

The need to establish innovative paradigm as the main internal factor in structural development of industry in the Arctic regions actualizes the task of studying relationship of structural changes and innovative development in regional economic systems, as well as nature and mechanism of structural changes in industry.

From the point of view of classical theory of innovation, the basis of sustainable economic growth is constant production and implementation of innovations. It is innovations that are the root cause of structural changes and the main structure-forming factor in the economy.

So, according to N.D.Kondratiev, «profound changes in technology of production and exchange (which in turn are preceded by significant technical inventions and discoveries)» [9, p. 370-371] precede the «upward» wave of each large cycle or occur at its very beginning.

S.Kuznets notes that «rapid changes in structure of production are inevitable – taking into account differentiated impact of technological innovations on a number of production sectors» [32, p. 250].

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B.Twiss also points out that «new technologies that laid foundation for formation of new industries that accelerate economic growth» [18, p. 25].

Currently, the majority of researchers recognize «radical acceleration of technical progress, decrease in the share of material production in aggregate social product, development of services and information sector, a change in motives and nature of human activity, and emergence of a new type of resources» as the main signs of transformation of social production [20, p. 62].

Depending on «significance» of innovation (nature of the innovation, degree of its novelty, duration and consequences of innovations), the consequences of their impact on economy and society will also differ. In other words, not every innovation leads to a change in the structure of economy. Thus, the impact of G.Mensch's «pseudo-innovations» [12] will not cause deep transformations in the structure of economy, in contrast to S.Kuznets' «epoch-making innovations» [11].

Yu.V.Yakovets suggests distinguishing between two types of epochal and basic innovations in dynamics of economy. According to him, the first type includes «deep transformations of the structure of economy in various forms, change of long-term and super-long-term cycles», and the second – «radical changes in economic institutions and market mechanisms» [22, p. 222-223].

In addition to taking into account the type of innovation, in assessing its ability to influence transformation of the structure of economy, it is also necessary to take into account willingness of the institutional environment to perceive innovations and phase of innovation-dynamic cycle of economic development.

Structural changes in relation to industry of the Arctic regions can be defined as transformation of proportional ratios between branches related to industry. Moreover, essence of structural changes is manifested in adaptation through innovative development to changes in the structure of social needs and interests of economic entities. In other words, the essential level of structural changes in industry as a transformation of interconnections between its elements, contributing to emergence of a new quality of the economic system, at the content level is manifested through an increase in its innovativeness.

Various innovation susceptibility of business entities determine uneven growth rate of structural components of regional industrial system. It is innovative development that underlies mechanism of structural changes and leads to modification of industry proportions, and in this sense, structural changes are the result of economic growth.

Methods and data. Currently, economic science has necessary tools for analyzing structural changes. The simplest way to analyze structural changes in industry is to study dynamics of individual shares of industries (in our case, types of economic activity attributed to industry).

Quantitative analysis of structural changes is carried out through assessment of dynamics of changes in proportion or specific gravity, as well as an indicator of structural changes index [1, 2, 5, 10, 14, 17, 26]. Influence of structural changes between types of economic activity on general dynamics of industry can be estimated using elasticity factors, advances, etc. There are also various integral indicators (integral coefficient of structural differences of Salai, integral coefficient of structural shifts of Gatev, Ryabtsev index, etc.), correlating qualitative characteristics of structural changes with their quantitative expression.

In international studies on regional economy, shift-share analysis method has been widely used, which makes it possible to distinguish three components in structural changes: national, regional, and sectoral [23-25, 27-31].

Despite the existence of tools for assessing structural changes in economy of the Arctic regions, possibilities for its application are quite limited. As N.Mikheeva rightly notes, «in reality, possibilities of choosing factors determining the quantitative measure of their influence on regional

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dynamics are limited by available statistical base, the number of statistical indicators included in the analysis, and their set are determined, in addition to substantive premises of the study, by availability of initial information» [13, p. 12].

To assess the rate of transformation of industrial structure of the Arctic regions of Russia, indicator of quadratic coefficient of absolute structural shifts was used [6]:

$$\sigma_{abs} = \sqrt{\frac{\Sigma(d_1 - d_0)^2}{n}}, \quad (1)$$

where d_1 and d_0 – the proportion of individual elements of the population in the considered and previous period, respectively; n is the number of allocated elements of the population.

In turn, intensity of changes in industrial structure of the Arctic regions using quadratic coefficient of relative structural shifts was estimated [19]:

$$\sigma_{rel} = \sqrt{\sum\left(\frac{d_1}{d_0} - 1\right)^2 d_1}. \quad (2)$$

The choice of quadratic coefficients instead of linear ones is due to the fact that they are more sensitive to sharp fluctuations in the structure.

To assess significance of structural differences in industry of the Arctic subjects of the Russian Federation, Ryabtsev index was used [16]:

$$I_r = \sqrt{\frac{\sum(d_1 - d_0)^2}{\sum(d_1 + d_0)^2}}. \quad (3)$$

The ratio of growth rates of certain types of industrial activity with growth rates of industry as a whole can be determined using the lead factor:

$$K_1 = \frac{K_{gr.ind.sec}}{K_{gr.ind}}, \quad (4)$$

where $K_{gr.ind.sec}$ – growth rate of industrial activity; $K_{gr.ind}$ is growth rate of industry as a whole.

Innovative development of the Arctic regions of the Russian Federation was assessed using analysis of indicators presented in official statistics [15]: share of domestic research and development costs in GDP and GRP; share of technological innovation costs in the total volume of goods shipped, work performed, services; innovation activity of organizations (proportion of organizations implementing technological, organizational, marketing innovations in the reporting year, in the total number of organizations examined); proportion of organizations implementing technological innovations in the reporting year, in the total number of organizations examined; volume of innovative goods, works, services; proportion of innovative goods, works, services in the total volume of goods shipped, work performed, services; share of investments aimed at reconstruction and modernization in the total volume of investments in fixed assets in constituent entities of the Russian Federation.

Information base for assessing structural changes in economy and industry of the Arctic regions of the Russian Federation was compiled by Rosstat [15]: on gross regional product; about the structure of GRP by sectors of the economy; indices of physical volume of gross value added by sectors of the economy as a percentage of the previous year; volume of shipped goods of our own production, works and services performed on our own by type of economic activity «Mining operation» in constituent entities of the Russian Federation; volume of shipped goods of our own production, work and services performed on our own by type of economic activity «Manufacturing» in

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constituent entities of the Russian Federation; volume of shipped goods of own production, performed works and services on their own by the type of economic activity «Production and distribution of electricity, gas and water» in constituent entities of the Russian Federation.

Discussion. Let us consider the current state of innovation activity in the Arctic regions of Russia (Table 1). The indicator presented in the table characterizes R&D expenditures per unit of gross output and is called «research intensity» in Russian literature [4, 7]. The research intensity indicator of the economy, depending on the Arctic region, from 2010 to 2016 ranged from 0.001-0.86 % in 2010 to 0.01-0.56 % in 2016. In all regions, except for the Yamal-Nenets Autonomous District (YNAD), there is a tendency to reduce research intensity of economy. During this period, in the Yamal-Nenets Autonomous District, indicator under consideration increased by an order of magnitude, which is primarily due to the low base effect.

Table 1

Current state of innovation in the Arctic regions of Russia*

Region	Year						
	2010	2011	2012	2013	2014	2015	2016
Research intensity of economy, %							
Nenets Autonomous District	0.03	0.03	0.03	0.03	0.04	0.03	0.02
Murmansk Region	0.86	0.79	0.84	0.82	0.79	0.63	0.56
Yamal-Nenets Autonomous District	0.001	0.004	0.01	0.01	0.01	0.01	0.01
Chukotka Autonomous District	0.08	0.08	0.08	0.09	0.07	0.06	0.06
Technological innovation, %							
Nenets Autonomous District	0.00	0.00	3.88	0.00	0.00	0.00	0.39
Murmansk Region	1.48	0.43	0.38	0.79	1.00	0.48	0.47
Yamal-Nenets Autonomous District	1.46	0.63	0.92	0.16	0.20	0.13	0.15
Chukotka Autonomous District	0.00	0.20	0.14	0.17	0.10	0.91	0.19
Innovative activity, %							
Nenets Autonomous District	5.30	11.40	10.50	6.30	3.10	5.00	6.20
Murmansk Region	9.70	8.50	9.00	13.50	10.20	9.40	7.20
Yamal-Nenets Autonomous District	10.90	10.10	7.60	5.10	7.80	7.40	9.00
Chukotka Autonomous District	12.50	12.50	17.90	25.00	29.20	17.80	7.20

* According to Rosstat data (www.gks.ru)

The share of technological innovation costs in the total volume of goods shipped, work performed, services and innovative activity of organizations in the period under review also tend to decrease in all regions of the Arctic, with the exception of the Nenets Autonomous Area.

Current situation in innovation sphere of the Arctic regions of Russia is quite accurately described by the concept of «technological stalemate» proposed by G.Mensch [12]. According to this concept, as potential for implementation of basic innovations is exhausted, economy goes into a state of «technological stalemate». In this situation, despite presence of innovative activity, innovations are almost everywhere replaced by «pseudo-innovations». So, in modern conditions in the regions of the Arctic, despite the fact that individual organizations carry out technological innovations (Table 2), proportion of innovative goods, works, services in the total volume of goods shipped, performed work and services does not increase. Consequently, there is creation of new goods (only in the form), production of cheaper copies of other people's developments, modernization of outdated generations of equipment and technologies that do not have long-term growth potential, etc.

In the Arctic regions of the Russian Federation, the situation, that has developed in innovation sphere, is associated primarily with the lack of motivation among corporations to introduce innovations and new technologies in the real sector of economy due to availability of cheap labor resources and high prices for raw materials and energy in the world market, as well as insufficient attention from the state.

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For innovation-oriented development of mineral resource complex, this issue is currently one of the main ones [33].

Let us analyze relationship between structural changes in industry and innovative development of economy in the Arctic regions of Russia, as well as the main trends in structural and dynamic processes in economy of the Arctic regions from 2010 to 2016 using indicators considered above.

Table 2

Costs of organizations for technological innovation and innovative products*

Region	Year						
	2010	2011	2012	2013	2014	2015	2016
Technological innovations, %							
Nenets Autonomous District	5.3	8.6	5.3	4.7	3.1	5.0	3.1
Murmansk Region	6.4	5.9	6.6	9.9	8.2	7.8	5.7
Yamal-Nenets Autonomous District	6.6	7.4	7.2	4.7	7.3	6.3	6.8
Chukotka Autonomous District	12.5	12.5	14.3	21.4	29.2	17.8	7.2
Innovative products, %							
Nenets Autonomous District	0.0	0.0	–	–	–	–	0.0
Murmansk Region	0.5	0.2	0.1	0.8	3.6	1.7	1.5
Yamal-Nenets Autonomous District	1.4	1.5	1.3	–	–	0.2	0.1
Chukotka Autonomous District	0.6	0.0	1.2	1.7	–	0.1	0.7

* According to Rosstat data (www.gks.ru)

Results of calculating the rate of absolute and relative structural changes are presented in Table 3.

Table 3

Quadratic coefficient of absolute and relative structural changes in industrial production in the Arctic regions*

Region	Year						
	2010	2011	2012	2013	2014	2015	2016
Absolute structural changes							
Nenets Autonomous District	0.20	0.21	0.18	0.21	1.98	1.91	2.71
Murmansk Region	4.85	4.66	2.32	4.01	6.16	2.71	3.53
Yamal-Nenets Autonomous District	0.31	0.99	1.17	0.59	0.97	4.48	0.15
Chukotka Autonomous District	0.31	2.84	4.91	3.58	9.08	0.49	0.92
Relative structural changes							
Nenets Autonomous District	0.25	0.29	0.24	0.27	3.08	1.45	1.45
Murmansk Region	1.44	1.32	0.65	1.12	1.75	0.92	0.96
Yamal-Nenets Autonomous District	0.20	0.50	0.44	0.24	0.45	1.84	0.06
Chukotka Autonomous District	0.46	0.99	1.85	1.13	2.65	0.18	0.40

* According to Rosstat data (www.gks.ru)

Calculation results indicate that, similarly to indicators of innovative development discussed above, change in the structure of industrial production in the Arctic regions from 2010 to 2016 was characterized by significant interregional differences in the rate of transformation processes. Surge in innovation activity in 2014 in the Chukotka Autonomous District (see Table 1) determined the maximum rate of structural changes in industry of the district among all the regions under consideration in the analyzed period.

Indicator of structural changes intensity in the industry of the Arctic regions assumes maximum value also in 2014, but in the Nenets Autonomous District.

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The analysis showed that dynamics of changes in the structure of industrial production in the Arctic regions of Russia in the period under review was associated with innovative factors. Moreover, significant fluctuations in speed and intensity of structural changes in industry in 2010-2016 indicate the absence of targeted regulation of these processes by regional authorities.

To analyze the extent of structural changes in industry of the Arctic regions, happened in 2010-2016, we calculate Ryabtsev index according to the formula (3). Calculation results are presented in Table 4. In order to determine connection between structural changes in industry and individual indicators of innovative development of economy of the Arctic regions of the Russian Federation, we will calculate correlation coefficient (Table 5).

Table 4

Ryabtsev Index

Region	Value	Interpretation
Nenets AD	0.03	Identity Structures
Murmansk Region	0.19	Significant level of structural differences
Yamal-Nenets AD	0.06	Extremely low structural differences
Chukotka AD	0.13	Low structure differences level

Table 5

Connection of structural changes in industry and innovative development in the Arctic regions

Indicator	Nenets AD	Murmansk Region	Yamal-Nenets AD	Chukotka AD	Correlation coefficient with Ryabtsev index
Research intensity of economy	0.02	0.56	0.01	0.06	0.84
Growth rate of the share of innovative products					
in the total volume of goods shipped	106.74	322.36	7.36	123.42	0.81
in the total volume of goods shipped by industry	0.00	263.85	7.22	206.71	0.97
Growth rate of innovative products	69.49	500.44	18.17	337.22	0.95
Costs of modernization	5.00	13.40	1.70	4.30	0.76

Results. Results of the analysis showed that there is a positive correlation between structural changes in industry and innovative development of economy in the Arctic regions.

In the Arctic regions, increase in research intensity of economy is one of the reasons for transformation of structure of regional industry. So, the correlation coefficient between indicator of «research intensity» of economy and Ryabtsev index for the regions of the Arctic is 0.84.

There was found the presence of a strong positive correlation between impact of innovative development factors, manifested in an increase in growth rate of innovative products, and structural changes in industry of the Arctic regions. In particular, correlation coefficient between Ryabtsev index and growth rate of volumes of innovative goods is 0.95, growth rate of the share of innovative goods in the total volume of goods shipped is 0.97 and 0.95 shipped by industry, respectively. In all cases, correlation coefficient exceeds 0.7, which allows us to assert that there is a strong connection between the analyzed indicators: the more effective was innovative activity in the region in terms of achieving a result – increasing the volume of innovative goods – the greater is the scale of happened structural changes in industry of the Arctic subjects of the Russian Federation.

Increase in modernization costs also contributes to structural changes in industry of the Arctic regions. Correlation coefficient between costs of modernization and Ryabtsev index is 0.76.

Conclusion. According to the results of studies in correlation of structural changes with innovative development of regional economic systems, we believe that a necessary condition for further sustainable economic growth in the Arctic regions is a significant increase in «research intensity» of economy, including industries related to extraction of mineral resources for a number of reasons:

1) in three of the considered regions of GVA, the type of activity «Extraction of mineral resources» occupies more than half of the GRP structure. Consequently, an increase in the «science intensity» of this industry sector is capable of providing a significant increase in GRP;

2) this is the only industry sector that is growing at a faster pace in all Arctic regions;

3) global trend towards depletion of non-renewable natural resources is clearly visible in the Arctic regions of the Russian Federation [32].

In the situation, when structure and quality of raw material base deteriorates and geological and economic indicators of its development decrease, without serious investments in development of innovative technologies, further development of new deposits, including offshore fields, is impossible. As noted by the authors of [21, p. 438]: «The main tool for achieving comprehensive development of the Russian economy and improving the quality of life of population in remote northern regions is implementation of active innovative policies in the Arctic regions aimed at modernizing and increasing innovative activity of economic entities».

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Author **Sergei A. Berezikov,** *Candidate of Economics*, *Senior Researcher*, *bsa@iep.kolasc.net.ru* (*Institute of Economic Problems G.P.Luzin*, *Kola Scientific Center of the Russian Academy of Sciences*, *Apatity*, *Russia*).
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