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# Strategic Forecasting of Multimodal Container Traffic Basing on Transport and Economic Balance of the Russian Federation

# Strategic Forecasting of Multimodal Container Traffic Basing on Transport and Economic Balance of the Russian Federation

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**Abstract.** International cargo containerization system continues progressive development supporting increase of multimodal transport traffic. Containerized commodity transportation schemes are highly efficient for majority of transcontinental and long-distance deliveries optimizing costs, time and quality of transport operations basing on exact forecasting of container turnover. Following these headline routes, research article represents actual methodology of forecasting cargo volumes in accordance with Big Data stated in Transport and Economic Balance of the Russian Federation (TEB), as per spatial input-output predictions of freight traffic between regions of the country by rail, road, inland water and maritime transport by types of commodities. Expanding transportation network is linked to the core freight multimodal transport and logistics centers (TLC), connected with 12 transport hubs having strategic value for Russian economics. Represented research algorithms consider cargo base for 12 TLCs in backbone network subject to types of commodities, growth production and consumption, import and export balance in the strategic timelines of 2024 and 2035. Methodology of forecasting container traffic balance across the country is based on coefficients of container demand for each category of cargo as well as transport modes and transportation schemes. Container traffic forecast indicated by scenarios of TEB model reflect strategy of development and optimization for the freight flows in TLC network. These information models, due to their complex structure and rich semantics, are more likely to belong to the class of models based on knowledge, than on data, that requires further improvement of forecasting methods using intelligent processing of Big Knowledge-Based models.

## 1. Introduction

According to actual foreign trade techniques, the majority of cargo types can be transported in universal intermodal containers. Application of intermodal containerized schemes is efficient for transcontinental and long-distance deliveries, furthermore combined delivery is especially effective since fast transshipments of intermodal containerized units optimize costs, time and quality of transport operations.

In the recent periods international cargo containerization system continued progressive development increasing multimodal transport traffic. Constantly expanding growth of transportation in import, export and domestic transport routes, industrial cargo traffics required the developed backbone network of transport and logistics centers (TLC), implementing effective technologies of multimodal transportation. Reasoning from this circumstances, economically developed countries of the world support the development of modern transport and logistics infrastructure for multimodal transportations.

Increasing the availability and quality of transport services for shippers is a strategic target of the development of the transport system of Russia [1] and is one of the main directions of the confirmed (coordinated) development of transport corridors of the Eurasian Economic Union (EAEU) [2]. In Russian Federation is adopted the strategic decision approving development of backbone network of core freight multimodal transport and logistics centers (TLC), providing high speed container traffic «Just in time». Transport infrastructure of TLC is supported by network of railways and highways. Considering long distances of transportations in Russia, the main applied mode of transport is railway. Organization of regular container trains traffic between the TLCs of the backbone network is considered subject to constant tight schedule. Delivery of containerized cargo from shipper to TLC and from TLC to consignee is provided by road transport.

It is planned to locate TLCs in 12 central transport hubs of Russia - in the cities: Moscow, St. Petersburg, Yekaterinburg, Samara, Kazan, Kaliningrad, Krasnodar, Nizhny Novgorod, Novosibirsk, Rostov-on-Don, Ulan-Ude, Ussuriysk shown in the Figure 1.
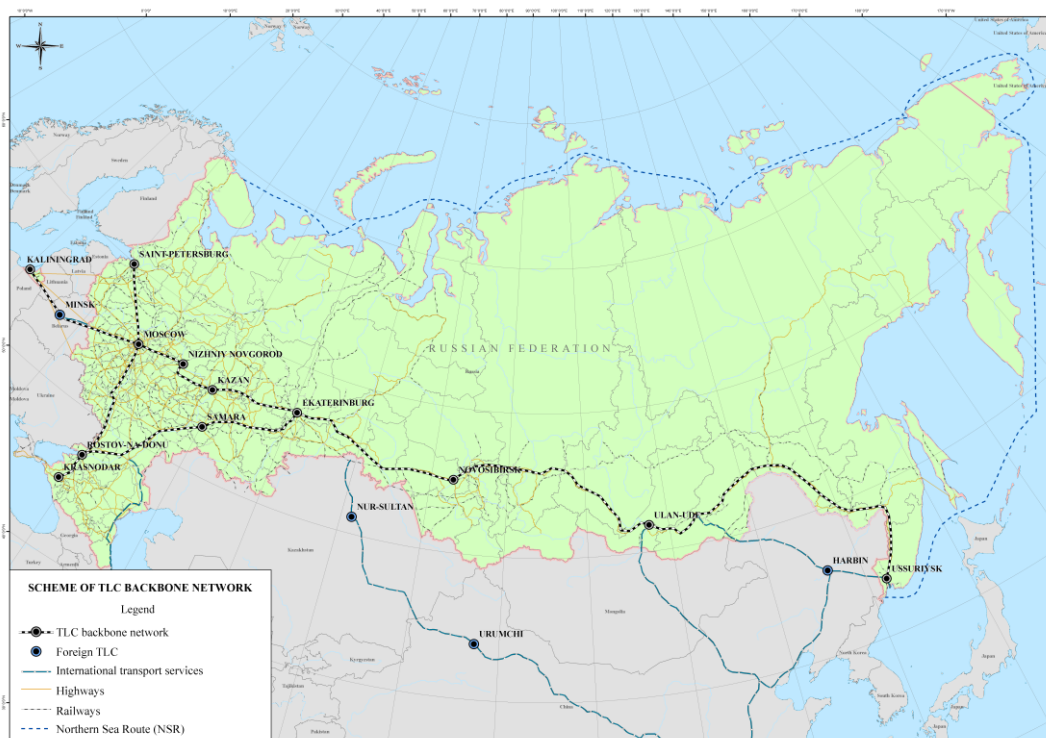


**Figure 1.** Structure of the national TLC network.

Creation of transport and logistics infrastructure for TLCs will be implemented by commercial investors. Considering this forecast, it is important to determine the necessary and sufficient capacity of TLCs, corresponding to the real demand of shippers for high-speed container transportation. At the same time, growth of container traffic in the TLC backbone network will be gradual, determining the appropriate value of initial capacity and volumes of subsequent increase in capacity as per the growth of demand for provided transport services of multimodal transportation growth. Summarizing the above

mentioned, actual forecasting of multimodal container traffic in the TLC network is an important stage in foundation and development of backbone network of core freight multimodal TLCs.

## 2. Research Objectives

Efficiency and processing capacity of TLCs depends on the demand for container transportation in specific regions, transporting certain products to other regions of Russia or for export, as well as receiving goods in import status from other countries. In this regard, on the stage of designing the TLC infrastructure it is important to know the volume of forecasted cargo base formed by the demand of regions for the transportation of containerized goods through the TLC backbone network. It is necessary to estimate the volume of cargo base both for the departures and arrival of goods for each TLC, taking into account the planned development of processing capacity for the period up to 2035.

The purpose of represented process is forecasting growth of freight base for multimodal container transportation through the backbone network of TLCs being created in the Russian Federation during the period up to 2035. It is necessary to conduct analysis of container volume traffic for main categories of goods by type of export, import and local transit. The initial data for calculating forecast of estimated traffic can be taken from the Transport and Economic Balance of the Russian Federation (TEB) [[3],[4]].

The Transport and Economic Balance of the Russian Federation includes freight flows between all the regions of Russia by modes of transport and all main types of commodities. At the same time, important feature of forecasting container traffic is the following aspect – TEB is not including information about created TLCs and the transportations that can be performed on its basis. The main target in this case is to determine the nomenclature of traffic and build forecast for commodity volumes in TLC network, based on assessments of the container suitability for cargo transported in the Russian Federation, including export and import, as well as assessments of the feasibility of transporting various cargo types through the TLC network.

The result of forecasting should be volume of containerized cargo transported through the TLC network during the period up to 2035, including the volume of cargo base for each TLC by departure and destination status, by categories of cargo and types of transportation, as per volume of traffic in the network sections between the TLCs, considering cargo volumes switching from road transport to the TLC network, estimation of total freight traffic in the TLC backbone network.

## 3. The Transport and Economic Balance of the Russian Federation

TEB provides information on actual and forecasted freight flows by types of commodities between regions of the Russian Federation by rail, road, inland waterway and maritime transport.

TEB is based on the balance methodology of research and forecasting the parameters of the Russian economy [5]-[8].

TEB is partially analogous to the ETIS - BASE project (European Transport Policy Information System) that consolidates national transport statistics of European Union countries and provides analytical data for transport planning and decision-making in developing transport in the EU [9].

TEB uses a convenient notation system of the SUST-RUS Project which was held with the participation of experts from Russian Economic School and aimed to describe economic relations and transport links between federal districts of Russia by basic equations [10].

Effective mathematical models of transport and economic balance were developed also in scientific studies [[11]-[13]] having a significant impact on setting and pursuing objectives of the TEB study.

TEB is described in the format of multi-region input-output database tables or multidimensional origin-destination matrix (OD-matrix) of interregional freight flows [[14]-[25]].

Structure of TEB OD-matrix is shown in Figure 2. Rows and columns of the matrix correspond to the regions of origin and destination. Intersections of rows and columns refer to the volumes of freight flows between the regions by types of commodities and modes of transport.

TEB matrix also has a time dimension that shows the origin-destination background of cargo flows from 2007 up to the present. The forecast of cargo flows for the period 2019-2035 is represented in the similar TEB matrix. Various TEB cargo flows are also shown on maps as it is shown in Figures 3-5.
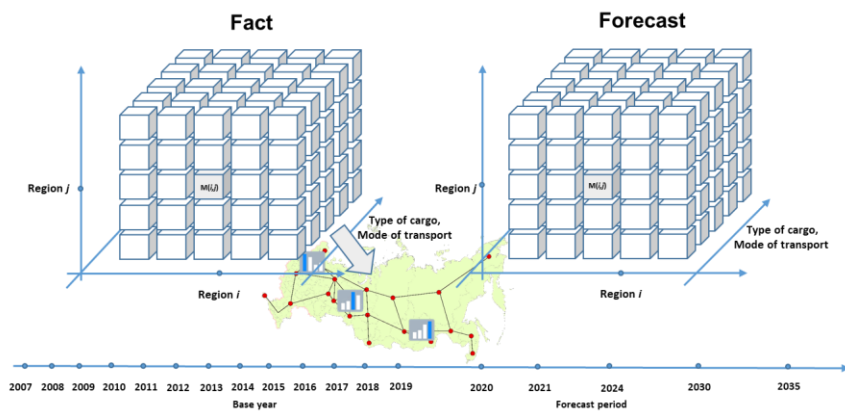
**Figure 2.** Multidimensional matrixes of volumes and correspondence of freight traffic between regions by type of cargo and by modes of transport - an actual data and forecast for the period up to 2035.
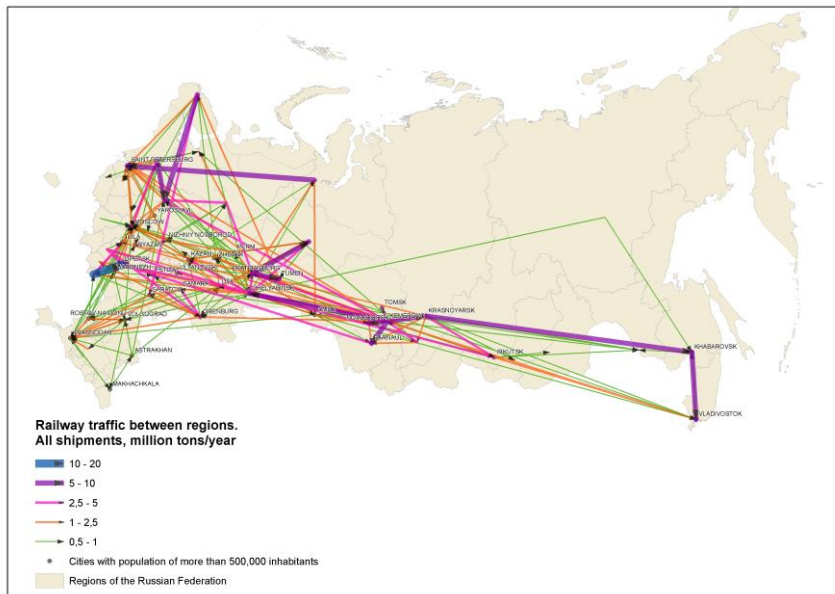


**Figure 3.** Freight traffic between regions of the Russian Federation by rail. All shipments.
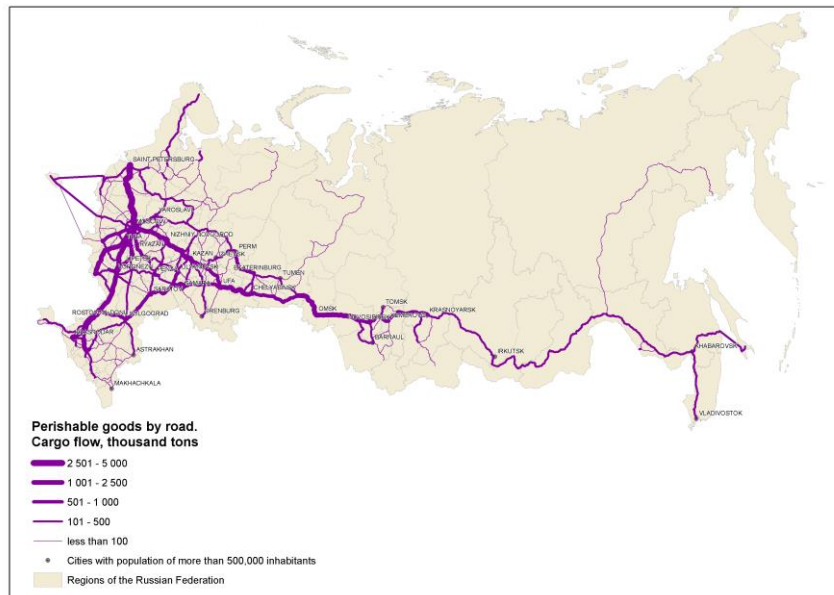
**Figure 4**. Perishable goods cargo flows by road and their density.



**Figure 5**. Dry cargoes by inland water transport.

The TEB matrix satisfy balance equations describing production, consumption, trade and cargo flows between regions within the country, as well as in exports and imports.

The basic balance equations of TEB include the following relations [[3],[4]]:

$$X0_{i,r} = TR_{i,r} + EX_{i,r} \tag{1}$$

$$EX_{i,r} = \sum_{rr} \sum_{k} EX_{i,k,r,rr} \tag{2}$$

$$IM^*_{i,r} = \sum_{rr} \sum_{k} IM_{i,k,r,rr} \tag{3}$$

$$TR_{i,r} = \sum_{rr} \sum_{k} TR_{i,k,r,rr} \tag{4}$$

$$TEB_{i,r,rr} = \sum_{k} TR_{i,k,r,rr} + \sum_{k} EX_{i,k,r,rr} + EX_{i,r,rr}^{MAR} + EX_{i,r,rr}^{IWW} + IM_{i,r,rr}^{MAR} + M_{i,r,rr}^{IWW}$$
$$+ TR_{i,r,rr}^{RAIL} \tag{5}$$

$$EX_{i,r,rr}^{MAR} = EX_{i,r,rr}^{RAIL \rightarrow MAR} + EX_{i,r,rr}^{TRUCK \rightarrow MAR} + EX_{i,r,rr}^{IWW \rightarrow MAR} \tag{6}$$

$$EX_{i,r,rr}^{IWW} = EX_{i,r,rr}^{RAIL \rightarrow IWW} + EX_{i,r,rr}^{TRUCK \rightarrow IWW} \tag{7}$$

$$IM_{i,r,rr}^{MAR} = IM_{i,r,rr}^{MAR \rightarrow RAIL} + IM_{i,r,rr}^{MAR \rightarrow TRUCK} + IM_{i,r,rr}^{MAR \rightarrow IWW} \tag{8}$$

$$IM_{i,r,rr}^{IWW} = IM_{i,r,rr}^{IWW \rightarrow RAIL} + IM_{i,r,rr}^{IWW \rightarrow TRUCK} \tag{9}$$

where:

$XO_{i,r}$ – shipment of goods (cargo) $i$ in region $r$ ;

$TR_{i,r}$ – domestic transportation of goods (cargo) $i$ from region $r$ ;

$EX_{i,r}$ – export of goods (cargo) $i$ from region $r$ ;

$EX_{i,k,r,rr}$ – matrix of export transportation of goods (cargo) $i$ from region $r$ through the border of Russia, passing in the region $rr$ , by mode of transport $k$ ;

$TR_{i,k,r,rr}$ – the matrix of domestic transport of goods by modes of transport, including intraregional transportation;

$IM_{i,r}^{*}$ – the matrix of import shipments of goods (cargo) $i$ by modes of transport to the region $r$ across the border, passing in the $rr$ region;

$EX_{i,r,rr}^{MAR}$ –multimodal transportation of goods (cargo) $i$ from region $r$ with transshipment via maritime transport in the region $rr$ by road, inland waterway and rail transport;

$EX_{i,r,rr}^{IWW}$ –multimodal transportation of goods (cargo) $i$ from the region with transshipment to inland water transport in the region by road and rail transport;

$EX_{i,r,rr}^{RAIL \rightarrow MAR}$ – transshipment of export goods (cargo) $i$ , delivered from the region $r$ to the seaport located in the region $rr$ by rail;

$EX_{i,r,rr}^{IWW \rightarrow MAR}$ – transshipment of export goods (cargo) $i$ , delivered from the region $r$ to the seaport located in the region $rr$ by inland water transport;

$EX_{i,r,rr}^{TRUCK \rightarrow MAR}$ – transshipment of export goods (cargo) $i$ , delivered from the region $r$ to the seaport located in the $rr$ region, by road;

$IM_{i,r,rr}^{MAR}$ –multimodal transportation of goods (cargo) $i$ , arrived across the border of Russia by maritime transport, for transshipment to other modes of transport and further transportation to regions of destination $rr$ ;

$IM_{i,r,rr}^{IWW}$ –multimodal transportation of goods (cargo) $i$ , arrived via the Russian border by inland water transport for transshipment to other modes of transport and further transportation to the regions of destination $rr$ ;

$IM_{i,r,rr}^{MAR \rightarrow RAIL}$ –multimodal transportation of goods (cargo) $i$ , arrived across the border of Russia by maritime transport for transshipment to rail transport and further transportation to the regions of destination $rr$ ;

$IM_{i,r,rr}^{MAR \rightarrow TRUCK}$ –multimodal transportation of goods (cargo) $i$, arrived across the border of Russia to the region by maritime transport for transshipment into road transport and further transportation to the regions of destination $rr$;

$IM_{i,r,rr}^{MAR \rightarrow IWW}$ –multimodal transportation of goods (cargo) $i$, arrived across the border of Russia by maritime transport for transshipment to inland waterway and further transportation to the regions of destination $rr$;

$IM_{i,r,rr}^{IWW \rightarrow RAIL}$ –multimodal transportation of goods (cargo) $i$, arrived via the Russian border by inland water transport for transshipment to rail transport and further transportation to the regions of destination $rr$;

$IM_{i,r,rr}^{IWW \rightarrow TRUCK}$ –multimodal transportation of goods (cargo) $i$, arrived via the Russian border by inland water transport for transshipment to road transport and further transportation to the regions of destination $rr$.

$TR_{i,r,rr}^{RAIL}$ – transshipment of goods (cargo) $i$, within the region $r$ from road to rail and from rail to road.

Equation (1) describes the statement that all produced goods must be transported within the region, or to other regions, or for export. Equations (2), (3) and (4) fix the geographical splitting of exports, imports and domestic cargo flows, respectively. Equation (5) is the basic transport balance equation related to the multimodal transport. Equations (6) and (7) determine the procedure for estimating combined export traffic on the maritime and inland water transport. Equations (8) and (9) determine the procedure for estimating multimodal import traffic involving maritime and inland water transport.

Russia does not conduct regular statistical surveys like the Commodity Flow Survey (CFS) [26] and does not maintain a detailed Commodity Trade Statistics Database [[27],[28]], as is the case of the USA, but possesses a variety of transport and economic statistics that can provide reconstruction of cargo flows using balance equations.

The source data for TEB is Rosstat statistics on the volumes of shipped products in mining and manufacturing industries, trade, construction industry, agriculture, export and import volumes including data from the Federal Customs Service of Russia (FCS of Russia), economic statistics of the fuel and energy complex, as well as transport statistics, including Russian Railways databases, statistics on maritime and inland water transport, road transport.

All the initial information is structured and converted to a harmonized cargo nomenclature of the TEB ensuring the mutual comparability and compatibility of all elements of the source data.

The TEB harmonized cargo nomenclature includes 44 types of cargo [[3],[4]] shown in Table 1.

**Table 1.** Categories and types of cargo in the TEB harmonized cargo nomenclature.

| Code | Categories of cargo | Types of cargo |
|------|---------------------|----------------|
| 1 | construction materials | sand, gravel and stone; cement; construction materials (bricks, blocks, glass and other except wood materials); fireclays and heat resistant materials |
| 2 | coal, coke, peat and shale | coal; coke; peat and shale |
| 3 | oil cargo | crude oil; light petroleum products (gasoline, diesel fuel, kerosene, etc.); heavy petroleum products (heating oil, etc.); compressed or liquefied gas |
| 4 | ore | ferrous metal ore; non-ferrous metal ore and other ore |
| 5 | ferrous material | rolled stock of ferrous metals; steel pipes; other ferrous metals |
| 6 | fertilizers | mineral and chemical fertilizers; raw mineral and chemical fertilizers (ore); organic fertilizers |

| 7 | timber cargo | roundwood (round logs); wood process products |
|---|---|---|
| 8 | grain and grind products | grain; grinding products |
| 9 | other cargo | chemicals and soda; non-ferrous metals and products from them; fluxes; hardware and metal construction materials; cellulose; cardboard, paper, printing products; agricultural products; compound feedstuff; food and drink products (except for mixed fodder); sugar; scrap metal, other recyclables, waste; ferrous scrap; non-ferrous scrap; recyclables, waste, garbage; textiles, garment production; leather, leather goods and shoes; rubber products; other non-metal products not included in other groups; hardware, machinery and equipment; vehicles; electrical equipment, electronic and optical equipment; other goods not included in other groups |

Exports and imports of goods (products) for regions of Russia are estimated on the basis of harmonized industrial statistics and foreign economic statistics. The volume of cargo loaded in the regions is estimated on the basis of production data. Interregional origin-destination transportation matrix for the regions and intraregional volumes of transportation are generated from transport statistics. Calculation of the balance [3] does not need additional time-consuming surveys.

Spatial input-output TEB tables represent origin-destination flows (OD-matrix) covering 97% of actual and forecasted freight traffic between Russian regions by types of commodities and modes of transport. Road transport traffic estimation is based on economic statistics, transportation by other modes of transport and data from traffic tracking points.

Accounting technology differences for the initial statistical forms in couple with their incompleteness and inaccuracy as well as small data converting errors to unified cargo (product) accounting units used in TEB cause certain discrepancies that are corrected using TEB balance equations (3.1) – (3.9). As a result, the TEB has 95% accuracy, and interregional discrepancies are 3-5% on average.

## 4. Forecasting Methodology

Forecast TEB model is based on the economic scenario forecast of the Ministry of Economic Development of Russia and economic development scenarios of Russian regions.

Forecast of cargo base for the regions covering the period up to 2035 is formed according to the types of TEB harmonized cargo nomenclature, multiplying the actual cargo base by the indices of economic development corresponding to the types of economic activity, supported by statistics of the Ministry of Economic Development of Russia and regional economic development scenarios.

The software forecast model of TEB takes into account changes in technological and transport connectivity of main cargo generating industries, reflecting the technological links of these industries with resource suppliers and consumers of products. At the same time, the forecast model uses the direct cost matrix of the symmetrical input-output table (inter-sectoral balance) for Russia as a whole as well as assessing the parameters of regional development by types of economic activities [29].

TEB forecast based on current transport data provides an assessment of imbalances in the use of various types of transport, identification of cargo-intensive transport directions, determination of measures for switching traffic flows to the most profitable transport schemes and development of the transport infrastructure capacity.

On the basis of TEB of the Russian Federation will be formed strategic forecast of TLC backbone network cargo base for time periods up to 2024 and 2035.

For all categories of cargoes from the TEB nomenclature have been calculated coefficients of container demand, reflecting the expected values of shares for corresponding goods that will be

potentially transported in containers by rail and road transport in export, import and internal deliveries between the regions of Russia. The calculations are based on existing data representing level of containerization for transportation by rail and other modes of transport in Russian Federation.

Coefficient of container demand K (C, M) for type of cargo C on a mode of transport M expresses the share of traffic volume V (C, M) for cargo of a given type C transported in Russia by type of transport M in containers in a certain Routing, taken out of the total volume $V_{total}$ (C, M) goods of this kind C, carried by mode of transport M in considered direction:

$$K(C,M) = \frac{V(C,M)}{V_{total}(C,M)} \qquad (10)$$

For example, coefficient of container demand for transportation of paper products by rail is 0,231. Considering this, totally 23,1% of interregional transportations of paper, including cardboard, cellulose and printing products, are implemented by containers. The level of containerization for import transportation of paper is significantly higher - 0,351. The share of container shipments in paper exports is even higher – 0,683. Basically, more than two thirds of the exported paper products are transported in containers.

Above mentioned calculations are implemented on the basis of statistical data of JSC "Russian Railways" for 268 categories of cargo, processed for interregional domestic transportations, export and import. At the same time, it was necessary to combine the railway nomenclature of goods, the expanded nomenclature of TEB cargoes and the nomenclature specifying container transportation.

In calculation of forecast for TLC cargo base it was taken into account that after commissioning of the TLC backbone network it is possible to switch a number of freight flows from road transport to the railway network connecting TLCs. The main reason for represented transport scheme transformation is based on fact that long-distance transportation of containerized cargo becomes more efficient in case of applying intermodal road-rail transportation using the TLC network in comparison with transportation by road only. In order to assess the additional volumes of such traffics it is necessary to calculate coefficients of container demand, which can have possibility of switching from road to rail transport after creation of the TLC backbone network. These coefficients are calculated for all categories of cargo and types of transportation basing on the assessments of demanding TLC backbone network for long-distance container transport and subject to actual coefficients of container demand on railway.

The competitiveness of container transportation by road is associated, first of all, with a higher speed over short distances. According to the results of 2018, the average distance of container transportation by road in Russia did not exceed 500 km. The efficiency of using road transport will remain only for transportation over relatively short distances (within 500 - 800 km), which occur within the TLC attraction zone. At the same time, in accordance with the used forecasting methodology, transportation within TLC attraction zone is not taken into account in the cargo base of this TLC. In future it can be expected that the majority of containerized cargo transportation (30 categories), carried by road, leaving the TLC attraction zone will transfer to the TLC network.

Potentially the cargo base of TLC network, referring to goods with a high level of containerization, can be attributed on average to 50% of the volume of domestic transportation by road over long distances, and from the volume of export-import traffic - up to 80%. Let us denote by $Sw_{in}$ the average share of the volume for domestic container transportations by road transport over long distances, for which transportation via the TLC network is more attractive (efficient) than direct transportation by road transport, and $Sw_{out}$ - the average share of the volume of export-import traffic, for which the TLC network is more attractive in comparison with road transport.

In provided forecast calculations these coefficients were determined by experts: $Sw_{in} = 0,5$; $Sw_{out} = 0,8$. For export and import transportations the global trend of cargo containerization is taken into account, as well as the fact that exports and imports are associated with long transportation distances. At the same time, in many cases, such transportations are carried out by road transport in combination with sea transport, after unloading or before shipment in seaports. For such transportation of export-import

cargoes to / from seaports the TLC network will provide significant advantages. In this regard, such transportations will be included in potential cargo base for the TLC backbone network.

In the coefficient of container demand for goods moving from road to rail transport, deviations of the volumes of transportation of various types of goods in containers by rail from the average value are taken into account. These deviations describe positive or negative difference in shippers preferences for transportation of certain goods by rail in containers from the average level of container transport for all goods transported in containers by rail. Thus, calculating the coefficients of container demand for goods that will switch from road to rail transport, will be taken into account preferences of shippers sending goods in containers by rail, in relation to the average value determined in the amount of $Sw_{in} = 0.5$ from transportations by road.

If the coefficients of container demand of a certain type of cargo by rail is less than the average value, then the coefficient for domestic transport for road transport is assumed to be:

$$K_{in}(C, Avt) = Sw_{in} \cdot \frac{K_{in}(C, Rail)}{K_{Rail}^{ave}} \tag{11}$$

In the formula $K(C, Avt)$ - the required coefficients of container demand for transportation by road, taken into account in the forecast of the cargo base of the TLC; $K(C, Rail)$ – the coefficients of container demand of this category of goods for transportation by railway; $K_{Rail}^{ave}$ – the average value of the coefficients of container demand on rail for all categories of cargo.

If the coefficient of container demand related to a certain type of cargo on railway exceeds the average value, then for road transport the coefficient of container demand for this cargo for domestic transportations is calculated by the formula:

$$K_{in}(C, Avt) = Sw_{in} + (1 - Sw_{in}) \cdot \frac{K_{in}(C, Rail) - K_{in, \ Rail}^{ave}}{1 - K_{in, \ Rail}^{ave}} \tag{12}$$

Similarly, the coefficients of container demand for export and import transportation are determined for road transport. In categories of goods for which the coefficient of container demand in export or import transportations by rail is less than the average value, the corresponding coefficient for road transport is calculated by the formula:

$$K_{out}(C, Avt) = Sw_{out} \cdot \frac{K_{out}(C, Rail)}{K_{Rail}^{ave}} \tag{13}$$

If the coefficients of container demand for a certain category of goods in export or import transportation by rail exceed the average value, the following formula is applied for road transport:

$$K_{out}(C, Avt) = Sw_{out} + (1 - Sw_{out}) \cdot \frac{K_{in}(C, Rail) - K_{in, \ Rail}^{ave}}{1 - K_{in, \ Rail}^{ave}} \tag{14}$$

If the rail coefficient of container demand is very small, then the coefficient for road transport is exceedingly small. Such case with particularly low values of the coefficients takes place, for example, for the transportation of construction cargo, especially for non-metallic construction materials, which are leading in terms of the volume of traffic in road transport. At current time the level of containerization in the transportations of this kind of cargo by rail is entirely insignificant, therefore, in the considered conservative version, the predicted values of the volumes that can be transferred from road transport to the TLC network for this cargo are also insignificant and practically equal to zero. If the level of containerization for these cargoes increases, then the cargo base of the TLC network can grow significantly (by 20-30%) due to this category of cargo.

Table 2 represents the coefficients of container demand for a conservative option of assessing predicted traffic by categories of cargo from the extended nomenclature TEB in the cargo base of the TLC, both by rail and by road.

**Table 2**. Coefficients of container demand (transportability) for each category of cargo in the TLC network as well as for transportation modes by rail and road transport.

| Extended nomenclature of cargo | Railway transport | | | Road transport | | |
| --- | --- | --- | --- | --- | --- | --- |
| | Domestic delivery | Export | Import | Domestic delivery | Export | Import |
| cardboard, paper, printing products | 0,231 | 0,683 | 0,351 | 0,563 | 0,928 | 0,853 |
| cellulose | 0,231 | 0,683 | 0,351 | 0,563 | 0,928 | 0,853 |
| textiles, garment production | 0,092 | 0,008 | 0,378 | 0,382 | 0,054 | 0,859 |
| milling products | 0,049 | 0,013 | 0,002 | 0,203 | 0,087 | 0,013 |
| chemicals and soda | 0,230 | 0,238 | 0,600 | 0,562 | 0,827 | 0,909 |
| sugar | 0,032 | 0,000 | 0,000 | 0,134 | 0,000 | 0,000 |
| leather, leather goods and footwear | 0,092 | 0,008 | 0,378 | 0,382 | 0,054 | 0,859 |
| electrical equipment, electronic and optical equipment | 0,092 | 0,008 | 0,378 | 0,382 | 0,054 | 0,859 |
| refractories | 0,003 | 0,158 | 0,044 | 0,011 | 0,809 | 0,293 |
| other ferrous metals | 0,012 | 0,044 | 0,086 | 0,049 | 0,293 | 0,570 |
| other tare-pcs. cargo | 0,092 | 0,008 | 0,378 | 0,382 | 0,054 | 0,859 |
| food products and drinks (except for compound feed) | 0,199 | 0,029 | 0,074 | 0,545 | 0,194 | 0,492 |
| mineral and chemical fertilizers | 0,015 | 0,024 | 0,001 | 0,063 | 0,159 | 0,004 |
| products of the timber industry | 0,104 | 0,255 | 0,235 | 0,434 | 0,831 | 0,826 |
| Rubber products | 0,092 | 0,008 | 0,378 | 0,382 | 0,054 | 0,859 |
| non-ferrous metals and products from them | 0,466 | 0,380 | 0,827 | 0,696 | 0,859 | 0,961 |
| Construction Materials | 0,075 | 0,012 | 0,154 | 0,311 | 0,078 | 0,808 |
| rolling of ferrous metals | 0,012 | 0,044 | 0,086 | 0,049 | 0,293 | 0,570 |
| hardware, machinery and equipment | 0,535 | 0,134 | 0,736 | 0,736 | 0,803 | 0,940 |
| hardware and metal structures | 0,317 | 0,723 | 0,880 | 0,612 | 0,937 | 0,973 |
| other goods not assigned to other groups | 0,092 | 0,008 | 0,378 | 0,382 | 0,054 | 0,859 |
| corn | 0,005 | 0,002 | 0,012 | 0,022 | 0,014 | 0,081 |
| agricultural products | 0,199 | 0,029 | 0,074 | 0,545 | 0,194 | 0,492 |
| compound feed | 0,149 | 0,004 | 0,255 | 0,517 | 0,026 | 0,831 |
| organic fertilizers | 0,008 | 0,024 | 0,001 | 0,034 | 0,159 | 0,004 |
| mining chemical raw materials | 0,008 | 0,024 | 0,001 | 0,034 | 0,159 | 0,004 |
| non-metallic building materials, industrial raw materials and forms. mat. | 0,000 | 0,014 | 0,010 | 0,001 | 0,096 | 0,070 |
| cement | 0,000 | 0,000 | 0,001 | 0,001 | 0,000 | 0,005 |

| Extended nomenclature of cargo | Railway transport | | | Road transport | | |
|---|---|---|---|---|---|---|
| | Domestic delivery | Export | Import | Domestic delivery | Export | Import |
| recyclable materials, waste, garbage | 0,100 | 0,100 | 0,100 | 0,417 | 0,667 | 0,667 |

In accordance with the calculated coefficients of container demand (transportability) 30 types of the most containerized cargo potentially carried in containers through the TLC network are identified in the nomenclature of TEB.

The following categories of goods have been selected in descending order of the container transportation coefficients for domestic cargo delivery over the TLC network: hardware, machinery and equipment; non-ferrous metals and products from them; hardware and metal structures; cardboard, paper, printing products; cellulose; chemicals and soda; food products and drinks (except compound feed); agricultural products; compound feed; products of the timber processing industry; recyclable materials, waste, garbage; textiles, garment production; leather, leather goods and footwear; electrical equipment, electronic and optical equipment; other packaged goods; rubber products; other goods not assigned to other groups; other non-metallic products not classified in other groups; construction materials; milling products; sugar; mineral and chemical fertilizers; other ferrous metals; rolling of ferrous metals; organic fertilizers; mining and chemical raw materials; corn; refractories; cement; non-metallic building materials, industrial raw materials and forming materials. For other cargo categories the coefficients of container transportation and accounting of the cargo base are small, less than 1%.

For export-import transportation, the arrangement of cargo categories from the fuel and energy balance nomenclature by container transport coefficients is significantly different (in descending order of coefficients): hardware and metal structures; cardboard, paper, printing products; cellulose; non-ferrous metals and products from them; products of the timber processing industry; chemicals and soda; refractories; hardware, machinery and equipment; recyclable materials, waste, garbage; other ferrous metals; rolling of ferrous metals; food products and drinks (except compound feed); agricultural products; mineral and chemical fertilizers; organic fertilizers; mining and chemical raw materials; non-metallic building materials, industrial raw materials and forming materials; milling products; construction materials; textiles, garment production; leather, leather goods and footwear; electrical equipment, electronic and optical equipment; other packaged goods; rubber products; other goods not assigned to other groups; other non-metallic products not classified in other groups; compound feed; corn; sugar; cement.

For each TLC were identified two attraction zones for the projected traffic flows. First attraction zone includes the region where TLC is located, as well as adjacent regions (subject to distance from the center to the TLC is less than 400 km by road). This zone includes regions where goods can be effectively delivered to mentioned TLC by road. The second attraction zone of TLC includes regions for which this TLC is the closest of 12 TLCs in the backbone network along the roads, and also the most preferable for passing through the road routes in main cargo flows generated by this region. The distance from the center of the region for the second attraction zone to the TLC is more than 400 km.

Distribution of Russian regions by the TLC attraction zones is represented in Table 3.

**Table 3.** Distribution of regions of the Russian Federation by zones of attraction of the TLC.

| TLC | Region of Russia | Attraction zone |
|---|---|---|

| Ekaterinburg | Kurgan region, Perm region, Sverdlovsk region, Tyumen region (except KhMAO, YaNAO), Chelyabinsk region | 1 |
|---|---|---|
| Ekaterinburg | Khanty-Mansi Autonomous Okrug - Yugra, Yamalo-Nenets Autonomous Okrug | 2 |
| Kazan | Republic of Mari El, Republic of Tatarstan, Udmurt Republic, Chuvash Republic | 1 |
| Kazan | Komi Republic | 2 |
| Kaliningrad | Kaliningrad region | 1 |
| Krasnodar | Karachay-Cherkess Republic, Krasnodar Territory, Republic of Adygea, Stavropol Territory | 1 |
| Krasnodar | Sevastopol, Kabardino-Balkar Republic, Republic of Dagestan, Republic of Ingushetia, Republic of Crimea, Republic of North Ossetia-Alania, Chechen Republic | 2 |
| Moscow | Vladimir region, Moscow, Ivanovo region, Kaluga region, Moscow region, Ryazan region, Smolensk region, Tver region, Tula region, Yaroslavl region | 1 |
| Moscow | Arkhangelsk Region (except for the Nenets Autonomous District), Vologda Region, Nenets Autonomous District (Arkhangelsk Region), Bryansk Region, Kursk Region, Lipetsk Region, Oryol Region, Tambov Region | 2 |
| Nizhny Novgorod | Kostroma region, Nizhny Novgorod region, Republic of Mordovia | 1 |
| Nizhny Novgorod | Kirov region, Penza region, Ulyanovsk region | 2 |
| Novosibirsk | Altai Territory, Kemerovo Region, Novosibirsk Region, Omsk Region, Tomsk Region | 1 |
| Novosibirsk | Krasnoyarsk Territory, Altai Republic, Tyva Republic, Khakassia Republic | 2 |
| St. Petersburg | St. Petersburg, Leningrad region, Novgorod region, Pskov region, Republic of Karelia | 1 |
| St. Petersburg | Murmansk region | 2 |
| Rostov-on-Don | Rostov region | 1 |
| Rostov-on-Don | Astrakhan region, Belgorod region, Volgograd region, Voronezh region, Republic of Kalmykia | 2 |
| Samara | Orenburg region, Samara region, Saratov region | 1 |
| Samara | Republic of Bashkortostan | 2 |
| Ulan-Ude | Irkutsk region, Republic of Buryatia, | 1 |
| Ulan-Ude | Trans-Baikal Territory, Magadan Region, Republic of Sakha (Yakutia) | 2 |
| Ussuriysk | Primorsky Territory, Khabarovsk Territory | 1 |
| Ussuriysk | Kamchatka Territory, Sakhalin Region, Chukotka Autonomous District, Amur Region, Jewish Autonomous Region | 2 |

For country regions belonging to first TLC zone of attraction, the values of container demand coefficients are summarized in the Table 2. For regions of second zone of attraction of the TLC, container transport coefficients are scaled depending on the distance of the region of the second zone from this TLC in accordance with the gravity model. The predicted volumes of cargo base are calculated for each TLC by departure and destination for two zones of attraction of this TLC.

The calculation of cargo forecast base for the TLC is performed as follows. For each TLC were selected all forecasted traffic volumes from the TEB basing on the period up to 2035, for which the

regions of destination or departure belong to the zone of attraction of this TLC, and the category of cargo is among the selected container-suitable cargo, where service of TLC network is effective. Only long-distance transportations are taken into account, all transportations between regions in the zone of attraction of one TLC are excluded. Selected cargo traffic volumes are automatically grouped by categories of goods from the extended nomenclature of TEB, applied modes of transport (rail and road), types of transportation (domestic, export, import). The cargo traffic volumes for these categories of goods are multiplied by the corresponding coefficients of container demand (transportability). At the output, total values of the potential cargo base by departure and destination are obtained for each TLC and the distribution of the cargo base in the sections of the nomenclature of goods, types of transportation, modes of transport, zones of attraction of the TLC.

Tables 4 and 5 show the results of calculations of the potential cargo base for departure and destination for all objects of the TLC backbone network up to 2035 with distribution by type of transportation and modes of transport (including switching from road transport to the TLC network).

**Table 4.** Departure freight base of the TLC in 2035 by type of transportation and modes of transport (thousand tons).

| TLC | Freight base of TLC for departure | | | | | |
|---|---|---|---|---|---|---|
| | **Sum** | **Domestic delivery** | **Export** | **Import** | **Railway** | **Switching from auto** |
| Ekaterinburg | **9 161** | 5 084 | 3 866 | 212 | 6 960 | 2 201 |
| Kazan | **3 889** | 2 108 | 1 753 | 28 | 2 576 | 1 312 |
| Kaliningrad | **425** | 396 | 12 | 17 | 261 | 164 |
| Krasnodar | **3 319** | 2 596 | 235 | 488 | 963 | 2 355 |
| Moscow | **11 019** | 5 832 | 3 611 | 1 576 | 6 528 | 4 491 |
| Nizhny Novgorod | **3 644** | 2 312 | 1 304 | 28 | 2 031 | 1 613 |
| Novosibirsk | **6 696** | 3 147 | 3 455 | 94 | 5 712 | 984 |
| Rostov-on-Don | **7 921** | 5 977 | 1 144 | 800 | 2 348 | 3 040 |
| Samara | **6 316** | 3 782 | 2 234 | 300 | 3 411 | 4 510 |
| Petersburg | **5 388** | 2 264 | 1 064 | 2 060 | 4 622 | 1 694 |
| Ulan-Ude | **4 713** | 939 | 2 931 | 843 | 4 209 | 504 |
| Ussuriysk | **3 075** | 922 | 11 | 2 142 | 2 918 | 157 |
| **Total** | **65 567** | **35 359** | **21 620** | **8 588** | **42 540** | **23 027** |

The largest volumes of the freight base for dispatch on the Moscow TLC - 11 million tons, Yekaterinburg and Rostov TLC – 9,2 and 8 million tons, respectively. For the rest of the TLC, except Kaliningrad TLC, the potential cargo base of outgoing cargo flows exceeds 3 million tons. According to the calculations carried out, for 8 out of 12 TLCs, domestic traffic makes up more than half of the freight base for dispatch. Export shipments account for more than half of the freight base for dispatch for two Siberian TLCs: Ulan-Ude (62%) and Novosibirsk (52%). Import prevails in the cargo base of Ussuriysk (70%).

**Table 5**. Destination freight base of the TLC in 2035 by type of transportation and modes of transport (thousand tons).

| | Freight base of TLC for destination | | | | | |
|---|---|---|---|---|---|---|
| **TLC** | **Sum** | **Domestic delivery** | **Export** | **Import** | **Railway** | **Switching from auto** |
| Ekaterinburg | 4 269 | 3 036 | 300 | 933 | 3 388 | 881 |
| Kazan | 2 115 | 1 686 | 3 | 426 | 1 429 | 686 |
| Kaliningrad | 272 | 174 | 82 | 16 | 143 | 129 |
| Krasnodar | 6 572 | 2 548 | 3 510 | 514 | 4 579 | 1 993 |
| Moscow | 17 705 | 10 698 | 1 807 | 5 199 | 7 601 | 10 104 |
| Nizhny Novgorod | 2 465 | 2 034 | 21 | 410 | 1 002 | 1 462 |
| Novosibirsk | 4 201 | 2 764 | 368 | 1 069 | 3 476 | 724 |
| Rostov-on-Don | 4 098 | 2 978 | 682 | 438 | 9 662 | 2 387 |
| Samara | 4 274 | 2 861 | 927 | 486 | 1 803 | 2 295 |
| Petersburg | 12 049 | 3 197 | 8 387 | 466 | 2 823 | 1 451 |
| Ulan-Ude | 3 164 | 1 757 | 876 | 531 | 2 620 | 545 |
| Ussuriysk | 4 380 | 1 617 | 2 690 | 72 | 4 047 | 333 |
| Total | 65 562 | 35 350 | 19 654 | 10 559 | 42 573 | 22 990 |

Moscow TLC is the firm leader in terms of the potential volume of incoming containerized cargo in 2035. It accounts for 17,7 million tons of incoming goods transported to the constituent entities of the Russian Federation related to the zone of attraction of the Moscow TLC. The second place is taken by St. Petersburg - 12 million tons. These two TLCs account for almost half of the entire cargo base for its intended purpose. Krasnodar ranks third in terms of cargo base volume (6,6 million tons). For all TLCs except Kaliningrad, the potential cargo base of incoming cargo flows exceeds 2 million tons.

According to provided analysis, the main directions of export traffic through the TLC network are forecasted to St. Petersburg, Krasnodar and Ussuriisk. Thus, export cargoes transported through the TLC network are exported through the large seaports located in the zones of attraction of these TLCs.

Table 6 presents the calculated estimation of total cargo base of the TLC network for 2035 distributed by categories of transported goods and by types of transportation.

**Table 6**. Total freight base of the TLC network on 2035 by the nomenclature of goods, by types of transportation (thousand tons).

| Volume of freight traffic through the TLC network, cargo categories | | | | |
|---|---|---|---|---|
| **Cargo categories** | **Sum** | **Domestic delivery** | **Railway** | **Switching from auto** |
| chemicals and soda | 41 807 | 21 916 | 11 871 | 8 020 |
| food products and drinks (except for compound feed) | 27 253 | 25 028 | 255 | 1 970 |
| products of the timber industry | 11 940 | 1 355 | 10 400 | 185 |
| cardboard, paper, printing products | 6 345 | 1 070 | 4 208 | 1 068 |
| non-ferrous metals and products from them | 5 984 | 1 175 | 4 452 | 357 |
| mineral and chemical fertilizers | 5 403 | 2 273 | 3 130 | 0 |
| rolling of ferrous metals | 4 928 | 973 | 3 372 | 582 |
| agricultural products | 4 292 | 4 216 | 5 | 71 |
| construction materials | 3 213 | 2 781 | 26 | 407 |

| | | | |
|---|---|---|---|
| hardware, machinery and equipment | 2 745 | 1 198 | 40 | 1 506 |
| hardware and metal structures | 2 605 | 1 048 | 194 | 1 363 |
| compound feed | 2 587 | 2 488 | 2 | 97 |
| cellulose | 2 141 | 220 | 1 864 | 57 |
| sugar | 1 505 | 1 505 | 0 | 0 |
| other goods not assigned to other groups | 1 353 | 528 | 7 | 818 |
| others are dumb. products not attributed to other groups | 1 045 | 326 | 28 | 690 |
| textiles, garment production | 997 | 279 | 2 | 717 |
| recyclable materials, waste, garbage | 902 | 627 | 263 | 13 |
| other ferrous metals | 753 | 31 | 683 | 39 |
| electrical equipment, electronic and optical equipment | 607 | 80 | 1 | 525 |
| corn | 562 | 497 | 46 | 19 |
| rubber products | 552 | 299 | 6 | 247 |
| milling products | 547 | 527 | 18 | 1 |
| refractories | 498 | 23 | 358 | 118 |
| leather, leather goods and footwear | 228 | 30 | 0 | 198 |
| mining chemical raw materials | 176 | 176 | 0 | 1 |
| **Total** | **131 129** | **70 709** | **41 274** | **19 146** |

According to the forecast estimate for 2035, there are three leaders among all categories of cargo in terms of potential volumes of freight traffic through the TLC network.

In the first place are chemicals and soda. The chemical industry accounts for almost a third, 32% of the entire cargo base. The projected volume of processing this category of goods at the TLC network is 41,8 million tons. Chemicals and soda occupy leading positions in the cargo base for the vast majority of TLCs. Second place in terms of freight traffic for the TLC network refers to the transportation of food and beverages. For this category, the projected processing volume for 2035 is 27,3 million tons. Third place is taken by products of timber processing industry, the expected volume of processing at the TLC network is 12 million tons. Totally 3 largest cargo categories in terms of volume account are equal to 60% of the total cargo base of the TLC network.

Further, in terms of traffic volumes, there are such categories of goods as: paper (6,4 million tons); non-ferrous metals and products from them (6 million tons); mineral and chemical fertilizers (5,4 million tons); rolled ferrous metals (5 million tons); agricultural products (4,3 million tons); building materials (3,2 million tons, excluding non-metallic building materials).

In terms of the forecasted volumes of export traffic on the TLC network, the leading positions are taken by chemicals and products of the timber processing industry.

It is important to determine that characteristics of the TLC network operation are effecting forecast of distribution for freight traffic over the sections of the TLC backbone network. In this case, the volume of traffic on one section in opposite directions is generally different.

Based on the analysis of TEB data in more than 200,000 actual and predicted freight traffics, the forecast volumes of correspondence for 2035 between all TLCs of the backbone network, traffic volumes for all sections of the network were calculated.

The TLC backbone network includes 12 sections, which organize the movement of freight trains in both directions. Table 7 shows the calculated forecasted traffic volumes for each section of network by type of traffic and mode of transport. The sections (edges of the TLC network) are grouped in accordance with the routes of the International Transport Corridors "East-West" and "North-South".

**Table 7.** Distribution of containerized cargo transportation volumes by sections of the TLC network.

**Forecasted volume of containerized cargo transportation by sections of the TLC network for 2035**

**West - East**

| № | Section start | Section end | Domestic delivery | Export | Import | Sum | including | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Railway | Switching from auto |
| 1 | Kaliningrad | Moscow | 395,1 | 12,4 | 17,1 | 424,6 | 261,1 | 163,5 |
| 2 | Moscow | Nizhny Novgorod | 3819,4 | 180,9 | 1099,1 | 5099,4 | 3539,6 | 1559,8 |
| 3 | Rostov-on-Don | Samara | 1812,1 | 357,6 | 606,1 | 2775,9 | 2080,4 | 695,5 |
| 4 | Samara | Ekaterinburg | 2470,0 | 149,2 | 411,9 | 3031,1 | 2242,4 | 788,7 |
| 5 | Nizhny Novgorod | Kazan | 3937,6 | 255,9 | 808,7 | 5002,2 | 3750,2 | 1252,0 |
| 6 | Kazan | Ekaterinburg | 4282,2 | 445,3 | 536,4 | 5263,8 | 3771,3 | 1492,5 |
| 7 | Ekaterinburg | Novosibirsk | 4118,3 | 383,5 | 569,5 | 5071,4 | 4268,3 | 803,1 |
| 8 | Novosibirsk | Ulan-Ude | 3161,1 | 2159,2 | 284,2 | 5604,5 | 4998,9 | 605,6 |
| 9 | Ulan-Ude | Ussuriysk | 1617,3 | 2690,3 | 60,9 | 4368,5 | 4047,2 | 321,3 |
| | | Total | 25 613,2 | 6 634,2 | 4 393,9 | 36 641,3 | 28 959,4 | 7 681,9 |

**East - West**

| № | Section start | Section end | Domestic delivery | Export | Import | Sum | including | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Railway | Switching from auto |
| 1 | Moscow | Kaliningrad | 174,0 | 82,2 | 15,5 | 271,7 | 142,3 | 129,4 |
| 2 | Nizhny Novgorod | Moscow | 5194,6 | 6738,1 | 1659,7 | 13592,5 | 10496,3 | 3096,2 |
| 3 | Samara | Rostov-on-Don | 2972,4 | 3338,7 | 234,2 | 6545,3 | 5411,2 | 1134,1 |
| 4 | Ekaterinburg | Samara | 2709,9 | 2066,8 | 199,1 | 4975,8 | 3774,5 | 1201,3 |
| 5 | Kazan | Nizhny Novgorod | 5035,3 | 5536,5 | 1736,4 | 12308,1 | 9682,5 | 2625,6 |
| 6 | Ekaterinburg | Kazan | 4957,5 | 3987,2 | 1857,2 | 10801,9 | 8563,7 | 2238,2 |
| 7 | Novosibirsk | Ekaterinburg | 2988,1 | 2536,2 | 2250,3 | 7774,6 | 6987,8 | 786,8 |
| 8 | Ulan-Ude | Novosibirsk | 1647,6 | 1230,2 | 2874,6 | 5752,4 | 5459,3 | 293,1 |
| 9 | Ussuriysk | Ulan-Ude | 921,9 | 11,1 | 2141,9 | 3074,9 | 2918,4 | 156,5 |
| | | Total | 26 601,3 | 25 527,0 | 12 968,8 | 65 097,2 | 53 436,0 | 11 661,1 |

**North - South**

| № | Section start | Section end | Domestic delivery | Export | Import | Sum | including | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Railway | Switching from auto |
| 1 | St. Petersburg | Moscow | 2263,7 | 413,3 | 2060,4 | 4737,4 | 2346,7 | 2390,7 |
| 2 | Moscow | Rostov-on-Don | 2753,2 | 1785,0 | 771,6 | 5309,8 | 3144,4 | 2165,4 |
| 3 | Rostov-on-Don | Krasnodar | 2547,7 | 3510,0 | 398,4 | 6456,2 | 4579,4 | 1876,9 |
| | | Total | 7 564,7 | 5 708,4 | 3 230,4 | 16 503,4 | 10 070,4 | 6 433,0 |

**South - North**

| № | Section start | Section end | Domestic delivery | Export | Import | Sum | including | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Railway | Switching from auto |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | Moscow | St. Petersburg | 3196,6 | 8386,6 | 421,1 | 12004,3 | 9661,4 | 2342,9 |
| 2 | Rostov-on-Don | Moscow | 6958,8 | 1826,9 | 864,9 | 9650,6 | 4464,4 | 5186,2 |
| 3 | Krasnodar | Rostov-on-Don | 2595,1 | 112,9 | 487,9 | 3195,8 | 962,4 | 2233,5 |
| | | Total | 12 750,5 | 10 326,4 | 1 773,8 | 24 850,7 | 15 088,2 | 9 762,5 |

The total forecasted traffic volume for 9 sections belonging to the East-West direction is 65 million tons. The volume of traffic on these sections in the West-East direction - 1,8 times less and is equal to 36,6 million tons. The volume of traffic on three sections in the South - North direction (including the Moscow - St. Petersburg section) is 24,9 million tons. In the North-South direction, cargo turnover is forecasted at 16,5 million tons. The largest traffic volumes are predicted for the sections serving freight traffic from east to west from Novosibirsk to Moscow. In the westward sector, there is an accumulation of goods, and, accordingly, an increase in traffic. The Kazan - Nizhny Novgorod section should be the most heavily loaded, the estimated traffic volume on this section is 12,3 million tons.

The volumes and correspondence of cargo traffics served by the TLC backbone network, including actual and forecast for the period up to 2024 and 2035, are shown in Figures 6 and 7.



**Figure 6.** Forecasted volumes and correspondence of freight traffic between TLC by type of cargo and by modes of transport for the period up to 2024.
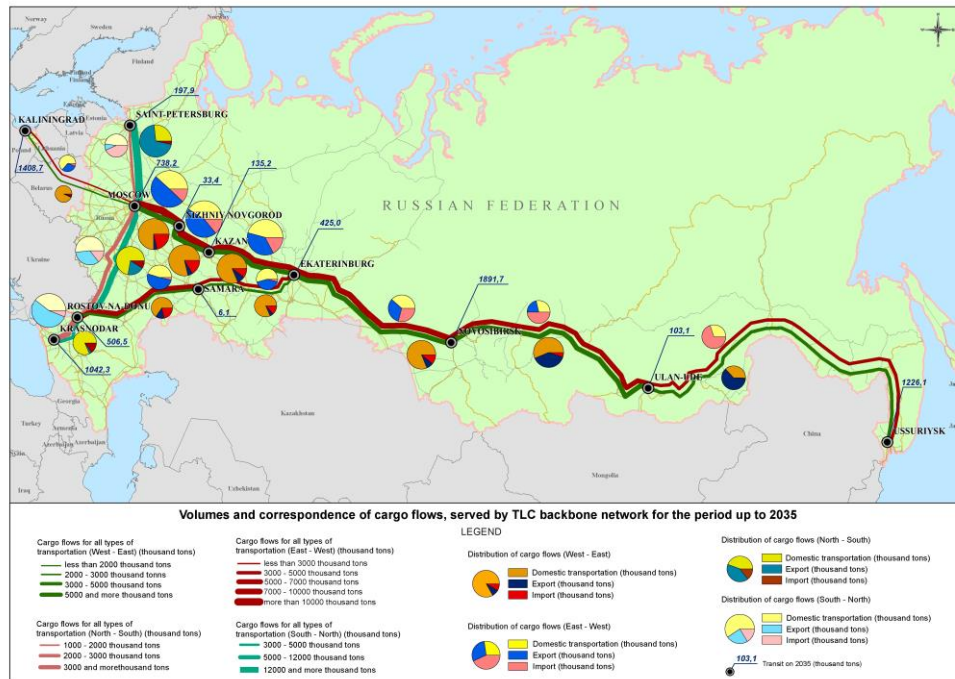
**Figure 7.** Forecasted volumes and correspondence of freight traffic between TLC by type of cargo and by modes of transport for the period up to 2030.

## 5. Discussion of Results

Foundation of a backbone network of core freight multimodal transport and logistics centers (TLCs) is an important direction in the development of transport complex of the Russian Federation and containerization in Russian Federation.

Basing on the analysis of a large data amount from the Transport and Economic Balance (TEB) of the Russian Federation, were performed calculations of potential cargo base for departure and destination for 12 basic TLCs for 2024 and 2035. Forecast estimates were obtained considering all volumes of containerized cargo flows through the TLC network as a whole and for each object separately in the sections of the cargo nomenclature, types of transportation and the TLC attraction zones. Estimated traffic volumes were forecasted for all sections of the TLC network. On the basis of this forecast transport schemes can be optimized using formed Federal standards [30] aimed to improve competitiveness, safety and quality of national and international multimodal deliveries.

The conducted studies have shown that a number of practical cases in transport and economic planning can be solved basing on large data on transportation and economic statistics at the national scale. Working with large volumes of data of the Transport and Economic Balance of the Russian Federation is automated, applying generated algorithms for automatic grouping of data and evaluating total indicators based on calculations of container transport coefficients. However, wider automation of this task will require processing data with a large number of different entities and complex relationships structure. Information models with complex structure and rich semantics are more likely to belong to the class of Knowledge based models than to Data models. In this regard, an important conclusion for the further research is the need of moving to development of models and algorithms for intelligent processing of Big Knowledge-based models. Generally, these processes result in the significant improvement of cargo traffic forecasting methods taking into account the development of transport infrastructure and transportation technologies, changes in the international economic activity, production and trade.

## Acknowledgments

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