

Investigation of the influence of investments in fixed capital of the region on its socio-economic development using mathematical modeling

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Abstract. The article is devoted to the analysis of the dependence of the socio-economic development of the region on investments in fixed assets. The main components of fixed capital (FC), which are most dependent on investments, have been identified. A method for constructing a mathematical model is proposed, taking into account factors: the population of the region, its size and location.

Keywords: management of the socio-economic system, investment in fixed assets, investment attractiveness, mathematical model.

Introduction

A region is a system consisting of interconnected parts that form an integral unity [1]. The main parts of the system are material production and social sphere, balanced among themselves, therefore the region is a socio-economic system [2]. Making effective management decisions for the socio-economic system is the main promising economic task of Russia [3]. The socio-economic development of a region depends on its socio-economic potential: various resources that ensure the satisfaction of the individual and collective needs of society [4]. It is generally accepted that fixed capital (FC) is capital assets involved in the entire production cycle [5]. Investments in FC represent various investments for the construction and reconstruction of fixed assets facilities [6]. We will evaluate the development of the region by the value of the gross regional product (GRP) [7].

Relevance of this study is determined by the task set before Rosstat: the development of an assessment of the impact of investments in FC on the socio-economic development of the region [8], because the mathematical assessment is insufficiently developed and it is required to create more universal models for an optimal economic strategy.

The subject of research is the process of researching the dependence of the level of investment in fixed assets of the region on its socio-economic development.

Research object is the process of constructing a mathematical model of the dependence of the influence of various investments in fixed assets on the dynamics of the economic development of the region.

The purpose of the work is the development of a mathematical model, taking into account the population of the region, its size and other factors.

Practical significance work: the proposed model can be used in automated decision support systems. And the methodological approach to constructing a model can be applied in further research and calculations.

Formulation of the problem

Figure 1 shows the schematic interaction of the socio-economic system with the external environment.

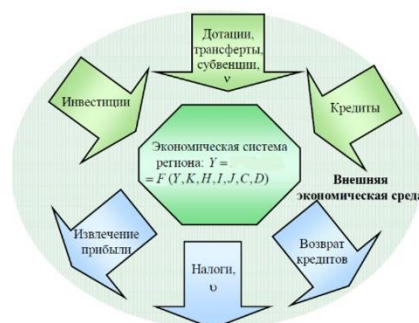


Fig. 1. Diagram of the socio-economic system

As a result of the study of the subject area, the main components of the mathematical model of the economic system of the region were identified. Each component is characterized by a specific set of factors. At one of the stages of building the model, the factors that have the greatest impact on the GRP as a result of incoming investments were selected, and the degree of this influence was assessed (the significance of the selected factor). The studies were carried out by the methods of regression and correlation analyzes [8]. All elements of the model are quantitative. Significant factors are presented in table 1.

Table 1

Significant factors of the main components of the mathematical model

Components	Composition (factors)
Labor (H)	X ₁ – Percentage of the working-age population (at the end of the year) in relation to the entire working-age population of the region, %. X ₂ – Percentage of workers with higher education, %.
Innovative (K)	X ₃ – Technological innovation as a percentage of total costs. X ₄ – Research expenditures, million rubles.
Financial (I)	X ₅ - The resulting financial income from the activities of organizations (million rubles). X ₆ - Number of companies with financial and insurance activities X ₇ - The size of the contribution physical. persons in credit companies of the Russian Federation, rubles. X ₈ - The number of small businesses per 10000 people.
Industrial (Y)	X ₉ – Gross product per capita, rubles X ₁₀ - The volume of goods, works, services created by the region's industries, million rubles.
Infrastructure (J)	X ₁₁ - Railway network of the region, km of tracks per 10000 km ² of territory. X ₁₂ – The number of goods transported by machine transport X ₁₃ – Length of highways (km of roads per 10000 km ²)
Agricultural development (C)	X ₁₄ –share of agriculture,%
Budget (D)	X ₁₅ – Tax receipts to the regional budget, million rubles.

When conducting the research, the authors used data from official statistical sources listed on the website of the Federal State Statistics Service for 2020 [9] on investments in 84 regions, as well as data on the population in these regions [10].

Statement of the research problem: to estimate the dynamics of GRP (dependent variable of the model) from investments in fixed assets per capita, taking into account the selected indicators.

Building the model

At the first stage of the study, a sample of empirical data was formed, a fragment of which is presented in table 2.

Table 2

Фрагмент исходных данных и удельных инвестиций по регионам

Регионы	Инвестиции, миллиардов руб.	Население, тыс. чел.	Инвестиции, тыс. руб./чел.
1	2	3	4
Пермский край	283,78	2,61	108,69
Кировская область	72,23	1,27	56,78
Нижегородская область	295,25	3,21	91,85
Оренбургская область	212,04	1,96	108,02
Пензенская область	89,37	1,32	67,80
Самарская область	293,73	3,18	92,28
Саратовская область	162,12	2,44	66,42
Ульяновская область	79,73	1,24	64,38
...

As a model, the authors propose to consider the regression equation [11]. An example of such an equation is given for the production component of the socio-economic system (1).

$$Y_i = a_0 \prod_{i=1}^n x_i^{a_i} \varepsilon^i \quad (1)$$

Y_i — gross regional product by constituent entities of the Russian Federation;

ε^i — error of each system component.

a_i — degree of significance of each factor (x_i).

$i=1, n$.

The values of calculation errors for each parameter are shown in table 3.

Table 3

Errors for model parameters [12]

Parameter	Y	K	J	I	H	C	D
Error	7.14	4.80	9.75	9.18	6.5	9.24	8.85

Since there were not very many data for statistical analysis (84 regions), the statistical significance of the constructed model was assessed using Fisher's criterion for the probability of selection errors of factors $p=0.05$. $F=125.207$, which indicates the reliability of the mathematical model.

Analysis of the built model

Despite the simplified approach to choosing the regression equation for all parameters of the system (each parameter can vary according to its own law, which requires a separate study), the authors obtained reliable results when testing the model.

The assessment of the adequacy of the model was carried out on the example of predicting data on the VLOOKUP for the North Caucasian Federal District [12]. The check consisted in constructing a forecast of the independent variable (VLOOKUP) and comparing its

value with the value from the control sample - data from open sources. The result is shown in fig. 2.

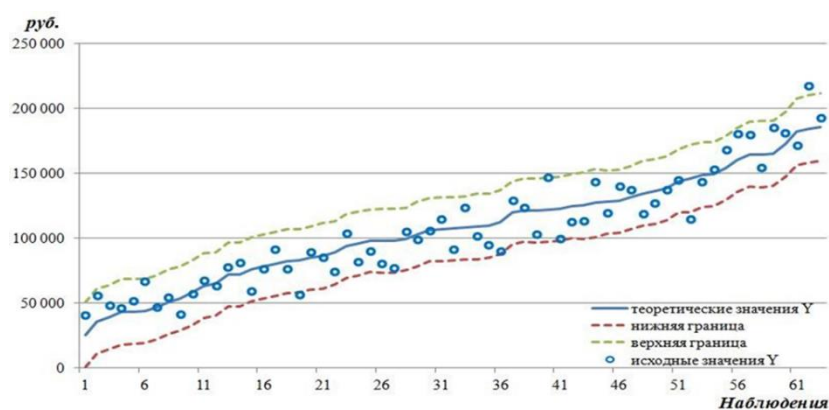


Fig. 2. The result of checking the adequacy of the constructed model

Only three points did not fall into the confidence interval: the per capita VLOOKUP value for the Stavropol Territory (217566 rubles), for the Republic of Ingushetia (114911 rubles) and the Republic of Dagestan (56813 rubles) [13].

Conclusion

In conclusion, conclusions can be drawn according to the results of the selection of significant factors that the most dependent on investment, and therefore, the parameters most influencing the socio-economic development of the region are the production, infrastructure, budget and development of agriculture (fig. 3).

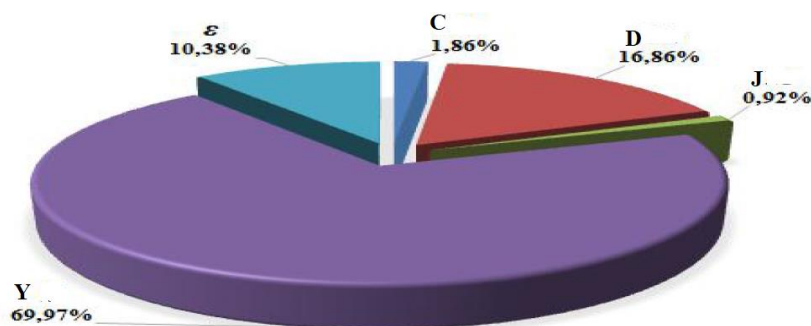


Fig. 3. Significant parameters for the development of the region's economy

The example of an algorithm for constructing a mathematical model can be applied to simulate the behavior of each parameter of the economic system shown in fig. 1 separately. As a result of solving the system of equations consisting of six equations, it may lead to a more accurate description of the behavior of the system, but the process of computing will become more time consuming, which in turn will increase the error of calculations.

As a result of the study, the authors received an adequate mathematical model that shows the impact of investments in the main capital of the region on its socio-economic development.

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