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Research on the Benefit of High-speed Rail's Investment Promotion

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Abstract: High-speed railway, as one of the competitive innovative achievements in modern scientific technology, has been developing greatly. How to rationally analyze high-speed rail's effect on regional development and make comprehensive appraisal of high-speed rail's regional economic effect become more important and urgent . This study firstly analyzes Keynes's investment promoting theory and the structure as well as basic modulus of input-output model. Secondly, this study studies direct promotion benefit on GDP brought by high-speed rail construction using investment promoting theory and input-output table. Finally, it analyzes direct promotion benefit on GDP brought by high-speed rail construction of the Hu-ning railway investment construction.

Key words: High-speed rail, investment promoting, investment benefit

INTRODUCTION

Investment promotion benefit of high-speed rail is a special expression form of its social economic benefit, which is brought by associated industries and departments in the process of newly-constructed high-speed rail. During the construction of high-speed rail project, the needed intermediate construction material, such as cement, rolled steel and so on, will raise net production value of these construction departments. As a result, the intermediate input demand, such as iron, coal, machinery and power needed by producing rolled steel and cement will become increased due to production expansion of construction material departments, which will promote these intermediate input departments to expand production and increase net production value (Zhang, 2007). High-speed rail construction investment can boost GDP and promote economy to grow. In foreign countries, Sasaki *et al*. (1997) indicated the positive relation between Japanese Shinkansen investment and economic development as well as the linearity relation between Japanese Tokaido, Shanyang Shinkansen' GDP and passenger flow quantity through module establishment. Bonnafous (1987) took the Tennessee Continent as an example for speculating that high-speed railway can promote the economic development in Tennessee Continent . This speculation is concluded through transportation demand module. Time, smooth and development benefit brought by high-speed railway foundation in Tennessee Continent were taken into consideration. In China, Ping (2001) combining with our nation's actual situation, analyses Japanese Shinkansen railway system and economic benefit which is brought by Beijing-Shanghai high-speed railway establishment project. The conclusion indicates that no matter choose which proposal, ratio of expense benefit can reach above 1.9 which shows high investment benefit. Yu (2006) took Beijing-Shanghai high-speed railway as an example. The internal economy of high-speed can be showed through project's internal benefit rate while external economy is shown through time saving for direct passengers flow and regional economy effect. Liu *et al*. (2010) from Transportation Economy Institution, Nankai University holds that indirect benefit brought is much higher that direct return which cannot be achieved in terms of Beijing-tian regional railway. From the view of investment economics, this study utilizes input-output chart model to analyze high-speed rail construction's effect and figures direct promotion on GDP is. 66.23122 billion RMB.

INTERRELATED THEORY AND CALCULATION METHOD

Investment promoting theory: Keynes's investment promotion theory is based on social total income and consumption. It is macro investment theory that is generated according to MPC (marginal propensity to consume). This theory supports that, under certain condition of MPC, the increase of national income and employment will be K times of investment capacity when total investment increases. K referring to investment multiplier. ΔI referring to a detailed investment, ΔY referring to increased capacity of national income after an investment, n referring to investment round number produced by the investment, ΔY_1, ΔY_2, ...ΔY_n, respectively referring to national income increase value for each one investment, β referring to MPC, K referring to investment multiplier, then the following formula can be concluded:

$$K = \Delta Y / \Delta I = (\Delta Y_1 + \Delta Y_2 + \Delta Y_3 + \cdots + \Delta Y_n) / \Delta I$$
$$= (\Delta I + \beta \Delta I + \beta^2 \Delta I + \cdots + \beta^{n-1} \Delta I) / \Delta I$$
$$= 1 + \beta + \beta^2 + \cdots + \beta^{n-1}$$
$$= (1 - \beta^n)(1 - \beta)$$

Multiplier K is the function of MPC, which is in proportional to β ($0<\beta<1$), n tends to infinitely great, $\beta^n = 0$ Therefore, calculation formula of multiplier K is: $K = 1/1-\beta$ ($0<\beta<1$). That is Keynes's investment multiplier model.

It is obvious that investment change will result in chained reaction of national income. When the investment increase, it definitely will result in production expansion of production material, then make social employment and national income grow. Consumption will increase due to the growth of employment and national income, which will make consumption material expand its production. Finally, it will make employment and national income further increase, in cycles; this will undoubtedly produce a great number of chained reactions.

Basic modulus of Input-output model (Xu, 2001): Gross output X_i of any department in input-output chart shall be equal to summation of intermediate demand plus final demand brought by total other departments that is:

$$\begin{cases} X_1 = X_{11} + X_{12} + \cdots + X_{1n} + Y_1 \\ X_2 = X_{21} + X_{22} + \cdots + X_{2n} + Y_2 \\ \cdots \\ X_n = X_{n1} + X_{n2} + \cdots + X_{nn} + Y_n \end{cases} \quad (1)$$

This formula is called as products allocation balance group, that is gross output = intermediate demand+final demand.

Gross input shall be equal to intermediate input plus initial input from input-output charts group, that is:

$$\begin{cases} X_1 = X_{11} + X_{21} + \cdots + X_{n1} + Z_1 \\ X_2 = X_{12} + X_{22} + \cdots + X_{n2} + Z_2 \\ \cdots \\ X_1 = X_{1n} + X_{2n} + \cdots + X_{nn} + Z_n \end{cases} \quad (2)$$

This formula is called as balance equation group for output value, that is: Gross input shall be equal to intermediate input plus initial input x_{ij}/x_j means how much product value the j department directly consumed from i department when unit product was manufactured by j department because while j department manufactures X_j, it will consume I department's X_{ij}. Its numerical value is:

$$a_{ij} = \frac{X_{ij}}{X_j} (i, j = 1, 2, \cdots, n) \quad (3)$$

It is the direct consumption modulus of j department toward i department and it is also called as input-output modulus. The larger the modulus is, the tighter the contact is among departments. In order to get input-output modulus, The formula (1) is transferred into:

$$\begin{pmatrix} X_1 \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{pmatrix} = \begin{pmatrix} X_{11} + X_{12} + \cdots + X_{1n} \\ \cdot \\ \cdot \\ \cdot \\ X_{n1} + X_{n2} + \cdots + X_{nn} \end{pmatrix} + \begin{pmatrix} Y_1 \\ \cdot \\ \cdot \\ \cdot \\ Y_n \end{pmatrix} \quad (4)$$

The formula (3) is transferred as:

$$X_{ij} = a_{ij} X_j \begin{pmatrix} X_1 \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{pmatrix} = \begin{pmatrix} \sum_{j=1}^{n} a_{ij} X_j \\ \cdot \\ \cdot \\ \cdot \\ \sum_{j=1}^{n} a_{nj} X_j \end{pmatrix} + \begin{pmatrix} Y_1 \\ \cdot \\ \cdot \\ \cdot \\ Y_n \end{pmatrix} \quad (5)$$

Then, put it into Eq. 4 and the outcome is:

$$\begin{pmatrix} X_1 \\ \vdots \\ X_n \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ & \vdots & & \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix} \cdot \begin{pmatrix} X_1 \\ \vdots \\ X_n \end{pmatrix} + \begin{pmatrix} Y_1 \\ \vdots \\ Y_n \end{pmatrix} \quad (6)$$

Formula (5) can be converted as Matrix in order that it can be better expressed and deducted:

$$X = AX + Y \quad (7)$$

In the formula, $A = (a_{ij})_{n \times n}$ is called direct consumption modulus matrix or input-output modulus matrix and input modulus chart; when the above formula is removed and both sides multiply $(I-A)^{-1}$, the outcome is:

$$X = (I - A)^{-1} Y \quad (8)$$

In the formula, $(I-A)^{-1}$ is called Leontieff Converse Matrix. Its element b_{ij} is called Leontieff Converse Matrix Modulus and it is the complete consumption modulus of j department, which means the gross direct consumption and indirect consumption of i department's goods and service while j department provides one unit for final use. That is when j department manufactures a product, it brings complete consumption to i department. Leontieff Converse Matrix is also called complete consumption modulus matrix, which is the basis of input-output analysis. Complete consumption modulus not only reflects direct technology and economy contact among national economy departments, but also the indirect technology and economy contact among national economy departments.

Relevant calculation method: This study uses investment multiplier theory and input-output chart to analyze high-speed rail construction project's direct promotion benefit on GDP. The formula of high-speed rail investment's direct promotion benefit on regional GDP can be expressed as following:

$$H = K_{HSR}.I$$

Where, H represents high-speed rail's multiplier contribution benefit on national economy; I represents high-speed rail construction investment amount and K_{HSR} represents high-speed rail investment multiplier. Typical input-output method is implemented to calculate.

If there are n kinds of main industries related to high-speed rail, y_i means the added value of final demand industry and f_i means its gross added value; X_{ij} has two kinds of meaning: On the one hand it means quantity of i products used for j department, on the other hand it means how many i products j department cost. Then simplified input-output analysis model will be produced, therefore, direct consumption modulus matrix A of model can be got.

The gross output of i industry:

$$X_i = \sum_{j=1}^{n} X_{ij} + y_i, (i = 1, 2, \cdots, n)$$

The gross input of j industry:

$$X_j = \sum_{i=1}^{n} X_{ij} + f_i, (i = 1, 2, \cdots, n)$$

Direct consumption modulus matrix:

$$A = \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ & \vdots & & \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix}$$

$$a_{ij} = \frac{X_{ij}}{X_j}, X_j$$

is the gross input of j department, Leontieff Converse Matrix through direct consumption modulus matrix A can be got. That is:

$$(I - A)^{-1} = \begin{pmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ & \vdots & & \\ b_{n1} & b_{n2} & \cdots & b_{nn} \end{pmatrix}$$

- Row vector:

$$y = (I - A) \cdot x \text{ or } x = (I - A)^{-1} \cdot y$$

- Column vector:

$$f = (I - d) \cdot x \text{ or } x = (I - d)^{-1} \cdot f$$

Here in:

$$d = \begin{pmatrix} \sum_{i=1}^{n} a_{i1} & 0 & \cdots & 0 \\ 0 & \sum_{i=1}^{n} a_{i2} & 0 & 0 \\ & \vdots & & \\ 0 & 0 & \cdots & \sum_{i=1}^{n} a_{in} \end{pmatrix}$$

If high-speed rail has ΔI investment added value, therefore:

Final demand vector will occur after the investment's change:

$$\Delta Y = (0, 0, \cdots, \Delta I, \cdots, 0)$$

The investment change' effect on gross production quantity:

$$\Delta Z = (I - A)^{-1} \cdot \Delta Y$$

The investment change' effect on added value:

$$\Delta F = (I - AC) \cdot \Delta Z$$

Calculate GDP multiplier:

$$K_{HSR} = \frac{\Delta I + \sum_{j=1, j=k}^{n} \Delta f_j}{\Delta I}$$

It is ordered = 1 when calculating high-speed investment multiplier.

This chapter introduces Multiplier Theory of Keynes, input-out module's basic modulus and related calculation method. The below texts will illustrate and analysis it on basis of it.

HIGH-SPEED RAIL CONSTRUCTION INVESTMENT PROMOTION BENEFIT ANALYSIS---TAKE HU-NING INTER-CITY RAIL AS AN EXAMPLE

Introduction of Hu-ning inter-city rail: Hu-ning inter-city rail, the important part of inter-city passenger transportation lines in the Yangtze Delta Region, has been put into operation since 8: 00 a.m. July 1, 2010 and is totally 300 km.

The construction of Hu-ning inter-city rail shortens space distance between Nanjing and Shanghai, promote regional economy integration's fast development. The total investment for Hu-ning inter-city rail is 39.45 billion RMB. This study takes Hu-ning inter-city rail as an example to analyze its investment promotion benefit on Hu-ning regional social economy.

Analysis of input-output chart in Year 2007: Firstly, national and Jiangsu provincial input-output chart (42×42 departments) in Year 2007 which is published by National Statistics Bureau can be applied, then make transportation infrastructure construction industry deprive from other construction industries. To enlarge (42×42 departments) chart into (43×43 departments) chart to analyze direct consumption modulus and complete consumption modulus of national and Jiangsu provincial transportation infrastructure construction industry.

Finally, direct consumption modulus shows the first 5 important direct supplier departments among national transportation infrastructure construction industry in Year 2007 are respectively nonmetallic mineral products industry, metal smelting and rolling processing industry, transportation industry, ware-housing industry, electrical machinery and equipment manufacturing industry and chemical industry. The first 5 important direct supplier departments among Jiangsu transportation infrastructure construction industry in 2007 are, respectively nonmetallic mineral products industry, nonmetallic mines and other mines, transportation industry, ware-housing, comprehensive technical service industry, wood processing and furniture manufacturing industry.

Otherwise, complete consumption modulus shows that the first 5 important direct supplier departments among national transportation infrastructure construction industry in Year 2007 are, respectively metal smelting and rolling processing industry, nonmetallic mineral products industry, chemical industry, manufacture and provision of electricity and heating power, transportation and ware-housing industry. The first 5 important direct supplier departments among Jiangsu transportation infrastructure construction industry in Year 2007 are respectively mining of petroleum and natural gas, metallic mines industry, nonmetallic mines and other mines industry, exploration of coal, nonmetallic mineral products industry, transportation industry and ware-housing industry.

Therefore, nonmetallic mineral products industry, metal smelting and rolling processing industry, transportation and ware-housing industry, electrical machinery and equipment manufacturing industry, chemical industry, nonmetallic mines and other mines, comprehensive technical service industry, wood processing and furniture manufacturing industry, manufacture and provision of electricity and heating power, mining of petroleum and natural gas, metallic mining and exploration of coal are chosen to analyze high-speed rail investment construction's direct promotion benefit on GDP.

Analysis of Hu-ning high-speed rail investment construction's direct promotion benefit on GDP: This study uses infrastructure investment multiplier theory to analyze city track transportation construction project' input benefit. According to input benefit's investment multiplier model about high-speed rail investment in chart 1.1, high-speed rail's input-output model-input-output chart should be established before calculation is done. Then the main modulus (direct consumption modulus) will be reached according to the calculation method.

Matrix ΔY = (0 0 0 0 0 0 0 0 0 0 0 0 1)
Matrix$\Delta Z = (I-A)^{-1}.\Delta Y$
(0.104074 0.026271 0.039479 0.498424 0.160569 0.310536 0.826231 0.288101 0.085161 0.138469 0.294947 0.139476 1.010132)
Matrix $\Delta F = (I-AC).\ \Delta Z$ =
(0.0701313 0.0187961 0.023105 0.2717259-0.079991 0.1402567 0.397095 0.1073034 0.0386179 0.1032811 0.2630101 0.1091732 -0.78364)

Therefore:

$$\sum_{j=1,j=k}^{n} \Delta f_j = 0.678865$$

beside $\Delta I = 1$, therefore:

$$K_{HSR} = \frac{\Delta I + \sum_{j=1,j=k}^{n} \Delta f_j}{\Delta I} = 1.678865$$

$$H = K_{HSR} \cdot I = 1.678865 \times 394.5 = 66.23122 \text{ billion RMB.}$$

The investment of Hu-ning inter-city high-speed rail is 39.45 billion RMB, and the GDP created by it is 66.23122 billion RMB. Hu-ning inter-city high-speed rail's effect on regional development is obvious.

This chapter takes Hu-ning inter-city high-speed rail as an example and takes use of investment multiplier theory as well as input-output module to analysis that the direct GDP RMB66.23122 billion is created by Hu-ning inter-city high-speed rail construction.

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