ANALYSIS ON THE CHARACTERISTICS OF TRANSPORTATION SYSTEM BETWEEN CHINA AND AMERICA BASED ON THE INPUT-OUTPUT THEORY

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Abstract: In order to analysis the position and role of transportation industry on the national economy rationally, the paper use the input-output theory to compare and analyze the characteristics of industry relevancy and industry spread in transportation industry and five transportation mode between China and America. Comparatively, the status of the Chinese transportation industry plays important role than before in the national economy. But currently due to the lower level of the Chinese industrial structure, the degree of transportation requirement by other industries is lower than America. The transportation industry in China belongs to the industries that the ratio of intermediate demand is high, and its drawing power for the relevant industries is larger than America. The impact coefficient of the Chinese transportation industry is obviously larger than its response coefficient, the inducing ability of export to transportation industry is higher than other ultimately demands. Finally, the proposals in developing Chinese transportation industry are put forward.

Key Words: transportation industry, five transportation mode, input-output analysis, industry relevancy, industry spread

1. INTRODUCTION

Transportation industry, which is the fundamental one in the national economy, co-exists with other industries and is related with them closely, therefore, the development of it depends on and stimulates that of others, to some extent. Temporarily transportation industry in China is still on the developing stage, and facilities of it are far from the requirement of deeper development. For sake of being acquainted with the real situation of transportation industry in Chinese national economy and social development, and fulfilling the demand of this industry’s development in the process of globalization, we here, based on the input-output theory, make a comparative analysis about functions and characteristics of transportation system between China and America.
The input-output theory, by which we could analyze economic relevancy, between production and distribution, between input and output, of different departments in one economic system, was firstly put forward by Wassily Leontief, a famous American economist and Nobelist. This model has been put into practice by increasing number of countries all over the world, calculating national economy of them, and has been modified ceaselessly. In the past, the industry of transportation, post and telecommunication were combined together, considered as one single department, thus, it is impossible for us to analyze interact and interplay between transportation industry and other departments effectively, and to do research of comparing them with each other.

In the newly posted China Input-output Table of 2002, which published in October 2006, five transportation modes have been divided into independent departments, thus, reality is precise quantitative analysis of interact and interplay between transportation industry and other departments, as well as between these five modes. It also makes comparative analysis of characters between our country and others available.

This thesis, based on China and U.S. Input-output Table of 2002, divides national economy into four departments in the analysis of whole transportation system: first industry, second industry, transportation industry, and third industry (excluding transportation industry); and divides it into eight department in the analysis on five transportation modes: first industry, second industry, railway transportation, highway transportation, transportation by water, airline transportation, pipe transportation and third industry (excluding transportation industry). According to the result of comparing some indexes between Chinese transportation and American, such as share of transportation industry in GDP, direct consumption coefficient to other industries, ratio of intermediate input and demand, impact coefficient and response coefficient, product inducing coefficient and price spread coefficient, and etc, the thesis reveals different functions and characters of transportation industry in national economy between these two different countries. At last, based on the final result, the thesis puts forward some suggestions both on developing policy and on developing emphasis about our country’s transportation.

2. SHARE COMPARISON OF TRANSPORTATION INDUSTRY IN GDP

Based on China and U.S. Input-output Tables of 2002, calculate the rate of increment about three different industries and transportation industry. (See Table 1)

<table>
<thead>
<tr>
<th>Name</th>
<th>China</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Industry</td>
<td>13.35%</td>
<td>0.91%</td>
</tr>
<tr>
<td>Second Industry</td>
<td>45.22%</td>
<td>20.58%</td>
</tr>
<tr>
<td>Third Industry</td>
<td>41.43%</td>
<td>78.51%</td>
</tr>
<tr>
<td>Where: Transportation industry</td>
<td>5.49%</td>
<td>2.63%</td>
</tr>
</tbody>
</table>

From the Table 1, it can be easily found that Chinese first and second industry’s increment is far higher than U.S, while the third industry is in the opposite way, only revealing currently that Chinese transportation industrial structure level is much lower, and that Chinese economic development is lagged, compared to American.
However, the rate of Chinese transportation industry’s increment is 5.49%, compared to 2.63% in America, shows the share of transportation Industry in GDP in China is larger. It thanks to Chinese government’s recognition for programming improvement of transportation industry these years, as well as American transportation system has been well developed. It can be forecasted that Chinese transportation industry will enter into a stage of rapid development in future, taking account for that Chinese economy is increasing fast, and that Chinese government is thinking more of this industry, supporting it, and inputting more into it, and that its own development will inspire scale economy. The rate of transportation industry increment is going to be enhanced, consequently.

3. CHARACTERISTICS OF TRANSPORTATION INDUSTRY RELEVANCY

3.1 Direct Consumption Coefficient

Direct consumption coefficient is viewed as, when an industry manufactures per production, the amount of consumed productions and services in other industries (also including those in its own industry), thus, as follows:

\[ a_{ij} = \frac{x_{ij}}{X_j} \quad (i, j = 1, 2, \ldots, n) \quad \text{(1)} \]

Where: \( x_{ij} \) = consumed productions and services in \( j \) industry caused by \( i \) industry

\( X_j \) = gross input of \( j \) industry

Matrix A formed by \( a_{ij} \) is called direct consumption coefficient matrix

3.1.1 Direct Consumption Coefficient as Transportation Industry to Others

According to Chinese and American Input-output in 2002 Tables, calculate direct consumption coefficient as transportation industry to others in two countries. (See Figure 1)

![Figure 1 Direct consumption coefficient as transportation industry to others](image)

The figure above illustrates that agriculture productions of first industry consumed directly is the least amount in three industries, which means the degree of transportation industry depending on first industry is limited. In general, the quantity of consumed agriculture production caused by transportation industry in China is more than that in America.
The direct consumption as transportation industry to second industry in China is more than that in America, demonstrating Chinese transportation industry is still in the stage of “quantitative expansion”. A large amount of industrial productions are required in this stage as intermediate input, including transportation tools, construction materials of container yard, raw materials for service production, transportation auxiliary tools, and etc, thus, the huge amount of direct consumption to second industry is undoubted. Considering the tendency of development that the level of opening is being raised, Chinese transportation industry will not traverse this stage in which not only size but quantity of the industry is outspreading, thus, the degree of transportation industry depending on second one will remain high in future.

3.1.2 Direct Consumption Coefficient as Other Industries to Transportation Industry

Based on calculating result, direct consumption coefficient as other industries to transportation industry is as follows (See Figure 2):

![Figure 2 Direct consumption coefficient as other industries to transportation industry](image)

Throughout Figure 2, it can be reflected that the direct consumption coefficient as first industry to transportation industry is less than that of second industry in both countries, namely, the degree of first industry depending on transportation industry is lower than that of second industry. The before-mentioned result illuminates transportation service received by second industry is more than first industry, because the direct consumption coefficient as first and second industries to transportation industry reveals that the amount of transportation services got by these, actually.

While the degree of Chinese third industry depending on transportation lies between that of first and that of second, the degree of American is much lower than first and second industry, which illustrates the fact, the extent of specialization and socialization of first and second industry in America is deeper than China. The degree of third industry depending on transportation in China is far higher than America, reveals that the development of transportation industry cannot be ignored, when China is making a marvelous progress of third industry (excluding transportation industry).

3.1.3 Direct Consumption Coefficient between Five Transportation Modes
Table 2 Direct consumption coefficient between five transportation modes

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th></th>
<th></th>
<th>U.S.</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>railway</td>
<td>highway</td>
<td>water</td>
<td>airline</td>
<td>pipe</td>
<td>highway</td>
</tr>
<tr>
<td>railway</td>
<td>0.02278</td>
<td>0.00877</td>
<td>0.00522</td>
<td>0.00157</td>
<td>0.01010</td>
<td>0.001803</td>
</tr>
<tr>
<td>highway</td>
<td>0.00167</td>
<td>0.05610</td>
<td>0.12138</td>
<td>0.06407</td>
<td>0.00440</td>
<td>0.003379</td>
</tr>
<tr>
<td>water</td>
<td>0.00364</td>
<td>0.00529</td>
<td>0.05903</td>
<td>0.00279</td>
<td>0.00482</td>
<td>0.000237</td>
</tr>
<tr>
<td>airline</td>
<td>0.00006</td>
<td>0.00076</td>
<td>0.00113</td>
<td>0.04245</td>
<td>0.00077</td>
<td>0.000562</td>
</tr>
<tr>
<td>pipe</td>
<td>0.00052</td>
<td>0.00075</td>
<td>0.00149</td>
<td>0.00081</td>
<td>0.01411</td>
<td>0.000118</td>
</tr>
</tbody>
</table>

It can be viewed, from Table 2, that the direct consumption coefficient as transportation by water to highway transportation is 0.12138, far more than others, and that Chinese transportation by water definitely depends on highway transportation. So, it can be induced that the main mode of multi-transportation in China temporarily is sea and land combined transportation. Comparatively, coefficients in America are almost on the same level, owing to its outstanding transportation system, as well as its rational transportation structure. Currently, all sorts of transportation modes, well developed, in American are divided into separate work and cooperate with each other in harmony, forming a wholly and rational transportation system.

3.2 Ratio of Intermediate Input and Demand

The ratio of intermediate input is considered to be the proportion intermediate input taking up in gross input in an industry, explaining the degree of added value here, as follows:

\[
    k_j = \frac{\sum_{i=1}^{n} x_{ij}}{\sum_{i=1}^{n} x_{ij} + N_j} \quad (j = 1, 2, \cdots n)
\]

The ratio of intermediate demand defines the ratio of intermediate demand (intermediate usage) dividing gross demand (intermediate demand plus final demand) in an industry. The larger the ratio, the more possibility that this industry behaves the characteristic of offering intermediate productions (production materials). The expression is as follows:

\[
    h_i = \frac{\sum_{j=1}^{n} x_{ij}}{\sum_{j=1}^{n} x_{ij} + Y_i} \quad (i = 1, 2, \cdots n)
\]

3.2.1 Ratio of Intermediate Input and Demand in Transportation Industry

Based on Chinese and American Input-output in 2002 Tables, calculate ratio of intermediate input and demand in transportation industry in two countries. (See Table 3)

Table 3 Ratio of intermediate input and demand in transportation industry

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio of intermediate input</td>
<td>50.410</td>
<td>48.571</td>
</tr>
<tr>
<td>Ratio of intermediate demand</td>
<td>73.786</td>
<td>64.804</td>
</tr>
</tbody>
</table>

The transportation industry should be classified into “Intermediate production model”
industry, that is, both ratio of intermediate input and demand are large, according to the data. Large ratio of intermediate input means transportation industry has mean drawing power to upriver industries, and large ratio of intermediate demand transportation industry mainly offers production services, whose aim is not supporting living services, and thus, fulfilling the final demand, but fulfilling the intermediate demand. Construction of railways, ports, highways, and airdromes has boosted the development of construction industry. One of critical factor mining and metallurgy industries have developed drastically is demand of railways and transportation machines for metal materials. Large scale of production of transportation tools has had a positive impact on the development of machining industry. Besides, the development of transportation industry has spurred agriculture, commodity circulating, and tour industry, etc. Indexes in China are larger than America, because demand is still exceeding requirements in its transportation system. As a result, the development of transportation industry can draw up that of its upriver industries noticeably, and is better for fulfilling the task of transportation production in the economic development.

3.2.2 Ratio of Intermediate Input and Demand of Five Transportation Modes

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway</td>
<td>0.4086</td>
<td>0.5408</td>
<td>0.4051</td>
<td>0.7544</td>
</tr>
<tr>
<td>Highway</td>
<td>0.4442</td>
<td>0.7410</td>
<td>0.7556</td>
<td>0.5387</td>
</tr>
<tr>
<td>Water</td>
<td>0.5983</td>
<td>0.6853</td>
<td>0.5387</td>
<td>0.4361</td>
</tr>
<tr>
<td>Airline</td>
<td>0.6165</td>
<td>0.9332</td>
<td>0.62129</td>
<td>0.96811</td>
</tr>
<tr>
<td>Pipe</td>
<td>0.5408</td>
<td>0.7410</td>
<td>0.7544</td>
<td>0.5387</td>
</tr>
</tbody>
</table>

Comprehensibly reckoning ratios of intermediate input and demand of five transportation modes in both China and America, and putting it into standard of 50%, the position and function of every transportation mode in national economy could be recognized precisely. The ratio of intermediate input of airline is high in both countries, however, the ratio of demand is high in China, viewed as “intermediate production industry”; low, America, views as “final demand industry”. In both countries, the ratio of intermediate input of highway is low; meanwhile, the ratio of demand is high, behaving the typical character of “intermediate production fundamental industry”. Chinese transportation by water has high ratio of intermediate input and demand, considering as “intermediate production industry”, and American should be thought as “final demand industry”, because the ratio of input is high, and that of demand is low. All data in regard to pipe transportation is high, so, this mode is “intermediate production industry”.

4. INFLUENCE OF TRANSPORTATION INDUSTRY SPREAD

4.1 Impact coefficient and response coefficient of transportation industry

The impact coefficient represents the degree of $i$ industry, when added per unit of final usage, drawing demand of every industry in national economy. This kind of influence can show the drawing power of this industry to the whole national economy. The expression is as follows:
The response coefficient is viewed as, when every industry is added a unit of final usage, the quantity of input needed in \( i \) industry. Consequently, it reflects the drawing power of other industries to this industry. Here is the expression:

\[
F_i = \frac{\sum_j b_{ij}}{\frac{1}{n} \sum_i \sum_j b_{ij}} \quad (j = 1, 2, \ldots n)
\]  

\[
E_i = \frac{\sum_j b_{ij}}{\frac{1}{n} \sum_i \sum_j b_{ij}} \quad (j = 1, 2, \ldots n)
\]

From Figure 3, we know that Chinese transportation industry’s impact coefficient is 0.98284, close to that of first industry, which is lower than second industry but higher than third industry (excluding transportation industry), only explaining the influence of this industry is just in the intermediate level. Comparatively, American transportation industry’s impact coefficient is 0.94204, lower than both first and second industry, just a little higher than third industry (excluding transportation industry), the push function of transportation industry to national economy in America is not as effective obviously as that in China. As regards five transportation modes, the data of Chinese transportation by water, airline transportation, and pipe transportation is all higher than 1, means these modes industry have magnificent influence. This result is the further explanation it is necessity for China to develop transportation industry, boosting national economy, especially transportation by water, airline transportation, and pipe transportation.

![Figure 3 The impact coefficient of transportation industry to others](image)

The Figure 4 illustrates that response coefficient of Chinese transportation industry is 0.57373, lowest in all industries. Obviously, the drawing power received by transportation industry from national economy is the least. That index of America is 0.63721, thus, the case is the same. Response coefficients of highway transportation in both countries are higher than other four modes, the enhancement of consuming and investing level led by the development of national economy, is first reflected by the increment of highway transportation’s data. It demonstrates part of cargoes transported by other modes before is converting into highway, with the improvement of economic level.
The response coefficient reflects the degree of demand as one industry in development of national economy. Theoretically, the demand for transportation industry caused by development of national economy, namely, the response received by transportation industry, presents in two different aspects: one is the demand for production services, that is, deeper specialization and socialization achieve, more demand for production services. The other is the demand for living services, namely, higher average salary level go, more demand for living services. So, it is justified that the response coefficient of transportation industry in United States is higher than China.

After comparison between the impact and response coefficient, it can be attained that the latter is lower in each county (China and U.S.), and this phenomenon is more obvious in China. In other words, the push function of transportation industry to national economy surpasses the pull function from national economy. Consequently, positive strategies should be taken to develop transportation industry, aiming at stimulating the overall development of national economy.

4.2 The Inducing Relationship of Every Final Demand to Transportation Industry

The expression of the final demand, namely, production inducing coefficient of one industry, is production inducing value of every sort of final demand item, such as consumption, investment, export, and etc., dividing tot of corresponding final demand item. It is actually the multiplier of inducing relationship of every final demand to transportation industry, as follows:

$$ w_{ij} = \frac{\sum_{j=1}^{m} x_{ij} \cdot B_{ij}}{\sum_{i=1}^{n} x_{ij}} \quad (i, j = 1, 2, \cdots; n; l = 1, 2, \cdots, m) $$

Where: $x_{ij}$ = demand of i industry for l item of final demand

$m$ = number of items of final demand

$B_{ij}$ = element of reciprocal matrix

Through Table 5, it can be found that the inducing coefficient of final demand to third industry is the highest one, and that index in U.S. is higher than China, attributing to the fact the salary level in developed country is higher and the power of final consumption is greater. The production inducing coefficient of second industry caused by capitalization is the highest, due to, in general, second industry is a kind of capital-intense industry, and therefore, it is
easiest for investment to boost this industry improving rapidly.

Table 5 Consumption, investment and output induction coefficient to various industries

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>U.S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>consumption</td>
<td>investment</td>
</tr>
<tr>
<td>Fist industry</td>
<td>0.2960</td>
<td>0.0492</td>
</tr>
<tr>
<td>Second industry</td>
<td>0.7824</td>
<td>2.7212</td>
</tr>
<tr>
<td>Transportation industry</td>
<td>0.0623</td>
<td>0.0123</td>
</tr>
<tr>
<td>railway</td>
<td>0.0115</td>
<td>0.0013</td>
</tr>
<tr>
<td>highway</td>
<td>0.0334</td>
<td>0.0026</td>
</tr>
<tr>
<td>water</td>
<td>0.0120</td>
<td>0.0065</td>
</tr>
<tr>
<td>airline</td>
<td>0.0028</td>
<td>0.0025</td>
</tr>
<tr>
<td>pipe</td>
<td>0.0001</td>
<td>(0.0001)</td>
</tr>
<tr>
<td>Third industry(excluding transportation)</td>
<td>1.2408</td>
<td>0.1142</td>
</tr>
</tbody>
</table>

Among all the items of final demand in two countries, export has the most power to induce transportation industry, far more than final consumption and capitalization. Export’s inducing function works most in transportation by water, and airline transportation, in China, and in highway transportation, and airline transportation, in U.S. Therefore, transportation industry belongs to typical export-pulled industry, namely, export could pull this industry most.

4.3 Influence of Price Spread

The production price of one or more industries fluctuating influences that of other industries in national economy doing so, also, the degree of which is viewed as the effect of price spread. The reason for that lies on every industry in national economy is related, functions, influence with each other, thus, production price in one industry changing will inevitably causing the price waving in those industries connected with it directly, and then, those industries will function in the same way, and the price waving will spread over till all the industries influenced.

Assume the production price of No. \( n \) industry in national economy will increase by \( \Delta P_n \), and calculate the overall influential effect caused by it to other \( (n - 1) \) industries, by the means of Leontief reciprocal matrix, as follows:

\[
\begin{bmatrix}
\Delta P_1 \\
\Delta P_2 \\
\vdots \\
\Delta P_{n-1}
\end{bmatrix} =
\begin{bmatrix}
b_{n1} & b_{n2} & \cdots & b_{nn}
\end{bmatrix}
\cdot
\begin{bmatrix}
\Delta P_n
\end{bmatrix}
\]

(7)

According to the result listed in the Table 6, the influence degree, which caused by general transportation service price changing, of second industry’s manufacture price is superior to that of first industry’s agriculture price. It has something to do with the larger amount of service production of second industry offered by transportation, compared to first industry.
Table 6 Effect of price spread as transportation industry to others

<table>
<thead>
<tr>
<th></th>
<th>Fist industry</th>
<th>Second industry</th>
<th>Third industry (excluding transportation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>4.275</td>
<td>8.504</td>
<td>5.472</td>
</tr>
<tr>
<td>U.S.</td>
<td>4.568</td>
<td>5.151</td>
<td>2.086</td>
</tr>
</tbody>
</table>

Table 7 Effect of price spread as other industries to transportation

<table>
<thead>
<tr>
<th></th>
<th>Fist industry</th>
<th>Second industry</th>
<th>Third industry (excluding transportation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>4.899</td>
<td>35.960</td>
<td>20.097</td>
</tr>
<tr>
<td>U.S.</td>
<td>0.755</td>
<td>16.859</td>
<td>32.542</td>
</tr>
</tbody>
</table>

Table 7 reveals that the price waving of third industry influences transportation most. The value of China and America is 20.097 and 32.542, respectively. It is obvious that transportation and third industry is tied up, and the relationship is much closer than first and second industry. So, the improvement of third industry is indispensable, if we decide the develop transportation.

Table 8 Influence of price spread among five transportation modes

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>railway</td>
<td>1 1.586 1.488</td>
<td>1 0.299 0.329</td>
</tr>
<tr>
<td>highway</td>
<td>14.333 8.307</td>
<td>0.755 1.139</td>
</tr>
<tr>
<td>water</td>
<td>2.199 0.860 1</td>
<td>1 0.125 0.115</td>
</tr>
<tr>
<td>airline</td>
<td>0.054 0.382 0.623</td>
<td>0.379 1</td>
</tr>
<tr>
<td>pipe</td>
<td>0.088 0.113 0.211</td>
<td>0.163 0.246</td>
</tr>
</tbody>
</table>

From the table 8, we can understand influence of price spread between five transportation modes in China is greater than that in America, illuminating the competition among them in China is much fiercer than America, especially, highway transportation and transportation by water. In the table, the coefficient of highway transportation Vs. transportation by water is 14.333, higher than any others. Therefore, changing fare of highway transportation will shift that of transportation by water inevitably, which is in accord with the result mentioned above that transportation by water has larger consumption coefficient to highway transportation than other modes.

5. CONCLUSION

The share of transportation industry in GDP in China is larger than that in America, demonstrating that the position of transportation is becoming essential ceaselessly. Transportation industry’s dependence on first and second industry in China is severer than America; however, dependence on third industry (excluding transportation industry) is much lighter. Throughout it, it can be reflected that currently Chinese transportation industry is still in the lower stage, and that transportation in both countries are high ratio of intermediate demand, where Chinese ratio of intermediate demand and input is higher, means the overall power of Chinese transportation industry drawing up upriver industries is bigger. Both countries’ impact coefficient of transportation exceeds response coefficient. Consequently, the
development of Chinese transportation should be superior to that of national economy, and some actions, such as augmenting investment to it, enlarging financing channels, and etc., should be taken to attain this target.

Compared to American perfect transportation system, Chinese transportation industry should unloosen price restriction properly, make either transportation mode compete with others completely, encourage each mode to take advantage of its comparative advantages, strengthen the inter-modal transportation, harmonize the relationship between them, and then, form a rational transportation structure.

The inducing ability of export to transportation industry in China is far greater than other final demands, thus, making use of export to stimulate transportation’s development, rising demand for transportation in society, and inducing first, second, and third industry including transportation to add consumption of transportation auxiliary and logistics industry, are definitely wise choices.

REFERENCES