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Macroregional Modifications of the Spatial Structure of GRP in the Context of Newly Industrialized Economy

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***Abstract* - The development of national economies relates to modifications of the spatial structure of macroeconomic indicators, including gross value added. The article defines macroregional trends in the structure of gross regional product (GRP), evaluates the structural changes of Russian economy in various macroregions. This study first describes concentration levels and statistical evaluation of the spatial structure in the period from 1998 to 2016. The authors reveal the main differences in the macroregional structure of GRP in different periods of Russian economy. The article presents a medium-term forecast of the spatial structure of GRP in Russian economy considering new industrial possibilities of individual regions. The research explores how the current economic zoning correlates with the spatial structure of economy. The authors formulate practical recommendations for potential changes of economic zoning in the country's strategic planning.**

Keywords – spatial structure; spatial changes; economic regions; strategic planning; GRP; newly industrialized economy

I. INTRODUCTION

During economic development spatial changes of the national economies, modification of the spatial structure of macroeconomic indicators occur. Macroeconomic development is always combined with structural changes in gross domestic product (GRP), investment, industrial production, and other macroeconomic indicators in various economic zones. Therefore, various processes, such as concentration, reallocation, spatial differentiation of factors of production, economic activity and capital take place.

An analysis of the spatial structures of macroeconomic indicators is essential to carry out positive and normative research. Evaluation, description, modeling of the spatial structure of macroeconomic indicators are significant to explain spatial development. These methods also provide relevant information to predict regional economic proportions. Examination of macroeconomic structures and spatial objects proportions gains practical importance to allocate economic regions for public administration purposes.

The national economy of Russia is one of the unique testing ranges to study spatial changes and modification of spatial structures. This is due to a high economic asymmetry of the regions and a considerable length of the country. In the period from 1992 to 2016 there were profound changes in the spatial structure of macroeconomic indicators in Russia. It requires scientific reflection, the development of entire theoretical concepts.

However, current studies of Russian economy relate mainly to a qualitative, descriptive representation of spatial changes. The results of spatial changes, spatial economic structures of foreign countries have a limited value due to the specific character of the Russian economic model. Therefore, further research of the spatial structure of Russian economy is demanded.

New industrialization demands an additional scientific research to identify regularities of spatial development, at least for two reasons. Firstly, the increasing importance of economic regions may indicate successful practical aspects of new industrialization and need to be replicated. Secondly, the processes of new industrialization are one of key factors for a rational use of the economic space, the development of progressive spatial structures.

This article aims to determine the main modifications of the spatial structure of GRP in Russian economy, as well as to evaluate its compliance with the taxonomic grid of the current macroregions.

II. LITERATURE REVIEW

In Russian economic studies significant ideas have been formulated to analyze spatial changes and spatial structures. P.A. Minakir, A.N. Demyanenko state modern national economies are systems of large interacting economic regions. Therefore, there is a need for a proportional

distribution of resources between macroregional systems to maintain economic equilibrium [1]. Consequently, we need to evaluate modifications of the spatial structure of economy in terms of economic equilibrium and a balanced territorial distribution of economic activity. It is also vital that the quality of space is subject to control [2]. This idea indicates the need to regulate the spatial changes from public administration and develop relevant strategic planning documents.

Researchers of the Ural Scientific School of Regional Economy define the main components of the spatial structure modification in macroregions. To wit, when examine the economy of the Ural macroregion, Ya.P. Silin, E.G. Animitsa, N.V. Novikova use the following variables: shares in total GRP, shipped industrial products, investments, innovation costs, average annual number of employed as well as the import structure, the share of people employed in the manufacturing [3]. This allows us to consider the macroregional structure of GRP and other macroeconomic indicators as a key indicator of spatial changes.

Additionally, E.G. Animitsa reveals the spatial structure modifications of the Ural economic region taking into account the index of structural changes calculated by A. Salai. This provides us with important data on the concentration of economic activity in the largest cities (Yekaterinburg, Chelyabinsk, Perm and Ufa) due to re-industrialization [4]. Thus, it is appropriate to examine modification of the spatial structure of GRP, industrial production, investment with the coefficients of structural changes.

E.V. Dvoryadkina and others, when investigating the regulation of spatial development, propose to evaluate modifications of spatial structures considering the Herfindahl-Hirschman index, as well as the coefficient of central-peripheral differences introduced by A.N. Bufetova [5, 6]. This enables us to calculate the numerical characteristics of polarization, space concentration. Particularly, it is stated that the gap between the central and peripheral areas of the Sverdlovsk region decreases under the economic fall and increases under the economic growth [6].

In world economy one of the first evaluations of the correlation between spatial structure and economic growth was obtained by J.B. Parr [7]. He revealed the hierarchical spatial systems and the dependence of area growth around megaregions on the dynamics of the megaregion itself. Subnational proportions of economic growth and human development are presented in the study by M. Kummu and others. [8]. It emphasizes that such countries as Brazil, China, India, Russia, and the United States require such evaluation methods as grid lines and heat maps, due to their deep subnational differences.

A possibility to achieve spatial structure equilibrium under the economic growth is considered by M. Fujitaa, N. Hamaguchi. They reveal there are stable monocentric configurations subject to low transaction costs. Along with it, small cities specialize in production of intermediate goods, while large ones specialize in final output production [9]. Similar trends are found in the papers of M. Berliant, H. Watanabe [10].

According to R.W. Helsley, W.C. Strange, centers and poles of growth, to which economic agents tend to interact with other agents, are more dependent on transport accessibility than domestic infrastructure. Consequently, a positive effect of spatial concentration finds its place under transport subsidies to increase availability of cities [11]. E. Glaeser, J. Gottlieb state a direct correlation between the growth rates of city's economy and its size [12]. Similar studies use Zipf's law, showing the distribution of cities by population in relation to their place in the national economy [13, 14].

Thus, the main part of research is focused on the examination of the urban structure of the economy, development of large industrial centers, metropolitan agglomerations, and develops the theory of "central places" in the national economy. Consequently, there is a scientific and practical demand for a deeper research of macroregional proportions of the GRP in spatially extended heterogeneous countries, such as Russia.

III. RESEARCH METHODS

Research data are obtained from official statistics of the Russian Federal State Statistics Service (Rosstat) which is a public authority on statistics. The study used data on the market value of GRP for the Russian macroregions (federal districts). The study covers the period from 1998 to 2016. This is the longest available data series of 8 federal districts. GRP is chosen as a key indicator of economic development, comparing economic regions. Gross domestic product is less suitable for this purpose, as it does not coincide with the sum of GRPs of the whole range of regions. To ensure the comparability of long time series we excluded data of the Republic of Crimea and Sevastopol, which became part of Russia in 2014, from the indicators of 2014-2016.

We used the method of structural analysis, measures of variability for grouped population and for structural heterogeneous population according to A. Salai, a comparative structural analysis, and concentration analysis. To predict spatial structure modification of GRP in Russian macroregions, we applied the moving average method to smooth the time series with the subsequent selection of the approximating curve for substantive reasons and with use of the least squares method.

IV. RESULTS

Tables 1-2 provide initial research data which are the structure of Russian GRP by macroregions.

TABLE I. STRUCTURE OF RUSSIAN GRP IN FEDERAL FEDERAL DISTRICTS, 1998-2007, PARTS PER UNIT

	1998	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***
Central	*0.28*	*0.31*	*0.32*	*0.31*	*0.33*	*0.33*	*0.33*	*0.35*	*0.35*	*0.37*
Northwester	*0.11*	*0.11*	*0.10*	*0.10*	*0.10*	*0.10*	*0.11*	*0.10*	*0.10*	*0.10*

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Southern	*0.06*	*0.06*	*0.06*	*0.06*	*0.06*	*0.06*	*0.05*	*0.05*	*0.05*	*0.06*
North Caucasus	*0.02*	*0.02*	*0.02*	*0.02*	*0.02*	*0.02*	*0.02*	*0.02*	*0.02*	*0.02*
Volga	*0.19*	*0.18*	*0.18*	*0.18*	*0.17*	*0.17*	*0.16*	*0.16*	*0.16*	*0.15*
The Urals	*0.14*	*0.14*	*0.15*	*0.16*	*0.15*	*0.15*	*0.16*	*0.17*	*0.16*	*0.15*
Siberian	*0.13*	*0.12*	*0.11*	*0.12*	*0.11*	*0.11*	*0.12*	*0.11*	*0.11*	*0.11*
Far Eastern	*0.06*	*0.06*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.04*	*0.05*

Source: Russian Federal State Statistics Service

TABLE II. STRUCTURE OF RUSSIAN GRP IN FEDERAL DISTRICTS, 1998-2007, PARTS PER UNIT

	2008	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***Increment***
Central	*0.37*	*0.36*	*0.36*	*0.35*	*0.35*	*0.35*	*0.35*	*0.35*	*0.35*	*0.07*
Northwestern	*0.10*	*0.11*	*0.10*	*0.11*	*0.11*	*0.10*	*0.10*	*0.11*	*0.11*	*0.00*
Southern	*0.06*	*0.06*	*0.06*	*0.06*	*0.06*	*0.07*	*0.07*	*0.07*	*0.07*	*0.01*
North Caucasus	*0.02*	*0.02*	*0.02*	*0.02*	*0.02*	*0.03*	*0.03*	*0.03*	*0.03*	*0.01*
Volga	*0.16*	*0.15*	*0.15*	*0.16*	*0.16*	*0.16*	*0.16*	*0.15*	*0.15*	*-0.04*
The Urals	*0.14*	*0.14*	*0.14*	*0.14*	*0.14*	*0.14*	*0.14*	*0.14*	*0.14*	*0.00*
Siberian	*0.10*	*0.11*	*0.11*	*0.11*	*0.10*	*0.10*	*0.10*	*0.10*	*0.10*	*-0.03*
Far Eastern	*0.05*	*0.05*	*0.06*	*0.06*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*-0.01*

Source: Russian Federal State Statistics Service

Tables 1-2 show that from 1998 to 2016 there was a modification of the spatial structure of Russian GRP in macro-regions. The share of the Central, Southern and North Caucasus federal districts increased. The spatial significance of the Volga, Siberian and Far Eastern federal districts decreased. We calculated measures of variability to evaluate the significance of deviation, its changes over time. To evaluate spatial concentration changes of gross output, we calculated the Herfindahl-Hirschman index. These indicators are presented in table 3.

TABLE III. INDICATORS OF CONCENTRATION AND VARIATION OF GRP OF THE FEDERAL FEDERAL FEDERAL DISTRICTS OF RUSSIA, 1998-2016

	Range of variation	***Median***	***Dispersion***	***Mean deviation***	***Excess***	***The coefficient of variation***	***Herfindahl – Hirschman index***
1998	*0,26*	*0,13*	*0,01*	*0,10*	*0,63*	*0,67*	*0,1707*
1999	*0,29*	*0,12*	*0,01*	*0,10*	*1,97*	*0,72*	*0,1800*
2000	*0,30*	*0,11*	*0,01*	*0,10*	*2,02*	*0,77*	*0,1900*
2001	*0,29*	*0,12*	*0,01*	*0,10*	*1,42*	*0,74*	*0,1900*
2002	*0,31*	*0,11*	*0,01*	*0,10*	*2,64*	*0,79*	*0,1900*
2003	*0,31*	*0,11*	*0,01*	*0,10*	*2,64*	*0,79*	*0,1900*
2004	*0,31*	*0,12*	*0,01*	*0,10*	*2,41*	*0,78*	*0,1900*
2005	*0,33*	*0,11*	*0,01*	*0,10*	*2,77*	*0,83*	*0,2045*
2006	*0,33*	*0,11*	*0,01*	*0,10*	*2,93*	*0,85*	*0,2003*
2007	*0,35*	*0,11*	*0,01*	*0,10*	*4,15*	*0,86*	*0,2105*
2008	*0,35*	*0,10*	*0,01*	*0,10*	*4,18*	*0,87*	*0,2086*
2009	*0,34*	*0,11*	*0,01*	*0,10*	*4,13*	*0,84*	*0,2024*
2010	*0,34*	*0,11*	*0,01*	*0,10*	*4,33*	*0,84*	*0,2014*
2011	*0,33*	*0,11*	*0,01*	*0,10*	*3,77*	*0,80*	*0,1995*
2012	*0,33*	*0,11*	*0,01*	*0,10*	*3,69*	*0,83*	*0,1963*
2013	*0,32*	*0,10*	*0,01*	*0,10*	*4,06*	*0,81*	*0,1960*
2014	*0,32*	*0,10*	*0,01*	*0,10*	*4,06*	*0,81*	*0,1960*
2015	*0,32*	*0,11*	*0,01*	*0,10*	*4,31*	*0,80*	*0,1950*
2016	*0,32*	*0,11*	*0,01*	*0,10*	*4,31*	*0,80*	*0,1950*

To test a hypothesis of concentration on the Herfindahl – Hirschman index, we calculated Student's *t*-distribution under the null hypothesis. Sampling error (1) was defined:

$$m_p = \frac{\sqrt{k(1-k)}}{\sqrt{n}}, \qquad (1)$$

Where k is an indicator of concentration, n is the number of degrees of freedom for the given population.

The Student's *t*-distribution under the null hypothesis (lack of concentration of GRP between federal districts) is 1.5 in 2016, which is slightly lower than the tabular value for 9 degrees of freedom (which is 2.2622).

We evaluated significance of deviation in structures using the composite index of structural changes introduced by A. Salai I_S (2):

$$I_S = \sqrt{\frac{\sum_{i=1}^{n}\left(\frac{w_i^1 - w_i^0}{w_i^1 + w_i^0}\right)^2}{k}}, \qquad (2)$$

Where w^0 is the proportion of the i-th unit of the aggregate at the base period; w^1 is the proportion of the i-th unit of the aggregate at the reporting period, k is the number of units in the aggregate.

Calculations of the Salai index carried out according to Tables 1-2 show that its value for 1998 and 2016 was 0.11. For changes for the period 1998-2007 and 2007-2016 this ratio was 0.08 and 0.09, respectively.

Prediction of GRP structure in macroregions by selecting the appropriate form of the trend equations led to the selection of the second-order polynomials (parabolas) to calculate promising values for the federal districts with the greatest variation. The predicted results are presented in Figure 1.

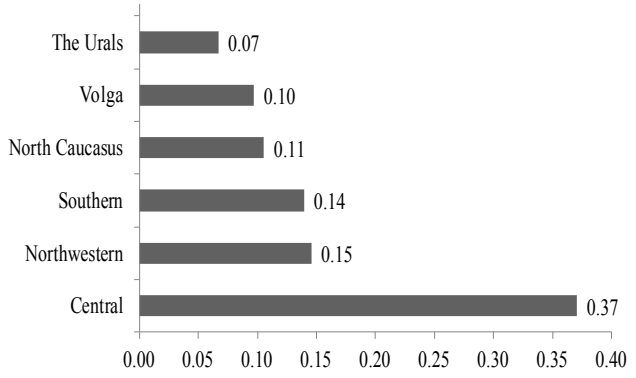

Fig. 1. Forecast of GRP spatial structure in federal districts of the Russian Federation for 2019.

The obtained results reflect spatial structure modification of GRP in macroregions of Russia during 1998-2016. These results allow to expand a scientific belief of the spatial structure of Russian economy, as well as to validate the practical recommendations concerning more reasonable taxonomy of economic regions.

V. DISCUSSION

The analysis of spatial proportions of macroregions showed they are highly constant. Therefore, Russian GRP could not have been highly redistributed for 18 years. But the structural shift in favor of the Central and Southern federal districts due to the Siberian and Far Eastern, as well as the Volga federal districts, is clearly visible. The share of the Central federal district in the structure of the Russian GRP increased from 28% to 35%, which indicates the concentration of economic activity in the central regions, particularly, Moscow and the Moscow region.

We can reveal a growth trend of the North Caucasus and Southern federal districts in the total GRP of the country (1% of each district during the analyzed period). This contrasts with the widely accepted belief that the spatial significance of Southern regions is decreasing. The share of these federal districts in the GRP remains small. But there is a shift in economic activity not only in the Central, but also in the Southern districts.

Therefore, the spatial redistribution of Russian GRP can be explained due to leaning of factors of production, economic activity to more developed central regions. There is a movement of resources from the periphery to the center. The rise of the North Caucasus and the Southern federal districts in the national economy relates to development of a large attractive Krasnodar agglomeration, agriculture development in the context of conflicts due to sanctions, the accelerator effect concerning public spending during the Olympic Games in Sochi, Crimean bridge construction, implementation of Sochi development projects as a mountain resort.

It should be noted the spatial modifications of GRP structure were not connected with industrial development or new industrialization, but with the development of the transactional sector (the Central federal district) or agriculture, construction (the North Caucasus, the Southern federal district). Thus, the potential of new industrialization is used insufficiently to increase the spatial significance of economic regions. Industrial areas and centers are gradually losing ground. It is illustrated mainly by the Volga federal district and by the Siberian federal district but to a lesser degree.

The share of the Volga federal district in the structure of Russian GRP declined to the maximum (by 4%). It is important that industrial production (engineering, chemical, petrochemical industry) predominates in the economic structure of this region. However, it does not develop dynamically enough. A chance of value-added chains development is not realized. The technical and technological levels of production, its economic efficiency give way to better world economies. Moreover, the Volga federal district is characterized by a negative migration balance. Human capital moves to the Central and Southern regions of the country.

Similar trends were inherent to the Siberian federal district. Its share of the Russian GRP fell by 3%. This is caused by both lag of growth rates of the manufacturing sector behind the national economy dynamics, and by the problems of the extractive industries (fluctuations of world prices, demand constraints, transportation and logistics problems). The Siberian federal district keeps losing human capital in favor of the Central and Southern districts of the country.

The share of the Far Eastern federal district in Russian GRP of the country decreased by 1%. This macroregion experienced capital outflow to the Central regions of the country. However, the main reason for GRP decline of the whole federal district is depopulation and migration outflow. In the period from 1998 to 2016 population of the Far Eastern federal district decreased by 940 thousand people or by 13.2%. Even significant value added in the extractive industries cannot compensate human capital loss.

The Northwestern and Urals federal districts retained their positions in GRP spatial distribution. A stable position of the Northwest federal district is achieved due to the St. Petersburg agglomeration and developed extractive industries. In the Urals federal district, significant fluctuations were observed in some years. So, in 2005, the share of this region in Russian GRP reached 17%. But in 2008-2016 it returned to the level of 1998 (about 14%). We explain these fluctuations by the instability of the oil and gas sector of the Tyumen region, insufficient development potential of the processing industries of the Sverdlovsk and Chelyabinsk regions.

Therefore, for the period of 1998-2016 the modification of the spatial structure of Russian GRP took a centripetal character. The spatial significance of the central and southern regions increased. The concentration level of economic activity and factors of production increased in the most attractive districts. The spatial significance of the peripheral districts of Siberia and the Far East, as well as the Volga federal district, decreased due to the insufficient dynamics of the manufacturing industries. The spatial

structure modifications of the economy were related to migratory population movements.

Apparently, the most attractive Central and Southern districts experienced an inflow of human and financial capital from all other Russian districts. Moreover, we suppose the Ural and Northwestern federal districts could maintain profile due to two parallel processes. On one hand, they lost human and financial capital in favor of the Central and Southern districts. On the other hand, they managed to attract part of the capital from the federal districts with an absolute outflow of production factors. Thus, a model of spatial changes of the Russian economy has developed in two directions:

1) Movement of factors of production, capital, economic activity from all other districts to the Central and Southern ones;

2) Movement of factors of production, capital, economic activity from the peripheral Siberia, the Far East districts to other areas.

It should be noted that there is no significant correlation between the spatial structure of the gross domestic product and the phase of the economic cycle in Russia. In 2009, there was a slight decrease in the share of the Central federal district under the maximum decline of Russian macroeconomic indicators. The shares of the North-West and Siberian federal districts grew. These modifications can be explained by the fact that postindustrial types of economic activity are more subject to crisis than extractive industries.

The Russian model of spatial changes cannot be evaluated unambiguously. On one hand, concentration of resources in the central districts and in the areas with more favorable conditions is expected to be a natural process. In the central economic zones there is usually a higher return of capital, factors of production are used with the greatest effect for the national economic growth. On the other hand, an excessive heterogeneity of economic space is formed. The area of economic activity shrinks. There are risky spatial imbalances.

According to the forecast obtained in the study, the Central federal district is going to account for more than 37% of GRP of the country already in 2019. In 4 federal districts out of 8 less than 10% of GRP is going to be produced. An excessive size of one central economic region leads not only to a relative, but an absolute economic slowdown of the rest.

Properties of variations in GRP structure show the economic growth of 1998-2008 was accompanied by interregional differentiation. The range of variability increased from 0.26 to 0.35, and the coefficient of variation rose from 67% to 87%. This is an extremely high value. In the period of 2009-2016 the values of these indicators decreased slightly but remained significant. In addition, the standard deviation of the indicator showing a share of the federal district in Russian GRP was about 10% during the whole period. The variation of GRP in all Russian federal districts remains high.

However, the spatial concentration of gross output declined slightly in 2009-2016. This can be seen from the Herfindahl – Hirschman index fall. The main reason is a slowdown of post-industrial economic activities that are sensitive to economic conditions. They take leading positions in the economy of the Central federal district. Along with it, we can see a gradual correction of the federal district shares with extracting industries predomination. But these trends do not take a determinative character.

In the reporting period there is a stable median of about 10-13%. This value is close to the arithmetic mean. Hence, the distribution of federal districts by share in GRP is normal (Gauss distribution). There are classic large economic areas, which account for 10-15% of GRP. This share (10-15%) corresponds to the accepted proportions of allocation of 7-12 economic regions with a similar share in macroeconomic indicators.

In Russia, such areas include the Northwest, Volga, Urals, Siberian districts and the Southern district with some doubt. The central federal district is too large to be considered as a single economic region of the country. The North Caucasus and the Far East districts, on the contrary, are too small. Such allocation of macroregions can be justified for the purposes of political or social management; however, it does not correspond to objective economic laws. Therefore, when designing a new perspective grid of Russian economic regions, the requirement of proportionality must be considered.

VI. CONCLUSIONS

Spatial structure of the total Russian GRP in federal districts changed in 1998-2016. The spatial concentration of economic activity in the Central, Southern and North Caucasus federal districts increased. The shares of the Volga, Siberian and Far Eastern federal districts decreased significantly. This is due to the lag of the manufacturing industries from macroeconomic development, capital movement to the most attractive areas, intensification of attracting resources from the periphery to the center. An essential factor in weakening character of industrial regions is the insufficient technical level of manufacturing companies, which requires a new industrialization.

The concentration level of GRP in the macroregions is average. Increased concentration occurred in 1998–2008. In 2009-2016 post-industrial economic activities gave way to extractive industries in growth rate. This reduced a little the concentration of gross output in the Central federal district in favor of the Siberian and North-Western federal districts.

The current system of federal districts is suitable for forecasting and regulating the national economy to a limited extent. The share of some federal districts in Russian GRP differ in 10-12 times. Consequently, when developing strategic planning documents for economic zoning, it is necessary to change the configuration of large economic regions of Russia. The main criterion for this is a proportional contribution to macroeconomic indicators.

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