Analysis of Industrial Characteristics of China's Transportation Industry Based on Input-output Model

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Abstract

Transportation is a traditional and fundamental industry of the national economy. Using the input-output analysis method, this paper calculates the direct consumption coefficient, complete consumption coefficient, influence coefficient and sensitivity coefficient of China's transportation industry from 1992 to 2017. It analyzes the industrial development characteristics and evolution law of the transportation industry. China's transportation industry has gradually entered the quality improvement stage from the quantity expansion stage. The economic relationship between the transportation industry and the secondary and tertiary industries is strong. The impact of transportation on the national economy is lower than the average level of the tertiary sector, and it is still an indispensable primary and productive service industry in the national economy.

Keywords- *Input-output Analysis, Communications, and Transportation Industry, Influence Coefficient, Induction Coefficient*

1. INTRODUCTION

Transportation runs through all production, circulation, distribution, and consumption links. It is an essential service and leading industry of the national economy. According to the data of China's input-output table of 42 sectors in 2017, the added value of China's transportation industry accounts for about 5.6% of GDP, ranking fourth in the service industry, less than wholesale and retail (9.36%), real estate (7.09%) and Finance (6.56%). Input-output analysis is a quantitative economic method to study the interdependence between input and output among various parts of the financial system, which is used to analyze the balanced relationship between various national economy departments.

Many scholars use the input-output model to analyze the industrial characteristics of the transportation industry and its position and role in the national economic system. Wang (2004), Betancourt (2001) and Duan (2012) used input-output tables to study the part of the transportation industry in driving and supporting the national economy and analyzed the industrial correlation and ripple effect of the transportation industry[1-3]. Zhu(2018),Cheng et al (2021) further examined the impact of transportation industry on general prices and employment[4,5]. Si et al. (2021) measured the position of China's transportation industry in the industrial chain based on the input-output data and the industrial upstream degree measurement model[6]. Xiong (2015) and others measured the contribution of the logistics industry to the national economy by using the input-output method[7]. Cheng(2014), Banancloche et al (2020) and others calculated the linkage development of the logistics industry and related industries in eight economic regions from 1992 to 2007[8,9]. Han Song et al. (2020) used the data of China's input-output table in 2017 and the world's input-output table in 2014 to construct the measurement methods of external backward correlation, external forward correlation and external dependence from the perspective of the supply chain and analyzed the spatial correlation between China's logistics industry and its industries and 43 countries or regions[10].

This paper uses the input-output analysis method to analyze the status and role of the transportation industry

in the national economic system, study the direct and indirect related sectors of the transportation industry, analyze the evolution process of the industrial characteristics of the transportation industry, and study the status and role of the transportation industry in the national economy.

2. DATA

2.1. Data Sources

To strengthen the macro-control and management of the national economy and improve the scientificity of economic decision-making, China conducts a national input-output survey and tabulation every five years. This paper focuses on the input-output tables of China's transportation industry in 1992, 1997, 2002, 2007, 2012 and 2017, and analyzes the input-output situation of China's transportation industry. Due to the different industrial divisions and statistical caliber, the industrial categories in the input-output table of each year are different. In 1992, there were 33 departments in the input-output table, which measured the cargo post industry, telecommunications industry, and passenger transportation industry, respectively; In 1997, there were 40 departments in the input-output table, which measured the transportation industry and passenger transportation respectively; In 2002 and 2007, there were 42 departments in the input-output table, including transportation and storage industry; There were 42 departments in the input-output table in 2012 and 2017, including transportation industry, storage industry and postal industry.

2.2. Input-Output Analysis

1) Analysis Index of Industrial Relationship

Direct Consumption Coefficient and Complete Consumption Coefficient. Direct consumption coefficient refers to the number of products of other departments directly consumed by one unit of products produced by one department, expressed as $a_{ij} = x_{ij}/X_j$, $i, j = 1, 2, \ldots, n$, x_{ij} refers to the consumption of products in department j; X_j refers to the total investment of department j. The complete consumption coefficient refers to the total consumption of one unit of final product produced by a department to the effects of other departments. The n*n entire consumption efficient matrix B with each entry in the matrix called b_{ij} could be calculated by the n*n direct consumption coefficient matrix A with each entry in the matrix called a_{ij}. The

formula of $B = (I - A)^{-1} - I$, and I is n*n identity matrix.

Intermediate Demand Rate. The intermediate demand rate refers to the ratio of the intermediate demand provided by an industrial sector for other industrial sectors to the total demand supplied by the industrial sector for the whole national economic system, expressed as $G_i = \sum_{j=1}^{n} x_{ij} / (\sum_{j=1}^{n} x_{ij} + Y_i)$, $\sum_{j=1}^{n} x_{ij}$ refers to the sum of the intermediate demand of the industrial sector j for the products of the industrial sector i, Y_i represents the total final demand of the industrial sector i. The higher the intermediate demand rate of the industry, the lower the final demand rate, and the stronger the intermediate product attribute, which is more inclined to productive industries; On the contrary, it is more prone to consumer industries.

Intermediate Input Rate. Intermediate input rate refers to the proportion of intermediate input of an industry in its total input, expressed as $F_i = \sum_{i=1}^{n} x_{ij} / (\sum_{i=1}^{n} x_{ij} + D_j + N_j)$, $\sum_{i=1}^{n} x_{ij}$ is the sum of the intermediate input quantity of j industrial sector, D_j represents a depreciation of department j, N_j represents the value created for sector j. The intermediate input rate can reflect the transfer value of products or services in the production process. If the intermediate input rate is high, the added value rate is low, and the driving effect on other industries is strong.

2) Analysis Index of Industrial Ripple Effect

Influence Coefficient. The influence coefficient is the ratio of the influence of the Department to the average level of the impact of each department of the national economy, $T_j = n \sum_{i=1}^{n} A_{ij} / \sum_{i=1}^{n} \sum_{j=1}^{n} A_{ij}$, which reflects the relationship between an industrial sector in the national economy and the industrial sector that provides it with means of production, is also known as a backward connection. The higher the influence coefficient, the greater the driving force of the industry on the development of the national economy.

Sensitivity Coefficient. The sensitivity coefficient is the ratio of the sensitivity of a department to the average level of the sensitivity of various departments of the national economy, $S_i = n \sum_{j=1}^{n} A_{ij} / \sum_{i=1}^{n} \sum_{j=1}^{n} A_{ij}$, which reflects the relative level of an industry affected by the pulling force of national economic development, and is also known as forwarding linkage. The higher the sensitivity coefficient, the greater the pulling effect of national economic growth on the industry; the more it has the attribute of primary industry.

TABLE 1. DIRECT CONSUMPTION COEFFICIENT AND COMPLETE CONSUMPTION COEFFICIENT OF TRANSPORTATION INDUSTRY FROM 1992 TO 2017

Year	Industry	To All Industrial Sectors		To the Primary Industry		To the Secondary Industry		To the Tertiary Industry	
		Direct Consumption Coefficient	*Complete Consumption Coefficient*	*Direct Consumption Coefficient*	*Complete Consumption Coefficient*	*Direct Consumption Coefficient*	*Complete Consumption Coefficient*	*Direct Consumption Coefficient*	*Complete Consumption Coefficient*
1992	Freight, post and Telecommunications	0.4345	1.1716	0.0153	0.1388	0.3231	0.7599	0.0962	0.2770
	Passenger Transport Industry	0.4552	1.2297	0.0080	0.1388	0.3411	0.7994	0.1061	0.2915
1997	Freight Storage Industry	0.4343	1.1505	0.0130	0.1465	0.2647	0.6857	0.1566	0.3153
	Passenger Transport Industry	0.4846	1.3006	0.0046	0.1595	0.3220	0.8079	0.1581	0.3332
2002	Transportation and Storage Industry	0.5160	1.3157	0.0148	0.1674	0.2537	0.6649	0.2476	0.4834
2007	Transportation and Storage Industry	0.5387	1.5952	0.0167	0.2519	0.3220	0.8824	0.1999	0.4609
2012	Transportation, Storage and Postal Industries	0.6299	1.8019	0.0264	0.3169	0.2643	0.7858	0.3391	0.6993
2017	Transportation, Storage and Postal Industries	0.5917	1.7424	0.0283	0.3327	0.2512	0.7723	0.3122	0.6374

3. CALCULATION OF INPUT AND OUTPUT OF CHINA'S TRANSPORTATION INDUSTRY

According to the input-output tables of China in 1992, 1997, 2002, 2007, 2012 and 2017, the author uses MATLAB software to calculate the correlation coefficient between transportation industry and other industrial sectors, as shown in Table 1 and table 2.

In China's 2017 input-output table, the transportation, storage and postal industries are divided into nine sub-sectors, and the correlation coefficient calculation with other industrial sectors is shown in Table 3.

TABLE 2.   INFLUENCE AND INDUCTION COEFFICIENT OF TRANSPORTATION, STORAGE AND POSTAL INDUSTRY FROM 1992 TO 2017

	Industry Name	Influence	Influence Coefficient	Department Ranking	Sensitivity	Sensitivity Coefficient	Department Ranking
1992	Freight, Post and Telecommunications	1.1716	0.6997	28/33	2.2069	1.2781	8/32
	Passenger Transport Industry	1.2297	0.7344	30/33	0.3177	0.1840	27/32
1997	Freight Storage Industry	1.1505	0.7254	34/40	1.8245	1.1503	16/40
	Passenger Transport Industry	1.3006	0.8200	29/40	0.3961	0.2497	31/40
2002	Transportation and Storage Industry	1.3157	0.8633	28/42	3.7456	2.4576	4/42
2007	Transportation and Storage Industry	1.5952	0.8246	30/42	3.3079	1.7099	9/42
2012	Transportation, Storage and Postal Industries	1.8019	0.9227	26/42	3.6339	1.8608	7/42
2017	Transportation, Storage and Postal Industries	1.7201	0.8603	28/42	3.5772	1.8121	8/42

TABLE 3.   INPUT-OUTPUT INDICATORS OF VARIOUS TRANSPORTATION MODES IN 2017

	Direct Consumption Coefficient	Complete Consumption Coefficient	Influence	Influence Coefficient	Inductive Force	Induced Force Coefficient
Transportation, Storage and Postal Industries	0.5917	1.7424	1.7201	0.8603	3.5772	1.8121
Railway Transportation	0.4911	1.4111	1.3709	0.6340	1.2662	0.5947
Road Transport	0.5563	1.7233	1.6609	0.7681	6.0590	2.8457
Water Transportation	0.7233	2.1102	1.9181	0.8871	0.9799	0.4602
Transport Aviation	0.7752	2.2533	2.2289	1.0308	1.4003	0.6577
Pipeline Transportation	0.5702	1.5779	1.5722	0.7271	0.2544	0.1195
Handling and Transportation Agent	0.6604	1.7532	1.8159	0.8398	1.4161	0.6651
Storage	0.7553	2.2364	2.0434	0.9451	1.1545	0.5422
Postal Service	0.5215	1.5502	1.5225	0.7042	0.4456	0.2093

4. ANALYSIS ON THE INDUSTRIAL CHARACTERISTICS OF CHINA'S TRANSPORTATION INDUSTRY

According to the calculation of input and output, the industrial characteristics, status and role of transportation, storage and postal industries in the national economy from 1992 to 2017 are analyzed as follows:

1) There is a robust economic relationship between the transportation industry and secondary industry and tertiary industry.

The consumption coefficient is an index that reflects the close economic relationship between various national economy departments. In Table 1, the complete consumption coefficient of transportation to the primary industry has shown an apparent upward trend over the past 20 years. However, the economic connection

between the secondary industry and the tertiary industry is still significantly higher than that of the primary industry. With the optimization and adjustment of China's economic structure, the driving effect of transportation on related industries has gradually increased, showing the characteristics of producer services; Among them, the direct consumption coefficient of transportation to the secondary industry shows a gradual downward trend, and the complete consumption coefficient fluctuates slightly; The direct consumption coefficient and indirect consumption coefficient of transportation to the tertiary industry have increased significantly.

2)China's transportation industry has gradually entered the stage of quality improvement from the stage of quantity expansion.

According to China's input-output table in 2002, 2007, 2012 and 2017, the intermediate utilization rates of the transportation industry in the four years are 0.7376, 0.7505, 0.7496 and 0.7255 respectively, and the intermediate input rates are 0.4872, 0.4948, 0.5827 and 0.4585 respectively. The high intermediate demand rate of the transportation industry shows that its products or services are more intermediate products, which are mainly used to meet the needs of other industries; The low intermediate input rate indicates that the industrial added value is high and has a driving solid effect on other industrial sectors.

Ranking the direct consumption coefficient of various industrial sectors by transportation over the years, it is found that among the top ten industries, oil processing and transportation equipment manufacturing have always been the industrial sectors most closely related to the transportation industry. Before 2000, the transportation industry was closely related to the relevant departments of the secondary industry such as machinery, construction, power and heat supply, which shows that the support of energy resources is indispensable for the development of the transportation industry. At the same time, the energy consumption structure of the road transportation industry is changing, and the proportion of clean energy such as natural gas is gradually increasing. Since 2000, with the optimization and adjustment of China's industrial structure, the driving of transportation to the tertiary industry has been significantly enhanced, and the connection between finance and insurance and the transportation industry has been further improved. This shows that the transportation industry has the characteristics of a "capital intensive" industry and has apparent attributes of a service economy, closely related to the development of Commerce and trade services, resident services, accommodation and catering, and other industries. At this time, the development of China's transportation industry and manufacturing industry, including a large number of transportation equipment and manufacturing industry, must be in the middle stage,

which also reflects the development of China's transportation industry and manufacturing industry; When transportation enters the set of "quality improvement" from "quantity expansion," the relationship with relevant departments of the tertiary sector is significantly strengthened.

3) The driving effect of the transportation industry on the national economy has gradually increased, but it is still lower than the average level of the tertiary sector.

Influence reflects the ability of the change of final transportation products to affect the change of the total output of the whole national economy. The data in Table 3 shows that for each additional unit of final use in the transportation industry, the output of various departments of the national economy needs to increase gradually from 1.2 units in 1992 to 1.7 units in 2017; However, from the perspective of influence coefficient, it is significantly lower than the average level of the tertiary industry and ranks lower in various industrial sectors, which shows that the driving role of the transportation industry with transportation services as the main product still needs to be improved.

4) Transportation industry is an indispensable basic and productive service industry in the national economy.

The sensitivity and sensitivity coefficient of the transportation industry has been maintained at a high level. Since 2000, the sensitivity and sensitivity coefficient of the transportation industry has been further improved, and its ranking in various industrial departments has also been significantly improved. In 2017, the output of different industries in the national economy increased by 1 unit. The demand for the transportation industry was 3.5772 units, which was much higher than the average level of the tertiary sector and higher than the intermediate level of the secondary industry in some years, indicating that transportation has a crucial essential function in the national economy, especially in promoting the development of the secondary sector. The characteristics of the "productive" service industry of transportation have further emerged.

5) The essential role of road transport industry is more prominent.

Among the sub-sectors of transportation, storage and postal industry, the road transportation industry is the main body of passenger and freight transportation with many points, comprehensive coverage, flexibility and convenience. In 2017, the direct consumption coefficient and complete consumption coefficient of road transportation industry were roughly the same as those of transportation, storage and postal industry, which were lower than the average level of water and air transportation industry. In comparison, the water and air transportation industries were also more sensitive to the fluctuation of national economic growth. In 2017, the level of influence and influence coefficient of the road

transportation industry was higher than that of the railway transportation industry, lower than that of the water and air transportation industry, and the sensitivity and sensitivity coefficient was significantly higher than that of other transportation modes. On the surface, the basic role of the road transportation industry is more prominent. The development of the national economy will improve the output of the transportation industry and have an apparent pulling effect on the transportation industry. It should be noted that the basis of the input-output analysis is China's commercial road transport industry. With the rapid entry of private cars into families and the continuous improvement of social motorization level, travel consumption has increased rapidly, self-driving travel has made significant progress, and new modes such as shared travel have been widely popularized. The GDP created by this part and the relationship with various national economy departments have not been reflected in the input-output table.

5. CONCLUSION

The input-output analysis method analyzes the industrial characteristics and their status and role in the national economy by studying the interdependence between various national economy departments. The transportation industry belongs to the tertiary sector, an industrial sector with passenger and freight transportation services as its products. Through the analysis of input-output data from 1992 to 2007, it can be seen that China's transportation industry has gradually entered the stage of "quality improvement" from the stage of "quantity expansion". The economic relationship between the transportation industry and the secondary and tertiary industries is strong. The driving role of the transportation industry in the national economy has gradually increased, but it is still lower than the average level of the tertiary industry. It is an indispensable basic and productive service industry in the national economy, especially the basic role of the road transportation industry.

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