Inter-Sectoral Linkages and Structural Change in Azerbaijan: Insights from the Transport Sector

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***Abstract*— The aim of this research is to determine the role of the transport sector in inter-sectoral relations and the key characteristics of structural changes in Azerbaijan. For this purpose, input-output tables for the years 2011, 2016, and 2021 have been used to assess the interactions between the transport sector and other sectors. Specifically, the input-output model has been applied to evaluate both the demand created by increasing activity in the transport sector for other sectors and the demand generated by other sectors for the transport sector. Additionally, trends in certain key coefficients of the input-output analysis for the transport sector have been examined. The findings of this study provide insights into the dynamics of the Azerbaijani economy from the perspective of the transport sector and help to identify existing problems and future prospects in this field.**

Keywords—transport, multiplier effects, feedback effect, spillover effect, forward and backward effects, leontieff matrix, Gosh matrix

I. Introduction

The transport sector is a crucial component of the economy, influencing various aspects of economic activity and societal well-being. In Azerbaijan, the transport sector plays a significant role in economic growth, international trade, and global economic integration. In recent years the average annual number of employees in the transport sector has increased from 130,793 in 2019 to 151,640 in 2023, an increase of 20,847 employees. Simultaneously, the average monthly salary of workers in the transport sector rose from 855.8 AZN in 2019 to 1,278.0 AZN in 2023, reflecting a 422.2 AZN increase. Moreover, during this period, there has been a significant rise in investments allocated to the transport sector. Investments in the transport sector grew from 2,189.2 million AZN in 2019 to 5,417.2 million AZN in 2023, marking an increase of 3,228.0 million AZN. Parallel to these developments, Azerbaijan's GDP grew from 123,005.5 million AZN in 2023 to 126,337.0 million AZN in 2024, an increase of 3,331.5 million AZN. The share of transport and storage in GDP also increased from 7,637.0 million AZN (6.2%) in 2023 to 8,822.9 million AZN (7.0%) in 2024 [16].

Azerbaijan's strategic location at the intersection of international transit corridors, along with the transport-transit sector's multiplier effect, significantly influences the development of other industries. Each year, more than 19% of the non-oil sector's growth is attributed to transportation, with approximately 58% of non-oil sector cargo transportation accounted for by the transport sector. The continuous development of Azerbaijan's transport-transit sector has led to the formation of a favorable infrastructure across various areas. Since more than 85% of the national transport network covers regional/rural areas, strengthening this sector can play a key role in implementing social and economic development programs for the rural regions.

Given this context, assessing the inter-sectoral linkages of the transport sector using input-output tables is of great importance in efficiently organizing Azerbaijan's service-trade system and ensuring economic growth in the non-oil sector. This study utilizes input-output tables from 2011, 2016, and 2021 to analyze the interconnections between the transport sector and other industries, examining how these relationships have evolved over time. Through input-output modeling, this research evaluates the additional demand generated for the transport sector by other industries and vice versa. Furthermore, it analyzes key input-output coefficients related to the transport sector, providing insights into structural changes within the sector. The findings of this study contribute to a deeper understanding of the transport sector's role in Azerbaijan's economic development and help identify existing challenges and future growth opportunities.

II. Literature review

Numerous studies assess the significant role of the transport sector in the economy and examine how structural changes over time impact this field. [8] analyzes the production-stimulating effects, supply constraints, price impacts across sectors, and forward and backward linkages of the transport sector (across four modes of transport) in the Korean economy using input-output tables for the years 2000, 2005, and 2010. [7] compares type I and type II multipliers of the transport sector in the Croatian economy by utilizing input-output tables for 2010 and 2015, examining the reasons for these changes. [14] evaluates structural changes and stability in Russia's transport sector using multi-input/multi-output systems and empirical input-output data from 2000 to 2014.

[12] assesses Azerbaijan's transport sector and its subsectors in terms of employment, investment, turnover, and other aspects. This study employs a principal component analysis (PCA)-based index approach to measure the economic activity of the transport sector and utilizes the Hodrick-Prescott (HP) filter to compare the sector's annual potential and actual indicators. [9] investigate the role of transport infrastructure in Azerbaijan's economic development, arguing that infrastructure improvements significantly contribute to reducing transport costs, expanding access to new markets, enhancing product competitiveness, increasing labor mobility, improving cargo transportation speed, and lowering logistics costs—ultimately fostering national productivity and comparative advantage. [5] examines the strategic importance of transport-transit corridors in enhancing the potential of Azerbaijan's non-oil sector. This research explores the role of transport infrastructure in non-oil sector development and analyzes the efficient use of transit corridors to ensure sustainable economic growth. [6] use econometric modeling to assess the dependence of key transport sector indicators on determining factors.

In this study, input-output tables will be utilized to analyze the interactions of the transport sector with other industries and the dynamics of these relationships over the period 2011-2021.

III. METHODOLOGY

The input-output table is a quantitative economic tool that reflects the relationships between various sectors of the economy. This table captures the monetary flows of goods and services between industries, illustrating how each sector produces its output by utilizing intermediate goods and primary production factors from other sectors. It also demonstrates how the produced output is used by other sectors as intermediate consumption and by economic agents as final consumption. This table serves as a fundamental framework for understanding economic interdependencies and is widely used in economic analysis and decision-making processes [3].

The input-output table consists of three main sections: the first section represents intermediate consumption, the second section reflects final demand, and the third section shows the structure of value-added. Based on these indicators, the following coefficients can be calculated.

Labor compensation coefficient measures the share of annual wage payments (L) in the total output (X) of a given sector, indicating the labor intensity of the sector:

$$a_L = \frac{L_j}{X_j} \tag{1}$$

Direct profit coefficient represents the share of net income (M) in total output (X), reflecting the economic performance or profitability of the sector:

$$a_M = \frac{M_j}{X_j} \tag{2}$$

Final consumption coefficient measures the proportion of final consumption (Y) in the sector's total output (X):

$$a_Y = \frac{Y_j}{X_j} \tag{3}$$

Additionally, the intermediate demand rate (q_i) and intermediate input rate p_j are used in the analysis, representing, respectively, the share of intermediate product demand from other sectors in a sector's output (sector i) and the share of intermediate product input used by the sector in its total output.

$$q_i = \frac{\sum_{j=1}^{n} x_{ij}}{X_i} \tag{4}$$

$$p_j = \frac{\sum_{i=1}^{n} x_{ij}}{X_j} \tag{5}$$

Analyzing the rows of the input-output table allows us to observe how each sector's total output is allocated between intermediate and final consumption. This leads to the fundamental equation of the input-output table:

$$\mathrm{AX} + \mathrm{Y} = \mathrm{X} \tag{6}$$

where X represents total output, Y denotes final demand, and AX indicates intermediate consumption. The matrix A is called the direct input coefficients matrix, with its elements calculated as:

$$a_{ij} = \frac{x_{ij}}{X_j}$$

where each element of this matrix represents the share of sector i's intermediate product in the production of one unit of output in sector j. This matrix describes production technology and is assumed to remain stable in the short- and medium-term.

The equation (6) represents the initial equilibrium condition of the production process, where any change in the final demand vector results in a new equilibrium state. This change can be simulated using the following equation:

$$\Delta X = (\dot{\mathrm{I}} - A)^{-1} \Delta Y = B \Delta Y \tag{7}$$

Here, the matrix $B = (\dot{\mathrm{I}} - A)^{-1}$ is referred to as the total input coefficients matrix, which expresses the direct and indirect contributions of sector i to the production of one unit of sector j's output. Using this simulation model, the impact of exogenous demand shocks on total output in different sectors can be evaluated.

One of the widely recognized concepts in input-output analysis is the notion of backward and forward linkages. Backward linkages measure the extent to which a sector depends on inputs from other sectors. A sector with strong backward linkages has significant demand for inputs from other industries, highlighting its importance in the economy. By altering final demand in equation, the demand created by one sector for other sectors can be assessed. [13] proposed measuring the backward linkage effect of each sector (sector j) by summing the elements in the total input coefficients matrix's corresponding column. To enable sectoral comparisons, this quantity is normalized by summing the backward linkage effects across all sectors and calculating each sector's share in the total. Thus, the backward linkage effect is calculated using the formula [14]:

$$GBT_j = \frac{1/_n \cdot \sum_{i=1}^{n} b_{ij}}{1/_{n^2} \cdot \sum_{j=1}^{n} \sum_{i=1}^{n} b_{ij}} \tag{8}$$

Here, b_{ij} - are elements of the total input coefficients matrix.

This equation shows that the average backward linkage effect across all sectors equals 1. If a sector's backward linkage effect exceeds 1, an increase in demand for its products will generate above-average production increases in other sectors, whereas if it is below 1, the impact will be below average.

Conversely, an increase in the production of sector i means that its supply of intermediate products to other sectors has expanded, allowing these sectors to enhance their own production. This type of interconnection between a sector and the industries it supplies is referred to as forward linkages [4].

[2] proposed using the Ghosh inverse matrix to calculate forward linkages. For this purpose, the matrix C is obtained by dividing inter-sectoral intermediate product volumes by row sums. Using this matrix, the Ghosh inverse matrix is computed as follows [1]:

$$G = (\dot{\mathrm{I}} - C)^{-1}$$

where I is the unit matrix.

Similar to backward linkages, the elements of the G matrix are used to compute the forward linkage effect (FL) using the formula [14]:

$$\dot{I}BT_i = \frac{1/_{n} \cdot \sum_{j=1}^{n} g_{ij}}{1/_{n^2} \cdot \sum_{i=1}^{n} \sum_{j=1}^{n} g_{ij}} \tag{9}$$

Furthermore, in equation (7), by evaluating the additional demand created in any sector due to a unit of investment allocated to each sector, the forward linkages of that sector with other industries can also be analyzed separately.

IV. Results

The data for this research is based on the input-output tables published by the State Statistical Committee for the years 2011, 2016, and 2021. Initially, these tables, which consist of 96 sectors, were grouped into 19 sectors using the classification of economic activities. Subsequently, based on the methodology outlined above, the interconnections of the transport sector with other industries and structural changes were analyzed.

First, using equations (1) to (5), the dynamics of coefficients characterizing some key indicators of this sector were calculated, and the results are presented in Table 1.

TABLE I. SOME KEY INDICATORS OF THE TRANSPORTATION SECTOR

Nəqliyyat	**2011**	**2016**	**2021**
labor compensation coefficient	0.07	0.10	0.11
Direct profit coefficient	0.50	0.42	0.41
İntermediate input rate	0.27	0.33	0.36
Final Consumption Coefficient	0.66	0.83	0.46
Intermediate demand rate	0.34	0.17	0.54

Source: Authors' calculations

The table shows that during the observed period, labor intensity in the transportation sector increased, while profitability, on the contrary, decreased. The share of intermediate products from other sectors in the costs of the transportation sector also increased over the analyzed period.

From 2011 to 2016, the increase in the final consumption coefficient indicates a growing demand for the services of this sector in the market. However, in 2021, a sharp decline in this demand was observed, which can be explained by the lockdowns caused by the COVID-19 pandemic. At the same time, intermediate demand for transportation sector products from other industries increased, which may be attributed to a partial shift in production structures during the pandemic.

Furthermore, to assess the backward linkages of the transportation sector with other industries, the study used the input-output model for every three years to estimate the additional demand generated by a unit of investment allocated to this sector within itself, in other sectors, and in the overall economy. The results of this assessment in Excel are reflected in Table 2.

The table shows that an investment of 1 million manats in the transportation sector generated 1.45 million manats in revenue across the country in 2011, 1.54 million manats in 2016, and 1.56 million manats in 2021. This indicates that the role of the transportation sector in the economy has grown over time. Examining the structural changes in this growth reveals sectoral differences. Naturally, the most significant increase occurred within the transportation sector itself. In other sectors, growth was recorded to varying degrees, depending on the nature of their links with transportation. In all three years, the transportation sector predominantly relied on the products of the "Manufacturing" sector.

TABLE II. THE NATIONWIDE MULTIPLIER EFFECTS OF A 1 MILLION MANAT INVESTMENT IN THE TRANSPORTATION SECTOR (THOUSAND MANATS)

	2011	**2016**	**2021**
Agriculture, forestry and fishing	14.68	13.00	9.22
Mining	**33.36**	**30.11**	21.35
Manufacturing	**195.09**	**232.43**	**196.58**
Electricity, gas and steam production, distribution and supply	16.17	19.08	12.83
Water supply; waste treatment and disposal	1.78	2.59	2.04
Construction	18.59	27.97	**40.06**
Trade; repair of transport means	**28.93**	**65.37**	**63.77**
Transportation and storage	**1061.25**	**1052.58**	**1129.91**
Accommodation and food service activities	3.71	4.77	8.71
Information and communication	5.33	13.02	4.91
Financial and insurance activities	12.87	17.42	16.39
Real estate activities	**28.34**	22.74	23.65
Professional, scientific and technical activities	23.27	23.99	19.25
Administrative and support service activities	4.81	7.68	4.83
Public administration and defence; social security	0.16	0.19	0.08
Education	0.26	0.16	0.13
Human health and social work activities	2.12	1.64	0.28
Arts, entertainment and recreation	0.14	0.12	0.10
Other service activities	1.40	10.06	8.56
Total	1452.26	1544.91	1562.64

Source: Authors' calculations

In 2011, an investment of 1 million manats in the transportation sector created a demand for 195,000 manats worth of "Manufacturing" products, 33,360 manats worth of "Mining" products, and 28,930 manats worth of services from the "Trade; repair of transport means" sector. A comparative analysis with 2016 shows that demand in the "Manufacturing" sector increased from 195.1 thousand to 232.43 thousand manats, in the " Trade; repair of transport means" sector from

28.93 thousand to 65.37 thousand manats, and in the construction sector from 18.59 thousand to 27.97 thousand manats. This can be explained by the increasing share of infrastructure development in the output of the transportation sector during those years.

However, in 2021, particularly due to the impact of the COVID-19 pandemic, a decline was observed in these sectors. During this period, the transportation sector prioritized using its own products and services as intermediate goods.

Overall, this table allows for an assessment of the changes in other sectors caused by the increase in exogenous demand for the transportation sector due to the use of goods and services from various industries in its production. As noted, these relationships represent the backward linkages of this sector. However, the transportation sector's interactions with other industries do not end there. The transportation sector also plays a crucial role in the organization of production across various economic activities by providing indispensable transportation services. Therefore, the development of any sector results in increased demand for transportation services. To evaluate this, the input-output model for every three years was used to assess the supply capacity of the transportation sector to other industries. The demand generated in the transportation sector by an investment of 1 million manats in each industry is presented in Table 3.

TABLE III. THE DEMAND GENERATED IN THE TRANSPORTATION SECTOR BY AN INVESTMENT OF 1 MILLION MANATS ALLOCATED TO EACH INDUSTRY, IN THOUSAND MANATS

	2011	2016	2021
Agriculture, forestry and fishing	**106.19**	39.19	**117.66**
Mining	10.13	12.60	64.76
Manufacturing	**108.67**	**65.40**	**182.73**
Electricity, gas and steam production, distribution and supply	**113.85**	**61.49**	**131.80**
Water supply; waste treatment and disposal	70.17	35.91	82.74
Construction	59.31	**61.75**	**126.64**
Trade; repair of transport means	32.08	22.35	72.58
Transportation and storage	44.69	23.71	**139.05**
Accommodation and food service activities	16.38	11.21	28.37
Information and communication	12.33	4.53	6.73
Financial and insurance activities	42.26	9.42	17.09
Real estate activities	25.91	24.59	67.25
Professional, scientific and technical activities	31.48	16.33	53.96
Administrative and support service activities	28.52	20.30	50.29
Public administration and defence; social security	10.99	10.81	22.96
Education	41.87	20.47	66.35
Human health and social work activities	33.49	10.87	44.95
Arts, entertainment and recreation	25.06	17.50	46.39

Source: Authors' calculations

The changes in sectoral demand for transportation services in 2011, 2016, and 2021 can be explained by the transformation of the economic structure, shifts in production processes, and price factors. The macroeconomic trends and events in Azerbaijan during these periods shaped the demand for transportation services across industries in different ways.

Among the major economic events during 2011–2016, the sharp decline in oil prices and the 2015 devaluation played a significant role. As a result of these processes, the price of imported goods increased in the country, the diversification of the non-oil economy accelerated, but some industries were forced to cut costs. For example, demand for transportation services from the manufacturing sector dropped from 108,670 manats in 2011 to 65,400 manats in 2016. The main reason for this could be the optimization of production processes and the shift towards more localized sources to reduce transportation costs.

The decline in demand for transportation services in "Agriculture, forestry and fishing" can also be attributed to the effects of the 2015 devaluation, which led to rising import costs and increased domestic production. However, structural changes within the sector may have played a role in this trend.

Overall, demand for the transportation sector declined across many industries in 2016, which may be linked to economic downturns and measures taken to improve efficiency in production processes.

During the period from 2016 to 2021, Azerbaijan's economy entered a phase of recovery and growth, with increased investments in the non-oil sector and an expansion of infrastructure projects. Key developments during this period included the development of industrial zones, state support for transportation and logistics infrastructure, as well as large-scale projects aimed at rebuilding the Karabakh region following its liberation.

As a result, demand for transportation services in the "Manufacturing" sector rose to 182,730 manats in 2021, which can be attributed to the expansion of industrialization and the increased need for transporting manufactured goods. The "Construction" sector's demand for transportation services increased from 61,750 manats in 2016 to 126,640 manats in 2021. This was primarily driven by reconstruction efforts in Karabakh and surrounding areas, the construction of new roads and railways, and the expansion of infrastructure projects.

In the "Accommodation and food service activities" sector, demand for transportation services dropped to 23,710 manats in 2016 but surged to 139,050 manats in 2021. This fluctuation can be explained by changes in the sector before and after the pandemic. The year 2016 can be considered a period of stagnation for Azerbaijani tourism, as economic instability led to reduced tourism expenditures. Although domestic tourism was developing, demand for transportation services remained limited. However, by 2021, during the post-pandemic recovery, the growth of both domestic and international tourism significantly increased the demand for transportation services.

In the "Mining" industry, demand for transportation services remained relatively stable between 2011 and 2016 (10,130 → 12,600 manats) but surged to 64,760 manats in 2021. This increase can be attributed to the implementation of new projects in the oil and gas sector, as well as the expansion of the non-oil mining industry. Additionally, since 2021, growing interest in renewable energy and alternative raw materials has contributed to a rise in demand for logistics and raw material transportation.

Overall, changes in demand for the transportation sector can be seen as a result of macroeconomic processes, price fluctuations, and structural reforms in the country. The varying dependence of different industries on transportation is influenced by sectoral development strategies, shifts in product structure, and price dynamics.

TABLE IV. THE FORWARD AND BACKWARD LINKAGE EFFECTS OF THE TRANSPORTATION SECTOR

	2011	2016	2021
Forward linkages	1.026	0.841	1.166
Backward linkages	0.899	0.961	0.986

The changes in the forward and backward linkage effects of the transportation sector between 2011 and 2021 indicate significant structural transformations in the economy. In 2011, the forward linkage effect of the transportation sector was 1.026, but by 2016, this figure had decreased to 0.841. However, this decline should not be interpreted as a reduction in demand for transportation services due to an overall economic downturn. Instead, it reflects a changing structure of demand for transportation services driven by investments across various sectors.

In particular, the optimization of transportation costs resulted from improvements in production technologies and logistics systems, the expansion of local production, and reduced dependence on imports in some industries. Additionally, the increasing share of the service sector and high-tech manufacturing led to a relatively lower demand for transportation services generated by investments. However, in 2021, the forward linkage effect rose to 1.166, indicating the growing strategic importance of the transportation sector for other industries. This increase can largely be attributed to post-pandemic economic recovery, large-scale construction projects in the region, the expansion of local production, and transportation projects aimed at transforming Azerbaijan into an international logistics hub.

On the other hand, the backward linkage effect of the transportation sector increased from 0.899 in 2011 to 0.961 in 2016 and further to 0.986 in 2021. This trend suggests that the sector generated a higher demand for products and services from other industries to sustain its operations. Notably, efforts to reduce import dependency and promote local production led the transportation sector to rely more on goods such as construction materials, fuel, vehicles, and equipment.

Thus, in recent years, the transportation sector has not only served as a supporting component of economic activities but has also emerged as a key economic driver that promotes local production and maintains strong interconnections with multiple industries.

V. CONCLUSIONS

The study evaluated the role of the transportation sector and structural changes in the Azerbaijani economy using input-output tables for the years 2011, 2016, and 2021. Comparisons across these three years highlight key economic shifts: in 2016, the optimization of transportation costs following the devaluation, and in 2021, structural changes in production due to the COVID-19 pandemic and the initiation of reconstruction efforts in newly liberated territories.

Additionally, by assessing the demand generated by the transportation sector in other industries, the study demonstrates that investments in this sector do not only contribute to its internal development but also drive significant transformations across the broader economy. This underscores the crucial role of the transportation sector in fostering more sustainable and balanced economic growth in Azerbaijan.

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