

# *The Competitiveness Factor in Transport Work Forecasting for the Regional Transportation Market*

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**Abstract** - The transport system development in Russia is focused on transportation indicators increasing and infrastructure quality. It will ensure the growth of macroeconomic parameters. The article shows the review of some calculation approaches connected with planning parameters of road transportation demand taking into account the competitive advantages of transportation enterprises. The competitiveness of road transportation enterprises is presented in the article as a multi-level and multi-criteria indicator. The methods for predicting the regional demand for cargo transportation are proposed in the article. They are completed on the total and incomplete certainty using the extrapolation method. A mathematical model of the forecast demand determining for cargo transportation is presented in the article. The model can be applied in the resource management and for capacity of regional motor transport enterprises calculation based on their efficiency.

**Keywords** — *motor transportation enterprise, freight transportation, region, forecast, model, competitiveness, efficiency.*

## I. INTRODUCTION

Effective state work in the regions development in Russia is determined by the regulation measures and the availability of state programs for the infrastructure development components. Insufficient development of the regional transport systems is characterized by low volume and quality indicators of the transport infrastructure.

This may be the cause that leads to a significant limitation of the business activity growth in the regions and to create threats to its sustainable development in the future. It also does not allow solving the tasks of the modern economy effectively.

The freight traffic in the Strategy of the transport system in Russia for road transport is estimated as 10 million tons, and the resource support for regional budgets is not over 1.015 trillion rubles.

Transportation system is the main element of the competitive infrastructure. However regional peculiarities are also have great importance as well as the competitive capabilities of carriers. This will allow forecast the regional

demand for the carrying capacity of road transport enterprises (RTE) more clearly.

## II. THEORY (RESEARCH DATA AND METHODS)

The elements of demand planning for RTE have been studied in many scientific works. The authors focus on the infrastructure components and regional features of carrier competitiveness. We can describe the following parameters that determine the regional demand for road freight transportation:

- The long-term contracts with the cargo owners and transport logistics advantage (E. Bergkvist and L. Westin, 1998 [1]).
- Macrologistics features increasing the regional demand for road transportation (taking into account cargo switching from railway transport) L.H. Roller, 2006 [2].
- Goods availability, quality and carrying capacity of roads, alternative types of transport, the road pricing (C. Cherry fare, 2005 [3]).
- Competitive advantages of road carriers in supply chains based on cost minimization, taking into account service, type of navigation programs, etc. (Michael F. Gorman and Daniel G. P. Conway, 2005 [4]).

The authors also emphasize the fact that the competition factors and regional differences make a significant correction to the planning method of freight transport infrastructure. For example, the authors propose the following methods for the freight traffic forecasting:

- Correlation of traffic flows in ideal conditions, neural network modeling and operational forecasting of freight traffic based on the regional transport infrastructure carrying capacity (Fengxiang Qiao, Hai Yang and H.K. Lam William, 2001 [5]).
- Transportation planning and forecasting of traffic flows based on demand modeling taking into account transportation time, time for loading and unloading operations and optimal routing (Y. Kamarianakis, P. Prastacos, 2005 [6]).

- Methods of autoregression, dynamic modeling of space-time dependence, which will increase the effects of forecasting regional traffic flows.
- Methods of tariff rates formation as a basis for the regional carriers competitive advantages assessing (E.A. Ponomareva, 2007 [7]; O.N. Sheblova, 2003 [8]).
- Information and innovation technologies for processing of goods and vehicles to optimize planning, dispatching and monitoring of foreign trade traffic and ensuring competitive advantages for transport enterprises in the region (G.I. Naydenova, 2005 [9]).
- Methods for ensuring the competitiveness of domestic carriers in border regions based on the renewal and expansion of vehicle fleets (I.V. Domnin, 2003 [10]).
- Meta-heuristic algorithm of cargo transportation planning generating plans and measures taking into account the uncontrollable travel time in real time based on navigation systems (A.P. Zatvornitsky, 2007 [11]; A.S. Drobitsheva, 2011 [12]).

A lot of approaches to the forecasting of regional cargo transportation demand confirm the relevance of this study, as well as describe its vision of the parameters of the features of the forecast of freight road transport in the regions.

### III. RESEARCH RESULTS

Transportation of goods is the operational process in RTE management. It is decomposes into many operations and works. Its function determines the enterprise effectiveness. RTE is a large system. Its operational activities are the freight of goods, maintenance of the rolling stock.

The road transportation technology for goods is based on the interaction of operations for transport services and cargo delivery starting with the issuance of cargo and documents at the sender's warehouse and ending with receiving goods at the recipient's warehouse.

The technological process of transportation has a number of features that are determined by the type of cargo, the type of rolling stock, delivery conditions, place of performance (city, region, intercity, international transportation) (A.I. Vorkut, 1986, [13]).

Regional differences of transportation are described by the influence of many factors (L.S. Trofimova, 2017, [14]). The competitiveness of RTEs as a factor in regional transportation demand is a multi-level and multi-criteria indicator, determined with the region's macroeconomic indicators (business activity, gross regional product dynamics, freight base, delivery routes, etc.).

The indicator takes into account factors that determine both possible capabilities and potential demand for the services of each RTE: technological, technical, organizational, economic, etc. Macroeconomic factors of business activity also affect the demand for transportation in the region, they are discussed in details in (V.A. Gubenko, 2016 [15]).

Regional factors of RTE competitiveness could be represented hierarchically. At the first stage, inside the brunch the carriers competitiveness (sub-sectors transport modes in the region) acquires particular importance. Factors of competitiveness are the state and dynamics of technical-technological and organizational-economic parameters. Elements for assessing the RTE competitiveness are:

- Carriage opportunities.
- Carrier reliability.
- Characteristics of vehicles (capacity, vehicle type, level of technical readiness, statistics of faults, etc.).
- Customer focus.
- The share of carrier in the regional transport market.
- Quality of transport services, etc.

Organizational and economic factors determine the effectiveness of the transportation processes for RTE. It also has a significant impact on the quality of services and reliability of carriers, on the level of its customer focus, market image.

All these parameters contribute to the formation of long-term contracts, the growth of demand for the enterprise and the share of RTE presence on the regional transportation market (L. S. Trofimova, N.V. Lovygina [16]).

To conduct a multi-level assessment of RTE competitiveness the following assumptions must be done:

- Every vehicle has an individual number for easy identification in the model.
- Every vehicle can be included in one technological process of transportation of goods.
- Vehicles in urban and long-distance transportation of goods are interdependent working units.

The mathematical demand model founded on the competitive position on the regional transport market assessment allows you to plan the RTE functioning.

The demand for the transportation of goods is estimated by the output in tons per year,  $Q_i$ :

$$\sum_{x=1}^X \min_{j=1, J} (Q_{c i, x, j} \cdot n_{i, x, j}) \cdot (S_i - b_i) \geq Q_{n i i}; \quad i = \overline{1, I}, \quad (1)$$

where  $I$  – number of technological processes;  $x$  - sequence number of the vehicle in the RTE;  $X$  - number of vehicles in RTE;  $j$  - index of the vehicles types corresponding to the type of cargo;  $J$  - number of vehicles types;  $Q_{c, i, x, j}$  - daily production of the  $x$ -th unit of the vehicle for the  $j$ -th index transported by the  $i$ -th process, in tones;  $n_{ixj}$  - boolean destination variable taking into account the possibility of using the  $x$ -th vehicle of the  $j$ -th index transporting by the  $i$ -th process,  $n_{ixj} = \overline{0, 1}$ ,  $n_{ixj} = \text{int}(n_{ixj})$ ;  $S_i$  - number of shifts of the vehicle during transportation by the  $i$ -th technological process;

$b_i$  - number of shifts in the repair and maintenance of vehicle for the  $i$ -th technological process in accordance with the schedule of maintenance and repair;  $Q_i$  - the planned traffic by the  $i$ -th technological process, in tones.

The mathematical model (2) takes into account the possibility of transporting technically serviceable mobile composition:

$$n_{i,x,j} = \begin{cases} 1, \text{ if } a \begin{cases} (N_{TO-1 i,x,j} \cdot u_{TO-1 j}) \geq y_{TO-1 i,x,j}; \\ (N_{TO-2 i,x,j} \cdot u_{TO-2 j}) \geq y_{TO-2 i,x,j}; \\ (N_{TP i,x,j} \cdot u_{TP j}) \geq y_{TP i,x,j}; \end{cases} \\ 0, \text{ otherwise;} \end{cases} \quad i = \overline{1, I}; \quad x = \overline{1, X}; \quad j = \overline{1, J}, \quad (2)$$

where  $N_{TO-1 i,x,j}$ ,  $N_{TO-2 i,x,j}$  and  $N_{TP i,x,j}$  - number of impacts for the  $x$ -th unit of the vehicle for the  $j$ -th type-size when transported according to the  $i$ -th technological process TO-1, TO-2 and TP, unit;  $N_{TO-1 i,x,j} = \text{int}(N_{TO-1 i,x,j})$ ,  $N_{TO-2 i,x,j} = \text{int}(N_{TO-2 i,x,j})$ ,  $N_{TP i,x,j} = \text{int}(N_{TP i,x,j})$ ;  $u_{TO-1 j}$ ,  $u_{TO-2 j}$  and  $u_{TP j}$  - complexity of the impact for the  $j$ -th type-size, respectively, according to TO-1, TO-2 and TP, person · hour;  $y_{TO-1 j}$ ,  $y_{TO-2 j}$  and  $y_{TP j}$  - laboriousness of impacts for the  $x$ -th vehicle of the  $i$ -th size when transported by the  $j$ -th technological process according to TO-1, TO-2 and TP, respectively, according to the rules and procedures for maintenance and repair of vehicles established by the vehicle manufacturer, person · hour.

Calculation of traffic can be carried out under conditions of complete certainty and of incomplete certainty. Prediction of the transportation volume of goods by RTE of complete certainty with a certain volume of transportation for all inter-branch competitors in the region for the current period (year) can be carried out by two methods.

The first method is based on the extrapolation of the demand curve. The second method (3) is based on the competitiveness index changes. The projected traffic volume is calculated as an average value:

$$Q_{nnoi} = \frac{L_i + M_i}{2}; \quad i = \overline{1, I} \quad (3)$$

where  $L_i$  - projected annual traffic volume in accordance with the demand for the implementation of the  $i$ -th technological process, obtained by the method based on extrapolation of the demand curve, in tones;  $M_i$  - the projected annual traffic volume in accordance with the demand for the implementation of the  $i$ -th process, obtained by a method based on a change in the competitiveness index, in tones.

In our opinion, it is not enough to use the volume statistics of past periods to estimate the forecast demand.

The problem can be solved using the RTE competitiveness coefficient (index):

$$L_i = \frac{C_i \cdot S_i}{\sum_{f=0}^F C_{i,f}}; \quad i = \overline{1, I}, \quad (4)$$

where  $C_i$  - predicted demand for RTE for the implementation of the  $i$ -th process, in tones;  $S_i$  - forecasted demand for the implementation of the  $i$ -th technological process in the region, in tones;  $f$  - sectoral competitor index;  $F$  - number of inter-branch competitors in the region;  $C_{i,f}$  - the expected capacity of the  $f$ -th RTE during the  $i$ -th technological process operating in the intended region, t;  $\sum C_{i,f}$  - expected total capacity of all sectoral competing enterprises in the intended region for the  $i$ -th technological process (including RTE).

$$M_i = \frac{O_i \cdot K_i \cdot S_i}{\sum_{f=0}^F O_{i,f}}; \quad i = \overline{1, I}, \quad (5)$$

where  $O_i$  - cargo transportation volume (demand, transferred to the order) to perform the  $i$ -th technological process of the RTE for the current period (year), in tones;  $K_i$  - RTE competitiveness index at the beginning of the forecast period;  $O_{i,f}$  - completed volume of cargo transportation (demand, transferred to the order) of the  $f$ -th RTE by the  $i$ -th technological process for the current period (year), in tones;  $\sum O_{i,f}$  - completed volume of cargo transportation (demand transferred to the order) of all inter-branch competing enterprises in the region for the  $i$ -th technological process for the current period (year), in tons.

If there is no information on the transportation volumes made earlier, the demand forecasting in the conditions of incomplete certainty has particular relevance.

So, the cargo transportations volume (demand, transferred to the order), by RTE for the current period (year), and the competitiveness index are used:

$$Q_{nnoi} = O_i \cdot K_i; \quad i = \overline{1, I}. \quad (6)$$

The mathematical model is based on profit margins as a measure of effectiveness.

Most of the road transport enterprises have their own material and technical base (rolling stock, means of loading and unloading, etc.). In order to achieve economic efficiency this enterprises forecast the degree of loading of their material base in the future in order to correlate the parameters of supply and demand for transportation in the regional market.

The degree of rolling stock loading is determined by the following parameters:

- Specialization of rolling stock (type of vehicles for different types of cargo).
- Compliance of the material base of the RTE with the requirements of the customers for the quality performance of their goods.
- Competition level inside the nearest competitors group.

- Prices and quality level that form the logistics system configuration.
- The level of similar technical parameters and operational indicators inside the nearest competitors group.
- Regional business activity level.
- Transport and logistics infrastructure development in the region.

To determine the future production capacity workload (including the rolling stock RTE), it is necessary to assess its competitive index. It will also allow to carry out monitoring of the compliance of our own technical base with the required market parameters and to make its appropriate configuration for the clients' requests. In this regard it is necessary to perform a calculation of the competitiveness index, which will allow an assessment of the technical base level in comparison with the closest competitors in the region.

The following parameters can be used for calculation:

- Total production capacity of the closest competitors (grouped by type of transport, cargo transported, type of rolling stock, etc.).
- Market share in terms of freight (ratio 1).
- Technical conditions of the rolling stock (technical readiness ((ratio 2), release to the line, customer characteristics),
- Scoring «price / quality service» of the enterprise (ratio 3) and others (ratios 4, 5, etc.) (Fig. 1).

Then we make up outline of the assessment which is based on these indicators. It includes the parameters of the selected group of the closest competitors. Then the average index is compiled (weighted average for a number of parameters) for the group (competitiveness index = 1). The excess of some characteristics in comparison with the average value for the group can be observed.

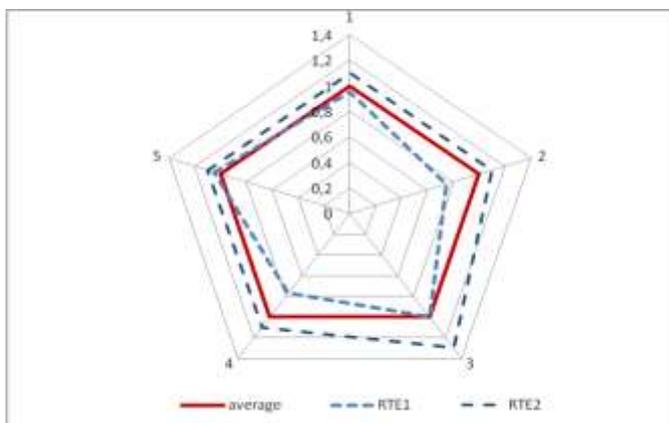


Fig. 1. Competitiveness index elements

Accordingly, the increase in the RTE competitiveness index in comparison with the average for the group is a factor of the company's growth of volume indicators due to its better position among competitors.

Practical implementation of the mathematical model involves software (L.S. Trofimova, N.V. Lovygina. [16]), where optimization is performed by a search method. For the programming - the language Visual Basic for Applications was used. Operating system: Microsoft Windows 2000 / XP. The volume of the program: 770 Kb.

The demand for carriage determining method includes the following steps:

1. Collection of information (study of the brunch state, regional market, customer needs, dynamics of cargo transportation technologies).
2. Determination of the RTE traffic volume in tons.
3. Calculation of vehicle performance in tons.
4. Calculation of transportation profits.

At stages 2, 3 and 4, we use software to calculate the cargo transportation volume under conditions of complete or incomplete certainty. Than we select the vehicle and determine of maximum profit in the most efficient use of RTE vehicles.

The article presents the approbation of the mathematical model including the forecast of construction materials transportation for 3 situations in Omsk. The following data was used in the calculations. The period is a year. The load is of the 1st class, the utilization factor of the cargo capacity = 1. Rolling stock - general purpose vehicles - GAZ-3512, GAZ-3307, KAMAZ-4326, KAMAZ-43114-02, KAMAZ-43118-02, MAZ-6312A5-320-015.

Others: loading and unloading are mechanized; operating time - 8 hours; average technical speed - 24 km / hour; the average ride is 14 km; work days per year - 300; total production capacity of all competing enterprises in the region ( $\sum C_{if}$ ) - 1595121.3 tons; the projected demand in the region ( $S_i$ ) - 1434014.0 tons; competitors - 5 enterprises; cargo transportation (demand, which passed to the order) of all competing enterprises for the period (year) taking into account of the competitiveness index ( $\sum O_{if}$ ) - 1563218.8 tons.

The annual traffic volume by the extrapolation method and profit (net income) of the RTE is shown (Fig. 2).

So in the conditions of full certainty the transportation in tons is 304159; profit in rubles – 4221086; in conditions of incomplete certainty the transportation in tons is 350743; profit (net income of RTE) in rubles is 4867574.

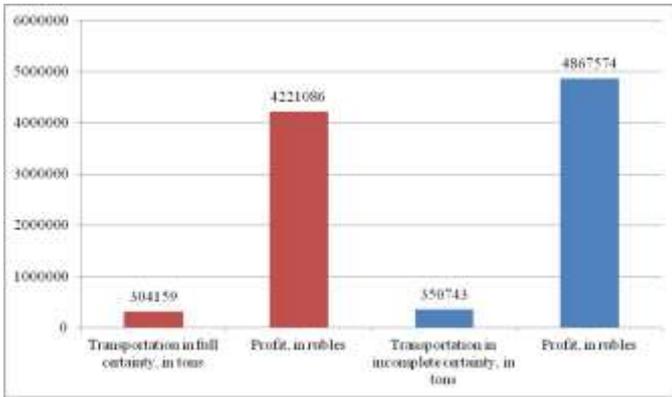


Fig. 2. The results of modelling

According to the statistical data the volume of cargo transportation ( $O_i$  - demand, transferred to the order) of the RTE in the current period (year) amounted to 318,857.1 tonnes.

The trend equation for RTP for Omsk region is  $Q = 159.59x + 317802$ . The projected demand for this RTE in the 6th year ( $C_i$ ) is 318759.5 tons.

The competitiveness index at the beginning of the period can be determined by any of the well known methods.

The competitiveness index of our RTE is determined on the expert evaluation (multicriteria weighted average).

$$K_i = 1.10.$$

The traffic volume in complete certainty, in tones:

$$Q_{n,oi} = \frac{286564.8 + 321752.8}{2} = 304158.8$$

The traffic volume in incomplete certainty, in tones:

$$Q_{n,ni} = 318857.1 \cdot 1.1 = 350742.8.$$

So we received the following projected indicators (tabl.1):

TABLE I Transportation statistics

Indicator	Value
Transportation in conditions of full certainty, in tons	304159
Profit in forecasting of full certainty, in rubles	4221086
Transportation in conditions of incomplete certainty, in tons	350743
Profit in forecasting under conditions of incomplete certainty, in rubles	4867574

#### IV CONCLUSION

The model in the article is intended for the determination of the projecting cargo transportation volumes according to the technological process. It makes possible to calculate the potential traffic volumes taking into account the forecasting production capacity of RTE.

This methodology using for the forecasting of cargo transportation volume will increase the economic efficiency of technological processes in full and incomplete certainty conditions.

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