MODELING THE DEVELOPMENT OF THE REGIONAL ECONOMY: STATIC AND DYNAMIC APPROACH

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Abstract

The article is devoted to the design and construction of the macroeconomic static model, in which the economy is considered as an integral unstructured unit to the input of which the resources come, and the output is the result of the functioning of the economy in the form of the gross regional product. Resources are considered to be arguments, and gross output - a function. Modelling performed using production functions as an example of the Volga Federal District of the Russian Federation. To construct the models, we selected macro-economic indicators such as gross regional product, the value of fixed assets, the population, the labor force employed in the economy, the number of economically active population. Models are built in current and constant prices, taking into account (and without) technical progress.

As an alternative to the macro models for the region economy via the production functions the article considers simulation models, highlights the main advantages and disadvantages of the method, analyzes the existing approaches and the constructed models, compares the results and draws conclusions about the applicability of simulation models. On the basis of this study there are assumptions about the future usage of simulation modeling and macroeconomic static models for forecasting of socio-economic development of the region.

During crisis and unstable economic development management decisions are characterized by high dynamism, complexity, multi-dimensionality and the presence of overlapping flows of control actions. Clarity, efficiency, completeness, consistency and scientific validity of decisions taken at the regional level is the key to development of the territory. In this regard, the study of socio-economic development of the region becomes especially important.

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1. INTRODUCTION

For the Russian Federation, with its vast territory and the high diversity of regional development, relevant problems related to regional management efficiency are still actual. In this regard, economic-mathematical analysis and forecasting of socio-economic development of regions is a very urgent task, which allows to determine the direction of economic development of the Russian Federation.

To improve the efficiency of the regional management of the economy is of great importance of economicmathematical modeling and forecasting its development, which allows to make economically sound decisions that contribute to the construction of optimal economic management strategies. Towards this goal it seems appropriate to build an appropriate mathematical model of formation of the gross regional product.

Inter-regional differences in socio-economic development in the Russian Federation are very important. Analysis of their development suggests that over time the differences in various regions in production and consumption is not reduced, but also tend to increase. The income differentials between subsidized and affluent regions become larger. This fact was highlighted in September 2016 by the President of the Russian Federation.

2. MODELING THE DEVELOPMENT OF THE REGIONAL ECONOMY

2.1. The static Approach

Currently, the identification of the most effective methods for assessing the socio-economic development is the main goal of the research in this area. Search evaluation methods is called, above all, the ability to most accurately and cost-effectively predetermine the various options for development of the region. Interesting for state regulation of regional development is a comparative analysis of the growth rates of different regions. This comparison will allow time to make a decision on the support of a particular region in one form or another. Unfortunately, a comparative assessment of regional structures is quite a complex process, due to the fact that the integral indicators used for the analysis, often cannot be used for a real comparison.

The task of analysis and assessment of the socio-economic development of regions is a subject of study in economics for a long time. Nowadays, not only the researchers on the regional economy consider this issue, but many other experts, which include and economists, mathematicians use to solve this problem, a variety of mathematical methods and models, ranging from models of interbranch balance and finishing systems econometric equations. This paper discusses the methods based on the use of econometric models, parameters which make it possible to quantify the level of regional development.

Among the most commonly used indicators include: gross regional product, or its rate of growth, the volume of investment in fixed assets, the share of employed in the economy and the proportion of the economically active population, the percentage of the subsistence minimum for per capita income, the proportion of people with incomes below the subsistence level, the level of education. In assessing the level of socio-economic development of the region should not be underestimated as the traditional indicators that determine the level of production and consumption of goods (gross regional product (GRP), nominal and real GDP per capita growth rates of these indicators).

Currently, regional development, researchers are paying particular attention to the innovative component areas, as there is a direct link between the innovativeness of the region and its economic and social development. Innovation is the key point in enhancing the competitiveness of the economy, an economy based on knowledge. Innovation policy is an integral part of the strategy of industrial-innovative development and is a major tool for increasing the competitiveness of the economy.

Economic-mathematical models of the form:

$$Y = F(K, L, H, R, T),$$

(1)

based on the production function (PF) form a separate group of single-circuit macroeconomic models. Here the output (Y) depends on the amount of physical capital (K), population (L), human capital (health and education, etc. H), resources - land, raw materials, etc. (R), the level of technological progress (T).

Typically, most of these measured values is difficult to quantify. Therefore, models based on production function, mainly, are theoretical and consider the impact of changes of any quantitative variable factors (physical capital, labor) related to population trends.

Regardless of the manner in which production is represented function (PF), these models have a number of distinctive features. First, describing the impact of factors on the volume of production, the production function assumes relatively free mutual substitution of these factors. Thirdly, production function is homogeneous, i.e. all the while increasing the resulting factors (endogenous) variable is incremented in a strict proportion to the increase of factors. Fourth, these models use the hypothesis of a stable population, according to which the rate of population growth is the rate of population growth in the working age.

In macroeconomics PF can be used to describe the relationship between the annual cost of resources and the annual release of the final product within the region or country. In the role of the production system here produces a region or country as a whole. PF are based on statistical data and are used mainly for solving problems of analysis, planning and forecasting.

As resources at the macro level often considered accumulated labor in the form of productive assets (capital) and the real (live) work, and as a function of - gross output. The capital and the gross output is measured quantitatively in value terms (current and comparative), and work - in physical terms, using official statistics. Then macroeconomics modeled following nonlinear macroeconomic PF type:

$$Y = F(K, L) \tag{2}.$$

The simplest production function, reflecting the impact of the two factors of production - labor and capital, expressed as a Cobb-Douglas $Y = \alpha_0 K^{\alpha} L^{1-\alpha}$, where the parameters $\alpha_0 > 0$, $\alpha > 0$, and α_0 - coefficient characterizing the level of performance. A more complex model is presented multiplicative production function of the form $Y = \alpha_0 K^{\alpha_1} L^{\alpha_2}$, where the parameters are $\alpha_1 > 0$, $\alpha_2 > 0$.

Often, the production function can also include a description and technical progress (TP) as a function of time A(t). TP affect either the effectiveness of a particular resource (in this case the issue is growing at a fixed physical volume of this factor) or total output. In these cases, we have:

1)
$$Y_t = F(K_t, L_t \cdot A(t))$$
(3)

Capital productivity growth - capital-TP or TA Harrod.

2)
$$Y_t = F(K_t \cdot A(t), L_t)$$
(4)

productivity growth - labor-saving TP or TA Solow.

3)
$$Y_t = F(K_t, L_t) \cdot A(t)$$
(5)

growth of total factor - neutral TP or TA Hicks. If the rate of neutral TS γ is constant, then $A(t) = e^{\gamma t}$. Then, for example, the multiplicative PF takes account of exogenous technological progress, can be represented as:

$$Y_t = e^{\gamma t} F(K_t, L_t) = \alpha_0 e^{\gamma t} K_t^{\alpha_1} L_t^{\alpha_2},$$
(6)

where $e^{\gamma t}$ takes into account the impact of scientific and technological progress (NTP), $\gamma > 0$ characterizes the rate of output growth under the influence of scientific and technical progress, as well as the elasticity of release on fixed assets, and - elasticity of labor issue. If, there is a labor-saving (intensive) growth, otherwise funds-saving (extensive) growth.

Typically, the transition to n-dimensional (n > 2) PF as an additional argument (resource) is introduced in the use of natural resources R. Then the corresponding production function with the influence and natural resources can take the form of:

$$Y_{t} = e^{\gamma t} F(K_{t}, L_{t}) = \alpha_{0} e^{\gamma t} K_{t}^{\alpha_{1}} L_{t}^{\alpha_{2}} R^{\alpha_{3}}$$
⁽⁷⁾

If we consider the discrete growth rates, given the approximate equality $\Delta Y_t \approx dY_t$, we obtain the equation of

the approximate equality. That is, in the discrete case volume PF corresponds to a linear formula of communication rates of growth indicators y, k, l.

However, it should be noted that these formulas (equations) are equivalent only in the continuous case. In the statistical evaluation of the parameters α_1 , α_2 , γ of these equations apply discrete sample data.

Therefore, the estimates α_1 , α_2 , γ obtained, for example, non-linear equation, incorrectly transferred to a linear equation, and vice versa. Even if we evaluate these equations for the same results of observations, it is possible to receive entirely different value assessments. Moreover, one of the resulting regression equations can be significant, and the other - not significant.

This means that one way to estimation (e.g., non-linear equation can yield significant statistical result) and the other (for example, a linear equation) - no. Therefore, it is better to evaluate both of these equations, and if similar results are statistically significant, and it will serve as a confirmation of the assessed real relationship formula variables obtained on them.

Note that from a linear equation that the constant term γ is the rate of neutral technical progress is not

associated with an increase of costs of labor l_i and capital k_i , and reflects the intensification of production at the macro level.

When using a linear equation for practical calculations, it should also take into account the fact that the option is built on a residual basis. In other words, it reflects the impact on the growth rate of the release of all

other factors, in addition to labor and capital. This means that this parameter γ describes the impact on the production and some other unaccounted factors. However, for the majority of macroeconomic processes, the leading role among the "other factors" belongs to the technical progress.

In the economic analysis of the constructed regression models Y = F(K, L) species attaches great importance to the elasticity of substitution of factors of production (σ_K and σ_L) that, for example, the multiplicative PF is equal to one.

Practical application of models based on production function has been limited due to the problems of quantitative measurement of a number of key parameters of these models. This fact predetermines a certain ambiguity in the conclusions on the basis of such models. This ambiguity stems from the fact that under constant returns to scale production and a constant share of the labor force in the total population level of performance becomes dependent on the availability of additional factors and technology. Hence the increase in population leads to slower productivity growth if the population growth will not affect the development of other factors of production, and / or technology. If population growth would weaken the development of other factors of production, and / or technologies, the growth of labor productivity will slow down even more. If the population growth stimulates the development of other factors of production, and / or technologies, the growth of labor production, and / or technologies, the labor and or technologies, the labor productivity will slow down even more. If the population growth will accelerate or slow down, depending on the ratio of the level of influence of positive and negative effects.

However, models based on production function is theoretically confirmed the link between the growth rates of labor and capital to the growth rate of gross domestic product, performing calculations justification expediency correlation between these indicators. Another thing is that the impact of forced neglect of other key factors of economic growth can often lead to diametrically opposite conclusions and the low statistical significance of the results.

2.2. The dynamic approach

To overcome these difficulties, the simulation modeling is used. Using this class of regional development models through a series of successive calculations we can predict the trajectory of almost any socioeconomic system with established parameters when exposed to a variety of factors and conditions. The methodology of forecasting economic activity in the region is the concept, according to which the forecast is presented as a result of changes in the initial state of the model in the region to a certain perspective with given the scenario conditions. In the process of modeling the source database is transferred to the point prediction model built by causal relationships.

The simulation method allows to create models of complex systems, describing the loosely structured socioeconomic processes in conditions of uncertainty taking into account the stochastic factors of different nature, as well as generate and evaluate contingency scenarios studied system or process, to analyze the effectiveness of management decisions and to choose the most optimal variant.

The main approaches of simulation include: system dynamics, Discrete event simulation, agent-based modelling. Also, there are dynamic simulation studies, the combined approach, the network of piecewise linear units, and others. In this article we look at three main approaches that are most common at the moment.

The processes occurring in the modern world, in the system dynamics are presented in terms of storage and transacts existing between them. System-dynamic models describe the behavior of the system and its structure in the form of a series of interacting, both positive and negative feedback loops and time delays. Systematic approach builds a graphical diagram cause-and-effect relationships and the impact of global factors on various parameters, and then it creates on the basis of these diagrams computer model. In the simulation in this manner does not operate with a separate economic objects and aggregated elements (the aggregated buyer, the aggregated service provider). Thus there is a depersonalization of specific subjects, their behavior is seen as a cost-effective and efficient. This assumption can lead to inadequate results of the forecast, as rational decision-making by individuals rather controversial issue. Terms may go beyond research to predict them may not be possible.

The system dynamics allows to predict the dynamics of changes in the main socio-economic parameters in the region due to the presence of differential equations, as well as dependencies on lagged variables derived tools of econometrics or neuroinformatics. System Dynamics is able to identify causal relationships and global interdependence in the system.

Discrete event simulation is one of the most widely used approaches to the study of socio-economic, technical, logistics and other processes. Analytical results of similar models used in queuing theory. Discrete event models work with passive transacts or requests for service. Each event occurs at a particular time and observed as a change in system status. Between successive events it is assumed that there is no change in the system; Thus, the model can go directly from one event to another. As TRANSACT can act as a worker, as well as raw materials, a signal resource and other objects of economic activity. Moving on the model TRANSACT are queued to the single-channel and multi-channel devices, hold and then release them, and then destroyed. The rules governing the order in which these actions take place and the conditions for them, can be extremely complex. Every TRANSACT may be prescribed characteristics that determine its behavior in the system. The duration of activity is usually defined by a probability distribution function.

Agent-based modeling is a fairly new trend, taking into account both the individual behavior of active objects (agents) and their interactions. Models based on the agent-based approach consists of dynamically interacting agents according to certain rules. With this approach the system can be created, which is comparable to the complexity of the real world. In contrast to the system dynamics, agent-based approach cannot afford to operate with generic elements of the system, and the entire set of agents with a specific set of characteristic (for example, as agents can be agent-consumers and agent - producers). The goal of agentbased models is a picture of the data of global rules, the general way the system acts on the basis of assumptions about the individual and private behavior of its individual active parts and the interaction of these parts in the system. In a sense, agent-based models can be complementary to traditional analytical methods. Where analytical methods allow only characterize the equilibrium of the system, agent-based approach allows for the possibility of establishing this balance. This feature can be a major advantage of agent-based modeling. Agent-based models can also be used to determine the critical points defined as the point in time at which interference can be critical and the subsequent change of the path system. In the case of the creation of simulation models of economic systems that have a significant number of active objects (people, vehicles, companies, projects, assets, goods, and so on), which are united by the presence of elements of individual behavior, agent-based modeling becomes the most versatile and powerful approach. since It has to take into account the complexity of the structure and any of its behavior.

Agent-based and system-dynamic methods are the most suitable for creating models of socio-economic systems. This is due to the different approaches of economic theory. The most widespread and developed in our time, the neoclassical school of economics, which describes the economy of limit values. These models are presented in the form of systems of differential equations and, therefore, comply with the methodology of system dynamics. The model, created on the basis of combination of different approaches, using system dynamics at the highest level of abstraction (to describe the behavior of macro), while agent-based modeling - low (to describe the behavior of individual economic agents), so you can achieve a more accurate reflection of the socio-economic dynamics of the region.

Agents may include system-dynamic charts, algorithms, rules of behavior, the variables of the phase

diagram. Created with the presented methods the model has the ability to predict the development of the socio-economic system under the condition of various factors, and to determine the optimal control strategy. In the process of research possible implementation of experiments to determine the optimal values of the individual parameters that optimize the objective function.

In conclusion, the development of agent-based and system-dynamic modeling, and software in the simulation area can open to scientists' great prospects for further study of the problems that may occur when modeling the effects of the possible effects of various external and internal factors influencing the stability of a particular system.

Key advantages of the simulation modelling are as follows:

• the ability to describe complex systems, characterized by a plurality of non-linear relationships and a large number of heterogeneous variables;

• playback of dynamic behavioral aspects and environmental processes;

• the ability to identify patterns, dynamics and trends in the development and operation of complex economic system in the absence of precise information or its small amount;

• description of the behavior and interaction of a plurality of active agents in the study of social systems;

• Implementation of object-oriented design and implementation of high-tech solutions in conducting computer simulations, etc..;

• use of a modular structure to create an information system based on them, since such an approach is the ability to use existing hardware resources with maximum efficiency, which in turn reduces the processing;

• the ability to monitor the performance at all stages of the simulation in the complex, as well as separately.

Naturally, the simulation models are not without drawbacks. First of all, it is worth noting the high cost of the development of the simulation model. So, for the regional model requires the involvement of more than one specialist, and the whole team. The time required to build such a model is also great. From the point of view of the implementation of the simulation results it is worth noting the need for financial and information support, as well as the training of public authorities in the region. There is also the complexity of the collection of baseline data for the simulation model. They are not always collected and analyzed by Russian Statistics. This can significantly reduce the adequacy of the model. Thus it can be noted that the created by combining different approaches model will use the system dynamics at the highest level of abstraction (to describe the behavior of macro), and agent-based modeling - low (to describe the behavior of individual economic agents), whereby it is possible to more accurately describe the socio-economic dynamics of the region. With the use of simulation able to understand the internal mechanisms of the development of different economic processes, hidden behind the visible, often seemingly paradoxical picture of the economic phenomena that do not fit into the known theoretical schemes. Experience in the use of models has shown that they provide a reliable tool for analyzing macroeconomic patterns, and predicting the effects of macroeconomic decisions while maintaining existing relationships.

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