

# Air transport investment and the promotion of economic growth: partial-closed I-O model

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**Abstract**—This paper studies the role of fixed assets investment in air transport industry on the economic output of the industry and the overall economy. Based on the input-output table and fixed assets investment data, it is found that the pull effect of air transportation industry is more significant and the degree of dependence on fixed assets is much higher compared with four different traffic modes. Further the input-output line model and the partial-closed model are compiled to measure the impact of investment on the sector economic output and the overall economy. Although the air transport industry has the lowest investment in fixed assets among the four modes of transportation, it has the highest investment efficiency. The proportion of the added value of its investment in transportation is 2-3 times that of its investment. Considering the impact of investment on sector output, the air transport industry is the highest among the four modes of transportation. The output that takes into account the influence of consumption is about twice as much as the output without considering the propensity to consume. The ratio between the two has been rising since 2002, indicating that the impact of investment on consumption is expanding year by year. This factor should be taken into account in investment planning. It is also found that the role of transport investment is gradually weakened.

**Keywords**—Partial-closed Model, Input-Output, Investment multiplier

## I. INTRODUCTION

Transportation is a basic, leading and strategic industry in the national economy. It is one of the most important modern service industries, and its development has spillover effects on all aspects of society. The pulling effect on social economy is the most important positive spillover effect. Transportation investment is the basis of the development of transportation industry, and plays an irreplaceable role in supporting the economic growth of the whole society. For developing countries, the greater the investment in transport development, the more obvious the positive spillover effect, and the more obvious the pull effect of transport investment on economic development.

Scholars at home and abroad have a wealth of research results on the pull of transportation on economic growth, involving three main research methods: the first method is based on production function to investigate the direct pull of investment on the national economy. A two-stage three-factor CES production function model was designed to determine the comprehensive effect of infrastructure investment on economic growth in [4]. Reference [5] used a

bi-variate regression model and Cobb-Douglas production function to study the direct pull effect of transportation infrastructure investment on national economic development. The study found that in the case of other social fixed assets investment and the employment input of the whole society remained unchanged, the direct pull on the national economy was 0.109 for each increase of transportation infrastructure investment. .

The second method is based on co-integration, including Gr-anger causality test, impulse response and variance decomposition analysis method. It is found that the impact of air transport on national economic growth is greater than the impact of national economic growth on air transport based on the statistics of the year 2002 to 2012 in [6]. Reference [7] used a VAR model research found that there is a long-term stable equilibrium relationship between transportation investment and economic development in Northeast China, and there is a two-way Gr-anger causality relationship. A Gr-anger model was used in [13] to study the causality relationship between traffic facilities construction and economic development, and found that the growth of GDP and inland waterway construction and civil aviation construction has the most obvious causality relationship.

The third method is based on the input-output table, from the perspective of industry association and industrial structure. According to the input-output data of Germany, It is found in [3] that although the correlation of German transportation to other industries is weakened, the industrial correlation of air transportation is increasing, especially to the steel and energy industries. Reference [8] shows that the driving effect of highway construction investment is the most significant in 1998, and the percentage of highway investment driving economic growth has been rising year by year since 1999. The input-output model and the error correction model are established on the basis of descriptive analysis of traffic infrastructure investment in [9]. It is found that the traffic infrastructure investment in Beijing has an obvious demand-driven effect on the economy. The pull coefficient was kept between 2% and 3%, which was relatively stable. Based on the analysis of the input-output table in 2002, it is found in [12] that the development of the national economy has a relatively small pull effect on the air transport industry, but as long as the civil aviation transportation industry has a small amount of development, it can play a greater role in the development of the national economy as a whole.

The fourth method is to establish a spatial panel model from the point of view of space economy. Reference [11] collected data from 28 provinces from 1985 to 2006 through a logarithmic production function model, found that from 1985 to 2006, the average increase of GDP brought by transportation investment in China was 24.8 billion yuan per year. Reference [14] constructed the correlation spillover model between traffic infrastructure investment and regional economic growth with the provincial panel data from 1993 to 2009 and found that the output elasticity of transport infrastructure to regional economic growth is about 0.05-0.07. Using the provincial panel data from 2001 to 2012 and adding the weight matrix representing different economic meanings. It is found in [15] that the spatial spillover effect of transportation infrastructure investment on regional economic development is significant. The spatial spillover effect is the most significant in the central region, and the effect in railway is larger than that in the highway.

For the study of the local closed model of investment-pull, [2] studies the relationship between investment and consumption in Beijing sub-sector. The research shows that the pull coefficient of investment-to-consumption is mainly determined by the coefficient of labor reward. The investment of basic service industry has a large pull coefficient on consumption. It is argued in [16] that the investment in the acquisition of transport vehicles should be included in the fixed assets investment of the transportation industry and he modified the statistical data and found the total pull coefficient of transportation infrastructure investment with the marginal propensity to consume taken into account to the total social output is 5.8409.

This paper studies the pulling effect of the fixed assets investment of civil aviation transportation on the output of the economy. Firstly, through the industrial correlation coefficient and the depreciation coefficient of fixed assets, it is found that the impact of aviation transportation on social economy is mainly demand-driven. And the degree of dependence on fixed assets investment is high. Then, based on the input-output table of 2002, 2007 and 2012, the local closed model is used to calculate the pulling effect of fixed asset investment. Finally, the four traffic modes are compared, and the conclusion of the study is summarized.

## II. TRANSPORT INVESTMENT STATUS

### A. The scale and efficiency of the infrastructure investment in Air Transport

Investment in infrastructure construction provides the necessary investment in fixed assets for all kinds of transportation activities. Civil aviation transportation infrastructure investment includes investment on airport, air traffic control system, safety and security inspection and fire control system. Among the four modes of transportation, civil aviation requires higher infrastructure. According to the data released by the Civil Aviation Authority, in recent years, the pace of civil aviation infrastructure construction in China has obviously accelerated, and the investment in airport system construction is the key point of investment. The share is basically more than 70 per cent, and has exceeded 80 per cent since 2015. The proportion of investment in ATC system is relatively stable at about 3%.

The fixed asset investment data of various transportation modes vary in caliber. We choose the fixed assets investment (excluding farmers) data published by the National Bureau of

Statistics to compare the scale, efficiency and dependence of fixed assets investment in various transportation modes.

In terms of investment scale, the proportion of fixed assets investment in air transport industry is low (although the investment growth rate is the fastest, railway and road transport is the most important part of transportation investment.). In terms of efficiency, it is reflected by the ratio of input to output (investment in fixed assets (excluding farmers), and output is expressed by the added value of the transport industry. As can be seen, the investment efficiency of the whole transport industry shows a downward trend: in 2002, the input-output ratio of the national transportation industry is 1.26, that is, the fixed assets investment of 1 yuan can bring 1.26 yuan of direct return. By 2012, the input-output ratio was only 0.68. There may be two reasons for the decrease of input-output ratio, one is that the direct impact of transportation investment is decreasing, and the other is spillover effect on other related industries and the impact of industry boom cycle and industry benefit as well. The period of high return on transportation investment has passed, and its investment effect has gradually weakened. Compared with other modes of transport, the air transport industry has the highest return on transport investment (still more than 1 in 2012), far higher than other transport mode.

TABLE I. INPUT-OUTPUT RATIO OF FIXED ASSETS INVESTMENT BY TRANSPORTATION MODE

Transport mode	Year		
	2002	2007	2012
Railway	2.50	0.99	0.41
Road	0.83	0.70	0.75
Water	5.86	5.00	0.86
Aviation	2.69	1.11	1.08
Transportation industry	1.67	1.01	0.68

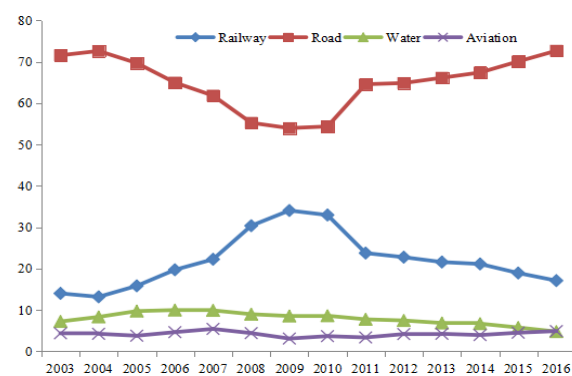


Fig. 1. Proportion of fixed assets investment by transport industry

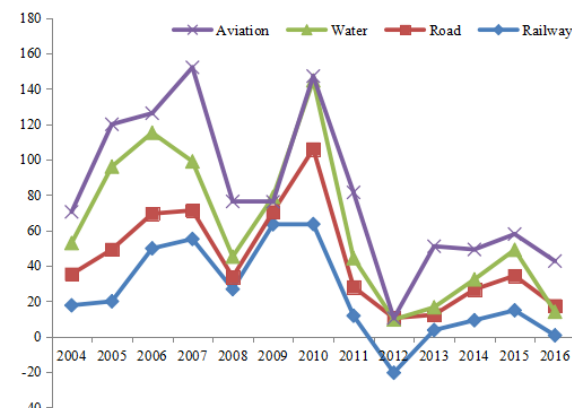


Fig. 2. Growth rate of fixed assets investment in various transport industries

According to the depreciation coefficient of fixed assets, the consumption relationship and dependence degree of each transportation industry on fixed assets. It can be seen that aviation and railway depend on the investment of fixed assets with high intensity, and the air transport industry is the highest among all the means of transportation.



Fig. 3. Depreciation coefficient of fixed assets in various transport industries

From the above, we can see that the air transport industry has a high degree of dependence on fixed assets investment. In recent years, the fixed assets investment of the industry has increased rapidly. Although the scale of the industry is still relatively small in various modes of transportation, the investment efficiency is relatively high. Its driving effect on the economy should not be underestimated.

### B. On the role of Air Transport Investment in the Perspective of Industrial linkages

Transportation investment is the basis of industrial development, and the impact of an industry on the economy is similar to that of a single industry in terms of both pull and push. The impact of investment in transportation infrastructure on the economy also includes the role of pulling and promoting. Therefore, the role of transportation investment can be analyzed through industry correlation, and reflected by influence coefficient and sensitivity coefficient. The impact of transportation investment on the economy is manifold: in the stage of transportation infrastructure construction, transportation needs to consume the products and services produced by various economic and industrial sectors, mainly production and means of subsistence, as well as labor consumption. At the same time, when the transportation infrastructure is completed and delivered, it will promote the transportation activities and promote the development of the transportation industry. Then it will increase its output, pull and promote the development of other industrial sectors.

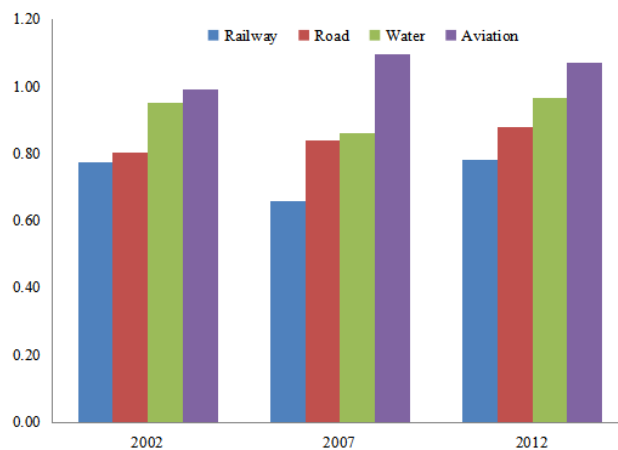


Fig. 4. Influence coefficient of each Transport Mode

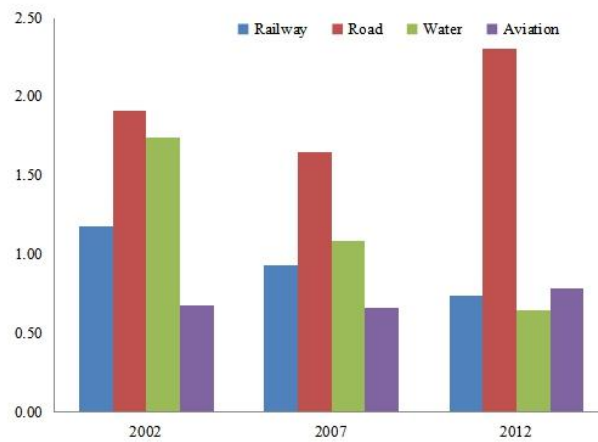


Fig. 5. Induction coefficient of each Transport Mode

From the industrial correlation coefficient, we can see that the overall sensitivity coefficient of the transport industry is greater than 1 and the influence coefficient is less than 1, which indicates that the overall industry of transport industry has a more obvious role in promoting the economy. Except for the general similarity between the road transport industry and the transport industry as a whole, the coefficients of the other modes of transport are less than 1. The air transport industry is the only transport mode with a coefficient of influence greater than 1 among several modes of transportation, which indicates that the role of the air transportation industry in stimulating the demand for other industries is greater than the average social level. Air transport industry in the production process of other industrial products consumption is relatively large. Meanwhile, the air transport industry sensitivity coefficient is less than 1, indicating that the impact of air transport industry on social and economic performance is mainly demand-driven role. Therefore, from the angle of industry connection, it is more effective to study the pulling effect of air transportation investment.

## III. DATA AND METHOD

### A. Data

This paper uses the input-output tables of 2002, 2007 and 2012 issued by the National Bureau of Statistics of China to measure the relationship between investment and sector. In the input-output tables of these sub sectors, the transport

sector includes rail transport, road transport, water transport, air transport and pipeline transport (it also included urban public transport in 2002 and is no longer included in 2007 and 2012). Because pipeline transportation cannot carry passenger, the railway, road, waterway and air transport are chosen to do the comparison.

### B. The local closed consumption model

This paper estimates the full pull effect of the marginal propensity to consume, and compares it with the pulling effect without considering the propensity of consumption. When considering the influence of consumption, the local closed consumption model is used.

The measurement of the pull effect of investment, in fact, is to measure the changes in the total social products caused by the increase in investment in the final product.

$$AX+Y=X \quad (1)$$

$$\Delta X=(I-A)^{-1} * \Delta K \quad (2)$$

Where X is the total output vector, Y is the final product, vector K is the investment vector in the final product, and the investment increment A is the direct consumption coefficient matrix. The column vectors of fixed investment classified by sector in the input-output table are brought into the model. It can be calculated that in order to form these fixed assets, all departments of the national economy should undertake the task of production (increase). Because the fixed capital formation is a part of the final product, the fixed capital formation caused by the transportation investment can be understood as the increment of the final product in a sense. The increment of the final product, through the magnification of the input-output multiplier, results in the increment of the total product. This is the incremental meaning of the transport investment demand pull the explanation.

Taking into account the marginal propensity to consume, the pulling effect of transportation investment on the economy will lead to the increase of residents' income, which in turn will lead to an increase in consumer expenditure in the residential sector, which is part of the final demand. Its increment will produce another round of pulling effect to each industry and the whole economy. Considering the full pull effect of marginal propensity to consume, that is to say, the pulling effect of this second round is also included in the scope of calculation, and the demand pulling effect of more comprehensive transportation investment is obtained.

The local closed consumption model is to integrate the consumption in the final demand and the labor compensation in the initial input into the residential sector and merge to the first quadrant. Its mathematical form is:

$$X_{n+1}=(I-A_{n+1})^{-1} * Y_{n+1} \quad (3)$$

$$\Delta X=(I-A_{n+1})^{-1} * \Delta K \quad (4)$$

Among them,  $X_{n+1}$  for the  $n + 1$  dimensional total product column vector added to the resident department,  $Y_{n+1}$  for the  $n + 1$  dimensional final product column vector excluding the consumption column, and  $A_{n+1}$  for the direct consumption coefficient matrix of  $n + 1$  after adding the resident department, that is, the investment multiplier for the input-

output local closed model. It depicts the multiplier effect of a certain amount of investment on the total product, that is, the driving capacity of the whole economy, and the pull coefficient of the transportation investment on the total economic output can be obtained.

### C. Result

It can be seen that air transport industry accounts for the lowest proportion of fixed assets investment among the four modes of transport, but the proportion of added value in transportation driven by investment is 2-3 times that of its investment, which is higher than that of railway transport and road transport. Second only to water transport, the pull on sector output is the highest among the four modes of transportation. After considering the influence of consumption, the output pulled is about twice as high as the output without considering the propensity of consumption and the ratio has been rising since 2002, indicating that the impact of investment on consumption is expanding year by year. This factor should be taken into account in investment planning.

When considering the marginal propensity of consumption, the complete pull coefficient of air traffic fixed assets to the total output is 1.5, that is, 1 unit of investment in infrastructure construction can completely pull 1.5 units of total output. In 2012, the total investment in air transport infrastructure construction was 221.962 billion yuan, totally pulling 332.985 billion yuan of total social output.

TABLE II. RATIO OF FIXED CAPITAL INVESTMENT TO DRIVING VALUE ADDED BY MODE OF TRANSPORT

Industrial sector	Year		
	2002	2007	2012
Railway	3.37	1.45	1.92
Road	0.28	0.54	0.46
Water	2.05	1.96	3.64
Aviation	3.48	2.64	3.22

TABLE III. PULLING FACTOR OF FIXED CAPITAL INVESTMENT BY TRANSPORT SECTOR

Industrial sector	Year		
	2002	2007	2012
Railway	3.8699	0.7629	0.4295
Road	0.3407	0.3920	0.1282
Water	3.4703	1.4868	1.3672
Aviation	6.1523	3.6221	1.5002

## IV. CONCLUSION

This paper delivers an empirical analysis on the demand-driven effect of fixed assets investment in four modes of transportation on the social economy. The conclusion are made as follows:

1) Compared with other modes of transport, the aviation industry has the highest return on transportation investment. The air transport industry is the only transport mode with a coefficient of influence greater than 1, which indicates that the air transport industry has a relatively large consumption of other industrial products in the course of its operation. The influence of air transportation on social economy is mainly demand-driven.

2) Air transportation has the lowest investment in fixed assets among the four modes of transportation, but the

proportion of added value of investment in transportation is 2-3 times that of its investment, which is higher than that of railway and road transportation, second only to water transport. The pull on sector output is the highest among the four modes of transportation. After considering the influence of consumption, the output pulled is about twice as high as the output without considering the propensity of consumption, and the ratio has been rising since 2002, indicating that the impact of investment on consumption is expanding year by year. This factor should be taken into account in investment planning.

3) The air transport industry has the highest pull coefficient to the total economic output in all kinds of transportation modes. When considering the marginal propensity to consume, the complete pull coefficient of air traffic fixed assets to the total output of the department is 1.5, that is, the investment in infrastructure construction of one unit can completely pull 1.5 units of the total output.

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