Management of transport and logistic infrastructure of the territory: methodological tools and their improvement

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Abstract. This article discusses the main problems of transport and logistics infrastructure management, which consist in the absence of one criterion for assessing the effectiveness of its operation, in the presence of institutional barriers for the development of transport and logistics complexes of territories, in the need for a new scheme and management system due to changing economic conditions dictated by globalization. The priority directions for the development of constituent entity of the Russian Federation - Voronezh region - are presented. Voronezh region has an advantageous geographical position and important transport corridors pass through its territory. A multi-level mathematical model has been built by its example for projects of regional transport infrastructure development, given by the initial conditions using multi-criteria optimization of the regional transport system that solves the problem in a dual formulation, based on a hypergraph superimposed on spatial planning scheme of this area.

1. Introduction

Business organizations, realizing their products, while meeting the needs of population in a certain territory and beyond its borders, need a developed transport and logistics infrastructure. This is a necessary criterion in the operation of economic entities, due to the limited number of commodity markets in the regions in terms of capacity and in the import of marketable products from other territories. This implies that a condition for the development of entrepreneurship and trade depends on the quality of transport infrastructure management, which predetermines the region's ability to participate and benefit from this during national and international division of labor and production specialization [1, 2].

Business environment of entrepreneurial structures changed when the Russian Federation switched to the market type of economic development; therefore it is necessary to change the existing management system of territorial transport and logistics infrastructure [3]. Due to the fact that flow of goods transported across the territory of Voronezh Region has significantly increased, greater importance is given to the transport and logistics infrastructure from the standpoint of business activity of business structures, and the role of private sector in its formation has increased significantly [4]. Therefore, in current conditions, changes in the management system of transport and logistics infrastructure of the territory and development of methodological approaches and methods to improve
the tools for its optimal management are needed.

2. Methods and Materials
Transport and logistics infrastructure is a tool for the development of economy of separate regions. One of the conditions for its development is competition in transportation, storage, processing, quality of provided services; the second condition is employment of local population, not the population invited by network operators.

Dynamics of changes in the main indicators of transport in Voronezh region is presented in Table 1. Quantitative indicators on the example of a single territory (Voronezh Region) clearly show that passenger traffic through railway transport has decreased by 2.5%, and bus transport - by 13.66%. Freight traffic by rail has increased by 18.26%, while highway transport has decreased by 30.19%. The length of roads has increased by 0.13%, and the length of paved roads has increased by 2.69%.

| Table 1. Main indicators of transport in Voronezh region. |
|----------------------------------------------------------|
| Indicators                                              | Years | 2013 | 2014 | 2015 | 2016 | 2017 |
|----------------------------------------------------------|-------|------|------|------|------|------|
| Mileage (km)                                            |       |      |      |      |      |      |
| Public railway tracks                                   | 1708  | 1684 | 1673 | 1671 | 1671 |      |
| Highways - total:                                        | 26132 | 29410| 29556| 29905| 29943|      |
| Including hard surface                                  | 16810 | 17563| 17777| 17972| 18456|      |
| Cargo transportation (mln.t.)                           |       |      |      |      |      |      |
| Transport - total                                       | 17.42 | 17.66| 46.5 | 48.6 | 39.5 |      |
| Railway                                                 | 11.32 | 10.92| 10.6 | 11.5 | 13.6 |      |
| Highway                                                 | 5.58  | 6.23 | 35.9 | 37.1 | 25.9 |      |
| Air                                                     | 0.03  | 0.01 | -    | -    | -    |      |
| Inland water                                            | 0.49  | 0.5  | -    | -    | -    |      |
| Cargo turnover (mln.t./km)                              |       |      |      |      |      |      |
| Transport - total                                       | 27472.4| 25897.5| 27426.1| 28420 | 30372|      |
| Railway                                                 | 26859.2| 24994.5| 25472.1| 26240 | 27440|      |
| Highway                                                 | 499.7 | 846.8| 1954.0| 2180 | 2932 |      |
| Air                                                     | 108.3 | 50.1 | -    | -    | -    |      |
| Inland water                                            | 5.2   | 6.1  | -    | -    | -    |      |
| Passenger transportation (mln. people)                  |       |      |      |      |      |      |
| Public transport – total                                | 283.0 | 294.1| 263.6| 260.6| 225.9|      |
| Railway                                                 | 9.8   | 9.8  | 8.9  | 8.0  | 7.8  |      |
| Bus                                                     | 266.3 | 276.7| 254.7| 252.6| 218.1|      |
| Surface rail transit                                    | -     | -    | -    | -    | -    |      |
| Trolleybus                                              | 6.6   | 7.3  | -    | -    | -    |      |
| Air                                                     | 0.3   | 0.3  | -    | -    | -    |      |

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At present, Russian transport and logistics infrastructure is being adapted to the European development model. One of the effective ways of social and economic development of Russia in general and its regions, in particular, is development and implementation of regional transport and logistics systems (TLS) [5].

The Central Black Earth region (CBER) acts as an important link in the overall development strategy of the world and Russian transport and logistics systems, since over 30% of the population of
the Russian Federation lives within a radius of 600 km with a circle center in Voronezh. CBER transport system is represented by federal highways (rail, road, aviation), which are in the format of European transport corridors.

Voronezh region has good geographical position, which allows expanding the service area by increasing flow of goods in the CBER and in transit cargo transportation from the regions of Central Federal District in the directions to the Ukraine and the regions of Southern Federal District along transport corridors.

Objects of transport and logistics infrastructure of Voronezh region are divided into PL providers depending on the level of comprehensiveness of provided services and the depth of integration [6]. Transport nodes are located in Voronezh, Liski, Borisoglebsk and Rossozh.

Criteria for assessing transport and logistics infrastructure are presented by two main groups [7]:

– Criteria directly reflecting characteristics of transportation process itself (grouping, cost, time of delivery, etc.). They play an important role in operational management of the economic entity;

– Criteria reflecting activities of transport and logistics infrastructure, or for each individual economic entity as a whole (that is, they are characterized by qualitative indicators of work, share of services rendered in a certain market segment, etc.). They have great importance in the strategic management of a business entity [8].

Classification of indicators of functioning of transport and logistics infrastructure enterprises is presented in table 2.

In a market economy, it is impossible to evaluate the efficiency of transport and logistics infrastructure by one criterion, a system of criteria with expert assessment approaches is needed, depending on the functions performed by transport and logistics infrastructure and the impact on economic and social development of a country’s subject [9].

These include, for example, meeting the needs of territory's population with transport services, solving social problems, etc. However, one should not forget that transport and logistics infrastructure is assessed not only by internal indicators, but also by effective indicators of those industries and industries that serve it, such as: meeting transport and logistics needs of material production and population of a specific subject of the Russian Federation and country as a whole.

**Table 2. Classification of performance indicators of enterprises of transport and logistics infrastructure.**

| Indicator classification criteria | Indicators |
|----------------------------------|------------|
| By initial values                | Past statistics, forecast indicators and engineering calculations Sectoral, general transport, specific, work of a particular type of transport in the subject of the Russian Federation is evaluated with their help, revealing the possibilities and reserves of resources to increase the efficiency of their activities |
| By transport group               | Characterizing the work of transport and transportation processes in physical terms |
| By performance                   | Absolute and specific indicators that make it possible to evaluate the effectiveness of transport process in value terms |
| By economic indicators           | |

The main factors that provide cumulative effect of transport and logistics infrastructure functioning in the region [10] are:

- increasing inter-sectoral and inter-regional coordination;
- use of modern logistics technologies for the organization of transport process;
- creation of appropriate institutional environment that forms a basis of a public-private partnership.

Of course, it is necessary to form and implement integrated schemes for the development of transport and logistics infrastructure in each region, which must cover the issues of creation of newly created or development of existing infrastructure facilities of transport types, available in a given subject, development of transport corridors, creation of multimodal logistics centers and terminal
complexes, organization of multimodal transport, formation of single information space, usage of integrated information management system, establishment of appropriate legal and regulatory framework, compliance with higher environmental standards, etc. [11].

Institutional barriers to the development of transport and logistics complex of subjects of the Russian Federation include:

- Large number of public authorities responsible for the development of transport and logistics complex in the region, resulting in difficulties with coordination of various authorities and increasing frequency of their authority crossing;
- Lack of communication and coordination of actions of various authorities, due to unclear organizational structure and uncertain responsibilities, authorities and accountability, as well as lack of dialogue between various authorities in solving transport and logistics problems;
- Lack of power to make management decisions for most of the authorities, in connection with which there are difficulties in implementation of regional policy in the development of transport and logistics complex, as well as lack of autonomy of authorities responsible for certain activities;
- Lack of resources for development of transport and logistics complex in the region and lack of mechanisms for monitoring and evaluating the effectiveness of policy implementation [12];
- Lack of clear framework for the development of transport and logistics complex of the region, due to the lack of proper principles, clear objectives and consistency of its development policies.

Development of new approaches to the long-term regulation of activities of transport and logistics complex contributes to building a model of its functioning and development for a long period of time.

Improving the management system for the development of transport and logistics infrastructure in the federal government system in the context of globalization significantly improves the efficiency of production, financial, managerial and human resources. This fact is a significant aspect for entrepreneurial structures with such organizational and economic form while increasing their competitiveness in the market conditions, as well as other restrictions that result from this and affect their independence from financial and economic point of view.

3. Results and Discussion

The priority directions of transport and logistics system of the territory are maintenance of:

1) Import cargo traffic that comes from Moscow, St. Petersburg and the seaport of Novorossiysk for consumption in the regions of the Central Federal District;
2) Export freight of the regions of the Central Federal District, in which goods are transported from the port of Novorossiysk by sea transport;
3) Import-export cargo traffic from the Ukraine, and in future from Kazakhstan and China, which follows the route of the international transport corridor "West - East": the Ukraine - Kursk - Voronezh - Borisoglebsk - Saratov - Kazakhstan - China;
4) Interregional transportation.

Increased interest in the theory of spatial economics gives a rise to an actualized search for points of growth in the regions of the Russian Federation.

A common feature is inherent in those studies in which formulation and solution of problems of transport and logistics are performed at the regional level. In the study this fact is closely related to the construction of the graph which informs and displays transport structure of the region (figure 1). In order to solve this series of problems, construction of a graph or hypergraph is carried out with the display of all necessary informative databases (key factor) in it [13].

The methodology which implies the development of projects for the development of regional transport infrastructure is as follows: a multilevel mathematical model is set by initial conditions; the use of multi-criteria optimization of the regional transport system solves the problem in a dual formulation.
Figure 1. Hypergraph of the transport system of Voronezh region with the main inter-regional transport links.

The construction of the model is based on the analysis of transport infrastructure of the territory of the Russian Federation. Morphology of economic space of the subject of the Russian Federation is determined the graph of transport network, represented by the main railways and road transport, because there is an anthropogenic factor in the process of its formation. Existing and project (for the development of the resources of the territory) main transport lines can become a locomotive or a brake in the development of the territory. Transport infrastructure is accessed through technical and technological parameters of the infrastructure and from the perspective of probability factor of reliability of transport subsystems.

At creation of model the parameters presented to table 3 which list can be continued are fixed.

Table 3. Parameters of model transport level.

| Lines                                                                 | Vertices                                                                 |
|----------------------------------------------------------------------|--------------------------------------------------------------------------|
| Distance                                                             | Loading                                                                  |
| Number of ways, lanes                                               | unloading                                                                |
| Maximum axial load                                                   | Freight transit                                                          |
| Speed limit                                                          | Passenger traffic by type of transport                                   |
| Average speed on the site                                            | Passenger traffic in long-distance trains                                 |
| Travel time on the site                                              | Passenger traffic in suburban and city traffic                            |
| Freight traffic density                                               | Population traffic mobility                                              |
| Traffic capacity                                                     | Number of transfer passengers at the connections of international flights (air) and domestic flights |
| Traffic-carrying capacity                                            | Level of public satisfaction with measures taken by the executive authorities to ensure the safety of population in transport |
| Number of traffic accidents                                          |                                                                          |
| Length of public roads complying with regulatory requirements for transport and operational indicators |                                                                          |
| Increase in transit traffic                                          |                                                                          |
| Level of supervisory authority equipment by technical means           |                                                                          |
| Share of roads maintained with long-term contracts                   |                                                                          |
| Share of the length of sections of the railway network where there are restrictions on throughput and carrying capacity |                                                                          |
| Probability of uptime                                                |                                                                          |

At the next stage, the resources, available in this territory, are determined; they are adjacent to the
vertices of the graph in building the model. Favorable natural resources play an important, and in most cases crucial, role in spatial economics and transport optimization.

In the nearest future, development of the territories of our country will be uneven, on the basis of this it is possible to identify areas with favorable geographical position in which made investments achieve the greatest effect.

The territory having the most favorable natural conditions should be covered by a well-developed dense network of transport infrastructure.

When forming the model determining criterion values, data on the parameters of the level “Favorable natural conditions” in Voronezh region are determined (table 4).

The average score for each factor of utility of natural conditions of the territory has been determined by expert means, for which 20 independent experts have been involved.

The principle must be fulfilled in order to realize the model: the available data, which in different planes reflect the parameters of the model and are recorded only once, and the possibility of their use can be achieved many times depending on the functions when solving various tasks.

Vector optimization is the basis for received data processing, provided by the method and ensuring conditions fulfillment. In other words, vectors display optimization criterion indicators that allow fixing values that act as elements of vectors for an array of data in the Python programming language using “list”.

Table 4. Parameters of the level "Favorable natural conditions" in Voronezh region.

| Favorable factors of the natural conditions of the territory | Points |
|-------------------------------------------------------------|--------|
| Recreational assessment                                     | 6.7    |
| Seismic hazard level                                        | 0      |
| Drinking water supply                                       | 8.9    |
| Landscape and Recreational Assessment favored for industrial and civil construction | 8.5    |
| Assessment favored for agriculture                          | 9.2    |
| Average temperature                                         | 9.1    |
| Accessibility and sufficient length of roads                 | 7.2    |
| The level of ecological cleanliness of the environment along the hard-surfaced roads | 6.7    |

Using this technique, one can carry out a multi-criteria analysis of the transport network and optimize it in regional economic development projects, get an assessment and compare various data obtained by related branches of science about the studied subject. Moreover, in this context, transport network acts as an infrastructure framework that links social and economic processes, as well as spatial configuration and flow that can pass through it. Using this methodology, it is possible to improve the quality of management of the development of territorial transport infrastructure through the implementation of original approaches by computer programs.

4. Conclusion

Enterprises of transport and logistics infrastructure, as well as business structures of other industries, can develop in two directions:

- expanding the range of services provided in the existing market segment;
- expanding the segment of management, based on consumer preferences and development programs developed by the authorities of other regions.

Global economy dictates its own conditions, for example, it requires an assessment of the effectiveness of economic entities activities on a national economy scale and in comparison with global competitors.

Profitability, cost effectiveness of the company for the period, the dynamics of revenue growth, the number of applications, capital productivity, output - these are the main indicators that characterize economic and managerial performance of the organization for a certain period, in other words, characterize the efficiency of motor transport logistics enterprise (MTLE).
Financial responsibility of the company, its turnover rates and growth rates of staff salaries, as well as the share of regular customers in the total traffic volume, characterize the stability of the company’s development.

During the study, the authors established the fact that it is impossible to determine the dynamics of MTLE development using only a standard approach to the calculation of performance indicators. This aspect is explained as follows:

- Due to the fact that the share of goods transported by owns MTLE vehicles with large volumes of order fulfillment is very small, this makes it impossible to use it for an objective assessment of the efficiency of using fixed assets;
- Since the planning of MTLE activity is connected with the execution of all applications received from customers, but not with obtaining maximum profit, i.e. it is based on a customer-oriented approach to the company’s activity, which does not allow planning the traffic volumes in the future period, and, consequently, coefficient of agreement of actual traffic volume with the planned one loses its economic sense;
- MTLE activities are carried out in the form of intermediation - implementation of the supply chain management process of various companies through the organization of cargo transportation by owners of vehicles which are not owned by the company.

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