

Study of regional stability by amplitude-frequency method

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Abstract. Interregional integration is the most important factor in the transformation of the national model of economic development. It facilitates the transition from a resource-based economy to an economy targeted at an innovative way of development. Such transformations promote an increase of competitiveness of the Russian economy. In this regard, the assessment of the level of interregional integrational interaction is an urgent task. The development of the theory and methodology of study of interregional economic integration processes, the development of mechanisms for assessing the instrumental and functional potential of interregional integration as a driver of the socio-economic development of partner regions for its improvement make it possible to replenish missing items in investigating the subject area under consideration. The new scientific results obtained in the paper on determining the indicators of interregional economic integration, characterizing the amplitudes of fluctuations in the value of the average per capita income in the regions of the Southern Federal District, develop a methodology for analyzing and forecasting the behavior of complex socio-economic systems and can act as a conceptual basis for creating a modernized instrumental and methodological apparatus for quantitative assessment, further formalized presentation and modeling of interregional interaction and substantiation of development directions and increasing the efficiency of interregional economic integration processes.

1 Introduction

The relevance of determining new directions for increasing the efficiency of reproduction processes is subject to the trends of contemporary economic development. The study of priorities, integration trends, regularities of economic dynamics of regions presupposes generation of a unified concept for the development of the national and regional economy including also interregional integration.

Investigations of the regularities of interregional integration are based, to a great extent, on the allocation theory. They are differentiated into static and dynamic. Spatial allocation theories are stipulated by international trends in the economy development, and, first of all,

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by expansion of the scope of international trade. The representative of this conceptual idea is the Heckscher-Ohlin theory.

Interregional integration, causing changes in the economic state of the country, results in transformation of its economic system. The study of the system of interregional economic integration in the form of trade economic ties allows us to determine the hidden resources of the economic system, and to identify the anticipated directions of the process of strengthening economic interdependencies between regions.

Interregional integration is based on the interrelation of the economies of the partner regions, on the unity of their economic and social interests. The establishment of federal administrative districts, covering a set of regions, connected by the community of various interests, reflects a territorial format of integration.

The advantage of the integration resource, as well as its relevance, is associated with the possibility of providing promising mechanisms of economic development taking into account exhaustion of natural resources and the specific nature of each region.

Improving the efficiency of functioning of the interregional innovation cluster, formed on the basis of investment potential, and ensuring economic growth can be achieved through the use of modernized tooling for assessing integration ties. The availability of a cumulative effect, stipulated by interregional integration ensures intensive development of the regional and national economy.

Thus, interregional integration is an economic integration of regions in a transregional spatial format. Developed interregional integration constitutes an operational base of the common economic space of the country. In addition, a high economic potential of interregional integration is performed on the basis of a consistent policy of the state.

Of the integration process of regional economic systems, based on the mutual interest of their economic entities in the joint implementation of the projects of interregional economic cooperation, as well as identifying the heuristic potential of the apparatus of economic, mathematical, and cognitive modeling, statistical analysis, including correlation-regression and index methods of investigation.

Some aspects of the market theory of international and interregional trade and economic relations, as well as the logistics principles of managing trade flows, are considered in the papers of L. Abalkin, A. Adamesku, R. Balloy, A. Vilensky, A. Granberg, E. Kolodina, V. Leontyev, A. Lesh, N. Nekrasov, B. Olin, B. Porter, D. Ricardo, P. Samuelson, A. Smith, E. Heckscher, R. Shapiro et al.

The main (strategic) goals of the integration process are both providing employment and increasing the standard and quality of life.

Achievement of integration goals is possible on the basis of solving the following tasks:

- enhancement of labor division in various sectoral and inter-sectoral structures, resulting in formation of specialized links of the production chain and stipulating the necessity of their integration;
- extension of internal and external economic ties, effective use of production factors on the basis of a single coordination center;
- ensuring the unity of formative processes: specialization, cooperation, and combination of production which form the operational base of integration;
- laying the groundwork which promotes entrepreneurial activity due to raising external sources of investment;
- increase of production efficiency due to the process of integration;
- formation of integration, investment-attractive territorial and economic structures.

Integration promotes the process of economy intensification, encouraging innovation and investment processes, results in the growth of competitiveness and efficiency of the economy [1-11].

Analysis of the papers on the problem of interregional economic integration makes it possible to identify of methodological approaches to the investigation of the role of integration processes in the formation of interregional socio-economic systems [12-18].

But such analysis indicates that currently there is not a single theoretical concept capable of integrating various methodological approaches into a joint holistic system of knowledge. This specifies limitation of the possibility of using effective methods of practical action supported by reasonable investigations and developments within the framework of the existing paradigm. The lack of unity of methodology leads to impossibility of implementing harmonious, logically consistent actions of a practical nature.

The necessity for the development of effective tooling, capable of analyzing interaction of economic entities in a trans-regional format, is the main task in this area. Let us briefly consider approaches and methods that are supposed to be used in our study.

Approach to the study of the stability of SES based on the analysis of the amplitudes of fluctuations of indicators is an unconventional and promising approach to the study of interregional interaction.

Functioning of socio-economic systems (SES) is characterized by dynamism in its development. In addition, equilibrium and nonequilibrium states of the system are distinguished. The development of the system is stipulated by the transition of the SES to a nonequilibrium state (loss of its stability). At the same time, high-amplitude fluctuations characterizing the loss of stability, in practice, cause dislocation of dynamic balance of the SES, and, ultimately, result in the system breakdown.

The peculiarities of the dynamic development of the SES in recent years and the specific character of the Russian economic reform have created prerequisites for developing statistical indicators and indicators on the basis of which it is possible to determine the boundaries of stability/instability of the SES functioning.

Taking into account the world practice of using comparative assessments of the development level of different kinds of SES (country, geographical region etc.) as an indicator of determining the boundaries of sustainability, we consider the amplitude of fluctuations in the indicators of social-economic development of the region, in particular, the amplitude of fluctuations of income value per capita [19].

2 Methods

For a quantitative assessment of the mentioned indicator, widely known indicators of variation are used [18]. It is proposed to determine this indicator "as a mean-square deviation in terms of GDP per capita, as well as a relative deviation from the expected value in terms of GDP indicators per capita.

$$A = \sqrt{\frac{\sum(x_i - \bar{x})^2}{N}}, A = \frac{\sum\left|\left(\frac{x_i}{\bar{x}} - 1\right) \times 100\right|}{N} \quad (1)$$

where A is the value of the variability amplitude of the SES under study; x_i is the mathematical expectation of the average per capita GRP for the i -th subsystem, $i = \overline{1, N}$; \bar{x} is the mathematical expectation of the value for GDP (GRP); N is the number of subsystems at the specific hierarchical level" [19].

The stabilization of the dynamic development of the regions, the identification of risks of emerging crisis states in the system, the quick reaction of the SES to the worked-out

managerial decisions are stipulated by identifying, at earlier stages, the fact of instability of the elements of the socio-economic systems under consideration.

Possible variants of the development of events can be characterized by the stages of surge, recovery, crisis, and regression.

Within the framework of this investigation, we have adapted the amplitude-frequency approach based on the method and consisting in determining the boundaries of stability based on the analysis of amplitudes of fluctuations in the indicators of the socio-economic development of the region, making it possible to carry on the monitoring of the dynamics of changes in indicators (fig.1).

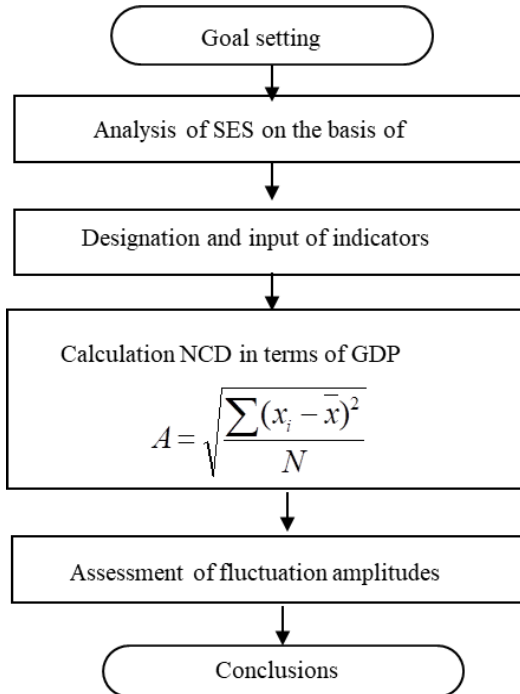


Fig. 1. Generalized diagram for calculating fluctuation amplitudes of the indicators of the socio-economic development of the regions of the Southern Federal District.

The assessment of the amplitude of fluctuations was performed with the help of: mean square deviation (MSD) in terms of the indicator of GDP per capita, as well as standard deviation from the mathematical expectation in terms of the indicators of GDP per capita.

The assessment of possibilities for the development of interregional interaction can be carried out on the basis of the deviation of this indicator (GRP) from the mathematical expectation for the Southern Federal District, and from the trend of the indicator for an individual participant in the integration process (partner region).

The paper [19] presents the assessments of boundaries of fluctuation amplitudes for the levels of the indicator under consideration, associated with different degrees of efficiency of economic interaction: high 19-24%, weak 25-44%, and its absence at 46-51%.

3 Results

The Southern Federal District as a large socio-economic system includes: Rostov Region,

Krasnodar Territory, Astrakhan and Volgograd Regions, Adygea and the Republic of Kalmykia.

It was previously found that interregional integration is based on economic interest and is regulated by the system of socio-economic regularities and legal rules. Any interregional relationships are implemented through various kinds of activities in the following spheres: innovation, investment, information, resource, energy, production and technological cooperation, scientific and technological cooperation, financial interaction, interchange of natural and labor resources.

Table 1. Statistical data of the time series of the gross regional product (GRP).

GRP	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Rostov region	104	134	129	154	179	198	215	235	280	303	318
Republic of Adygea	66.3	82.3	94.4	107	128	147	159	174	187	199	219
Republic of Kalmykia	58.9	71.4	82,5	84.3	101	125	145	163	185	220	240
Krasnodar Territory	125	155	165	196	236	275	309	330	352	374	398
Astrakhan region	100	146	133	143	170	206	269	283	316	340	414
Volgograd region	126	159	144	166	195	220	235	278	290	293	305
Average	96	124	124	142	168	195	222	244	268	288	316
amplitudes											
Rostov region and Krasnodar Territory	18	15	18	23	23	20	18	15	17	17	13
Rostov region and Republic of Kalmykia	15	17	15	16	16	17	18	18	13	9	11
Rostov region and Republic of Adygea	11.8	13.2	10.3	79.	8.7	11.7	15.7	16.1	12.9	12.9	14.8
Rostov region and Astrakhan region	5.4	12.4	5.1	4.7	3.6	3.4	9.1	6.2	10.9	11.4	15.9
Rostov region and Volgograd region	19.1	17.5	9.6	12.7	11.1	7.1	1.4	5.3	6.1	3.4	1.3
Total foSouthern Federal District	23.6	25.5	19.4	21.6	21.1	20.1	22.1	21.7	20.4	18.1	19.34

Therefore, the process of economic unification of regional entities on the basis of improvement of deep, stable, and permanent interrelationships and further development of the social division of labor lays behind the understanding of the subject content of the category of economic integration. The processes of specialization and cooperation as an objective regularity of economic development result in further deepening of social division of labor and forming relationships of competitive interaction and business partnership.

The capability of involving natural resources of other regions in the economic process in the absence of their own resource potential is being implemented. In addition, optimal redistribution of all kinds of resource potential takes place, and this creates an opportunity

for developing interregional structures and strengthening the competitive positions of all entities.

To solve the assigned task, we carried out calculations for the amplitudes of fluctuations of GRP of the socio-economic development of the regions of the Southern Federal District with the view to detect changes in the gross regional product (GRP) per capita, moreover, the data of official statistics for 2009 – 2018 were used in the calculations (table 1 and fig. 2).

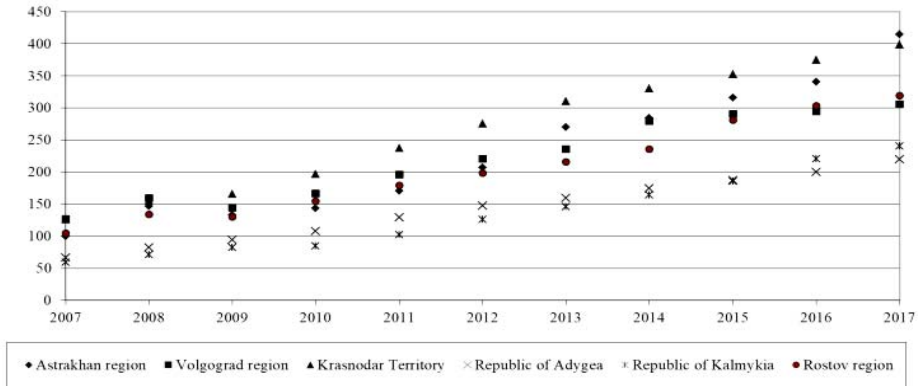


Fig. 2. Time series of changes in the gross regional product by regions of the Southern Federal District.

The calculated data of the fluctuation amplitudes for Rostov Region are shown in fig. 3.

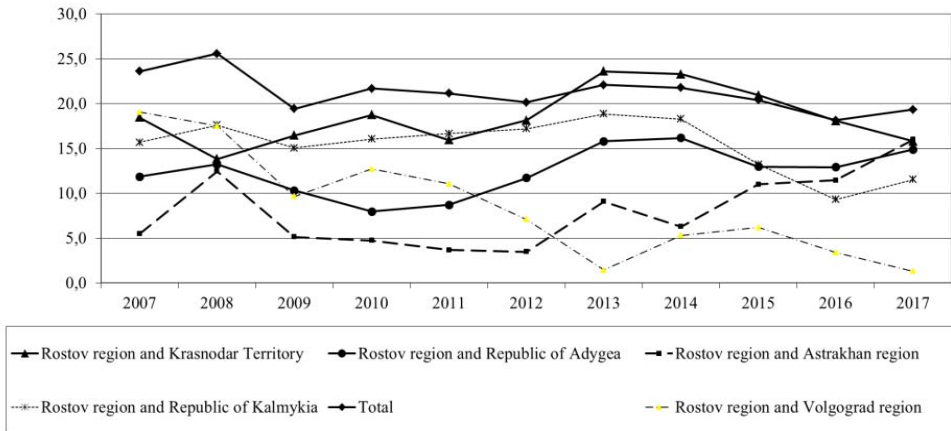


Fig. 3. Calculated data of the amplitudes of fluctuations.

Fig. 3 shows that the peak-to-peak amplitude in the regions of the Southern Federal District is in the range from 5 to 20%.

Differences in the levels of economic development of the integrated regions stipulates the value of peak-to-peak amplitude [19, 20].

Therefore, for the partner entities of the Rostov Region, the value of the amplitude of

fluctuations in GRP is 7 – 18%, and as a whole, it is less than the value of the amplitude in the Southern Federal District (about 26%).

Table 2. Peak-to-peak values of the amplitudes.

region	Krasnodar Territory	Volgograd region	Astrakhan region	Republic of Adygea	Republic of Kalmykia
amplitudes, %	17	19	15	16	18

Table 3 presents comparative data on the growth of GRP per capita region-wise from 2007 to 2017.

Table 3. Growth of the gross regional product by regions of the Southern Federal District.

region	Krasnodar Territory	Volgograd region	Astrakhan region	Republic of Adygea	Republic of Kalmykia	Rostov region
Growth of the gross regional product	3.2	2.4	4.4	3.3	4.1	3.1

Based on the data, shown in tables 2 and 3, we can note that the efficiency of integration of the Rostov region with the entities of the Southern Federal District is rather high (amplitude fluctuations vary from 20 to 22%).

Interregional socio-economic cooperation in the form of interregional commodity turnover is one of the regulators of integration rapprochement of economic entities.

Therefore, the proposed calculations of the amplitudes of fluctuations in the GRP of the region are one of the effective non-traditional approaches to the solution of the problem of detecting prerequisites of the process of interregional integration in the South of Russia, taking into account one of the most important factors – the value of per capita income, but it requires its further development, providing for the multiplicity of other aspects. Previously it was found that for a correct analysis of the interregional integration process it was necessary to take into account the set of multiple factors, including those, connected with the level of the available production and transport-logistics base and the level of the developed ties between regions which are the support infrastructure and service modules and the foundation of integration cooperation.

4 Conclusion

Based on the results of theoretical studies it has been revealed that interregional integration is the process of complementarity, interpenetration, merger of reproduction processes and a combination of economic interests of the entities of regional economies in the format of transregional economic space; it is the formation of the entire system of integration ties between regions, subject to the development regularities of any system-forming entity that reflects the depth of interrelations between the elements of the unified economic system. It has been found that interregional integration features the duality of its economic nature – it can be the factor of resource and process – a driver of socio-economic development of partner regions.

The directions of the factors of interregional interaction have been identified in the form of:

- strengthening the economic ties of the regions; - use of integration potential of social division of labor; - reduction in social differentiation of the regions; - strengthening of institutional ties; - sharing the infrastructure of a partnership; - creation and functioning of a highly developed infrastructure of the mainstream level.
- Acting as a driver-resource, interregional economic integration is a factor of economic development. The availability of participation in the process of integration makes it possible to become an inexhaustible source of development of regional economies. It is an indispensable evolutionary, anthropogenic resource that all the economy entities possess and which can be used for effective achievement of the state of integration of the trans-regional economic space.

It has been identified that the dynamics of distribution of resources, goods and services under the conditions of interregional integration increases in the case when the structure of meta-region incorporates regions with different resource potential, and in their interaction, there appears a synergetic and cumulative effect of an impulse for the economic development of the regions.

As a result of the investigations, the indicators of interregional economic integration of the regions of the Southern Federal District have been determined, and the results obtained are elements of the instrumental and methodical apparatus as a set of various methods and approaches for assessing the level of interregional economic integration, making it possible in the future to implement on its basis a cognitive modeling for the development of a knowledge base of the intelligent management decision support system, promoting increase in the efficiency of interregional economic integration.

The new scientific results, delivered in the paper, develop the methodology for analyzing and forecasting the behavior of complex economic systems and can act as a conceptual basis for substantiating development directions and increasing the efficiency of the processes of interregional economic integration.

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