Dynamics of Road Infrastructure Support of Russian Regions' Economic Subsystems

Anna Yu. Kosobutskaya
Voronezh State University
Voronezh, Russia
E-mail: anna.rodnina@mail.ru

Mikhail. N. Bakhtin
Voronezh State University
Voronezh, Russia
E-mail: bakhtinmn@yandex.ru

Abstract—**The article is devoted to the study of road infrastructure service parameters of economic subsystems in Russian regions. The maintained subsystems are the followings: mining, manufacturing, agriculture, investment, construction, trade, value added (gross regional product), population. Taking into consideration the significant number of regions in the Russian Federation, they are arranged into relatively homogeneous groups (virtual clusters) through cluster analysis. Representative regions nearest to the center of each cluster are identified in each virtual cluster. In case of significant number of regions in one virtual cluster, secondary clustering was performed to obtain groups that are more homogeneous. The article does not provide data on regions with the lowest rate of economic subsystems service due to the high heterogeneity of the virtual clusters obtained. Donor subsystems (characterized by a high level of service parameter) and recipient subsystems with a low level of service parameter are identified in each representative region. In relation to the representative regions, a dynamic analysis was undertaken, which allowed identifying the main trends in the service intensity of economic subsystems.**

Keywords—road infrastructure; virtual cluster; region; economic subsystem

I. Introduction

Problems of infrastructure development are constantly in the focus of attention of government authorities. Over the course of three decades, they have been reflected in various strategic planning documents at the federal, regional and local levels. Such attention requires a detailed study of not only the state of the roads as transport infrastructure elements, but also an assessment of the relationship between infrastructure level and level of regions' main economic subsystems development. M. Bitarova, K. Getmantsev, E. Ilyasova, E. Krylova, Yu. Vertakova, V. Mkrtyachan, V. Plotnikov, D. Treschevsky, N. Firsova and other researchers considered the problem [1], [2], [3].

II. Methodological Approach to Assessment of Road Infrastructure Support of Russian Regions' Economic Subsystems

To assess the state and prospects of the transport infrastructure development in the regions, we clustered them according to infrastructure support of various socio-economic subsystems. The following parameters were selected for the analysis: volumes of shipped goods of mining and quarrying, manufacturing; agricultural production; fixed capital investments; volume of work performed by economic activity "Construction"; turnover of trade organizations; gross regional product; population. These indicators are referred to the roads length. The obtained specific indicators (per 1 km of roads) are presented in a normalized form to obtain a comparable data array. Further processing was performed through cluster analysis, the theoretical foundations of which were developed by I. Mandel, M. Oldenderfer, R. Bleshfield, I. Hartigan, and M. Wong [4], [5], [6]. Methodological aspects of cluster analysis application in the context of regional economy are presented in the works of O. Golichenko, V. Kruglyakova, T. Myasnikova, M. Litovkina, I. Risin, I. Terzi, D. Treschevsky, Yu. Treschevsky, I. Shchepina and other researchers [7], [8], [9], [10].

The time series (from 2012 to 2016 inclusive) cover various periods of the country and its regions development: 2012 - stable economic situation, 2013 - deterioration in the business environment, 2014 and 2015 - a wide range of crisis phenomena (sanctions and ruble depreciation), 2016 – economic stabilization and return to relatively normal conditions.

The initial data were obtained from the official statistical sources [11], [12], [13], [14], [15], [16], [17].

III. Virtual Clusters of Road Infrastructure Support of Russian Regions' Economic Subsystems

For analysis, the regions were arranged in five clusters. The clusters are named "A", "B", "C", "D", and "E" in descending order of the total results calculated according to normalized indicators. To assess the homogeneity of clusters, the F-criterion was used; to assess the significance of the average values, the p-criterion was used. The statistical characteristics of clusters comply the requirements of homogeneity and significance. The characteristics of the virtual clusters obtained are the followings.

Cluster "A" is the most developed in terms of the economic subsystems' infrastructure support of the regions. The infrastructure support of construction and mining has the

highest intensity. The ratios of infrastructure support of fix capital investments and gross regional product are rather high. These subsystems can be considered as donor subsystems. Activity of the population, agriculture, and manufacturing are defined as recipient subsystems.

Cluster "B" takes the second position. Manufacturing and wholesale operations has the highest infrastructure support. The rate of infrastructure support of population is high. We consider these subsystems as donors. Recipient subsystems are agriculture, investment, construction. Gross regional product takes up a neutral station.

Cluster "C", although inferior in most positions to "A" and "B", has rather good rate of infrastructure support of manufacturing and agriculture. This is a good reason to consider these sectors as donor subsystems. The recipient subsystems should include gross regional product production and investment in fixed assets.

Cluster "D" is quite heterogeneous and extensive (it includes 26 regions). In this regard, it was divided into three considerably homogeneous sub-clusters.

The "D1" sub-cluster is characterized by a high level of infrastructure support of most subsystems with a pronounced emphasis on GRP production and attraction of fixed capital investment, and the life of the population. The only recipient subsystem is manufacturing.

The "D2" sub-cluster occupies the first positions in the "D" cluster in relation to infrastructure support of manufacturing and wholesale operations. Rates of infrastructure support of investment and construction are low.

The "D3" sub-cluster does not have donor subsystems due to the low rate of infrastructure support. Any subsystem can be considered as recipient.

The specific cluster "A" (includes Tyumen and Sakhalin regions), as well as the vast and heterogeneous cluster "E", are not examined in the article.

IV.   REPRESENTATIVE REGIONS OF THE CLUSTERS

To study the dynamics of the infrastructure support of donor and recipient subsystems, we have chosen the administrative-territorial entities that most reflect the specifics of the formed virtual clusters. The normalized valuated amounts of the regions are as near as possible to the centers of the corresponding clusters. We used correlation and regression analysis for trends evaluation; linear, logarithmic, and exponential functions were determined.

The representative region of cluster "B" is Sverdlovsk Region. The analysis showed declining infrastructure support rate of all donor subsystems. At the same time, coefficients of correlation and determination of the regression equations are quite low.

In the context of the recipient subsystems, the rate of infrastructure support of investment is inclined to fall dramatically. In relation to agriculture, the trend data is unstable (in our opinion, this is due to the specifics of the industry, the effectiveness of which depends significantly on

natural factors). In relation to construction, the changes are precipitous; growth is relative to the initial period. As in the case of manufacturing, there is a loosely correlation between the indicator values in the dynamic series. The low level of correlation and determination coefficients is largely due to the increase in the length of roads in 2013 (from 22,022.7 km in 2012 to 29,362 km in 2013). The state of the supported subsystems changed slightly.

In the representative region of cluster "C" – the Samara Region, the rate of the infrastructure support of manufacturing decreased markedly. The reduction was particularly expressed in 2013, but, although less noticeable, it continued in subsequent years. At the same time, volumes of shipped goods of manufacturing (respectively, by years: 757,031; 780,879; 833,357; 928,775; 938,869 million rubles) and the length of roads (respectively, 22,099.7; 27,289.8; 31,153.7; 31,330.9; 36,673.7 km) increased.

Rate of infrastructure support of agriculture is volatile.

Strong decrease in the rate of infrastructure support of the recipient subsystems (created value, investment) is observed. It changed unevenly, and the coefficients of correlation and determination are low.

Thus, we can assume that only a decrease of infrastructure support of manufacturing can be established reliably (although at the maximum level of the coefficient of determination).

We will proceed to an analysis of the rate of infrastructure support of the economic subsystems in the Krasnodar Krai (the region is the representative of the "D1" sub-cluster). In general, the length of roads in the Krasnodar Territory is growing steadily with an average growth rate of 2.4 per cent per year. Therefore, relative ratios vary depending more on trends absolute indicators for supported economic subsystems.

In general, it is possible to establish with a high confidence the positive dynamics of the infrastructure support of mining (correlation coefficient of the linear equation is 0.765).

The rate of infrastructural support of investments in fixed assets shows a negative trend. In 2013, the indicator assumed the maximum value (25.05 million rubles / km). In subsequent years, it steadily decreased. Over the analyzed period, the indicator value fell by more than half (in 2016 it amounted to 10.5 million rubles / km). The correlation coefficient is very high (0.8). However, amount of investments in the "G1" cluster representative region is huge by the standards of the Russian regions (respectively, by years: 798,476; 955,208; 750,236; 586,903; 428,972 billion rubles), which does not allow us to consider it typical for this indicator. Such kind of divergence is possible in other regions. Therefore, we consider it necessary to identify a group of regions "atypical" phenomena related in this case to investment processes. Relating to the Krasnodar Territory, the reason for this is simple – at the start of the researched period intensive construction of facilities for the Winter Olympic Games was going on. However, similar processes may relate to other economic phenomena.

The trend of infrastructure support of construction also has a negative linear dependence describing the ongoing changes for the period from 2012 to 2016 with sufficient statistical significance (correlation coefficient is 0.849). In 2013, there was a slight increase in the indicator (by 5 per cent). After that, in 2013-2014, the indicator fell sharply (by almost 50 per cent). Since the length of the roads increased evenly, it can be concluded that the volumes of construction influence values of this indicator. Indeed, the total volume of construction in the analyzed period has the following dynamics: 442,396.7; 480,663.6; 316,186.5; 275,549.8; 252,093.4 million rub.

The GRP infrastructure support in the Krasnodar Territory increased by 25 per cent for the entire analyzed period. The average growth rate was 5 per cent per year, while the highest growth happened between 2012 and 2013, and subsequently the growth rate decreased. In 2016, the growth rate of 2.4 per cent against 11 per cent in 2013. The GRP of the Krasnodar Territory amounted to 2015 billion rubles in 2015. The trend of the indicator is described by a linear regression equation with a correlation coefficient of 0.958.

The recipient subsystems include manufacturing. In the 2012 – 2015 timeframe, the infrastructure support of manufacturing in the Krasnodar Territory developed with the increased rate. The growth trend most closely corresponds to a linear trend with a correlation coefficient of 0.91. The average increase of the volumes of shipped goods of manufacturing is 14.8 per cent over the period, while it increased by 71 per cent throughout researched period.

The Voronezh region represents the "D2" sub-cluster. The infrastructure support of manufacturing shows an express positive trend. The coefficient of determination for linear dependence is sufficient.

The rate of infrastructure support of wholesale operations has a positive trend, which is the most described by a linear dependence (correlation coefficient is 0.83).

In the analyzed period, there has been a steady increase in fix capital investments in relation to the length of roads. The amount of fix capital investments increased by 48.6 per cent for the period as a whole, while the length of roads increased by 16.1 per cent. Investments represent average growth rate of 10.5 per cent per year, while in 2015-2016 it slows down to 2.5 per cent per year. With 96.9 per cent confidence, the graph is described by a linear dependence.

The volume of construction in the region increased in the 2012-2015 timeframe, while in 2013 the road infrastructure support of construction decreased to a minimum of 2.42 million rubles per km due to a significant increase in the length of roads. The highest rate of growth of the indicator (by 42 per cent) is observed from 2014 until 2015. However, over the period 2015-2016, the value of the indicator decreased, despite the decrease in the volume of construction. The dynamics is described by a linear trend with a sufficient (at a minimum level) coefficient of determination.

The Adygea Republic represents the "D3" sub-cluster. In the timeframe 2013-2016, the region shows a decrease in the

rate of infrastructure support of fix capital investments with regard to the length of roads. The amount of fix capital investments declined 9 per cent in general over the period, while the length of the roads increased slightly (by 0.3 per cent). The determination coefficient is low (below 0.3).

The volume of construction over the period 2012-2013 decreased by 3.5 per cent, while the length of the roads practically did not increase. Accordingly, the rate of infrastructure support increased. In general, the dynamics of the infrastructure support of construction is described by a positive linear trend with sufficiently high coefficients of correlation and determination.

The turnover of trade organizations in the period from 2012 to 2013 decreased by 1.5 per cent, while the length of the roads remained unchanged. The rate of infrastructure support of wholesales increased thereafter with a slowing growth rate in 2015-2016. In general, the dynamics is described by a linear trend with a sufficient coefficient of determination.

The ratio of GRP to the length of roads for the entire analyzed period increased by 39.5 per cent, the GRP increased from 2012 to 2016 almost by 40 per cent. On average, the region's GRP increased by 8.7 per cent annually. Accordingly, the dynamics of the infrastructure support of GRP is described by a linear trend with an extremely high level of determination (about 1.0).

The population of the Adygea Republic has little dynamic potential. In general, during the analyzed period, the increase rate was 2 per cent. The length of the roads in the region increased by only 0.3 per cent for the period from 2012 to 2016. Such minor changes in absolute indicators led to a low increase in the rate of infrastructure support (by 1.7 per cent). According to this indicator, the situation in the republic is quite stable; the trend is described by a linear dependence with a high coefficient of determination.

V. CONCLUSION

A generalization of the above allows us to draw the following conclusions.

The representative regions of the virtual clusters, leading in terms of the rate of infrastructure support of economic subsystems of the regions - Sverdlovsk and Samara regions - show a decrease in the corresponding indicators. In most instances, the dynamics is described by regression equations with sufficient confidence. There are also trends characterized by significant fluctuations. This is especially true of agricultural production, the results of which are most dependent on natural phenomena.

Three significantly different groups represent regions with an average level of development (cluster "D"). The Krasnodar Territory represents the "D1" sub-cluster. Extremely high activity for the Russian regions in road construction, investments and construction in the early 2010-s subsequently reduced a rate of infrastructure support of investments and construction subsystems.

At the same time, there was a statistically significant increase in the rate of road infrastructure support of mining, manufacturing and GRP due to a significant increase in their volumes beyond the growth in the roads construction.

The Voronezh region represents the "D2" sub-cluster. The rates of the road infrastructure support of manufacturing, wholesale operations and fixed capital investments have pronounced statistically significant positive trends. This phenomenon can be explained by rather strong positive changes in these sectors, more intense than the roads construction.

The Adygea Republic represents the "D3" sub-cluster. All subsystems of this region (as well as the sub-cluster as a whole) are recipients. Road construction has little dynamic potential in the region. In this regard, there is an inverse relationship between the rate of infrastructure support and indicators of economic subsystems.

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