# Evaluation of Railway Network Development Projects Considering Economic Conditions

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## ABSTRACT

*The article focuses on theoretical and practical issues of relationship between demand for rail cargo transportation and development of transit and traffic capacity of the railway network.*

*The current situation of public railway transport in the transport system of Russia is described. The dynamics of the main volume indicators of the transport complex over several years is analyzed, the key cargo groups, which account for more than 75 % of the traffic volume, are identified in the structure of traffic volumes. An algorithm is proposed for economic evaluation of railway infrastructure development projects in conjunction with the dynamics of development of commodity markets. The relationship and nature of mutual influence of the elements of the algorithm for economic evaluation of railway network development projects are identified. Examples of currently implemented integrated investment projects of JSC Russian Railways aimed at attracting perspective cargo volumes are commented.*

*The objective of the article is to develop methodological tools for economic evaluation of projects for developing the transit and traffic capacity of a railway network in the face of changing directions and volumes of cargo flows, considering the dynamics of development of external and internal commodity markets. In accordance with the objective, the main tasks comprise comparative assessment of the indicators used in domestic practice, used to determine the impact of market conditions as compared with indicators used by leading foreign companies for these purposes; assessment of the value of integrated investment projects for development of transit and traffic capacity (at the example of Russian railway network) under the conditions of dynamically developing external and internal commodity markets; development of an algorithm for evaluating railway infrastructure development projects to ensure a higher level of quality of transport services with the aim of assessing mutual influence of individual project parameters and their balance, depending on the dynamics of external and domestic product markets, as well as on the need to attract investment resources.*

*Empirical and theoretical methods, such as collecting and analyzing information, deduction, modelling, comparison, technical and economic calculations, an economic and statistical method, were used to implement the goals and objectives set in the article.*

*It is concluded that it is necessary to consider dynamically changing conditions of commodity markets when assessing the prospects for development of the railway network.*

*Keywords: railway transport, demand for cargo transportation, development projects, commodity market, market conditions.*

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**Background.** Railway transport, being an integral part of the transport complex of any state, is constantly both in interaction and in competition with other modes of transport for transportation of goods. One of the important conditions for competitiveness of railway transport is quality and timely satisfaction of the demand of shippers for transportation of goods.

Given that transport does not produce products in the physical sense and is an infrastructure industry [1, p. 74]. An important aspect of its cost-effective functioning (and that is valid for all participants in the transportation process), as well as of long-term development, is to achieve a balance of demand for «transport products» and of offers of transportation services.

According to leading experts in the field of transport in a market economy, transport can be characterized both as a market object and as a market entity. Depending on the view on the place of transport in the economy, several approaches to the prospects for its development can be noted: with a market approach, transport develops depending on the demand for its services; with the «classical approach» transport is an infrastructure of material production and requires accelerated development [2, p. 17].

Considering the actual state and future development of railway infrastructure through the prism of mutually interconnected categories «demand for cargo transportation – throughput and carrying capacity of the infrastructure», it can be noted that the multi-element nature of each category and a significant number of external and internal factors affecting the elements of each category, together with their diversity create a kind of balance, which can be expressed in the form of actually achieved or promising projected values of the volume of cargo transportation for the selected period of time.

In connection with the foregoing, the *objective* of this work is to develop methodological tools for economic evaluation of projects for developing transit and traffic capacity of a railway network with regard to changing directions and volumes of cargo flows, considering the dynamics of development of external and domestic commodity markets. To achieve this objective, empirical and theoretical *methods* of scientific research were used:

• collection and analysis of information for building a database on the volume of cargo transportation, and cargo turnover on the territory of the Russian Federation by modes of transport and analysis of the data;

• comparison for assessing the dynamics of coal mining in Russia, the total loading of coal and its transportation in export traffic via JSC Russian Railways railway network, assessing the dynamics of cargo turnover, average range and volume of cargo transportation via the railway network, as well as evaluating the largest public railway companies according to Global 2000 Forbes World;

• deduction and modeling for developing a scheme for determining the required investments in development of railway infrastructure and rolling stock;

• technical and economic calculations and economic and statistical method for constructing a coherent algorithm for economic evaluation of railway infrastructure development projects in conjunction with the dynamics of development of commodity markets.

Table 1

**The volume of cargo transportation within the territory of the Russian Federation by mode of transport in 2013–2017, mln tons**

| Transport mode | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Total transportation volume | 8275,8 | 8006,8 | 7896,8 | 7990,5 | 8113,6 |
| including | | | | | |
| Public railway transport | 1392,6 | 1375,5 | 1327,6 | 1327,4 | 1383,4 |
| Road transport | 5635 | 5417 | 5357 | 5431 | 5447 |
| Inland water transport | 135 | 119 | 121 | 118 | 119 |
| Pipeline transport | 1095 | 1078 | 1071 | 1088 | 1138 |
| Other modes of transport, excluding industrial railway transport | 18,2 | 17,3 | 20,2 | 26,1 | 26,2 |

Source: Federal State Statistics Service (Rosstat).

**Cargo turnover of transport in all sectors of the economy of the Russian Federation for 2013–2017, mln ton-kilometer**

| Transport mode | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Transport of all sectors of the economy | 5084,0 | 5078,2 | 5107,4 | 5196,6 | 5480,6 |
| including | | | | | |
| Public railway transport | 2196 | 2299 | 2305 | 2343 | 2492 |
| Road transport | 250,0 | 247,0 | 247,0 | 248,0 | 253,0 |
| Inland water transport | 80,0 | 72,0 | 64,0 | 67,0 | 67,0 |
| Pipeline transport | 2513,0 | 2423,0 | 2444,0 | 2489,0 | 2615,0 |
| Other modes of transport, excluding industrial railway transport | 45,0 | 37,2 | 47,4 | 49,6 | 53,6 |

Source: Federal State Statistics Service (Rosstat).
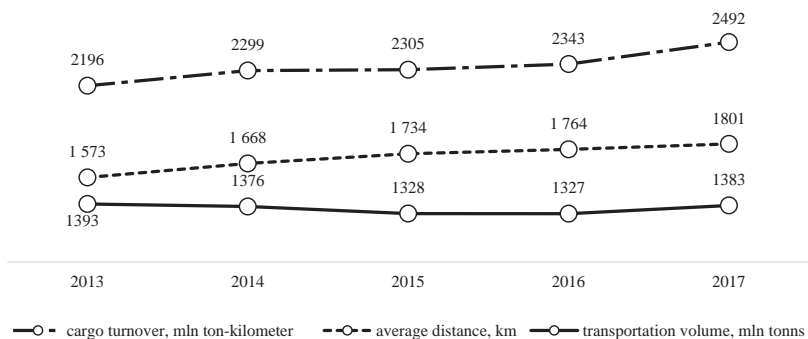


*Pic. 1. The dynamics of cargo turnover, average distance, and transportation volume along the railway network of JSC Russian Railways for the period 2013–2017. Source: according to the reports of TsO-12 form «Report on cargo transportation, mileage and revenues received».*

**Analysis and assessment of trends**

Considering the public railway transport as part of the general transport system of Russia, it should be noted that it takes a significant share in the structure of the total volume of cargo transportation and cargo turnover (17,1 % and 45,5 %, respectively, see Tables 1–2).

It should also be noted that the growth in cargo turnover in 2014–2016 occurred despite a decrease in the volume of cargo transportation (the main reason was recession of the Russian economy due to contraction of domestic demand for goods and services). This indicates an increase in the average distance of transportation by rail (Pic. 1), which is due to the favorable conjuncture of foreign markets amid devaluation of the ruble and, as a result, an increase in export of Russian raw materials through sea and land transshipment points.
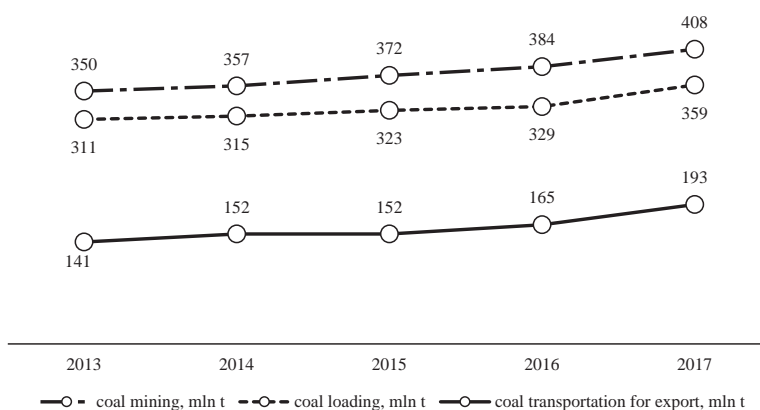
This trend influenced the change in the structure of cargo transportation in terms of types of destination: in 2017, the volumes of domestic Russian transportation decreased by

3 % compared to 2013; for the same period, the volume of transportation of import deliveries decreased by 28 %; transportation of export deliveries increased by 15 %.

The share of coal, which is amidst main export cargo items, is more than 35 % in the total structure of cargo turnover through JSC Russian Railways network. The increase in coal transportation in export traffic in 2017 amounted to 37 % compared to 2013. The analysis of indicators of coal mining in the Russian Federation and its transportation through JSC Russian Railways network for the period of 2013–2017 shows that there is a close relationship between the indicators of cargo transportation by rail and the dynamics of development of individual commodity markets.

Changes in directions and volumes of cargo flows through the railway network under the influence of the situation in Russian and world commodity markets lead to constraints regarding transit and traffic capacity of the railway infrastructure.

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*Pic. 2. The dynamics of coal mining in Russia, total loading of coal and its transportation for export along the railway network of JSC Russian Railways for the period 2013–2017. Sources: according to the data of reports of Ministry of Energy and JSC Russian Railways[1].*

Market research helps to optimize production and logistics operations, to increase productivity of technical systems and efficient use of production resources, to minimize resource consumption and production losses, to increase credibility of assessing market competitiveness, to work out in detail the dynamics and nature of price changes, market capacity, production and consumption volumes, to assess forecast data on the dynamics and development of commodity markets, prices in them, geography of consumption, etc. [3, p. 90].

Analysis of the market conditions for a transport company and its reflection in the dynamics of development of the transport market depend on the nature of the problem being solved. To make operational decisions, an analysis of the current condition of commodity markets is performed, which also makes it possible to fulfill loading forecasts for 3−6 months. For forecasting for longer periods, a deeper level study is necessary [4, p. 30].

The study of A. V. Ryshkov examines in detail the analysis of conditions of Russian transport during rise and development of market relations [5, p. 19], as well as the problems of the methodology for assessing the impact of market conditions on the basic parameters of transport [5, p. 57]. However, modern conditions, characterized by an increase in demand for transport services and an increase in the length of lines with a limitation of their transit and traffic capacity, require development of new methodological approaches to assessing projects for developing transit and traffic capacity of a railway network considering the dynamics of development of foreign and domestic commodity markets.

Leading world companies for assessing the influence of market conditions on their activity use indicators based on the transport market analysis in terms of revenues of market participants, their share on the market, as well as segmentation by fields of activity. Top-200 of the world's companies in 2016 include 16 railways, whose shares are listed on the stock exchange [6]. The ranking included six Japanese railways, four American, two Canadian companies, companies from respectively China, Hong Kong, and Taiwan (Table 3).

**Models and indicators**

The transport and logistics models used by world companies in planning their development prospects use e.g. the following transportation organization models: SAMGODS/NEMO, SMILE (Strategic Model for Integrated Logistics Evaluation), SLAM (Spatial Logistic Appended Module), EUNET, LAMTA (Los Angeles Metropolitan Area), CMAP (Chicago Metropolitan Agency for Planning), FAME (Freight Activity Micro simulation Estimator), GoodTrip, WIVER, TAPAS, TAPAS-Z [7, p. 6; 8, p. 829; 9, p. 384; 10, p. 9].

To analyze market conditions, international companies use the following indicators:

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[1] Statistics of the Ministry of Energy. [Electronic resource]: https://minenergo.gov.ru/activity/statistic; Annual reports of JSC Russian Railways. [Electronic resource]: http://ir.rzd.ru/static/public/ru?STRUCTURE_ID=32#2.

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**The largest public railway companies of the world according to Global 2000 Forbes, 2016**

| No. in the rating | Company | Country | Revenues, bln $ | Profit, bln $ | Profitability of sales, % | Assets, bln $ | Capitalization, bln $ |
|---|---|---|---|---|---|---|---|
| 172 | Union Pacific | USA | 21,0 | 4,6 | 21,9 | 55,8 | 75,4 |
| 233 | East Japan Railway | Japan | 23,5 | 1,9 | 8,1 | 63,1 | 36,2 |
| 284 | Central Japan Railway | Japan | 14,3 | 2,5 | 17,5 | 45,4 | 38,7 |
| 368 | Canadian National Railway | Canada | 9,9 | 2,8 | 28,3 | 26,7 | 51,6 |
| 377 | CSX | USA | 11,4 | 1,9 | 16,7 | 34,6 | 26,3 |
| 407 | Norfolk Southern | USA | 10,4 | 1,6 | 15,4 | 33,8 | 27,1 |
| 557 | MTR | Hong Kong | 5,4 | 1,7 | 31,5 | 31,1 | 29,1 |
| 625 | Daqin Railway | China | 8,6 | 2,3 | 26,7 | 17,0 | 15,0 |
| 662 | West Japan Railway | Japan | 11,8 | 0,7 | 5,9 | 23,4 | 12,1 |
| 785 | Canadian Pacific Railway | Canada | 5,1 | 1,2 | 23,5 | 15,0 | 22,8 |
| 883 | Tokyu | Japan | 9,0 | 0,5 | 5,5 | 16,8 | 11,0 |
| 1112 | Hankyu Hanshin Holdings | Japan | 5,4 | 0,5 | 8,5 | 18,9 | 8,3 |
| 1158 | Kintetsu | Japan | 10,0 | 0,3 | 3,0 | 16,1 | 8,0 |
| 1547 | Kansas City Southern | USA | 2,4 | 0,5 | 20,5 | 8,3 | 10,6 |
| 1582 | Taiwan High Speed Rail | Taiwan | 1,6 | 0,7 | 41,1 | 15,4 | 2,7 |

Revenues, Net income (loss), Total assets, Total liabilities, Employees, Revenue per employee, Profit per Employee, as well as macroeconomic indicators as e.g. Rail Freight, Volume Forecast, Population, GDP constant 2000 prices, GDP current Prices, Inflation, Consumer Price Index, Exchange Rate, Geography Segmentation [11–15].

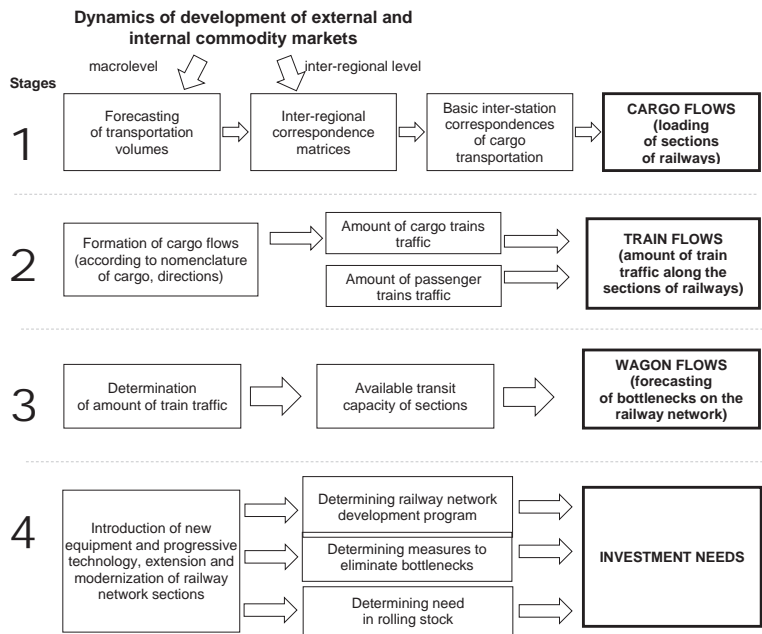The most important tasks of the analysis of market conditions are:

• identification, analysis and forecasting of volumes and geography of production of goods, materials and raw materials representing the main types of cargo;

• identification and analysis of sizes (production volumes) and the number of manufacturing enterprises;

• identification, analysis and forecasting of prices for goods (finished products, materials and raw materials, representing the main types of cargo): producer selling prices, prices in regions of consumption, export prices;

• identification, analysis and forecasting of volumes and geography of consumption of goods, materials and raw materials representing the main types of cargo;

• identification and analysis of the size (volume of consumption) and the number of enterprises-purchasers;

• analysis of the degree of differentiation of manufacturers in terms of quality, selling prices and production volumes, according to the specifics of the technological process that defines the requirements for quality of transport services and, as a result, the possibility of attracting their goods for transportation by railways;

• identification and analysis of regional distribution of producers according to the characteristics listed in the previous paragraph;

• analysis of the degree of differentiation of consumers in terms of quality, selling prices and production volumes, consumption specifics that determine the requirements for quality of transport services;

• identification and analysis of regional distribution of consumers according to these signs of possibility of segmenting the studied product market;

• analysis and forecasting of market development trends and its dynamic stability;

• analysis of seasonality and cyclicality of main indicators of market development (sales volumes by categories of goods, prices), their volatility and factors influencing them.

The comparative analysis of indicators used in assessing the impact of market conditions by similar leading foreign companies allows us to

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**Pic. 3. Chart to determine required investment for development of railway infrastructure and rolling stock (compiled by the authors).**

conclude that they can be used to substantiate indicators of Russia's economic development and target parameters of the Russian Railways holding company within the system of key performance indicators.

**Results and discussion**

As of January 1, 2017, the share of length of public railway lines of the Russian Federation that had capacity constraints in the overall operational length of public railway lines was 10,6 % [16, p. 22]. In turn, emergence of constraints regarding transit and traffic capacity of railway infrastructure leads to the unmet demand for cargo transportation.
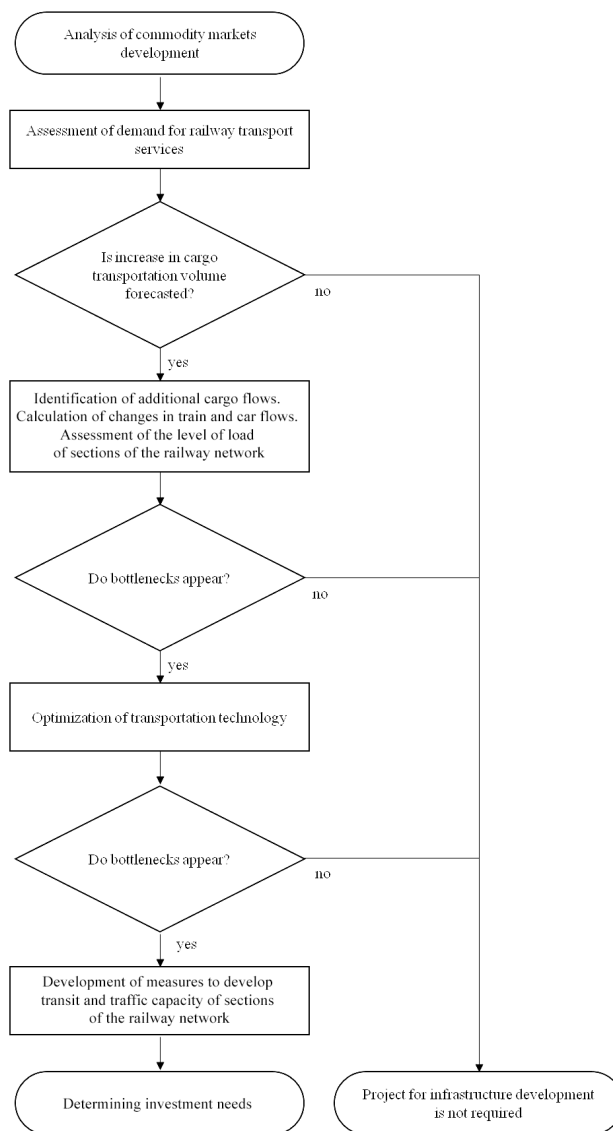
At the same time, the ratio of the presented and timely satisfied demand for cargo transportation determines the level of quality of transport services. To solve problems of unsatisfied demand in the short and medium term horizon for planning cargo railway transportation, a number of organizational and technological measures can be used, including those that seek to obtain feedback from customers to promptly fix local issues, to create conditions for flexible adaptation of production indicators of the elements of railway transport to demand fluctuations, to find ways to smooth out fluctuations in distribution of demand over

time via flexible tariff system and others [17, p. 104].

In the long term, a change in potential demand for railway transport services can be achieved by increasing the existing and by building new production capacity of enterprises, constructing new railway lines attracting cargo, developing sea ports, creating conditions for attracting goods from other modes of transport, etc. [18, p. 16]. To meet the long-term demand for railway cargo transportation, comprehensive investment projects are developed and implemented to develop transit and traffic capacity of the railway network. The basic scheme for identifying required investments in development of railway infrastructure and rolling stock is shown in Pic. 3.

Based on the above scheme, it seems appropriate to develop an algorithm for economic evaluation of railway infrastructure development projects in conjunction with the dynamics of development of commodity markets (Pic. 4).

Based on the presented scheme (Pic. 3) and the algorithm (Pic. 4), it is possible to determine the relationship between individual elements of the algorithm and the change in their parameters under the influence of individual factors (Table 4).

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*Pic. 4. Enlarged algorithm of economic assessment of railway infrastructure development projects in terms of dynamics of development of commodity markets (compiled by the authors).*

The examples in Table 4 show the different impact of factors on the elements of economic evaluation algorithm. The list of factors influencing railway infrastructure development projects is not limited to the positions given in the table but is much wider. At the same time, a change in the dynamics of development of external and domestic commodity markets (in fact, a change in demand for cargo transportation) is one of the key factors influencing the final configuration of elements when developing projects for development of railway infrastructure.

**Practical aspects**

If we take example of JSC Russian Railways, then as of 2018 the company was implementing a number of investment projects to upgrade and build a new railway infrastructure, the priority of which was to ensure transportation of increasing volumes of cargo (Table 5) [19].

The individual integrated projects presented in the Table are interlinked and included in the long-term development program of JSC Russian Railways. When developing investment projects, the company implements the priority principle of minimizing the volume of

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**Interconnections of elements of the algorithm for economic evaluation of railway infrastructure development projects and changes in their parameters under the influence of individual factors**

| Factor | Influence of the elements of the algorithm | | | |
|---|---|---|---|---|
| | Load of network sections | Size of train traffic in sections | Infrastructure bottleneck forecast | Investment needs |
| Decrease in demand for transportation | decrease | decrease | decrease | decrease |
| Constraints regarding the amount of investment in implementation of measures for infrastructure development | redistribution | redistribution | redistribution | decrease |
| | decrease | decrease | decrease | |
| Use of innovative rolling stock | does not change | decrease | decrease | decrease |
| Use of innovative technology for transit of car flows | does not change | does not change | decrease | decrease |

▢ Element of the algorithm, that is primarily changing under the influence of factors (graphs with darker background).

**The main integrated investment projects of JSC Russian Railways for development of transit and traffic capacity to ensure transit of increasing volumes of freight**

| Project name | Total investment volume, bln rub. | Target indicator |
|---|---|---|
| Modernization of railway infrastructure of Baikal-Amur and Trans-Siberian railways with development of transit and traffic capacity | I stage (until 2019): 182,6 | By 2024, increase in total traffic capacity of main lines to 182 million tons; increase in total available transit capacity of main lines to 129 pairs of cargo trains per day |
| Development of railway infrastructure of JSC Russian Railways on approaches to the ports of North-West of Russia | 253,6 | Development of the forecasted volume of cargo transportation by 2025 at the approaches to the ports of the North-Western basin in the volume of 145,6 million tons |
| Development of railway infrastructure of JSC Russian Railways on the approaches to the ports of Azov-Black Sea basin | 155,0 | Ensuring transportation of goods by rail to the ports of Azov-Black Sea basin in the amount of 125,1 million tons by 2020, as well as optimizing the work of Krasnodar railway junction with switching cargo traffic to bypass via Timashevskaya–Krymskaya section |
| Creation of the Northern Latitudinal Railway | 236,7 | Ensuring transportation of goods through the new line in the volume of 23,9 million tons by 2025 |

investment in infrastructure development and acquisition of rolling stock to ensure transportation of forecasted volumes of goods with the required level of quality of transport services. Considering implementation of the projects presented in Table 5 and a number of other projects, the volumes of prospective cargo loading on the Russian Railways network are projected until 2025 with an average annual growth rate of 2,5 % in the conservative scenario and 3,6 % in the target scenario [20]. In 2017, the loading indicator amounted to 1261,3 million tons [19].

Implementation of promising investment projects worth more than 820 billion rubles will allow JSC Russian Railways infrastructure company to decrease constraints on transit and traffic capacity of individual railways, to improve quality of their work, which will help to improve quality of transport services for shippers.

**Conclusions.**

1. In the context of a dynamically changing conditions of commodity markets, the relevance of the issues of economic evaluation of projects for developing transit and traffic capacity of the railway network, considering the dynamics of development of external and internal commodity markets, is increasing. Thus, a change in directions and volumes of

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cargo flows under the influence of the situation leads to constraints in transit and traffic capacity of the railway infrastructure.

2. A comparative assessment of the indicators used in assessing the impact of market conditions by leading international companies showed that the Russian Railways holding company uses most of those indicators.

3. Referring to Russian experience, integrated investment projects are important for development of transit and traffic capacity of the railway network of JSC Russian Railways in the conditions of dynamically developing external and internal commodity markets. Demand for railway transport services is formed depending on demand and supply of goods in the world and domestic markets. The implementation of promising investment projects helps to reduce the number of constraints regarding transit and traffic capacity and to increase the efficiency of operation of the infrastructure facilities of JSC Russian Railways.

4. The use of the developed algorithm for assessing projects for development of railway infrastructure to ensure a high level of quality of transport services allows us to evaluate mutual influence of individual parameters of the project and balance it depending on the dynamics of external and internal product markets, as well as on the need to attract investment resources.

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