Research on the Development of Railway Industry in China and the Correlation between Railway and National Economy Based on Input-Output Analysis

Li Xuemei, Yan Jun
School of Economics and Management
Beijing Jiaotong University
Beijing 100044, China

Abstract: Recently there is growing public concern about the development of China railway industry, and it has even become one of the critical issues that the influence degree of railway on social economic. The Chinese railway industry is taken as research object; the static and dynamic input-output model is established to research the correlation between railway industry and other industries in this paper. It is tried to find an approach to estimate and evaluate the economic impacts from development of railway networks within the multi-sector context in China. In this paper it is analyzed the development situations about railway industry in China by static input-output modeling, and used dynamic input-output model to update the input-output tables, which reveals the correlation between railway and other national economy industries as well as the changes of railway's development phase. Based on 1987-2007 linked input-output tables, the result shows that Chinese railway industry needs to be continually improved the status in the national economy.
Keywords: Input-output Analysis; China's railway industry; Correlation analysis

1 Introduce

Railway is the important national infrastructure, the artery of the country and a popular transportation. It takes a mainstay position in the integrated traffic system. Without modern railway, it would be difficult to realize the modernization of the country. China is a country with vast territory, deep inland, large population and imbalance distribution of resources and industrial. Chinese railway transportation plays a more prominent role in economic and social development than other transportations.

In recent years, the effect of railway transportation development on national and the surrounding area's economy has been researched by many scholars. A variety of methods has been used for the study on the correlation analysis between railway transportation development and economic growth. Among these methods, trend analysis between railway transportation development and GDP growth and correlation analysis between indexes of transportation and regional GDP [1], Gray Relation Analysis (GRA) [2] were used most. And in the aspect of Contribution analysis, regression analysis between regional GDP and transportation revolving quantity [3], Gray prediction model on the contribution rate of analysis of railway transportation [2], analytic hierarchy process, fuzzy comprehensive evaluation approach and input-output analysis were used most. It is used input-output analysis in this paper.

Input-output (IO) model is a mature method and has a long history in regional economics, which was put forward by Leontief and Strout (1963). It is applied to the port industry for the country's social benefit research by the port authority of New Jersey (1979). Input-output model is broadly applied, and the result is satisfactory. However, there are few applications in transportation and even railway, and only on the level of the static input-output analysis. This paper combined Static model with dynamic model to analyze the development of Chinese railway transportation and the incidence relation of national economy. This paper is based on the previous to improve and develop a better way to estimate and evaluate the economic impacts from development of railway networks within the multi-sector context in China.

Section 2 and section 3 of the paper build the input-output model for the Chinese railway transportation. In section 4, it is summarized the results of input-output model and made a further analysis of the results. Section 5 includes a summary of the major findings and conclusions.

2 A Static Input-output Model of Chinese Railway Transportation

Static input-output model is widely used and has been driven to maturity stage. We analyze from the aspects of economic benefits, product flow, value composition and national economy macro contact by building a static input-output model of China railway transportation. Data are from the national bureau of statistics of the Chinese input-output table (1987-2007).

2.1 Economic Benefits Analysis

$$EVA = 1 - a_{ij} \qquad (2.1)$$

where, EVA is the economic value-added rate; a_{ij} is the direct consumption coefficients.

The economic value-added rate is the reflection of proportional relation between production value added and total production value. It reflects the economic benefits level of production. Its raising means the economic benefits level of production has increased. In the formula, the direct consumption coefficient is that a sector products per goods with the direct consumption from other sectors in production management process, including goods and service value. The lower the direct consumption coefficient is, the higher the economic value-added rate is.

$$COR = X / (MC + FA + LR) \qquad (2.2)$$

where, COR is the cost-output rate; X is gross output; MC stands for material cost; FA is depreciation of fixed assets; LR is the labor remuneration.

The cost-output rate is a lateral comparison of rate of change between output and cost. It will increase when the change rate of output is faster than that of cost.

$$CNR = NPT / (MC + FA + LR) \qquad (2.3)$$

where, CNR is cost-profit tax rate; NPT is net profit tax.

The cost-profit tax rate is a lateral comparison of rate of change between net profit tax and cost. It will increase when rate of net profit tax change is faster than that of cost.

The cost-output rate and cost-profit tax rate are the economic indicators of production efficiency.

We can get these economic efficiency indices based on input-output tables from 1987 to 2007. The result is showed in table 2-1 and figure 2-1.

Table 2-1 Chinese railway's economic benefits from 1987 to 2007 (%)

	1987	1992	1997	2002	2007
value-added rate	79.5	71.27	65.41	59.14	64.30
cost-output rate	168.55	142.35	134.9	110.79	138.88
cost-profit tax rate	56.85	42.35	34.85	10.79	38.88

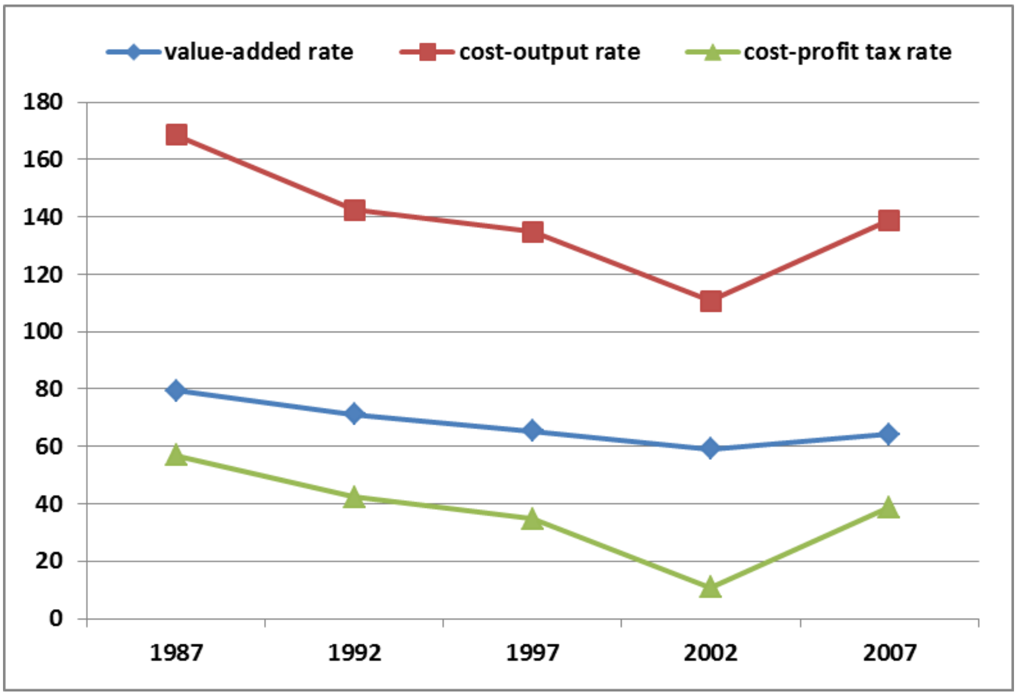

Fig.2-1 railway's economic benefits from 1987 to 2007

Here we can see, the value-added rate was essentially a trend of decrease, which indicates that the production economic benefits level of Chinese railway reduced year by year from 1987 to 2002. So did the cost-output rate. It indicates that the growth rate of railway's cost was faster than that of total output. But there was a transition in 2007. Meanwhile, railway's economic benefits reduced year by year from 1987 to 2007, and the cost-profit tax rate decreased by 69%. Both passenger transport and freight transport had obvious downturn before 2002. But it rose again through adjustment after 2002, and the benefits increase of railway leaded the cost-profit tax rate to increase 2.6 times higher.

2.2 Product Flow Analysis

Product flow is the consumption ratio of three big industries to railway industry on products using, which reflects the relevance of the product and use level between railway industry output and other industries.

There is a large adjustment to China's industrial structure in the 1980s and 1990s, which brought significant influence to the product structure of railway. We can get the railway's product flow to three big industries based on input-output tables from 1987 to 2007. The result is showed in table 2-2 and figure 2-2.

Table 2-2 railway's product flow from 1987 to 2007 (%)

	1987	1992	1997	2002	2007
primary industry	5.315	2.9	3.5	3.19	3.77
second industry	37.41	34.76	39.58	40.16	55.47
tertiary industry	18.865	35.5	37.47	34.985	28.53

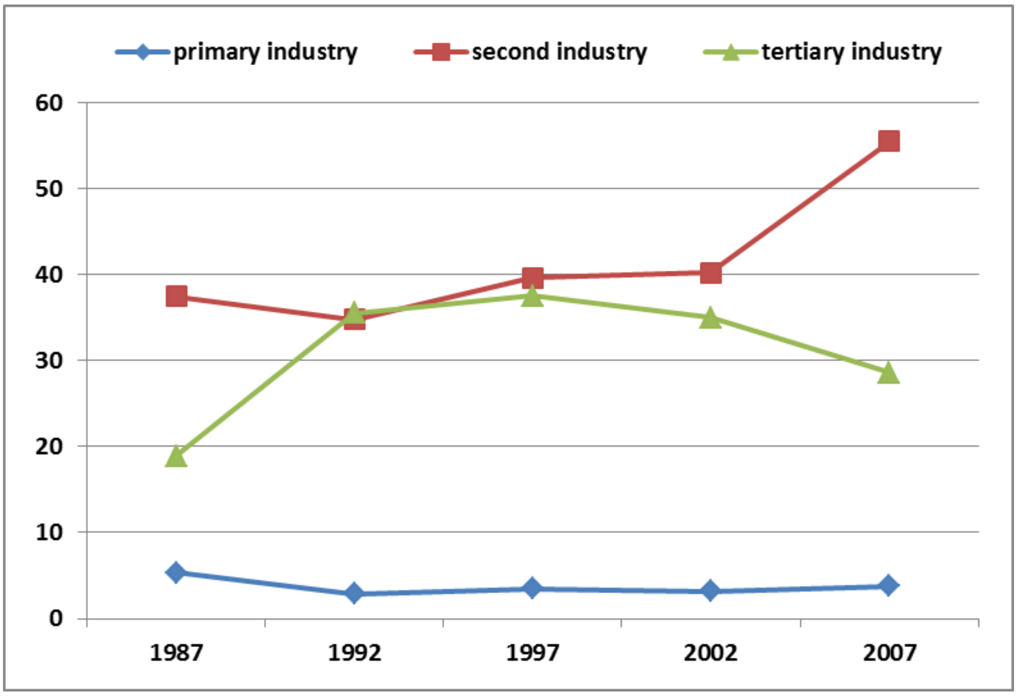

Fig.2-2 railway's product flow from 1987 to 2007

On the whole, railway's product flow in the second industry increased year by year from 1987 to 2007, and so did the growth rate. From the figure 2-2 we can see, there was a peak value from 1992 to 1997 in the tertiary industry. And overall, it had a rising trend. There was no much change in the primary industry.

2.3 Value Composition Analysis

Material consumption coefficient, depreciation coefficient, Labor remuneration coefficient, net tax coefficient and business surplus coefficient reflect the total cost in the proportion of investment. Formula as follows:

$$MCC = MU / IP \qquad (2.4)$$

$$DC = FA / IP \qquad (2.5)$$

$$LRC = LR / IP \qquad (2.6)$$

$$NTC = NPT / IP \qquad (2.7)$$

$$BSC = BS / IP \qquad (2.8)$$

where, MCC is material consumption coefficient; MU is Intermediate use; IP is total input; DC is depreciation coefficient; FA is depreciation of fixed assets; LRC is labor remuneration coefficient; LR is labor remuneration; NTC is net tax coefficient; NPT is net product tax;

BSC is business surplus coefficient; and BS is business surplus.

We can get the railway's value structure based on input-output tables from 1992 to 2007. The result is showed in table 2-3 and figure 2-3.

Table 2-3 railway's value structure from 1992 to 2007 (%)

	1992	1997	2002	2007
material consumption coefficients	0.28735	0.3463	0.4086	0.357
depreciation coefficient	0.2577	0.1432	0.1789	0.116
labor remuneration coefficient	0.1648	0.2567	0.3166	0.247
net tax coefficient	0.0532	0.0284	0.0375	0.0295
business surplus coefficient	0.237	0.2256	0.0599	0.2504

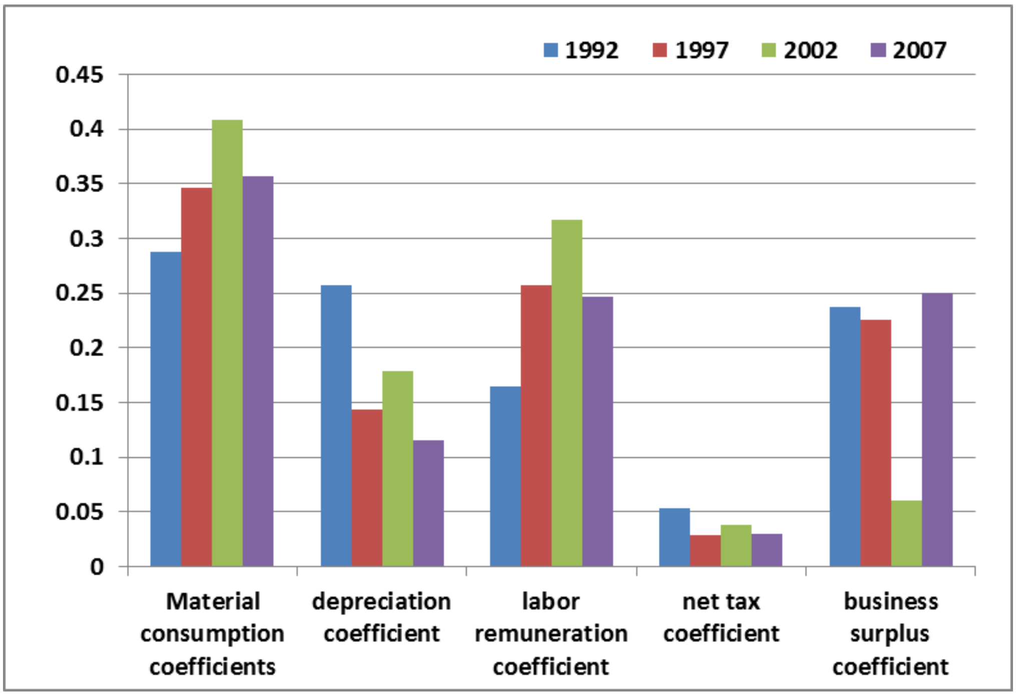

Fig.2-3 railway's value structure from 1992 to 2007

On the whole, the ratio of material consumption and labor remuneration changed in an increase trend from 1992 to 2002. Although the depreciation coefficient decreased, the growth of economic efficiency was not ideal because the net tax coefficient still decreased. And the business surplus coefficient had a sharp decline in 2002. The ratio of material consumption, depreciation coefficient and labor remuneration decreased from 2002 to 2007, but the net tax coefficient still did not increase. And from 2002 to 2007, railway's cost decreased and business surplus coefficient increased.

2.4 The National Economy Macro Contact Analysis

Influence coefficient stands for the ratio of the other industries production's increase ,which caused by one industry adds a unit of output ,to the average of all industries' production. Formula as follows:

$$F_i = \sum_{i=1}^{n} \overline{b_{ij}} \Big/ \frac{1}{n} \sum_{i=1}^{n} \sum_{j=1}^{n} \overline{b_{ij}} \qquad (i, j = 1, 2, \ldots n$$

where, $\overline{b_{ij}}$ is completely demand coefficient.

Induction coefficient stands for the ratio of the other industries production's increase to the average of all industries' production when one industry needs to add a unit of output. Formula as follows:

$$E_i = \sum_{j=1}^{n} \overline{b_{ij}} \Big/ \frac{1}{n} \sum_{i=1}^{n} \sum_{j=1}^{n} \overline{b_{ij}} \qquad (i, j = 1, 2, \ldots n$$

We can combine influence coefficient with induction coefficient to analysis Chinese railway's position and function in the national economy. Usually, the industry with high influence coefficient and induction coefficient plays a decisive role in the economic development, which is also one of main parameters to determine dominant industry.

Influence coefficient and induction coefficient are important parameters to reflect relation between railway and national economy. We can get the railway's national economy macro contact based on input-output tables from 1992 to 2007. The result is showed in table 2-4 and figure 2-4.

Table 2-4 railway's national economy macro contact analysis from 1992 to 2007

	1992	**1997**	**2002**	**2007**
influence coefficient	0.7171	0.729	0.7757	0.6575
induction coefficient	0.7855	0.7418	0.7869	0.9295

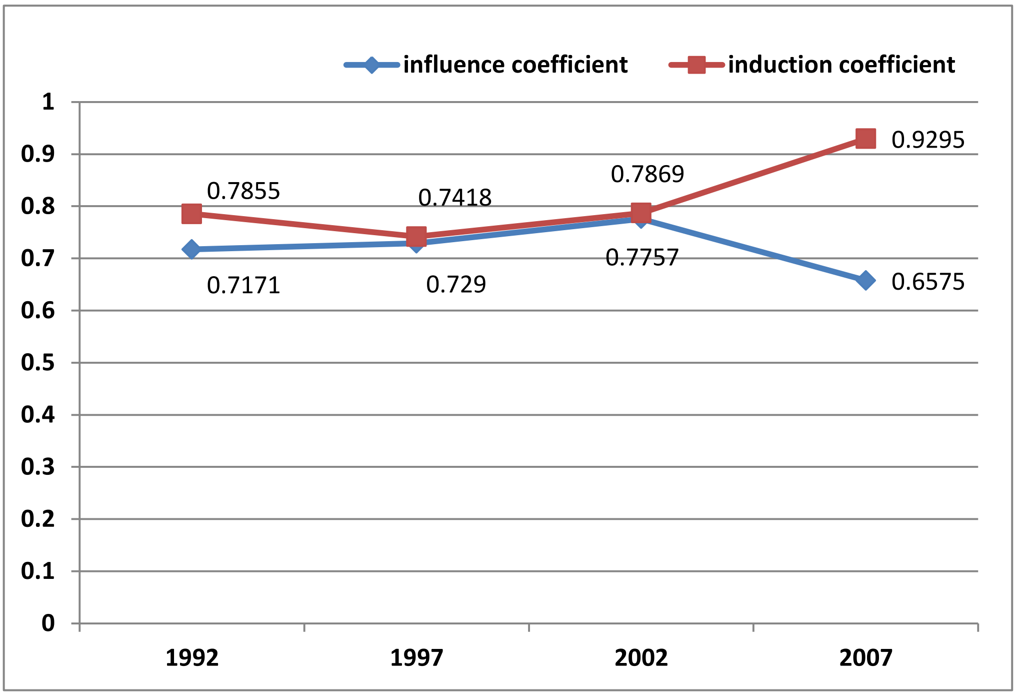

Fig.2-4 railway's national economy macro contact analysis from 1992 to 2007

Overall, there was no big change in influence coefficient and induction coefficient from 1992 to 2002, which indicates that railway's status and function still had no improvement. And in 2007, induction coefficient raised and came closer to the social average level.

3 A Dynamic Input-output Model of Chinese Railway Transportation

The data we used in the dynamic input-output model comes from China input-output table (1997-2007), national statistical yearbook (1998-2008) and China railway yearbook (1998-2008).

3.1 A Dynamic Input-output Model

In the static model, investment is an exogenous variable in the part of final consumption. So, static model cannot reflect the internal relations between productive investment and the production activities in next time series. It is introduced a capital coefficient to make investment endogenous. Link the investment demand and economic growth together by building a dynamic input-output model [5].

3.1.1 A dynamic input-output model with output growth rate

Based on Leontief dynamic input-output model:

$$X(t) - AX(t) - Q\Delta X(t+1) = Y(t) \qquad (3.1)$$

There are two coefficient matrix A and Q in this model. Where the direct consumption coefficients matrix A is related to total output column vector $X(t)$; Investment coefficient Q is related to output added column vector in the next year. If we can determine the output growth rate in advance, the increment $\Delta X(t+1)$ can be substituted by the product of output growth rate and total output in the year $t+1$. Assume output growth rate in sector j is a_j, we can get:

$$a_j = \frac{\Delta X_j(t+1)}{X_j(t)} \qquad (j = 1, 2, .. \qquad (3.2)$$

Assume a is a diagonal matrix composed of every sector's output growth rate in the year $t+1$:

$$a = \begin{bmatrix} a_1 & & & \\ & a_2 & & \\ & & \ddots & \\ & & & a_n \end{bmatrix}$$

Formula (3.1) can be expressed as:

$$X(t) - AX(t) - QaX(t) = Y(t) \qquad (3.3)$$

Or,

$$X(t) = (I - A - Qa)^{-1} Y(t) \qquad (3.4)$$

Put the above equation together, we can get:

$$X(t+1) = (I+a)(I - A - Qa)^{-1} Y(t) \qquad (3.5)$$

Formula (3.5) is the dynamic input-output model with output growth rate. After determined the output growth rate in the year $t+1$, we can put finally net products $Y(t)$ in the year t to get total output $X(t+1)$ in the year $t+1$.

3.1.2 Parameters

There are three parameters need to be paid attention to in the dynamic input-output model--investment coefficient matrix Q, output growth matrix a and the direct consumption coefficient matrix A。

(1) Investment coefficient matrix Q

Investment coefficient matrix $Q=(q_{ij})_{n\times n}, q_{ij}=k_{ij}/\Delta X_j\ (i,j=1,2,...,n)$ .where q_{ij} is the direct investment coefficient of the fixed assets i to the sector j ; k_{ij} is the amount of investment elements i distributed to sector j ; ΔX_j is the output growth of sector j .

We have known that one sector's growth rate in Output growth matrix a can be defined as $a_i=E_i a$. Where, a is output growth rate of one given economic system (like output growth rate of GDP); E_i is the induction coefficient.

(2) Output growth matrix a

We assume that investment coefficient matrix Q remains unchanged in the short term (Investment delay is 1 year). Therefore, only the direct consumption coefficient matrix A will change with the annual growth in the process of calculation, leading to the induction coefficient E_i change and so does the output growth matrix a . So,

The direct consumption coefficient matrix $A(t)=\begin{bmatrix} a_{11}(t) & a_{21}(t) & \cdots & a_{n1}(t) \\ a_{12}(t) & a_{22}(t) & \cdots & a_{n2}(t) \\ \vdots & \vdots & \ddots & \vdots \\ a_{1n}(t) & a_{2n}(t) & \cdots & a_{nn}(t) \end{bmatrix}$

The induction coefficient $E_i(t)=f[A(t)]$

The output growth matrix $a=f[E_i(t)]$

In conclusion, as long as we get the direct consumption coefficients matrix $A(t)$, the output growth matrix a can be turned out.

(3) The direct consumption coefficient matrix A

There are two factors determining the direct consumption coefficients：One is combined with production technology, management business level and the size of the production; the other is product substitution ability between each sector. We assume that the direct consumption coefficient remains unchanged in the short term. $r_i(t)$ is the substitution multiplier of sector i in the year t, which shows the substitution degree of sector i to other sector's goods; $s_j(t)$ is the manufacturing multiplier of sector j in the year t, which shows the change of sector j's intermediate consumption caused by the change of technology and process. So the relationship between $a_{ij}(t)$ and $a_{ij}(t-1)$ can be shown as follows：

$$a_{ij}(t) = r_i(t)a_{ij}(t-1)s_j(t) \qquad (i, j= 1, 2, .n$$

Assume $R(t)$ is substitution multiplier matrix and $S(t)$ is the manufacturing multiplier matrix, so:

$$R(t) = \begin{bmatrix} r_1(t) & & & \\ & r_2(t) & & \\ & & \ddots & \\ & & & r_n(t) \end{bmatrix} \qquad S(t) = \begin{bmatrix} s_1(t) & & & \\ & s_2(t) & & \\ & & \ddots & \\ & & & s_n(t) \end{bmatrix}$$

So, $A(t)$ has the following form:

$$A(t) = R(t)A(t-1)S(t) \qquad (3.6)$$

The direct consumption coefficient matrix $A(t)$ is the function of time variable t. In consideration of that input-output table is worked out every five years, the direct consumption coefficient matrix $A(t)$ actually is discrete. Therefore we need to put A into the formula (3.6). We mark A^* as current direct consumption coefficient, and $A^* = R(t)AS(t)$. Then we mark A^{**} as direct consumption coefficient in planning period and $A^{**} = R(t)A^*S(t)$. Iteration method can be used to solve this equation set, and we assume that the change of $R(t)$ and $S(t)$ is uniform. So formula (3.6) can be rewritten as follows:

$$A(t) = RA(t-1)S = R^2A(t-2)S^2 = \cdots = R^tA(0)S^t \qquad (t = 1, 2, T. \qquad (3.7)$$

Through direct consumption coefficient matrix A in every five years, we can find out R and S by iteration method.

3.2 Dynamic Input-output Analysis

We divide input-output table into four parts-- primary industry, second industry, tertiary industry (without railway industry) and railway industry. According to the growth rate of GDP recent years in China, the result is showed as follows:

Table 3-1 is the GDP growth rate in China from 2000 to 2007.

Table 3-1 GDP growth rate from 2000 to 2007 (%)

	2000	2001	2002	2003	2004	2005	2006	2007
GDP growth rate	7.6	7.5	8.4	9.3	9.4	10.7	12.0	13.6

(Data comes from national statistical yearbook)

Table 3-2 is the result of induction coefficient and railway's output growth rate.

Table 3-2 induction coefficient and railway's output growth rate（%）

	2000	2001	2002	2003	2004	2005	2006	2007
induction coefficient	0.820	0.875	0.787	0.769	0.863	0.846	0.877	0.928
growth rate	6.2	6.56	6.61	7.1	8.2	9.0	10.5	12.6

According to the result we can figure out that railway's induction coefficient was not high enough all the time. Although the induction coefficient increased year by year, but it never reaches the social average level---1。We compare GDP per capita growth rate with railway's output growth rate. The result is showed in figure 3-1.

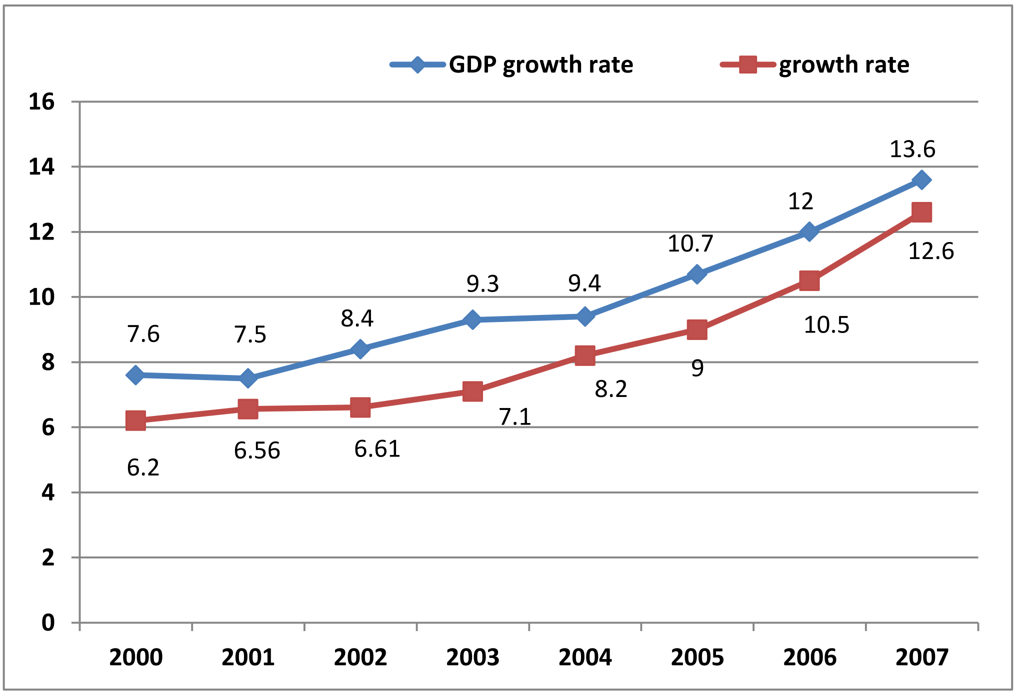

Fig.3-1 GDP per capita growth rate in comparison to railway's output growth rate from 2000 to 2007

We can see that railway's output growth rate changed with GDP per capita growth rate. It indicates that although it did not reach the social average level, the induction coefficient can make the railway's output growth rate rising with the change of GDP per capita growth rate.

4 Results

Railway's economic benefits reduced year by year from 1987 to 2002, and the largest amount of reduction was from 1997 to 2002. And from 2002 to 2007, there was a skip-type rise in the aspect of railway's economic benefits. It indicates that the speed acceleration of railway in 2007 had certain effect and promoted the development of railway in China.

In the aspect of industry structure, railway's product flow in the second industry increased year by year from 1987 to 2007, and so did the growth rate. There was a peak value from 1992 to 1997 in the tertiary industry. And overall, it had a rising trend. There was no much change in the primary industry. The general trend of railway's product flow was that it was stable in the primary industry and had obvious change in the second and tertiary industries. Passenger transport had a tertiary industry based product flow, and products flowed from the tertiary industry to the second industry after 1997. Freight transport had a second industry based product flow and presented "W" type change.

In the aspect of value composition, the ratio of material consumption and labor remuneration changed in an increase trend from 1992 to 2002. Although the depreciation coefficient decreased, the growth of economic efficiency was not ideal because the net tax coefficient still decreased. And the business surplus coefficient had a sharp decline in 2002. The ratio of material consumption, depreciation coefficient and labor remuneration decreased from 2002 to 2007, but the net tax coefficient still did not increase. And from 2002 to 2007, railway's cost decreased and business surplus coefficient increased.

The influence coefficient and induction coefficient were lower than the social average level. And there was no big change in influence coefficient and induction coefficient from 1992 to 2002, which indicates that railway's status and function still had no improvement. But the change trend of influence coefficient indicates that the impact of railway industry to the other industries was reducing. And the change trend of induction coefficient indicates that the reaction of railway industry from the other industries was increasing.

Through the dynamic input-output analysis we can see that although the induction coefficient increased year by year, but it never reaches the social average level. And by contrast, the induction coefficient of road transportation and water transportation were both beyond 1. Compared with the electric power, heat power production and supply industry, whose induction coefficient was 6.77 in 2007, railway transportation industry and even all the transportation industries for the development of national economy of sensitivity is not quite high, and correlation coefficient is too low.

In conclusion, there are still many problems for Chinese railway industry needs to be researched and solved. There is a tremendous development space for Chinese railway industry. In the national economic sectors, the development of railway still offers a lag state and it is not adapted to the demand of national economy and social development. Meanwhile, we need to improve the railway's status and the leading role of development in the national economy.

5 Summary and Conclusions

In this paper it is analyzed the developing situations about railway industry in China by static input-output modeling, and using dynamic input-output model to update the input-output tables from discrete to continuous, which reveals the correlation between railway and other national economy industries and the changes of railway's development phase.

According to the research, over the past decade, the Chinese railway has developed by leaps and bounds. However, in terms of economic benefits and value composition, the Chinese railway's production and economic benefits still keeps in a stagnate and low situation. Meanwhile, in association with the national economy, the railway industry has also been in a lag position. The role of railway development in boosting the national economy did not improve, yet declined year by year, which indicates that although the railway investment from government and the construction and operation of railway has been always ongoing over the past decade, the boosting role of railway development has not improved so much, that is, the development of national economy has not bring the synchronous development of railway. So the status of railway industry in the national economy should be further improved. In addition, reducing the costs and improving the level of railway efficiency are the key steps for the future development of railway.

Acknowledgements

This paper was supported in part by “National Science and Technology Support Projects (2009BAG12A10-1)” and “Railway Ministry Projects (2010Z012)”.

References

[1] Xiuyun Yang, Ming Cheng. Study on the Contribution of Railway Transportation’s Development to Shanxi’s Economy Growth [J]. Statistics and Information Forum.2009 (12):82-88

[2] Pei Yu, Wen Du, Maoru Chi. Quantitative Evaluation of Correlation and Coordination between Railway Transportation and Regional Economy [J]. Railway Transport and Economy.2010 (02):14-23

[3] Jing Zhang, Ting Liu. Study on Railway Transportation’s Contribution to Local Economy Growth [J].China New Technologies and Products. 2010(02):205

[4] Yongping Chu, Shaodong Meng. Quantitative Study on Transportation's Contribution to Shanghai's National Economy Growth [J].SCIENCE & TECHNOLOGY AND ECONOMY. 2009(06):69-72

[5] Xuewei Li, Xingang Zhao. China Railway Input-output Analysis [M].China railway publishing house.2004(4)

[6] Heejoo Ham, Tschangho John Kim, David Boyce. Assessment of Economic Impacts from Unexpected Events with an Interregional Commodity Flow and Multimodal Transportation Network Model. Transportation Research Part A 39.(2005):849－860

[7]Tantri Tantirigama, Joanne Leung. Contribution of Transport Productivity to Economic Growth in New Zealand.19th International Input-Output Conference.2011