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INTERACTION SPECIFICS BETWEEN MAIN FACTORS OF GRP PRODUCTION (RUSSIAN FEDERATION, NORTHERN RUSSIA)

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Abstract

The article presents the results of an analysis of interaction of the main factors of GRP production for the Russian Federation and regions of the North of Russia. The importance of resources of the North of Russia for the national economy determined the state support for investment in the economies of these territories. The legal mechanism for enhancing investment processes in the Arctic regions was described. It can ensure the development of the Russian North, support development zones, consisting of interconnected investment projects based on a large project. The problem is an insufficient substantiation of investment in the economies of the northern regions. This confirmed the relevance of reliable models expressing the dependence of performance indicators on production functions. Differences in the structure of regional production in the regions of the North require the development of two versions of the model of production functions, followed by the choice of the "best" model – the multiplicative production function (MPF) and the CES production function. The results of modeling the GRP production in the regions of the North of Russia were presented. For the Russian Federation as a whole and for most regions of the North of Russia, the models describing real processes of interaction of the main GPR production factors were selected.

Keywords: Russia, regions, North, modeling, GRP

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1. Introduction

At present, the issues of socio-economic development of the Russian North are being discussed by politicians, authorities, business, and scientists. This is due to the key importance of resources of the North for the Russian economy. Scientific research and legislation on the development of the North of Russia emphasize that it is the raw materials of the North that are significant for the budget (Kudryashova et al., 2019; Larchenko et al., 2019). This fact does not deny the tasks of diversifying the Russian economy; however, the reality is that the basis of this diversification is the resource base of Russia whose significant part is resources of the North (Larchenko et al., 2020; Suopajärvi et al., 2016). A large-scale regulatory and legal framework is aimed at ensuring the socio-economic development of the northern regions on the basis of supporting investment in the economies of these territories. Investment in the economy of Russian regions is not substantiated by quantitative estimates of its effectiveness (Baranov & Skufina, 2018). This determines the relevance of modeling regional production processes in the North of Russia.

2. Problem Statement

A special need for reliable modeling results is characteristic of the practice of managing the regions of the North (Baranov et al., 2018) due to the inherent complexity of regional economic processes characterized by uncertainty, a large number of factors that are difficult to take into account, incomplete information; increased costs of the economic systems of the North, which determine higher costs of managerial errors; increased importance of management for the economy of the North, where the application of liberal management models is difficult due to increased risks, high costs, limited labor resources; significant investment in the economy of the Russian North caused by the task of increasing the volume of extraction of natural resources (Davydova et al., 2019; Korchak & Serova, 2019; Leksin & Porfiryev, 2015). This determines the importance and need for scientific research aimed at identifying significant relationships between individual parts of the regional system, allowing for quantitative assessments of the interaction of the main factors of production. An independent direction is the search for opportunities to use models expressing the dependence of effective indicators on production functions. At the same time, our studies prove that there is no single model of production functions for the regions of Russia that would describe each region (Skufina et al., 2019). Therefore, the study of applicability of versions of the models of production functions for each region is of great scientific interest and practical importance.

3. Research Questions

3.1. Modern tasks of development of the North of Russia

An urgent direction of research is to consider possibilities of using production functions in managing the territorial development. The relevance is determined by the objective need of management based on a meaningful analysis of trends and patterns of interaction of the basic factors of regional development. This is due to the current macroeconomic conditions, which require an increased presence of the state in the economy and balanced development of the regions through a set of measures, including large investment projects based on public-private partnerships, allocation of territories for advanced socio-economic development and their support (Leksin & Porfiryev, 2015; Samarina et al., 2019). The expediency of these measures is confirmed by the wide distribution of analogue measures in international practice, the relative success of their implementation in some Russian regions, as well as their compliance with the macroeconomic situation (Samarina et al., 2020; Suopajärvi et al., 2016). The national economy adapts to the conditions of sanctions – a stable ruble exchange rate, a low inflation level, stable budget execution. However, a significant part of management problems is due to the lack of a visual, quantitative justification for the choice of investment projects, insufficient assessment of their impact on the economy and social sphere (Baranov et al., 2018). The problem is the absence of a consulting tool for making informed management decisions – there are no simple, understandable, manageable, easily interpretable models of interaction of the main factors of production, quantitatively confirmed dependencies and real factors for ensuring the economic growth of a certain territory (Uskova et al., 2017).

This problem is emphasized in modern tasks of managing the spatial development of the Russian Federation, aimed at developing specific territories with special tasks of socio-economic development and regulatory conditions. The largest macro-project is the Arctic zone of the Russian Federation. The purpose of implementation of this macro-project is to create conditions for an integrated, balanced socio-economic development of the Arctic zone of Russia by developing “support zones”. The State Program of the Russian Federation "Socio-economic development of the Arctic zone of the Russian Federation" allows us to consider the investment mechanism of support zones as a stabilizing factor for ensuring long-term socio-economic development of the Arctic zone of Russia and the entire North of Russia.

3.2. Production functions in solving the problems of development of the North of Russia

The main problem of the state in the development of support zones is to generate a sufficient number of large (anchor) projects, taking into account the effectiveness of activities of state and non-state companies. It is obvious that the generation of such projects requires an assessment of the return on investment, taking into account their impact on the production of GRP, efficiency of human resources. Such tasks can be solved using the toolkit of production functions.

The research shows that the economies of the regions of the North are extremely diverse in terms of the structure of regional production. The diversity gives rise to the need to search for such a model that would match the modeled reality, to use several models of production functions with the subsequent selection of the "best" one. The prospects of this approach are confirmed by the results of the author's research (Baranov et al., 2018).

4. Purpose of the Study

The article aims to identify the specifics of interaction of the main factors of production for Russia as a whole and the regions of the North of Russia using a model of production functions that matches the real data.

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5. Research Methods

This study presents the results of a series of works on modeling the dynamics of GRP production aimed at improving the quality of measuring the interaction of the main factors of production, assessing the specifics of their impact on the economic growth of the regions of the North and the Russian Federation as a whole (Baranov & Skufina, 2018; Skufina et al., 2019). These studies substantiated the feasibility of methodological features of several variants of the model. Two options of the model were developed.

Option 1. Multiplicative production function (MPF):

$$Y(t) = A \cdot K(t)^p L(t)^q, \quad A > 0. \tag{1}$$

where:

$Y(t)$ – output, GRP per year t;

$K(t)$ – capital, investment in fixed assets per year t;

$L(t)$ – labor, the number of people employed in the regional economy per year t.

Parameters:

p – capital elasticity (investment),

q – labor elasticity;

A – neutral technical progress.

The coefficient of elasticity of labor and capital substitution if MPF is equal to 1.

Option 2. CES production function (Arrow et al., 1961; Kmenta, 1967):

$$Y = \gamma[\delta K^{-\rho} + (1-\delta)L^{-\rho}]^{-\nu/\rho}, \quad \gamma \geq 0, \quad 0 \leq \delta \leq 1, \quad \nu \geq 0, \rho \geq -1. \tag{2}$$

Where Y – GRP per year t, K – capital, the value of the region's investment per year t; L – labor, the number of people employed in the regional economy per year t.

Parameter γ in (2) – productivity; δ – optimal distribution of production factors; ν – elasticity of scale, i.e., with an increase in labor and capital by k times, the GRP will increase by k^{ν} times. Initially, in CES, the function $\nu = 1$. If $\nu > 0$ (<0), the CES function describes the growing (reversing) economy.

CES function (2) can be used to model the production of GRP with different elasticities of labor and capital substitution.

Parameters of the production function models were estimated similarly to (Baranov et al., 2018) by the least squares method, taking into account the restrictions on the range of parameters.

The Akaike information criterion was used to select the best model, adjusted for small samples (Kmenta, 1967):

$$AICc = n\ln(MSE) + n\frac{1 + m/n}{1 - (m+2)/n}. \tag{3}$$

Here n is the amount of input data, m is the number of model parameters, MSE is the mean square error of the model:

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$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2 , \quad (4)$$

where

y_i – actual data;

$\hat{y}_i$ – model's values.

The smaller the AICc value, the better the model. At the same time, the AICc criterion does not allow us to understand how well the model matches the initial data.

The degree of conformity of the model to the initial data was measured using R^2:

$$R^2 = 1 - n \cdot MSE / \sum_{i=1}^{n}(y - E[y])^2 , \quad (5)$$

where

MSE – root mean square error (4);

$E[y]$ – average calculated from actual data.

The closer the R^2 value to 1, the better the model matches the original data. The use of R^2 in the nonlinear model is not correct; we will use this criterion only for a rough estimate of the degree of conformity of the model to the initial data.

To model the production of GRP, we use the following indicators: 1) the index of the physical volume of GRP in constant prices; 2) the index of the average annual number of employed; 3) the index of the physical volume of investment in fixed assets. The values of these indicators were taken from the materials provided by the State Statistics Committee of Russia (Federal State statistics ..., 2000–2018),

The object of the study was Russia as a whole and thirteen regions of Russia, whose territories are located in the North zone: Murmansk Region, Republic of Karelia, Arkhangelsk Region, Nenets Autonomous District, Chukotka Autonomous District, Kamchatka Territory, Sakhalin Region, Magadan Region, Yamal-Nenets Autonomous District, Khanty-Mansiysk Autonomous District, Republic of Komi, Republic of Sakha (Yakutia), Republic of Tyva.

6. Findings

Estimates of the model parameters in the form of MPF (1) are presented in Table 1. The analysis shows that the production of GRP for seven regions of the North is described by the MPF model (1) ($R^2 \geq 0.7$).

Table 1. MPF parameters (1) for 2000–2018, capital (p) and labor (q) substitution elasticity (*p*), R^2 (4), *AICc* (3) (calculated by the authors using the data provided by the Federal State Statistics Committee

Region	*A*	*p*	*q*	R^2	*AICc*
Russian Federation	0.03	0.52	1.20	0.99	57.97
Republic of Karelia	4.7	0.49	0.20	0.65	84.10
Republic of Komi	16.20	0.36	0.21	0.78	81.00
Arkhangelsk region	1.70×10^7	0.49	-3.64	0.71	103.19
Nenets Autonomous District	0.00	-0.05	1.70	0.83	119.98
Murmansk region	7.68	0.08	0.41	0.18	72.12

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Khanty-Mansi Autonomous District	0.59	0.50	0.58	0.54	108.66
Yamal-Nenets Autonomous District	0.02	0.11	1.69	0.88	67.20
Republic of Tyva	0.77	0.18	0.98	0.91	80.77
Republic of Sakha	0.53	0.32	0.75	0.69	98.93
Kamchatka Krai	4.10×10^5	0.39	-2.76	0.63	92.17
Magadan region	6.97	0.10	0.52	0.72	68.98
Sakhalin region	0.01	0.41	6.52	0.66	130.87
Chukotka Autonomous District	39.55	0.35	-0.09	0.36	137.99

Estimates of the model parameters in the form of the production function CES (2) are presented in Table 2. The analysis shows that the production of GRP is described by the MPF model (1) ($R^2 \geq 0.7$). Only two regions have growing economies (the values of scale elasticity (parameter ν in (2)) are greater than in (1). These are the Nenets and Yamal-Nenets Autonomous Districts. The elasticity of scale characterizes by how many percent the volume of GRP will change with an increase in factors of production (labor and capital) by 1 %.

Table 02. PF CES parameters (2) for 2000–2018, capital (p) and labor (q) substitution elasticity (*p*), R^2 (4), *AICc* (3) (calculated by the authors using the data provided by the Federal State Statistics Department)

Region	γ	δ	ρ	ν	s	R^2	*AICc*
Russian Federation	0.09	0.36	0.44	1.55	0.69	0.92	67.42
Republic of Karelia	5.60	1.03	21.04	0.68	0.14	0.74	77.90
Republic of Komi	4.00	0.56	1.92	0.67	0.23	0.89	65.42
Arkhangelsk region	1.89	1.01	20.89	0.69	0.06	0.75	110.11
Nenets Autonomous District	0.00	0.29	10.00	1.76	0.20	0.79	111.04
Murmansk region	36.09	1.02	60.33	0.18	0.05	0.20	71.09
Khanty-Mansi Autonomous District	6.47	1.00	64.97	0.71	0.02	0.46	103.45
Yamal-Nenets Autonomous District	0.02	0.07	-1.02	1.67	1.5×10^7	0.95	72.03
Republic of Tyva	19.43	0.67	0.98	0.42	0.46	0.87	71.82
Republic of Sakha	9.76	1.03	22.30	0.48	0.01	0.87	89.99
Kamchatka Krai	3.97	1.01	87.77	0.58	0.02	0.69	100.69
Magadan region	10.99	0.20	-1.03	0.78	6.9×10^7	0.77	67.87
Sakhalin region	0.00	0.39	2.66	5.88	0.24	0.71	145.55
Chukotka Autonomous District	11.44	1.01	19.67	0.53	0.11	0.67	152.22

The results of economic and mathematical modeling using the multiplicative production function (1) and the production function GES (2) have been obtained for nine regions of the North (Republic of Karelia, Arkhangelsk Region, Nenets Autonomous District, Kamchatka Territory, Magadan Region, Yamal-Nenets Autonomous District, Republic of Komi, Republic of Sakha (Yakutia), Republic of Tyva) and the Russian Federation as a whole; versions of the model were selected. The model explains 70% of the variation in the initial data (Tables 1 and 2). These models can justify investment in certain areas when developing support zones.

For four regions (Murmansk Oblast, Sakhalin Oblast, Khanty-Mansi Autonomous District-Yugra, Chukotka Autonomous District), it was not possible to select adequate models.

7. Conclusion

1. One of the most important problems in the management of the regions of the North of Russia is the lack of quantitative justification of investment projects. In particular, there is no assessment of the impact of investment on the economy, in particular, the production of GRP. The solution to the problem is simple, manageable, easily interpreted models of interaction of the main factors of regional production functions.

2. The study used two versions of the production function model – the multiplicative production function (MPF) and the CES production function. Both variants describe Russia as a whole. The situation in Russia differs from the situation in some regions of the North. This may indicate an imbalance in the processes of regional production in a number of regions of the North of Russia.

3. The resulting variants of the model for eight regions of the North (Republic of Karelia, Arkhangelsk region, Nenets Autonomous District, Kamchatka Territory, Magadan Oblast, Yamal-Nenets Autonomous District, Republic of Komi, Republic of Sakha (Yakutia), Republic of Tyva) can be used for justifying investment projects by assessing their impact on the production of GRP. The significance of this result is determined by the relevance of development of support zones in the northern territories of Russia based on a series of interconnected investment projects. The revealed discrepancy between the variants of the production function model and real data for four regions of the North (Murmansk Oblast, Sakhalin Oblast, Khanty-Mansi Autonomous District-Yugra, Chukotka Autonomous District) indicates violations of typical models of regional production processes and requires an in-depth further study.

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