

# A boundary approach to the study of sustainability in regional development

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**Abstract.** The article substantiates the need to use the methods of economic and mathematical modeling in studies of sustainable development, both at the regional level and at the state level. The authors propose a model for determining the level of sustainability of regional development, implementing a boundary approach for calculating the sustainability corridor considered in the dynamics of key indicators.

**Keywords:** sustainability, modeling, regional development, boundary, sustainability corridor

## 1. Introduction

Achieving the goal of a confident exit to the trajectory of sustainable development, currently positioned as a priority for the regions of the Russian Federation, is a task not only critical for the current period, but also determining promising ways and development potentials of the country for many years to come. Undoubtedly, a clear definition of the criteria and conditions for the sustainable development of regions should be made with the widest possible use of the capabilities of the tools at the disposal of economic researchers.

The most important tool for analyzing the sustainability of regional development is, in our opinion, the economic and mathematical modeling of the studied processes, applied both differentially (with respect to specific objects, which in this case are the territories of the regions) and integrated (with respect to the totality of the regions as an integral system uniting the subjects economic activity within the state) [17; 18].

The methods of economic and mathematical analysis, based on the application of the mathematical apparatus that has already proved its viability, are able to give clearly justified quantitative assessments of certain aspects of the phenomenon under study, as well as the accumulated vision of the process as a whole. Note that when using in the process of analyzing real statistical data characterizing the objects under study, and applying correct models that optimally describe these objects, similar estimates can be obtained both in retrospective and prospective versions.

Our proposed model for studying the sustainability of regional development is based on the estimated establishment of the reference and threshold levels of a key parameter that describes the range, defined as a corridor of parameter values that satisfies the conditions for sustainable development.

## 2. Materials and Methods

The task of justifying the criteria and determining the quantitative parameters of sustainable development requires the use of diverse approaches and methods. Along with the basic general scientific methods of cognition, such as comparative, typological and expert approaches, comparative analysis, structural-functional and causal methods, served as the theoretical foundation of the developed approach, we used the tools of theoretical and applied research, in particular, methods of economic-mathematical and statistical modeling, factor and index analysis. To obtain practice-oriented results, real statistical data published in official directories and bulletins of the State Statistics Service of the Russian Federation were used as data for calculations according to the developed methodology.

## 3. Results

In our study on the level of sustainability of development, we rely on the attitudes that determine the sustainability of the region's development as its ability to function in conditions close to equilibrium. This state characterizes the ability of the socio-economic system of the region to preserve without deterioration the parameters of the quality of life of the population of the region not only under the conditions of a stationary process, but also with a fairly massive impact, including negative, external and internal factors, generating wide fluctuations in system performance [1].

Within the framework of this approach, it is obvious that the position of the region for which the fluctuation of the values of an indicator chosen as the key at a particular stage of the study will not go beyond a certain framework. Within that framework, the fluctuations of the indicator with a high probability will not lead to structural changes trend of the region. Given that the development is a dynamic process, the above boundaries should determine not only the width of the stability corridor, but also a change in its coordinates, which is due to a permanent change in the target value of the key indicator over time. For a positively-directed key indicator, such a change, ideally, should be reflected by an increase in the ordinate values of the boundary lines, which is associated with a growing development trend.

Depending on the goals of the analysis and the type of data used for modeling, two options are possible for determining the limits of the regional development sustainability corridor. In the first variant, a separately taken region serves as an object of study and the sustainability of its development over time is considered, that is, a comparative analysis of key development indicators relative to their previous values for the same region is conducted. In this case, the reference statistical data for the analysis are time series data. The second option involves the use of panel, or spatial, data and consists in comparing the development parameters of the totality of regions within an integrated system, for example, the state system.

Both options imply the need to determine the boundary values in the upper and lower values of the stability corridor, expressed deterministically or functionally. The functional expression is more universal; however, in our opinion, it gives less final accuracy due to limitations imposed by the very nature of the functional connections. Deterministic determinants require more calculations; therefore, they reflect, first of all, the most relevant information. Second, it can be carried out automatically, using computer technologies that do not require significant computational power and complex mathematical calculations.

We believe that the best way to determine the limits of the sustainability corridor is one that reflects not the ideal expectations of society regarding the future, but is based on the realities of the global economy. If we take into account the social component of sustainable development, then it is necessary to recognize that those regions (macro regions) in which their territories are evenly developing are the most sustainable. In fact, it implements the principle of equal opportunities for the population of different territories. Approaches of advanced development of the leading territories, growth points, etc. allow us to give impetus to the development of individual sectors of the economy in certain territories. Unfortunately, the assumptions about the subsequent "pulling up" of the rest of the territories to the level of the leading territories are not always justified. In the Russian and foreign practice, there are not rare cases when there is one or two distinct growth centers with a high level of

development and, consequently, a high quality of life, but the possibilities and, accordingly, the level of development of the rest of the area, as they are distances from the centers decrease almost in proportion to the distance.

In this regard, we suggest choosing the expected value of this parameter by area, for the case of studying the totality of territories or by region in the case of an isolated study, as a baseline orienting level setting the target value of a key indicator. It should be noted that the value of the mathematical expectation of the indicator in dynamic studies will inevitably change, reflecting in the subsequent moments of time the formed development trend. The development trend, reflecting this trend, is the subject of close attention and concern for the leaders of the region, who must ensure the correct direction of movement of the trend, taking into account the intended goals. The method of graphic verification of the admissibility of a direction is to measure the angle of inclination of the trend line.

The trend line, built on the values of the mathematical expectation of a key indicator for the period of time, performs the function of the middle axis of the stability corridor. It is obvious that the deviation of the values of the indicator of the region from this axis indicates a deviation from the trend that defines the main direction of development. Moreover, with an increase in the deviation, the probability of difficulty in returning the region to the initial state increases. In other words, an increase in deviations indicates a decrease in the sustainability of the region's development by a key indicator in the period under consideration.

Based on the statistical laws of large numbers and using the properties of the Gaussian distribution, we propose to choose the values of the standard deviation as the limits of the stability corridor. Focusing on the expected normal distribution of the main economic indicators, it can be argued that the boundaries of the corridor, which are two standard deviations up and down from the trend line, will describe about 95% of all territories of the area under consideration, in the case of using panel data. For the case of an isolated study of a region, 95% of the values of a key indicator for the analyzed period of time fall into the stability corridor. When choosing a single factor for the standard deviation, approximately 67% of observations fall into the stability corridor. However, if the boundary is determined with a factor of 3, then 99.97% of observations are in the stability corridor.

From here, the studied regions' gradation follows naturally in terms of the sustainability of their development. Expansion of the corridor for a specific indicator characterizing some aspect of the socio-economic development of the region indicates a decrease in the sustainability of the regional development trend. Conversely, narrowing the corridor is a sign of a positive development of the situation in terms of sustainability.

#### **4. Discussion**

Numerous studies on the problems of sustainable regional development, conducted by both Russian and foreign scientists, confirm the undoubted importance and relevance of this topic for the world economic community.

At the same time, the number and variety of approaches used in the definitions, methods, views, opinions, interpretations indicate not so much the incompatibility of the positions of various authors, but rather the understanding and recognition of the need for coverage and in-depth analysis of the problem from different points of view. Without arguing with the classic concept of sustainable development, adopted in 1992 by the UN at the Rio Conference [2], the scientists contribute to the development of this concept, focusing on aspects that they consider most important and affecting their priority scope of activity.

Taking into account the findings of scientists who studied in detail the cyclical nature of the economy [3], [4], numerous studies of the nature and directions of economic growth [5], [6], [7] were carried out as a necessary condition for sustainable development, which formed the basis of the work on spheres of economic activity both at the regional level [8], [9] and at the state level [10], [11]. Scientists' interest in the topic of sustainable development and their concern with solving this problem is clearly demonstrated by a large number of publications on this topic: [12], [13], [14], [15], [16] and many, many others.

Despite the difference in approaches, methods, objects and priorities of their work, researchers are unanimous in their opinion regarding the enormous importance of a full-fledged economic and mathematical analysis and modeling of global economic processes. According to numerous scientists, such an analysis is especially important in the field of research on sustainable development, the achievement of which is currently the key to the future existence of all mankind.

## 5. Conclusion

It is difficult to overestimate the importance of economic and mathematical modeling in the study of economic processes. A correct mathematical model makes it possible not only to verify and confirm the theoretical calculations of general economic situations in the best possible way, but also complements them with mathematical substantiations for the formation of a long-term plan of action.

The proposed model of the boundary definition of conditions for sustainable development implements an algorithmized criterial approach, which allows for a clear and strict gradation of territories of any taxonomic level in terms of the sustainability of their development. The universality of the model, based on economic and statistical laws and using real statistical data in calculations, allows it to be used to assess the stability of most of the most important indicators characterizing the socio-economic development of the region.

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