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The Study of Regional Industrial Structure Resilience to Cyclical Crises

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Abstract. When forming economic policy, the question always arises: is there a long-term growth trend in the economy now, or is there a short-term economic growth associated with fluctuations in the business cycle? There are several approaches to answering this question. The first is oriented on the determine the phases of the business cycles. The second approach is to study the long-term growth trend and cycles as deviations from this trend. In modern works, was proved the regularity between the nature of the cycle and the elasticity of substitution of the utility function of a representative agent. In other words, as the economy stabilizes, the risk appetite increases, and it determines the greater impact of external shocks. In times of crisis, when uncertainty increases, on the contrary, the propensity to risk decreases and the dynamics of the cycle becomes more coherent with the long-term development trend. This fact makes considered the infrastructure as a factor of business cycle stabilizer. So the infrastructure should not be considered in the context of a competitive market. Since it is reflecting two types of market failures: technological indivisibility and planned increasing returns on scale. Using the method of mathematical clustering based on data from 2000-2018, the article identifies regions of Russia with different characteristics of the relationship between industrial and transport complexes. Complementing the study with an assessment of the overall dynamics of economic growth, the author identifies key industries and effects that occur in regions of the North-Western Federal District.

1. Introduction, a brief review of the literature, relevance

In the study of the dynamics of economic indicators and in the formation of economic policy on this basis, there is always an open question about what the decision-maker is currently dealing with. Is current situation a long-term growth trend, or a short-term economic growth associated with fluctuations in the business cycle? This issue is particularly relevant when planning decisions related to long-term prospects and delayed consequences. For example, this applies to planning the infrastructure development of regions, large-scale modernization processes, such as those currently taking place in the field of digital infrastructure formation.

The first description and attempts of analysis business cycles were made by Karl Marx [11]. To date, there are several approaches to answering the question about the growth trend or short-term growth. The first of them was defined by A. Burns and W. Mitchell [4]. It is still being actively developed within the National Bureau of Economic Research (NBER) school [13]. The essence of the approach is to determine the phases of cycles. Moreover, despite the macro-level specific of this approach, all researchers agree that cyclical fluctuations concern not only the GRP parameters. And what's more, study microdata is reinforces the rationale and supports the determining the intervals of



«ups» and «downs». For example, the modern NBER methodology involves assessing the dynamics of industrial production, employment, real income, and wholesale [9]. As a result, the P. Samuelson multiplier – accelerator model [21] was described in the framework of this method. The second approach was developed by R. Lucas [10] and consisted in the study of the long-term growth trend and cycles as deviations from this trend. In particular, he established a numerous of economic relationships that determined the trend dynamics. Among them: joint changes in output volumes in various sectors of the economy (later defined as the concept of coherence); a large amplitude of fluctuations in the output of manufactured goods; the dynamics of production and resource prices have low consistency.

For a long time, the question of the cycle nature remained open. The work of R. Kormendi and P. Meguire recognized the exogenous nature of the cycle, that is, its dependence on external shocks [8]. But the works of G. Ramey and A. Ramey, and also M. Bruno, on the contrary, proved the internal connection of the cycle and the long-term trend of the economy [3; 15]. In a later paper, L. Jones, R. Msnuelli, E. Stacchetti [7] the regularity was proved between the nature of the cycle and the curvature (elasticity of substitution) of the utility function of a representative agent. In other words, as the economy stabilizes, the risk appetite increases, and it determines the greater impact of external shocks. In times of crisis, when uncertainty increases, on the contrary, the propensity to risk decreases and the dynamics of the cycle becomes more coherent with the long-term development trend. P. Aghion and A. Banerjee [1] came to similar conclusions.

This is what makes considered the infrastructure (at particular transportation infrastructure) as a factor of business cycle stabilizer, which can act as an element of indirect countercyclical regulation through maintaining a long-term trend of growth and development.

2. Theoretical part and objectives of the study

The nature of the transport infrastructure provides the appearance of external effects. However, it is should note that transport infrastructure is not a public good in its purest form. The restriction is the fact that each economic agent consumes a different quantity of services, moreover, an increase in the consumption of one economic agent reduces the possibility of consumption for all others (the phenomenon of traffic jams). However, it is impossible to deny the importance of transport infrastructure for society, since it has various for the sources and directions of development effects.

In relation to transport infrastructure, market imperfections are emerging as technological indivisibility and planned increasing returns to scale [2]. Indivisibility implies that it is impossible to provide more or less than a certain fixed quantity of services per unit of time. In this case, the marginal cost of producing each additional unit of infrastructure services is essentially 0 (this is an expression of increasing returns to scale). Therefore, setting any fee will represent a deviation from the Pareto - optimal state and lead to an inefficiently low quantity of demand for services. On the other hand, when infrastructure service producers focus on the maximum (with existing resources) supply, a situation of loss-making occurs. This is reflected in the fact that the marginal cost curve lies below the decreasing curve of average costs. As a result, market prices (in terms of profit maximization in a competitive market, the price is set at the level of marginal costs) are lower than average costs, i.e. the company is not able to cover its costs. The result is a reduction in the number of competitors and inefficient allocation of resources. This feature determines the existence of a natural monopoly.

The need for public participation in regulating market failures is motivated by the need to eliminate the difference between private (companies that produce transport infrastructure services) and public costs. This kind of regulation goes back to the ideas of A. Pigou who argued the feasibility of subsidizing industries that create advantages for society, and taxing producers that generate social losses [19].

Thus, it can be seen that the structural adjustment of the Russian economy is due to infrastructure factors, which with each new cyclical crisis lead to an increase in transport costs for economic agents (in a competitive environment). In addition, the global trend of the world economy's transition to a sustainable development is important to take into account. But according to the authors J.R. Murua, A.M. Ferrero [12] sustainability is not resilience. Thus, it can be seen that due to the predominance of neoclassical models of growth and development (and sustainability trends, among others), an increase

in transport costs is an acceptable term, which, however, leads to a constant reduction in the level of industrial development of Russian regions. Which in turn generates current and future losses of GRP. In other words, there is a decrease in the importance and availability of resources (factors of production) in Russia's regions.

Therefore, we can conclude that infrastructure, having the role of a stabilizing factor, should not be considered in the context of a competitive market. The criterion for the infrastructure assets quality in the region is to minimize the damage to society (economy) from their underdevelopment [5]. At the same time, the different level of development of the transport infrastructure itself generates a multidirectional effect of the same factors on the economy of different regions, creating positive and negative effects.

In this regard, it is of great interest to study the development of the economy and industrial complex of the regions in connection with the transport infrastructure. The objectives of the study are to determine the differences between regions in terms of transport infrastructure presence (based on data from all regions of Russia) and to identify infrastructure factors that significantly affect the transformation of the economic structure (based on data from regions of the North-Western Federal District).

3. Results of Russian regions clusterization and its practical significance

In this regard, it is of great interest to study the development of the economy and industrial complex of the regions in connection with the transport infrastructure. The objectives of the study are to determine the differences between regions in terms of transport infrastructure presence (based on data from all regions of Russia) and to identify infrastructure factors that significantly affect the transformation of the economic structure (based on data from regions of the North-Western Federal District).

The estimate of the presence of transport infrastructure was based on the difference between the regions of the Russian Federation in the presence of universal routs (rail and road). For a generalized estimate of the territory's provision with transport infrastructure, the improved Uspensky coefficient (K_{SNQ}) was used, reflecting the level of joint services for the population and industry of the region i [14; 22].

$$K_{SNQ} = \sum Li / ((Si \times Ni \times Qi)^{(1/3)}) \quad (1)$$

L – is the length of the transport roars of the region i , km; S – is the area of the region i , km²; N – is the population of the region i , thsd persons; Q – total mass of all types of products sent from the region i , thsd tons.

There are no reference points to separate of regions into some groups, therefore, to forming groups we used clustering k-means method. We were able to identify 6 groups of Russian regions (Table 1 shows the generalized characteristics of these groups).

Table 1. Generalized characteristics of the group of regions, 2017.

Parameters Groups	Number of regions	Typical regions	Average GRP Bn rub.	K_{SNQ}
Group 1	2	Moscow reg.	3 298	58
Group 2	9	Sverdlovsk reg.	1 646	75
Group 3	17	Astrakhan reg.	298	43
Group 4	18	Primorsky Krai	823	77
Group 5	30	The Chuvash Rep.	295	131
Group 6	6	Pskov reg.	183	262

The regions of the North-Western Federal District (NWFD) were distributed by different groups: Murmansk and Arkhangelsk regions, Nenets Autonomous District, Republics of Karelia and Komi – group 3; Vologda and Leningrad regions – group 4, Kaliningrad and Novgorod regions – group 5;

Pskov region – group 6. It can be seen that the NWFD as a whole has a significant variation in presence of transport infrastructure.

We will briefly describe the main features of the groups that include the regions of the NWFD. Region of group 3 has the lowest transport sufficient. This is primarily due to the large areas of the regions of this group. A large area makes the unit density of road networks extremely small (from 0 to 26 km per 1 thsd km², with the national average of 150 km). We should pay attention to the fact that in parameters of railway density, the deviation from the national value is much smaller. The most "well-provided" regions with highways lag behind the national parameters by 5.8 times, while for railways the deviation of the average for this group is only 2 times. In other words, the idea that railway transport plays an important role in the economic development of the group 3 regions is reasoned. If we look at the role of this group of regions in industry of Russia, we can note their large share in the extractive industry (8 regions provide 19% of this activity in Russia, and all 17 regions – 22.6%). In the manufacturing industry, the share of this group is much more modest and amounts to 9.4% and 15.8% in the distribution of energy, gas and water. The predominance of the extractive industry also implies the great importance of railways.

This is followed by the group of regions 4, which includes 18 regions of the Russian Federation. Transport presence here is significantly higher (from 50 to 80 units of K_{SNQ}). This is due to the average and small area of these regions, and the lower level of production. Naturally, a small area determines the significance of the road density, which is 147 km per 1 thsd km² for highways and 17.8 km per 1 thsd km² for railways. In industrial production, the regions of this group do not have a distinct specialization: for 18 regions, the share in the national volume of the extractive industry is 8%, manufacturing – 20%, and the distribution of energy, gas and water – 20%. All this leads to the fact that there is a low (within 2.2 thsd tons per 1 km) load per unit of the road network and a lower than average load on the railway network (11.2 thsd tons per 1 km).

The next group of regions is 5, it is the largest group which consolidates 30 regions. They have even higher infrastructure development than regions of group 4. The population density in this group is 37 people per km². At the same time, the regions of this group have the lowest levels of load of rail among all Russian regions (within 1.5 million tons per year) and a low level of load of road (within 8 million tons per year). These levels are significantly lower than the national values of 15.8 million tons and 26.7 million tons per year for rail and road transport, respectively.

Such modest volumes of loads are easy to explain if you pay attention to the share of regions of this group in the structure of industrial production in Russia. In the extractive industry, all regions of the group generate 0.3% of the total Russian volume, in the manufacturing industry – 5.2%, in the production and distribution of energy, gas and water – 8%. At the same time, the regions of this group confidently bypass the regions of group 3 about the length of highways and demonstrate the highest indicators of road density among all groups.

The final group of regions 6 includes 6 regions. The GRP volume of these regions is at the lowest level, and the generalized indicator of transport infrastructure presence is the highest among all groups. These regions differ little in population from the regions of group 5 (800 thsd people on average in each region). But at the same time, they have extremely small areas of territories, which leads to very high population densities (58.3 people per km²) and road networks density (301 km for roads and 22 km for railways per thsd km²). These regions play a small role in Russia's industrial production as the regions of group 5. This results in the lowest network load and the greatest potential for increasing network usage.

In general, for all regions (according to 2017 data for 82 subjects of the Russian Federation) and for selected groups of regions, models were analyzed that evaluates the influence of the main production factors, some technological factors, and factors of the transport infrastructure. The dependent variable was the GRP of region i ($GRPi$). The analysis showed a very limited impact of the transport infrastructure on the regions of the NWFD [6; 16; 20]. Only GRP a number of regions (Vologda, Leningrad, and Novgorod regions) are significant associated with the use of transport infrastructure. This is due to a higher level of production development, which allows regions to get a relatively high level of added

value. In contrast regions with explicit resource orientation (regions of group 3 – Murmansk, Arkhangelsk regions, Rep. Karelia and Komi), which does not have a significant increase in GRP caused the increment of the infrastructure factor. Thus confirms the fact that the product produced in regions of group 3 is not consumed in these regions. These conclusions are confirmed by the results of clustering and analysis in the other works [17; 18].

To solve the problem of assessing the significance of other aspects of transport infrastructure, we will analyze information about dynamics of industrial production and GRP dynamics of the NWFD. Changes in the industrial structure will be evaluated for two industrial cycles: 1998-2008 and 2008-2018.

4. Conclusions about the transformation of the industrial structure in cyclical crises

If we consider the economy of the NWFD in the first approximation, we should refer to the dynamics and structure of the GRP indicator. Table 2 shows the dynamics of GRP in the regions and the degree of transformation of industry (estimated based on the coefficient of variation of the share of industry i in the total volume of industrial production).

Table 2. Ratio of GRP dynamics and shifts in industrial specialization of the NWFD regions in 1998-2018.

Characteristics of GRP dynamics	Level of industrial transformation			
	High (more than 20%)	Average (8-15%)	Low (2-4%)	
Stable growth	-	-	Arkhangelsk reg.	
All-Russian trend (crisis years of 1998 and 2009)	Kaliningrad reg. St. Petersburg	Leningrad reg.	Pskov reg.	
Deep crisis of 2008-2009 and 2014	The Karelia Rep.	-	Vologda reg.	
Instability (alternation of GRP growth and decline)	Murmansk reg.	The Rep. Komi	The Nenets AD, Novgorod reg.	

According to data from 1998 to 2018, only 4 out of 11 subjects of the NWFD have a typical situation in the Russian Federation (stable growth in all years except the crisis years of 1998, 2009, and 2014). These regions are Kaliningrad, Leningrad, Pskov region and Saint Petersburg. The two regions demonstrate a completely different situation – the alternation of growth and recession of the economy is the Komi Republic and Murmansk region. Two regions (Vologda region and the Karelia Republic) are characterized by the fact that the crisis recession of the economy began for them in 2008 and worsened in 2009. They are characterized by the largest drop among all regions of the NWFD in 2009 (about 14%), but the recovery in 2010 is in line with the average trend (4-5%). The Nenets Autonomous District showed mixed dynamics: the crisis reduction in GRP in 2008 was the largest among all regions of the NWFD (13%), in 2009 it changed to an increase of 23%, and ended with a 12% recession in GRP in 2014. Only the Arkhangelsk region, after overcoming the crisis in 1998, did not lose its growth trend. The Novgorod region not responding in 1998 had a recession in the economy in 2002 and the crisis in 2009 and 2014.

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