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Impact of sea Freight Rates to Railway Traffic: Case of Russian Railway

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Abstract: The purpose of the study is to assess the impact of sea freight rates on the import rail transportation market in Russia based on methods of correlation and regression analysis. To estimate the lag time of the influence of the price factor on the volume of transportation, the author's "component shift" method was used. As a result, a regression model has been developed that makes it possible to predict the volume of railway transportation of imported products depending on the dynamics of sea freight and plan in advance measures to reserve railway capacity.

Keywords: Rail transportation, Sea freight, Forecasting, Price elasticity of demand, Regression, Correlation

INTRODUCTION

Railway transport plays a vital role in the Russian economy. Currently, about 50% of freight turnover in the country's transport system is provided by railways.

Today, the most dynamically developing segment of Russian railways is the transportation of imported goods, mainly in containers. According to official statistics, the volume of imported goods transported by rail in 2022 increased by 18.3%, in 2023 – by 9.7% compared to the previous year. Based on the results of 6 months of 2024, the increase was 4% compared to the same period of the previous year.

The main reason for the rapid growth of railway transportation in the import direction is the reorientation of the Russian economy from Europe to Asia and the associated change in global supply chains.

As a result of sanctions adopted by the United States and the European Union in 2022, imports of Western goods into Russia are significantly reduced. The imposed sanctions also affected the seaports of St. Petersburg and Novorossiysk, where Western companies could no longer dock and unload their ships. The result of these events is an increase in imports from the countries of the Asia-Pacific region through the ports of the Far East and the Trans-Siberian railway.

Another important factor that changed the structure of import supply chains to Russia was the significant increase in sea freight rates. The rise in prices on the global shipping market is caused by a number of reasons: lack of sea vessels capacity and infrastructure limitations in ports; lack of capacity in the Suez Canal; Houthi attacks in the Red Sea in 2024.

As a result, a large volume of cargo traffic has switched from maritime transport, which traditionally accounted for the largest share of international transport, to rail traffic.

So, the objectives of this study are to quantitatively assess the impact of sea freight rates on the railway transportation market and to develop a regression model that allows predicting the volume of railway imports depending on the dynamics of prices for sea transportation.

Literature review

The degree of price influence on demand is its price elasticity. There are a bunch of studies that analyze the price elasticity in transport systems. For example, in Davis (2021), Toro-González et al. (2020), King & Taylor (2023) the price elasticity of demand for public transportation is investigated. The price elasticity of demand in the freight transport market is analyzed in Sokolov & Lavrov (2023) in relation to railways, in Merkel et al. (2022) for sea shipping, in Alnıpak & Kale (2022) for air cargo transportation.

A number of studies are devoted to the analysis of cross elasticity. For example, in Khan (2020) the long-run cross-price elasticity of rail freight and trucking is assessed. Toner et al (2020) analyzed cross-elasticities for different ticket types within a demand system framework.

However, existing studies do not take into account the time lag of the price effect on demand. Considering that the market does not react immediately to price changes, it is necessary to continue research in this area.

METHOD

When assessing the dependence of transport demand on freight rates, we encountered the following problems.

Firstly, the demand for freight transportation is seasonal, which is associated with climatic restrictions (freezing of some cargo at low temperatures), as well as the seasonality of consumption of individual goods.

Secondly, the influence of price factors on transportation volumes occurs with a certain time lag, since it is obvious that supply chains cannot be restructured instantly.

This does not allow the regression model to be made in accordance with classical algorithms and requires a number of transformations of the original data sample.

To exclude the seasonality factor from the analysis, we perform a transformation

$$q_t^* = q_t / \overline{I}_t \,, \tag{1}$$

where q_t is the actual value of traffic for the time period t, $\overline{I}_t$ – an average seasonality index of transportation during time period t.

An average seasonality index calculated based on data for several years using the formula

$$\overline{I}_t = \sum_{i=1}^{N} \frac{q_{it}}{\overline{q}_i} / N \,, \tag{2}$$

where $\overline{q}_{it}$ – an average annual traffic volume in the i-th year, N– number of years analyzed.

To estimate the time lag of the sea freight rates influence on the volume of railway imports, we will use the methodology proposed in Kochneva et al. (2020).

We will consider the size of the freight rate xt and the volume of transportation qt as discrete random variables. Let's create columns of actual values of these random variables by month.

Next, we perform a step-by-step shift of the data column of the parameter q_t under consideration relative to the column of x_t values, in order to find the moment of the highest correlation.

After each shift by one component (month), the correlation coefficient between the x_t value column and the q_t column is calculated. In this case, at each step, the columns of values x_t and q_t have to be shortened by one component remaining after the shift without a corresponding pair

Obviously, the lag time of the effect of freight size on traffic volume is the shift value (in months) that gives the maximum value of the correlation coefficient between the factor and outcome variables.

RESULTS AND DISCUSSION

The result of applying the presented methodology is presented in Figure 1. The correlation was assessed for the last 2 years between the sea freight rates and the volume of imported rail transportation, cleared of seasonality.

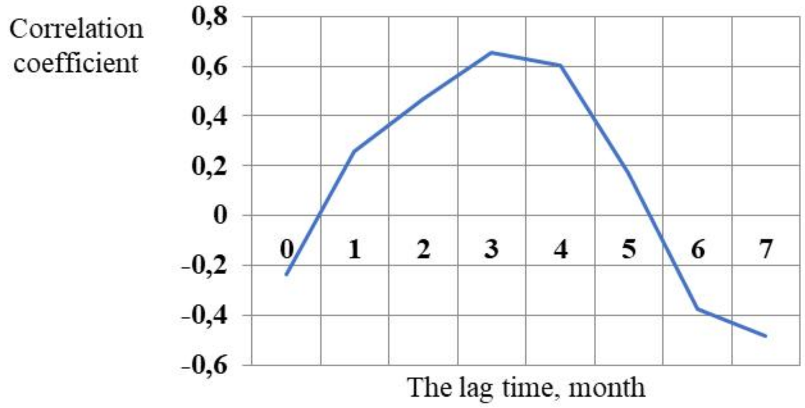

Fig. 1. Determination of the time lag of the price factor influence on the volume of transportation

The study found that the maximum correlation between sea freight rates and import rail volumes occurs when the columns are shifted by 3 components, implying that supply chain changes and rail market responses occur on average 3 months after sea freight rates are adjusted.

Based on the available data with a time lag of 3 months, we will construct a linear regression equation (Fig. 2).

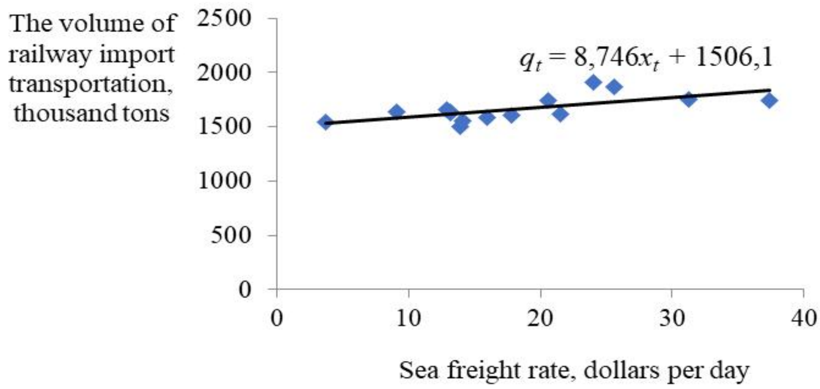

Fig. 2. Dependence of the volume of railway import transportation on sea freight rates

The regression equation obtained is $q_t = 8{,}746x_t + 1506{,}1$. To assess the impact in relative terms, we calculate the elasticity coefficient:

$$\Delta\% = \frac{8,746}{1506,1} \cdot 100 = 0,58\% \ .$$

So, an increase in the sea freight rate is expected to lead to the switching of part of imported cargo to rail transport and an increase in the volume of rail transportation by 0.58% in 3 months.

CONCLUSION

Thus, based on the developed model, it is possible to predict the volume of rail transportation of imported products depending on the dynamics of sea freight.

Implications

Taking into account the fact that the market reacts to price changes not immediately, but with a delay, Russian railways can plan in advance measures to reserve capacity to ensure future growth in demand for import transportation.

Research limitations

The resulting regression model makes it possible to predict railway transportation based on only one factor. To obtain a more reliable forecast, it is necessary to take into account many other variables: resource prices, transport capacity, the state of the economy, and so on.

This task is the subject of further research and will be implemented based on machine learning technologies.

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