FINANCIAL ANALYSIS ON THE INFLUENCE OF INFRASTRUCTURE CONSTRUCTION ON REGIONAL ECONOMIC DEVELOPMENT

Chunlu Liu[1], Yoshito Itoh[2] and Nashwan Dawood[1]

[1] *Centre for Construction Innovative Research, University of Teesside, Middlesbrough, TS1 3BA, UK*
[2] *Centre for Integrated Research in Science and Engineering, Nagoya University, Nagoya 464-8603, Japan*

In recent years, it has been widely recognized that infrastructure construction is highly correlated with economic development, especially in developing countries. The quality and quantity of civil infrastructure systems have a direct bearing on economic growth. Lacks in the provision of infrastructure facilities such as transportation infrastructure systems can severely affect the growth in all economic sectors of a country or a region. Therefore, developing countries are facing the challenges of updating and expanding their infrastructure facilities so that economic growth will not be hampered by the lack of infrastructure construction. This research focuses on modeling the relationships between economic development in terms of the gross domestic product growth rate, and the transportation infrastructure construction growth rates using statistical data reported from government agencies. These relationships are crucial for making financial decisions on transportation infrastructure construction and investment policies both within the transportation modes at the regional level and among regions of a country for a specific transportation mode.

Keywords: economic growth, estimation model, transportation, infrastructure

INTRODUCTION

In previous research, the importance of transportation infrastructure construction for regional economic performance has been extensively discussed, especially for developing countries and regions (Hewings *et al.* 1997, Kessides and Ingram 1994, World 1994, Wright 1996). The quality and quantity of transportation infrastructure systems have a direct bearing on economic growth. Bottlenecks in the provision of transportation can severely retard the growth in all economic sectors of a country or a region. Numerous authors have included infrastructure as an additional argument of the production function to declare that the public infrastructure can be taken as an input factor in the production process that contributes to output independently. The common and widely used methodology is the ordinary least squares (OLS) (Aschauer 1990, Kombard *et al.* 1992, Lu 1996, Munnel and Cook 1990), which is also named the single-equation regression model or linear regression model. The two-stage least squares (TSLS) regression model was also used to simultaneously estimate the relationships between the transportation infrastructure construction and economic development from two directions (Canning *et al.* 1994, man 1998, Mohamad 1998).

Developing countries such as China are facing challenges of updating and expanding their infrastructure facilities so that the economic growth will not be affected due to the lack of the infrastructure. For the last two decades, infrastructure issues have risen

Liu, C, Itoh, Y and Dawood, N N (2001) Financial analysis on the influence of infrastructure construction on regional economic development. *In:* Akintoye, A (Ed.), *17th Annual ARCOM Conference*, 5-7 September 2001, University of Salford. Association of Researchers in Construction Management, Vol. 1, 353-60.

to the forefront of the policy agenda of the central and local governments in China. Because the transportation infrastructure systems consist of networks, relieving bottlenecks at certain points of the systems can produce very high returns on the economic growth. One striking example is that of China's intercity transportation system with its links to the supply of raw materials, coal and electricity as mentioned in a World Bank report (World 1994). Therefore, research efforts are needed to study in detail the economic effects of various transportation modes in China so that better decisions can be made to allocate the capital investment either among transportation modes of a specific region or among regions of a specific transportation mode.

This research focuses on modeling the relationships between economic development in terms of the growth rate of the gross domestic product (GDP) and transportation infrastructure construction in terms of the growth rates of the lengths of various transportation modes using statistical data reported by government agencies. These relationships are important for making decisions on the transportation infrastructure construction and investment policies both within the transportation modes at the regional level and among regions of a country for a specific transportation mode. This paper is organized as follows: a conceptual framework is described and presented in the next section to show how the transportation infrastructure construction can improve the economic capacity. This is followed by discusses on four main construction transportation modes in Guangdong province in detail from the viewpoints of investment, supply and demand. Finally, an estimation model is established to include various transportation modes in addition to the traditional productive arguments such as the labour, investment and exports and applied for Guangdong province to identify a specific formulation using the historical data from statistical yearbooks. Main conclusions have also been presented.

ROLES OF TRANSPORTATION INFRASTRUCTURE CONSTRUCTION IN ECONOMIC DEVELOPMENT

The relationship between the transportation infrastructure construction and economic growth has been a controversial issue for many years. The key point is that either infrastructure construction causes the economic development or the economic development leads infrastructure investment. However, in recent years, greater recognition has been given to the role of infrastructure investment in economic development, following the findings of many studies that infrastructure variables are positive and significantly correlated with the GDP growth (Lu 1996). When a transportation infrastructure project is undertaken, various economic impacts will be generated (Munnel and Cook 1990). The impacts can be in the direct or indirect manner. As shown in Figure 1, a conceptual framework is represented to describe the influence of infrastructure construction on GDP via improving its various endogenous dominant parameters including the capital, labour, resource, facility, and technology, and so on in the following (Vickerman 1991):

- Capital: better transportation infrastructure may increase a region's capacity to attract investment from both home and abroad. The latter has proved an important stimulus to the economy and foreign trade in the Guangdong province since the 1980s. Because of its proximity to Hong Kong and Macao, Guangdong province has been achieving the rapid rural industrialization due to the financial support from abroad. Various manufacturing factories financially supported by foreign investors could be established in the rural area with the improvement of infrastructure.

- Labour: with the improvement of transportation infrastructure, the availability of employment for a locality will increase and the time consumption of users will be reduced generally. The costs of users to infrastructure will be decreased in the long term because of the improved infrastructure.

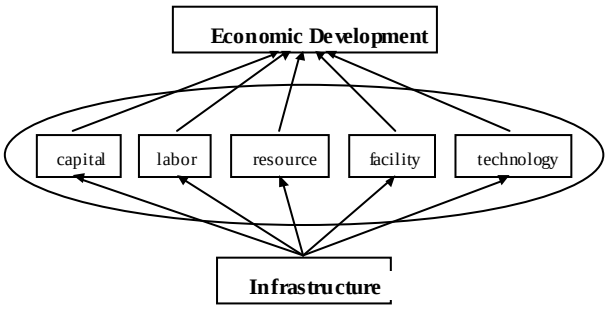

Figure 1: Influence Flow of Infrastructure Construction on Economic Growth

- Resource: the improved infrastructure systems are able to facilitate the formation and integration of the domestic market, and hence lead to the long-term effect of expanding the productive capacity of a region by increasing resources and enhancing the productivity of existing resources. Transportation shortage has also adverse affects on raw materials and energy supply, which is also vital to economic growth. In such a circumstance, improvement in the provision of transportation services should have a large marginal effect on output. As an important component of resources, the values of the land of a region will increase with the construction of new transportation infrastructure.
- Facility: impact of infrastructure development on economic growth is usually more significant when a bottleneck exists in the economy as a result of an under developed infrastructure. Although there has been rapid infrastructure development in recent years in China, it has not been able to adequately meet the economic growth.
- Technology: as the transportation infrastructure improves in the developing regions, it will become possible to raise productive technologies relatively quickly by either transferring from the industrial regions or developing in that area.

TRANSPORTATION INFRASTRUCTURE CONSTRUCTION IN GUANGDONG

Transportation infrastructure construction

As the economy in China grows and population mobility increases, the pattern of investment on various transportation infrastructure modes also changes. Figure 2 shows the percentages of capital investment in the four main transportation modes in China, including railways, highways, waterways, and airways.

In the past 5 years, the share of transportation investment in highway construction continued to increase from 24.9% in 1993 to 49.9% in 1997. Since the year 1996, construction investment on highways has surpassed it on railways. From this figure, it can be predicted that the highway construction will be the dominant investment area for improving the transportation capacity in China. The shares in the other three transportation modes decreased year after year, among which the yearly investment increase rate in airways is bigger than the rates in the other two. These figures may

indicate that the priority of development of the transportation system has shifted from the traditional means of transportation such as railways and waterways to highways and airways.

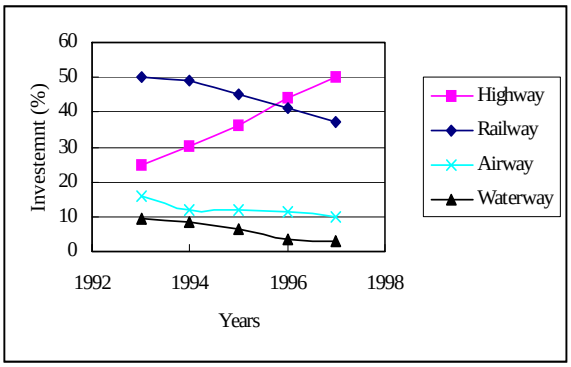

Figure 2: Change of Investment in Various Transportation Modes in China

In Guangdong province, the components of transportation infrastructure construction investment in the railways, highways, waterways, and airways are 14.4%, 47.7%, 24.4%, and 13.5% respectively in 1992. These percent rates changed to 11.7%, 56.5%, 8.5%, and 23.3% in 1996. As a result, the length of civil aviation routes increased by as much as five times from 1989 to 1996 in Guangdong province as shown in Figure 3. In this figure, the length index represents a relative rate by indicating the route length of each transportation mode as 100 in 1989. During this period, the length of railways, highways and waterways increased by 89.5%, 66.5% and 0.1% respectively.

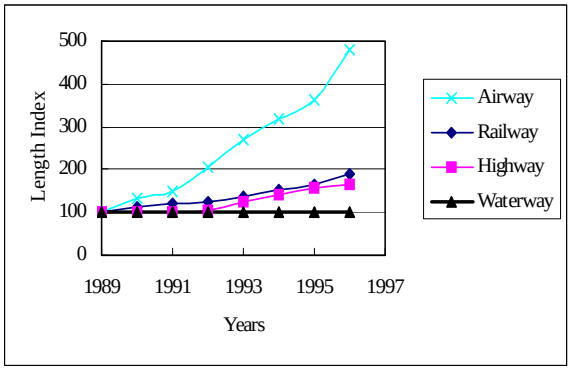

Figure 3: Change of Lengths of Various Transportation Modes in Guangdong Province

Demands of various transportation infrastructure

Figures 4 and 5 show the changes in indices of passengers and freights in various transportation modes in Guangdong province from 1989 and 1996. The values of passengers and freight in various transportation modes in 1989 are designated to be 100 in Figures 4 and 5 respectively.

Between 1989 and 1996, compared to the increasing rate of 113.6% for freight, the increasing rate for passengers was relatively low and is just 86.3%. Air transport increased faster than the other three ways in both the freight traffic turnover volume and passenger traffic. In terms of the turnover volume of freight traffic, the volume of water transportation decreased from 1992. The increasing speeds of the freight and

passengers are near in railways and highways in 1996. It should be noticed that the railway and waterway are still the highly dominant modes to transport freights although they took effects of less than 30% in transporting passengers in 1996. It can be predicted that the highways and airways will become increasingly important for the movement of passengers as the economy in Guangdong province continues to grow. The high demands in these transportation modes are accompanied with the present high increase speeds of construction as presented in Figure 2 and will lead high effects on the economic development.

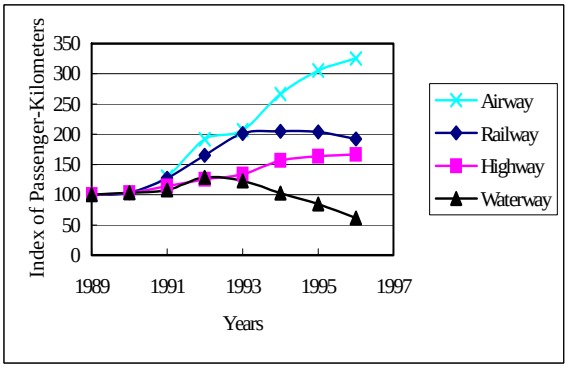

Figure 4: Change of Passengers of Various Transportation Modes in Guangdong Province

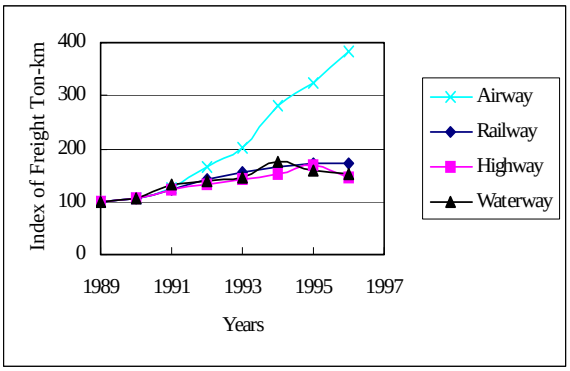

Figure 5: Change of Freights of Various Transportation Modes in Guangdong Province

INFLUENCE OF INFRASTRUCTURE CONSTRUCTION ON ECONOMIC GROWTH

Estimation model

The effects of transportation construction in various transportation modes on economic development are analysed in the framework of a production-function model using panel data of Guangdong province from 1989 to 1996 (Lu 1996, Guangdong 1997). The economic performance is measured as the growth rate of GDP in each year. Various transportation modes are considered as productive parameters in addition to the traditional input parameters such as the labour, capital, and export parameters, and the estimation equation is specified as follows:

$$\Delta GDP = \alpha_0 + \alpha_L \Delta L + \alpha_I \Delta I + \alpha_E \Delta E + \alpha_R \Delta R + \alpha_H \Delta H + \alpha_W \Delta W + \alpha_A \Delta A \quad (1)$$

where, the symbol ΔGDP represents the annual growth rate of GDP, and the symbols ΔL, ΔI, ΔE, ΔR, ΔH, ΔW, and ΔA are the growth rates of labour input, investment,

export, railway, highway, waterway, and airway, respectively. The coefficientsα_L, α_I, α_E, α_R, α_H,α_W, and α_A represent their elasticity of output, among which the symbols α_R, α_H, α_W, and α_A indicate the direction and the marginal impact on economic performance due to the increase of a unit of growth rates in various transportation modes.

Changes in infrastructure construction are generally related to changes in GDP. However, the distribution of central government funds and foreign funds and the decisions about where to invest has had a significant impact on the regional capacity to deliver infrastructure services to local economies in China. This is because the central government and increasing foreign funds available provide large grants for the regional development of infrastructure. Therefore, the physical stock of infrastructure rather than the investment data should be used to analyse the impact of infrastructure development on economic growth. This is because the physical stock is the outcome of earlier investment by both local and central governments as well as by foreign investors, and thus its changes are unlikely to be directly related to the different economic growth rates among regions. In this study, the growth rates of lengths, not the investments, of various transportation modes are taken as the indicators that may affect the economic growth. The labours and exports are the total values in all economic sectors of a region, and the investment represents the total investment in both capital construction and innovation in all economic sectors.

Penal data and estimation procedure

The empirical analysis uses the data obtained form various issues of the Guangdong Statistical Yearbooks (Guangdong 13). Data on the growth rates of GDP, labour input, investment, export and various transportation modes are shown in Table 1. The mean and standard deviation of these variables are also shown in this table. The ordinary least squares estimation method is applied to the above equation. Results from the multiple linear regression analysis are also presented in Table 1. From these results, the mean annual growth rate of gross domestic product with the growth rates of labour, investment, export and four transportation modes is given by

$$\Delta GDP = 13.87 + 0.03\Delta L - 0.04\Delta I + 0.12\Delta E - 0.45\Delta R + 0.98\Delta H + 0.21\Delta A \quad (2)$$

The influence of the growth rate of the waterway is near to zero due to its little change in the length in the previous years. The coefficient for railways is negative because the growth rates of GDP are relatively small while the growth rates of railways are high in several years such as in 1990 and 1996. In the case of highway, the peaks of growth rates appeared in the same year of 1993 and followed in 1994. The importance of infrastructure development for economic performance is clearly borne out in the above empirical results. These results indicate that a 1 percentage of improvement in the provision of highway and airway would lead to increases in output by 0.98 per cent and 0.21 percent respectively. These results are consistent with the earlier speculation there is a high need in the highway and airway.

Discussions on estimation approach

It should be noticed that due to the inadequacy of data at present, there is a need to improve this model by including more data to improve the accuracy of findings such as the coefficients. Further, with the collection of more consistent data, the simultaneous equations under the two-stage least squares will be developed to estimate the mutual relationships of transportation construction and economic development from both directions. In order to determine a rational numerical equation

representing the relationships between the growth rate of GDP and input variables, further studies are needed for identifying the endogenous variables of GDP incorporating them into a comprehensive formulation. On the other hand, the variables used in this research should be further specified such as by taking the paved roads and employed rate into consideration of the highway and labour respectively. In addition, comparative analyses will be carried out with the estimation results in other research focusing on other countries or regions. Finally, transportation infrastructure construction plays an important part in the protection of natural environment, and the improvement of income and living standards as well as economic development, and the formulations for such issues related to the sustainable development need further studies.

Table 1: OLS Estimation of Regression Equation in Guangdong Province

Year	ΔGDP	ΔL	ΔI	ΔE	ΔR	ΔH	ΔW	ΔA
1990	12.86	3.00	20.28	19.40	14.10	1.58	0.59	32.16
1991	21.44	4.53	23.90	29.62	6.14	1.16	0	14.35
1992	29.27	3.31	25.26	34.72	4.32	1.04	0	37.27
1993	40.22	1.98	37.66	46.57	9.75	20.88	-0.45	29.46
1994	31.61	1.73	47.49	73.87	10.29	12.08	0	19.05
1995	26.95	1.66	47.41	20.43	7.88	11.68	0	13.41
1996	13.54	2.54	40.59	4.87	14.83	5.99	0	32.04
Mean (Δ)	25.13	2.68	34.65	32.78	9.62	7.78	0.02	25.39
Standard Deviation	9.17	0.95	10.57	20.71	3.60	6.93	0.28	8.89
Coefficient (α)	13.87	0.03	-0.04	0.12	-0.45	0.98	0	0.21

CONCLUSIONS

This research aims to study the development of various transportation modes and their effects on the economic growth in the south area of China, Guangdong province. The main conclusions of this paper are:

1. A conceptual framework was presented and described in order to reflect the effects of transportation infrastructure construction on GDP via improving its endogenous variables.
2. Considering the possibility of future investment, and potential demand and supply in four transportation modes, it was concluded that highways and airways have more impact than railways and waterways in transporting freight and passengers in the future of Guangdong province.
3. An economic estimation model was presented to quantify the effects and needs of various transportation modes in Guangdong province. It was found that increasing investment of 1% in highways and airways would lead to the increases in GDP by 0.98% and 0.21% respectively. However, the railways and waterways did not show positive and statistically significant effects on economic growth in Guangdong province.

ACKNOWLEDGEMENT

A part of the work in this paper was supported by the Japan Society for the Promotion of Science (JSPS). However, the opinions stated in this paper are those of the author alone and do not reflect any official position of JSPS.

REFERENCES

Aschauer, D. A. (1990) Highway capacity and economic growth. *Economic Perspectives, Federal Reserve Bank of Chicago*, **14**(5), 14-24.

Canning, D., Fay, M., and Perotti, R. (1994) Infrastructure and growth. *International differences in growth rates: market globalization and economic areas*, Macmillan Press Ltd., New York, 113-147.

Guangdong Statistical Yearbook (1997) *China Statistical*, Publishing House, 1997 (in Chinese).

Hewings, G. J. D., Schindler, G. R., and Isailevich, P. R. (1997) Infrastructure and economic development: airport capacity in Chicago region, 2001-18. *Journal of Infrastructure Systems, ASCE*, **3**(3), 96-102.

Kessides, C., and Ingram, G. K. (1995) Infrastructure's impact on development: lessons from WRD 1994. *Journal of Infrastructure Systems, ASCE*, **1**(1), 16-32.

Lombard, P. C., Sinha, K. C., and Brown, D. J. (1992) Investigation of the relationship between highway infrastructure and economic development in Indiana. *Transportation Research Record*, (1359), 76-81.

Lu, W. (1996) Public infrastructure and regional economic development: evidence from China. *Pacific Economic Paper No. 258*, Australian National University, Canberra.

Man, J. Y. (1998) Transportation infrastructure and regional economic development in China. *International Journal of Public Administration*, **21**(9), 1307-1321.

Mohamad, D. (1998) The relationships between road infrastructure investment and economic development. *Proceedings of an International Conference on Transportation into the next Millenium*, Nanyang Technological University, Singapore, 261-270.

Munnel, A. H. and Cook, L. M. (1990) How does public infrastructure affect regional economic performance?. *New England Economic Review*, **15**(5), 11-32.

Vickerman, R. W. (1991) *Infrastructure and regional development*. Pion Limited, London.

World Development Report (1994) *Infrastructure Development*. Oxford University Press, New York.

Wright, D. W. (1996) Infrastructure planning and sustainable development. *Journal of Urban Planning and Development, ASCE*, **122**(4), 111-117.