

A systematic approach to the analysis of sustainable development of cross-border regions

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Abstract. This article is devoted to the consideration of the problem of sustainable development of cross-border regions of the neighboring states. We propose to classify the cross-border regions using multi-dimensional observations based on the use of discriminant analysis. The research relies on a systematic approach based on the decomposition approach of the synthesis of the control subsystem and the corresponding decision-making processes based on the methodology of the theory of hierarchical systems. Setting the tasks of managing financial and material resources of cross-border regions in conditions of incomplete and asymmetric awareness, we propose to rely on the logic that would follow from the decomposition of a more general (global) management problem and could be based on the methodology of the theory of hierarchical systems. The application of the decomposition approach and the development of probabilistic models allow to synthesize an integrated control system under conditions of uncertainty, in which the options for the sustainability trajectory of the development of a cross-border region are analyzed.

Keywords: systematic approach, decomposition approach, cross-border regions, decision-making process

1. Introduction

Sustainable development is a pressing global problem of our time. It was put before the humanity by the non-governmental organization of scientists, entrepreneurs, public figures "Club of Rome" [1]. In June 1970, at the meeting in Bern, the Club of Rome proposed the head of the system dynamics group, Professor J. Forrester, to develop a global development model imitating the main processes of the world system. Forrester built a mathematical model by studying complex systems with nonlinear feedback using the principles of system dynamics [2].

The main axiom adopted by the Club of Rome is the need for a systematic approach to the analysis and modeling of the world system processes [1]. It suggested that a group of J. Forrester's students, under the direction of D. Meadows, would conduct a research focused on some important characteristics of the modern stage of human evolution and review scenarios of possible future development of the process. D. Meadows's group built a world mathematical model, which was described in the book "The Limits to Growth" [3].

The problem of sustainable development of the regions is one of the priority problems studied by not only foreign, but also Russian scientists. The following Russian scientists made a theoretical and methodological contribution to the development of this problem: Yu. Demyanko, V. Koptuyug, S. Kurdyumov, K. Levashov, V. Matrosov, D. Urbanovich and others [4].

Held in Rio de Janeiro in 1992, the United Nations Conference on Environment and Development adopted the “Agenda for the XXI Century.” In that document, the concept of sustainable development is clarified, an assessment of crisis phenomena in the biosphere, the economy, the field of international relations is given, and the concept of sustainable development is advanced. From the point of view of sustainable development of cross-border regions, the principle No. 12 should be emphasized, “States should cooperate in creating an open international economic system that could lead to open growth and sustainable development in all countries” [5].

Scientists of the Siberian Branch of the Russian Academy of Sciences clearly outlined the priorities of the national sustainable development strategy. The first priority among them is determining economic prosperity as “creating conditions, motives and guarantees for equitably paid labor of citizens of society based on the functioning of a mixed economy and rational consumption of resources” [6].

2. Materials and Methods

On the one hand, the possibility of building a new class of economic and mathematical models of the cross-border region management systems arose after the formulation of the problem of the sustainable development of such territories. On the other hand, the development of such sciences as the theory of multilevel hierarchical systems and the study of operations have reached the necessary level for a comprehensive analysis of this problem.

Uncertainty of information about ongoing processes in cross-border regions, insufficient and inadequate knowledge of the functioning of the social, political and economic systems of neighboring countries require new approaches to the analysis of sustainable development and the decision-making process. A systematic approach to the analysis of the economic situation in cross-border regions and in neighboring countries, in general, is necessary. System analysis requires a comprehensive study of all spheres of life in the region, a long time and significant financial costs. The organizational and technological level of production is the basis of the economic indicators of the financial and economic activities of the region as a subject. Therefore, a comprehensive economic analysis provides for a joint study of the socio-economic and industrial-technological aspects of the region, although the latter is not the subject of an economic analysis.

The problem of sustainable development of territories is relevant both at the macro and micro levels. The sustainability analysis of the development of cross-border regions is one of the important stages of regional forecasting and should include monitoring of the socio-economic status. First of all, regional differences that have a significant impact on the development of cross-border regions and on government decision-making in neighboring countries should be studied. One of the most advanced approaches to this problem is the assessment of inter-regional differences on the vectors of regional indicators. This allows one to determine the desired levels and priorities of development in certain areas of the regions-outsiders, which is important to reduce their backlog and hence to weaken unjustified inter-regional differentiation [7].

3. Results

We propose to use the method of classification of cross-border regions, represented by multi-dimensional observations, based on the use of discriminant analysis. Using this method, we can construct a separating function in the form of a discriminant hyperplane. The task of discriminant analysis is to assign an object, characterized by the values of the p-signs, to one of the sets (groups, classes) defined by their distributions. In this case, the classification is possible according to two criteria: (1) depending on the distance to the scattering center; (2) depending on the distance to the “ideal” region.

The method of classification of objects by constructing a discriminant hyperplane was outlined in our work [8]. The logic of research is preserved, but the regional feature of cross-border territories are considered as additional quantitative and qualitative characteristics or classification identifiers.

Lack of financial material resources and inefficient management of them can lead to small random deviations affecting the sustainable development of the economic system. In a market economy characterized by dynamism, the efficient management of financial and material resources acquires great importance. Effective management allows one to optimally combine their high turnover in the region and in neighboring countries with the risk of failure, to perform financial forecasting on the calculation of budget revenues and investment needs of the region, determine the sources of development of the region, taking into account external and internal factors, to improve the financial sustainability of the region, and to carry out a comprehensive restructuring of enterprises and organizations in its territory.

Cross-border regions as large stochastic systems are the unique adaptive economies self-adjusting to the market. The results of the economic analysis of the development of cross-border regions clearly indicate that the process of managing such objects should be carried out on a systematic basis. For the “cross-border region” management facilities located in a partially uncontrolled environment, the need arises to develop the methods for solving synthesis problems and analyzing the financial and inventory management system based on a probabilistic-deterministic approach. Achieving this goal involves solving the following main research objectives:

- Formalizing the functioning process of cross-border regions in the conditions of random perturbations in order to set the task of managing financial and material resources taking into account the relationship with the upper and lower levels of management. This interconnection ensures the integrity of the created control system as a whole;
- Structuring the task of managing financial and inventory resources of a cross-border region in conditions of incomplete and asymmetric awareness;
- Building a system of models, procedures, and methods for solving problems of managing financial and material resources of a cross-border region;
- Developing and researching the methodology of probabilistic-deterministic modeling of the trajectory in the development of a cross-border region. This technique allows one to make design decisions on the synthesis of a financial and inventory management system;
- Developing a universal probabilistic-deterministic modeling software system for solving the problem of managing financial and inventory resources of a region with an arbitrary structure of business units;
- Establishing a reliable retrospective information base;
- Developing the spatio-temporal trajectories of development of a transboundary region with various initial data for the purpose of sensitivity analysis and sustainability analysis.

The research result is the solution of the problem of synthesizing the management system of the financial and inventory resources of a region under random disturbances by developing decision-making procedures. The logic of these decision-making procedures follows from the decomposition of the more general (global) control problem. Based on the characteristics of the organization and methodology of the retrospective, current, and prospective economic analysis, the structure of the management part of the financial and inventory management system is presented in the form of a three-level hierarchy of tasks. This hierarchy corresponds to the tasks solved by an integrated cross-border region management system:

- The upper level (centralization) is the task of external planning (macroeconomic forecasting);
- The average level (decentralization) is the task of internal planning (mesoeconomic forecast);
- The lower level (self-government) is the task of subject-object planning (microeconomic forecasting).

4. Discussion

The theory of cooperative games and the theory of hierarchical systems had a significant influence on the development of the approaches of the authors of the article (Yu. Germeyer, V. Gorelik, M. Gorelov, A. Kononenko, N. Moiseev and others). The proposed approach to modeling structurally

complex control systems has both the commonality and continuity with the work of scientists from the Institute of Control Sciences of the Russian Academy of Sciences (V. Burkov, A. Tsvirkun, and others) and the Central Institute of Economics and Mathematics (K. Bagrinovsky, N. Dementyev, etc.). Also, this approach is common to the development of optimization methods for structurally complex systems using decomposition methods with the work of Russian and foreign scientists (J. Lesdon, R. Lyublinsky, V. Marshak, N. Oskorbin, V. Tsurkov, and others).

The most promising in solving the problem of external planning is the use of a model for analyzing inter-regional financial flows, which is proposed by V. D. Marshak in work [9]. However, an equally important part of the task of external planning is the use of models of financial and material flows of exports and imports of goods developed by us in the work [8]. The task of internal planning should be considered as a task of intersectoral interaction in the production process of a regional product, the task of subject-objective planning at the level of interaction of individual organizations and their associations. At the same time, at all planning levels, the time-space structure with streaming and accumulative interaction of elements of the regional economic system is applicable.

At present, a decline in production, and sometimes its crisis, can be observed in individual economic units in cross-border territories. We identify the following three main reasons:

- Lack or absence of the necessary for the production of material and technical resources that are abundant in the cross-border region of the neighboring state;
- Loss or insufficiency of market capacity in the state;
- Reducing the volume of working capital and investments of business entities.

All these reasons are closely linked, and their consequences are difficult to fix for any single enterprise. First of all, this is due to the lack of reliable information about the financial, resource and product markets in the cross-border regions of neighboring countries, the long passage of financial payments, the accumulation of excess production, excess material and technical reserves at enterprises. To solve these problems, not only a significant restructuring of the management system of financial and material resources of the cross-border region is required, but also there should be an adaptation of hierarchical models of decentralized management systems [10].

5. Conclusion

Our research clearly shows that the tasks of managing financial and material resources of cross-border region in conditions of in the face of uncertainty, the logic of which would follow from the decomposition of a more general (global) management problem and would be based on the methodology of the theory of hierarchical systems, were not known. Using the decomposition approach and developing stochastic models made it possible to substantiate the need and possibility of developing a special class of economic and mathematical models for studying the stability of cross-border regions and optimizing structurally complex control systems, to substantiate the boundaries of the subject area of economic and mathematical modeling, to carry out a synthesis of an integrated management system in which the options for the sustainability of a region's development are analyzed in an explicit form.

Modeling will allow not only to build a trajectory of the process of sustainable development of a cross-border region in the context of incomplete and asymmetric information. But the simulation will allow an economic analysis of the influence of structural elements and decision makers on the system as a whole and establish the cause-effect relationships. Constant changes in the cross-border regions of neighboring countries require the time-spatial monitoring of financial and material resources at the macro, meso, and micro levels. And these changes require updating the national policy in this area in accordance with the real state of economic systems. At the same time, it is necessary to both the experience of leading economists and the development of new strategies based on fundamental scientific approaches.

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