Rail transport in the system of Russian national input-output tables

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Abstract. The paper analyzes the interaction of the railway industry with other sectors of the economy using the input-output tables published by Russian Federal State Statistics Service (Rosstat) in 2017 after a long pause. The added value of transport industries is being compared. The influence of railway tariffs on the price level in other sectors has been determined. The most sensitive sectors to tariff changes have been identified, as well as industrial relations of railway transport with other sectors. Rail transport is the most significant sector of the economy, since it has the functions of sustainable livelihood of vast territories, and socio-economic relations, and the provision of military security. In this context, the development of rail transport infrastructure directly affects the development of other sectors of the economy and the development of new territories. As a result of the calculations, we received a list of industries whose prices are largely dependent on rail transport tariffs.

1. Introduction

Intersectoral analysis - a method that can be used to analyze the relationships between various sectors of the economy. As a rule, if we are talking about interdisciplinary analysis, it means analyzing the sectors of a country's economy, but as W. Leontief points out [1], this could be the country's national economy, the world economy, and the economy of a company.

Intersectoral analysis allows using mutually connected tables to reflect all the main interactions between sectors of the economy, end users and the outside world. The detailed cost structure presented in the input-output tables provides information on the level of technology development in the economy. The analysis of Russian input-output tables and tables of other countries makes it possible to compare the development levels of the compared economies. The possibility of such an analysis makes it possible to solve problems of a strategic level when forming an economic policy. The coefficients of direct and full costs (or technological coefficients) reflect the degree of advanced technologies involved, or vice versa, the degree of resource intensity of industries. It is important that the input-output tables not only reflect the actual state of the economy, but also make it possible to make forecasts and model economic development scenarios.

The input-output tables are a recognized tool for analyzing and forecasting the structure of the economy. In the USSR, they were called inter-sectoral balances of production and distribution of products and were compiled according to data for 1959, 1966, 1972, 1977, 1982, and 1987. In modern Russia, they were developed in 1995 with a nomenclature in the context of 227 industries. In addition, the input-output tables for 2003 were built “on the basis of similar detailed tables for 1995 and current statistics for 2003”.
In 2009, the Government of the Russian Federation ordered to compile the input-output table for 2011, simultaneously setting the frequency of compiling these tables once every five years. Finally, in 2017, the Russian Federal State Statistics Service (Rosstat) published the input-output table for 2011 in the context of 126 industries, thereby providing information to a large number of researchers in this field. Since the input-output table with an extended nomenclature was developed only in 1995, the so-called off-balance period was 16 years, and if we consider that the input-output table were published only in 2017, it does 22 years. For the purposes of research, many scientists have used so-called input-output calculation tables for this period (based on current statistics, the input-output tables and tables of direct and full costs are compiled). It should be noted that the input-output tables are used by private companies, and this fact was noted by W. Leontief [2]. For eleven years, the US government did not develop the input-output tables, and their development was funded by private companies. Financial support for the development of input-output tables was suspended by the US government on various arguments, for example, assigning to the input-output tables the nature characteristic for “communist central planning”; excessive transparency of these tables (identification of critical economic events and their presentation to the public). In the era of “digitalization”, a renaissance of intersectoral balances takes place.

The task of production planning was formulated by L.V. Kantorovich in [3]. This pioneering publication on a linear optimization model actually became the basis for the development of various optimization models, including on the basis of an intersectoral balance matrix. In the scientific environment of the USSR, interregional intersectoral models of American scientists W. Leontief, H. Chenery, B. Stevens, W. Isard, L. Moses are widely known. The first intersectoral interregional model in the USSR was developed by V. V. Kossov and A. G. Aganbegyan. In 1967, the first forecast calculations were carried out using the Interregional Intersectoral Optimization Model (IIOM) for the economy of the USSR for the period 1966-1975 in the context of 11 regions and 16 sectors of the national economy under the leadership of A. G. Granberg [4]. Later, studies based on the interregional model were started in the Council for the Study of Productive Forces under the USSR State Planning Committee under the leadership of S.A. Nikolaev. A mathematical model of the input-output tables and basic properties can be found in almost any textbook on economic and mathematical modeling.

For any industry from intersectoral balance, these tables will be an important tool for analyzing, forecasting and making decisions in the field of strategic management. Railway transport is no exception, and given the degree of monopolization in this industry, it is a key tool for analysis and forecasting. In the input-output table for 2003, rail transport services were not allocated to a separate industry, but were included in the enlarged industry “Transport and Communications”. Such a degree of aggregation was a problem for analysis, and the results of the analysis could always be criticized. But, for example, it did not stop the Foundation “Center for Strategic Research” to make the assessment of the efficiency of the project for modernization of the Baikal-Amur Mainline and Trans-Siberian Railway, as well as the project of the high-speed line Moscow — Kazan.

Direct effects of strategic decisions can be obtained by simple calculations, for example, the increase in product releases, tax deductions, budget revenues, the number of new jobs and etc. At the same time, intersectoral analysis allows assessing the multiplicative effect of making such decisions. This is due to the fact that such decisions are made within one interconnected system, and within such a system, one cannot do without suppliers: producers of electricity, utilities, transport services, telecommunications services, financial services, and so on. Moreover, the transport industry will receive benefits even if the newly created object will depend on imported products. Since imported goods need to be transported either to the point of intermediate consumption, or to the point of final consumption. Thus, an increase in the output of one of the sectors generates growth in the output in other sectors of the economy.

The relevance of making macroeconomic forecasts is formed when justifying large-scale investment projects, in particular, it was once stated by the president of the Russian Railways JSC V.I. Yakunin.
To solve this problem, the ex-president of Russian Railways JSC V.I. Yakunin decided to conduct research in the area of the development of intersectoral balances for forecasting and analytical calculations and making strategic decisions on the development of the Company's infrastructure.

2. Rail transport in the national economy
Rail transport is the most significant sector of the economy, since it has the functions of sustainable livelihood of vast territories, and socio-economic relations, and the provision of military security. In this context, the development of rail transport infrastructure directly affects the development of other sectors of the economy and the development of new territories. Rail transport in Russia ranks first in providing freight and passenger traffic. In 2017, the freight turnover of rail transport is slightly inferior to pipeline transport, while in terms of passenger traffic, rail transport is leading. It should be noted that the importance of rail transport in the field of passenger transport is reduced against the background of the growth of air and road transport. According to the input-output tables, contribution of rail transport to the economy amounted to 1.4% and yielded to land transport (1.55%), pipeline transport (1.48%). Investments in the development of rail transport infrastructure made up 1.9% of the total investment in fixed assets in 2017. For comparison, 5.9% of the total investment was invested in the activities of pipeline transport. But such indicators as freight turnover, passenger turnover, loading volume, of course, are a “mirror” of the economy, but they do not provide an opportunity to analyze and predict macroeconomic indicators. For such an analysis and a subsequent forecast, on the basis of which it is necessary to make strategic decisions, it is necessary to analyze such indicators as the impact of investments in transport infrastructure on the development of the economy; the impact of the volume of production in other industries on the activities of rail transport (and vice versa); resource and technological constraints. Such an analysis comes from the complex interrelation of various sectors of the economy. Any incremental increase or decrease in production in one industry leads to an increase or decrease in “counterparty” industries, in turn, an increase or decrease in production in these industries leads to an additional change in output in third industries and etc.

3. Added value of rail transport services
The data from the third quadrant of symmetric input-output table provide information on the value added of rail transport services in the structure of the Russian economy. The value added in symmetrical input-output table includes: wages, consumption of fixed capital, profits, and taxes. Table 1 shows the share of value added and its structure in the output of the Russian transport industries. It can be seen from the table that the main share belongs to land transport services - 27%, slightly less, rail transport services - 23%, then pipeline transport services - 21%. The share of water and air transport is insignificant.

In general, the transport industry shows value added lower than the average for all sectors of the economy - 39.31% against 46.44%. At the same time, the added value generated by railway services is 4% higher than the average one. But less land transport.

Table 1. The share of value added and its structure in the output of the Russian transport industries according.

| Transport industry                        | The share of value added in the output,% | The structure of the value added of all types of transport,% |
|------------------------------------------|----------------------------------------|----------------------------------------------------------|
| Rail transport services                  | 50.12                                  | 23                                                       |
| Other land transport services            | 52.72                                  | 27                                                       |
| Pipeline transport services              | 43.72                                  | 21                                                       |
| Water transport services                 | 33.15                                  | 2                                                        |
| Air and space transport services         | 16.42                                  | 4                                                        |
| Auxiliary and additional transport services (incl. services of travel agencies) | 39.70                                  | 23                                                       |
| Transport of everything (as an aggregator) | 5.92                                  | 100                                                      |
The largest share in the value added of rail transport is wages - 63%, followed by net income (net mixed income) - 24%, followed by consumption of fixed capital - 11%, production taxes - 2%. For comparison, the national average values are distributed as follows: 39%, 49%, 11%, and 1%, respectively. That is, the wage bill in rail transport is 1.61% higher than the average for all sectors of the economy. However, the large share of remuneration in value added is not so much related to the large number of employees of Russian Railways JSC (1.5 million employees), but rather to the redistribution in the structure of value added due to net profit, it is two times lower than in the national average - 24% against 49%.

4. Tariffs in the industry
The most important consequence of the growth of tariffs of monopolies, and in particular, rail transport, will be an increase in prices in the economy. The rise in prices of goods or services in one industry affects directly or indirectly the results of activities in other industries. The rise in prices of transportation is not limited only by the increase in the cost of the transportation itself. The increase in these prices entails a rise in prices of used raw materials, consumables and components. The classical model of intersectoral balance reveals how the price rise in one industry affects price changes in other sectors of the economy. Since the rise in prices in one industry is inevitably associated with rising costs in other industries. Intersectoral balance is one of the tools in pricing policy. Total cost ratios allow determining the effect of price changes in one sector on prices in other sectors of the economy.

It is known that
\[ \Delta p_j = (b_{ij} / b_{jj}) \Delta p_i \]  

where \( \Delta p_i \) and \( \Delta p_j \) – changes in price indices in industries \( i \) and \( j \), respectively;

\( b_{ij} \) – coefficients of total costs.

It is worth noting that the input-output tables are compiled in value terms, and the parameters are calculated for 1 ruble of industry products. That is, \( p_j \) – is not the prices for units of physical output, but the indices of changes in those prices at which the input-output tables are developed.

As a result of calculations, we find that each percent of an increase in tariffs for rail transport services leads to an increase in prices for all sectors of the economy by an average of 0.56%. Here it is worth making an important remark that in the input-output tables, the activity of railway transport includes the activity of main railway transport, the activity of industrial railway transport, and without distinguishing between passenger and freight transport. Therefore, when analyzing the consequences of Russian railways tariff indexation, one should take this fact into account and systematically analyze the indexation of tariffs at Russian Railways JSC itself, in which indexation is approved from 3.5% to 3.9% per year in the period 2018-2024. For comparison, the increase in prices of 1% in the oil industry, including oil derived from bituminous minerals; oil shale (bituminous) and bituminous sandstone, leads to an increase in prices in other industries by an average of 4%. And, indeed, in the context of a weak ruble, these are certain risks. Oil has never been worth so much in rubles, almost 6,000 rubles per barrel. Before the price rose only up to 3600 rubles. It is known that the extraction tax was raised, the oil itself is expensive. With a weak ruble and with such a situation it became unprofitable to sell it domestically. As a result, we get high gasoline prices. An integrated approach is necessary in the context of where the money from the increase in tariffs on the rail transport will be sent, because in the base of tariff indexation, there is a surcharge on the capital infrastructure overhaul in the amount of 2%. If these funds will be spent on modernization and investment, this will lead to an increase in production volumes in other industries, and thus it will have a positive effect on gross domestic product. But questions of regulation of how this money will actually be spent remain open.

As a result of the calculations, we received a list of industries whose prices are largely dependent on rail transport tariffs. The first ten industries are presented in table 2. The table shows that the increase in tariffs for rail transport services has a greater effect on the prices of coke oven products.
The analysis should take into account the fact that the reaction of the manufacturers of industries may be different: some industries will raise the cost of their goods and services, while other industries may sacrifice their profitability.

If we make a comparison with other modes of transport, the services of land transport and others lead to an increase in prices by 0.6%; pipeline transport services by 0.29%; water transport services by 0.14%; air and space transport services by 0.12%. Thus, the increase in tariffs for rail and road transport to a greater extent affects the cost of products in other industries than the increase in tariffs of air, water or pipeline transport.

**Table 2.** The increase in prices for products of the economy sectors with an increase in tariffs of the railway industry by 1%.

| Industry | Perc. |
|----------|-------|
| 1 Coke oven products | 3.62 % |
| 2 Auxiliary and additional transport services; travel agency services | 2.39 % |
| 3 Iron, cast iron, steel and ferroalloys | 1.57 % |
| 4 Cement, lime and gypsum | 1.49 % |
| 5 Pipes and pipeline connecting elements | 1.37 % |
| 6 Other primary processing products of ferrous metals | 1.28 % |
| 7 Secondary raw materials | 1.16 % |
| 8 Concrete, gypsum and cement products | 1.11 % |
| 9 Black coal and brown coal (lignite); peat | 1.03 % |
| 10 Metal building structures (metal structures) | 1.01 % |

Using model (1), we will also determine how the price rise in the industries on which Russian Railways depends will affect the tariffs of rail transport. According to calculations, the rise in prices for the production, transmission and distribution of electricity by 1%, in one way or another, leads to an increase in tariffs for rail transport services by 0.26%.

**5. Industrial relations with other industries**

The intersectoral balance sheet is compiled primarily to obtain information about the industrial relations of the country's economic sectors. This information reveals the mechanism of expanded reproduction, shows how the exchange of products between industries takes place in the process of social division of labor. Table 3 presents the products from OKPD (Russian National Classification of Economic Activities) for the material costs of the rail transport industry. This table shows the first ten products that have the largest share in the structure of the material costs of rail transport services. From the table it can be seen that the largest share of costs is energy costs. This fact emphasizes the predominant use of electric locomotive traction on the Russian railways, and corresponds to the open reports of Russian Railways JSC. The second ones in the list of Table 3 are other vehicles. This industry, according to Russian National Classification of Economic Activities, includes the production and repair of railway rolling stock.

**Table 3.** The products from OKPD (Russian National Classification of Economic Activities) for the material costs of the rail transport industry.

| № | Products of Russian National Classification of Economic Activities | Million rubles | Total costs in rubles per 1000 rubles of products |
|---|---------------------------------------------------------------|----------|---------------------------------|
| 1 | Services for the production, transmission and distribution of electricity | 107 712 | 147.3288 |
| 2 | Ships, aircraft and spacecraft, other vehicles and equipment | 101 784 | 95.35645 |
| 3 | Services for the rental of cars and equipment (without operator), household goods and personal items | 79 207 | 66.9431 |
The indirect effects associated with an increase in the export of rail transport services do not significantly affect gross output. So, calculations show that an increase in exports in this industry by 10% results in only 0.04% growth in gross domestic product. The calculations of the tax burden in the structure of total value by types of economic activity show that the largest tax payments were made by companies providing pipeline transport services in the structure of value added of this industry of 3.3% of the gross value added created by them, followed by rail transport services 2.24%, which is above average in all sectors of the economy, which amounted to 1.49%.

6. Matrix multiplier of gross income in relation to the final product

The coefficients of total costs determine the output of each industry, which is necessary to obtain the final demand of each industry. In fact, they are the basis for making forecasts, since they contain information about the structural dependencies between the elements of final demand [5; 6]. The largest increase in gross output is an increase in the final demand for air and space transport services (see Table 4). Most of the transport industries are even lower than the average value of all sectors of the national economy. This situation is explained by the insignificant share of final demand in the total volume of output, i.e. the main output is aimed at industrial consumption (freight traffic), and not final one (passenger traffic). In this case, the inverse relationship confirms the thesis that an increase in gross output in all industries leads to an increase in output in transport industries.

| Products of Russian National Classification of Economic Activities | Sums of the coefficients of full costs (in rubles per 1000 rubles of products) |
|-------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Air and space transport services                                   | 1642.205                                                                     |
| Water transport services                                           | 1237.94                                                                      |
| Auxiliary and additional transport services; travel agency services | 1175.035                                                                     |
| Pipeline transport services                                         | 1050.93                                                                      |
| Rail transport services                                            | 1038.729                                                                     |
| Other land transport services                                       | 911.3036                                                                     |
| Average value by industry                                          | 1176.024                                                                     |
| Average value for all sectors of the economy                       | 1344.32                                                                      |

The input-output tables remain a globally recognized tool for analyzing intersectoral relations, which, in turn, is necessary for making macroeconomic forecasts. In our country, it is necessary to restore the regularity of compiling the input-output tables, and the first step has already been taken. Periodical publication on a single SNA standard will allow monitoring the coefficients of total cost, which will show the trend of economic development, show whether resource intensity is decreasing, whether innovation of the economy is growing, etc. Now the BRIC countries have entered the world market with their products and a shortage of certain resources. Therefore, at this stage, it is necessary to take into account detailed information about economic interrelations, and the input-output method will cope with this task.

Thus, the new detailing of the input-output tables in the context of 125 industries allows revealing the structural interrelations not only of the transport industry as a whole, but also with details on the
types of transport, including the rail one. The analysis shows the close relationship of rail transport with the industry for the provision of services for the production and distribution of electricity (as more electric locomotive traction is used). Rail transport services have 50.12% of value added in the total output. It has been established that such industries as coke oven products; auxiliary and additional transport services; travel agency services; production of iron, cast iron, steel, ferroalloys; cement, lime and gypsum are most sensitive to changes in tariffs for rail transport services. As for the matrix multiplier of gross income in relation to the final product, the rail transport services are below the national average, i.e. an increase in final demand for rail transportation (passenger) will not give a significant increase in gross output.

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