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Public Infrastructure and Regional Economic Development: Evidence from China

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AUSTRALIA–JAPAN RESEARCH CENTRE

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Abstract

This paper estimates an economic growth equation cross-sectionally for thirty provinces and cities in China for 1990–94 using an expanded production function which includes infrastructure variables as well as traditional variables such as labour, capital and export. Special care was taken in the selection of the infrastructure variables to avoid corruption of coefficients of these variables caused by a possible mutual influence between infrastructure investment and economic growth. The results show that transportation and telecommunication growth has had a large and positive impact on regional economic growth performance and infrastructure development should continue to be an important component of any policy package designed to promote balanced growth of China's regional economies.

Public Infrastructure and Regional Economic Development: Evidence from China

Introduction

Over the past several years, infrastructure issues have moved to the forefront of China's policy agenda — a result of mounting concerns about not only the strain of inadequate public infrastructure on national economic development but also the adverse impact of uneven infrastructure development on regional economic growth.

Broadly speaking, public infrastructure falls into two categories: 'economic infrastructure', which refers to facilities that directly affect economic activities, including power supply, transportation and telecommunication; and 'social infrastructure', which denotes facilities that mainly affect people's living standards, including education, sanitation and social welfare. The main purpose of this paper is to review the development of economic infrastructure in China from a regional perspective and to analyse its impact on regional economic growth.

The importance of infrastructure for economic performance has been extensively discussed in recent economic literature — for example, Aschauer (1989), Gramlich (1994) and the World Bank (1994). Numerous authors have included infrastructure as an additional argument of the production function, declaring that public infrastructure can be taken as an input in the production process that contributes independently to output.[1] In such regressions, infrastructure variables are generally found to be significant, though controversy exists over the method of estimating the expanded function and the interpretation of the results.

This paper estimates economic growth equations cross-sectionally for thirty provinces and cities in China for 1990–94, for which period sufficiently consistent data are available. Feder's model (Feder 1982), which expresses the growth rate of GDP as a linear function of the share of investment in GDP, the growth rate of labour and the growth rate of exports, is modified to include infrastructure variables. The hypothesis to be tested is that infrastructure development accelerates economic growth. Particular attention is paid to the selection of infrastructure variables in order to avoid corruption of coefficients on infrastructure variables caused by a possible mutual influence between infrastructure investment and economic growth. The results have important implications for the achievement of balanced growth in China's regional economies.

Review of infrastructure development in China

Since the beginning of the 1990s, increased efforts have been made in China to improve the country's economic infrastructure. Total investment in the fixed assets of state-owned units in the energy, transportation, postal and telecommunication sectors grew more than fivefold during 1985–94 (Table 1). Investment in infrastructure as a share of GDP stagnated in the second half of the 1980s but increased notably from 1990. There has also been a significant change in the composition of infrastructure investment, with the transportation, postal and telecommunication sectors assuming greater importance (Figure 1).

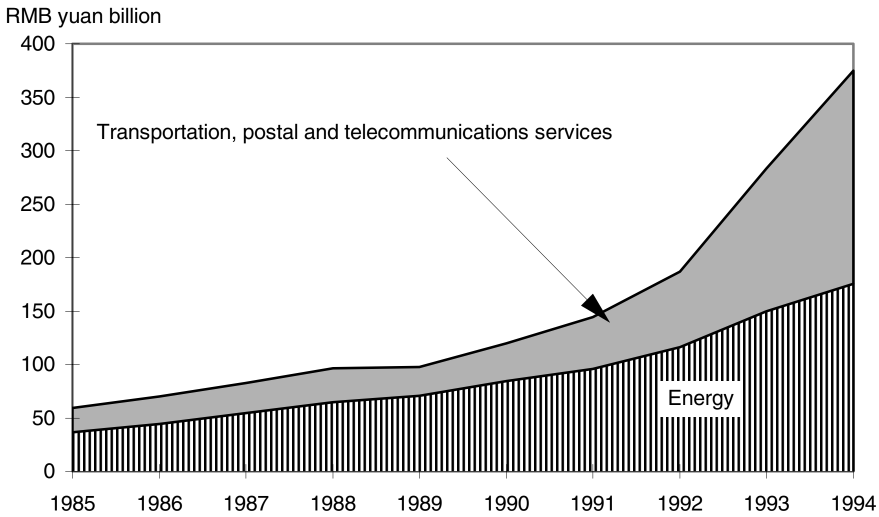
Table 1 Total investment in fixed assets of state-owned units in energy, transportation, postal and telecommunication sectors, 1985–94

	Total investment (RMB yuan billion)	GDP (RMB yuan billion)	Investment as a share of GDP (%)
1985	59.3	899.5	6.59
1986	70.1	1,021.1	6.87
1987	82.6	1,195.6	6.91
1988	96.3	1,492.2	6.45
1989	97.7	1,690.5	5.78
1990	119.5	1,854.5	6.44
1991	144.2	2,166.6	6.65
1992	186.6	2,665.1	7.00
1993	283.2	3,447.7	8.21
1994	374.6	4,491.8	8.34

Source: *Statistical Yearbook of China*, various issues.

Since the commencement of economic reform in 1978, there has been increased use of various forms of foreign funds to accelerate infrastructure development in China. These include loans from international financial institutions and foreign governments, overseas stock issuance, foreign direct investment such as joint ventures and solely foreign-funded methods (BOT), and commercial loans. For instance, during 1978–94 the power sector attracted a total of US$14.3 billion in foreign funds, US$11 billion of which was used in power construction (Zhao 1995). In 1993 alone, the transportation and telecommunication sectors signed contracts for foreign direct investment worth US$1.4 billion (State Statistical Bureau 1994).

Figure 1 Total investment in fixed assets of state-owned units in economic infrastructure (nominal value), 1985–94

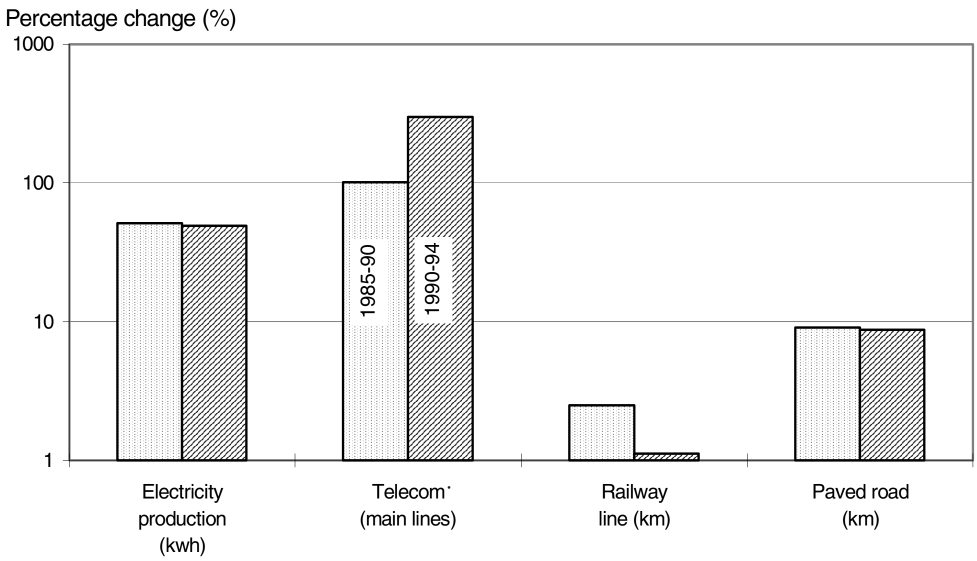


Source: *Statistical Yearbook of China*, various issues.

The development of infrastructure based on physical measures for the period 1985–94 is reported in Figure 2. Telecommunications was the fastest growing sector, with total switchboard capacity increasing by 100 per cent during 1985–90 and by 300 per cent during 1990–94. Power supply more than doubled over the ten-year period and recorded steady growth. Construction of roads and railway lines grew more slowly, with the length of railway line that was laid showing decelerated growth.

Despite the rapid development of economic infrastructure in the past ten years, it has still proven insufficient to meet China's needs in light of the high and accelerated economic growth that has taken place since the beginning of the 1990s. The picture of infrastructure under strain is reflected in numerous reports citing under-developed infrastructure as a major bottleneck for the Chinese economy. For instance, in recent years only about 60 per cent of demand for railway shipments has been met; the gap between electricity demand and supply was as high as 25 per cent in 1994, resulting in one-quarter of the nation's total production capacity being idle; roads and transportation have remained under-developed, with the average rate of speed for motor vehicles in large cities dropping to 15 km per hour; and the number of telephones per 100 persons is still extremely low (only 4.66 in 1995) (Lu 1995).

Figure 2 Infrastructure development based on physical measures, 1985–94 (logarithmic scale)



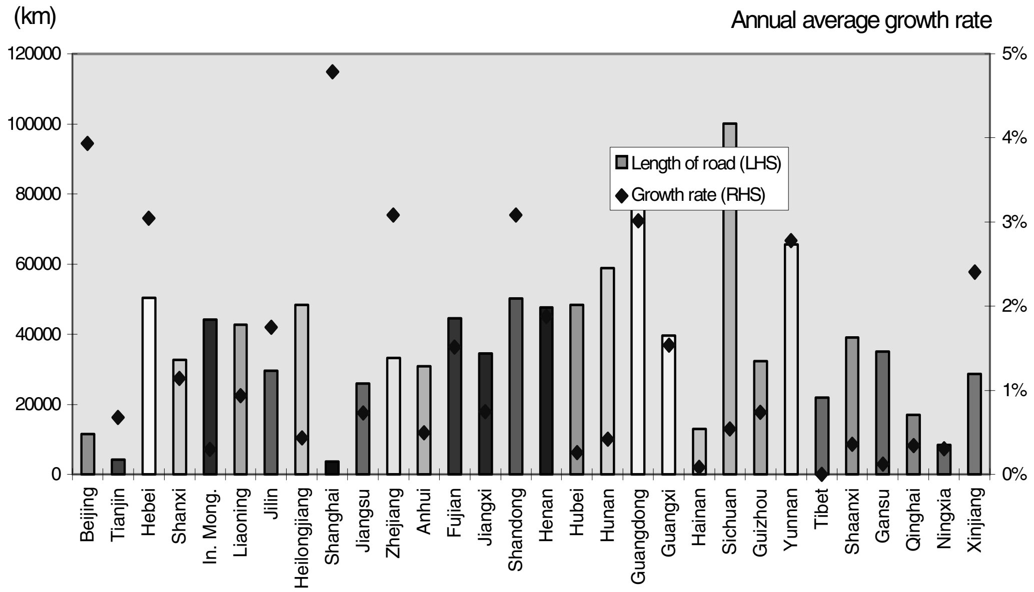
Source: *Statistical Yearbook of China*, various issues.

Moreover, development of infrastructure has been uneven among the different provinces and cities; as Figures 3, 4 and 5 demonstrate, the stock of infrastructure and its change varied greatly. Of most significance have been the different growth rates for road construction and the number of telephone subscribers, with important implications for the growth of China's regional economies.

The role of infrastructure in economic development

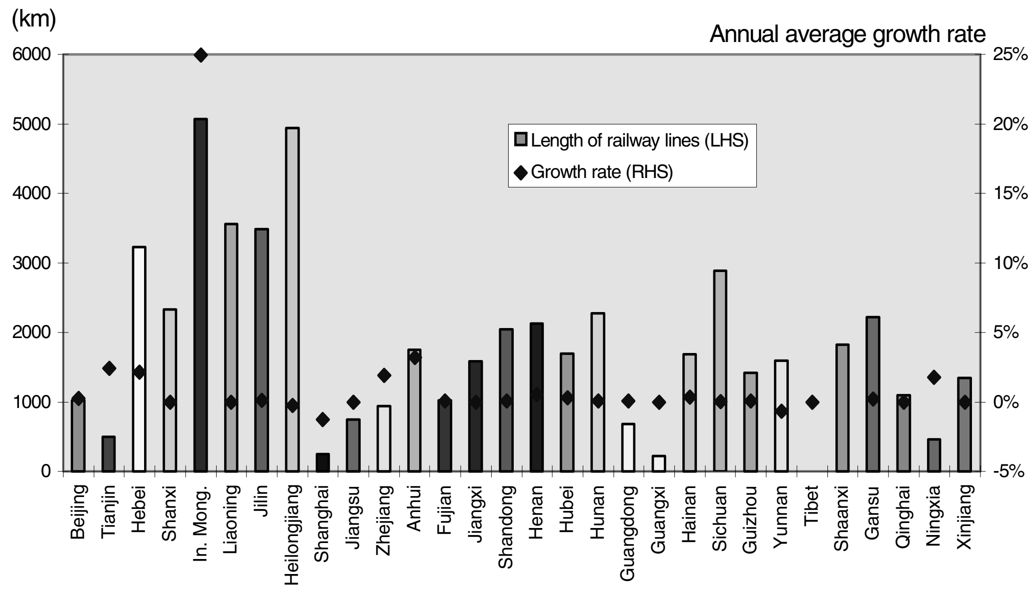
The relationship between infrastructure development and economic growth has been a controversial one. At its heart is the question of causality — whether infrastructure investment causes economic growth or economic growth causes infrastructure investment. However, since the seminal work initiated by Aschauer (1989), greater recognition has been given to the role of infrastructure investment in economic development, following the findings of many studies that infrastructure variables are positively and significantly correlated with GDP growth. Over time, studies attempting to link public infrastructure spending to GDP growth have become

Figure 3 Road length at the end of 1994 and change during 1990–94



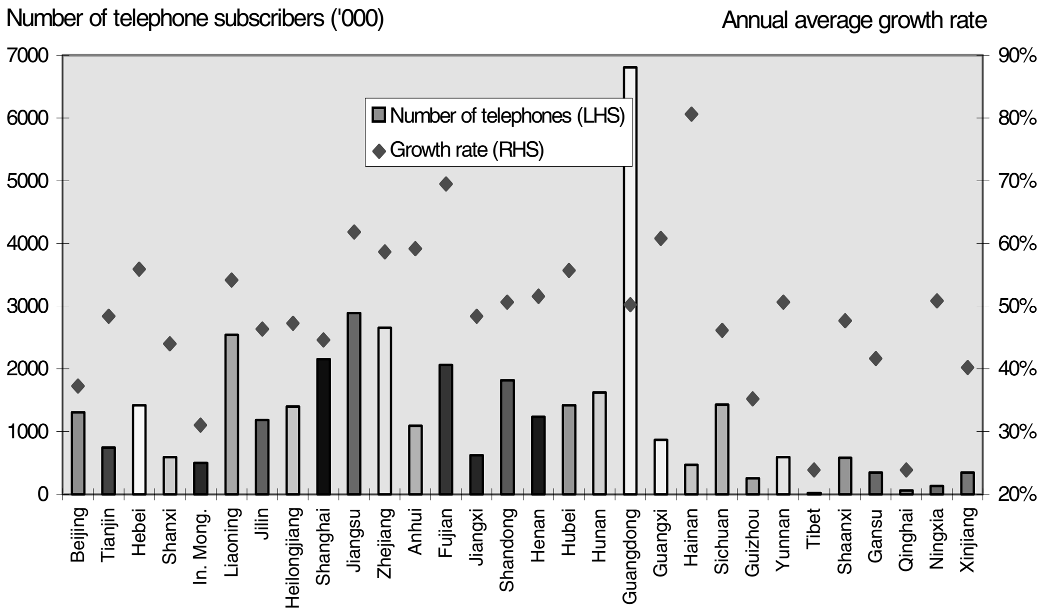
Source: *Statistical Yearbook of China*, various issues.

Figure 4 Railway line length at the end of 1994 and change during 1990–94



Source: *Statistical Yearbook of China*, various issues.

Figure 5 Number of telephone subscribers at the end of 1994 and change during 1990–94



Note: Telephones include cordless and mobile phones. Since there was a shortage of telecommunication services in China, number of subscribers is used as a proxy for telecommunication capacity.

Source: Statistical Yearbook of China, various issues.

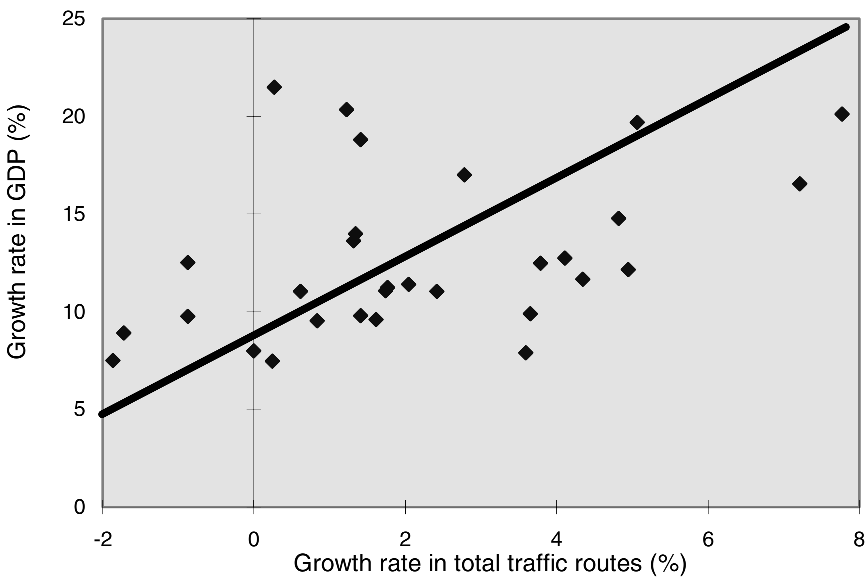
more cautious in their choice of infrastructure variables in response to criticism of the purported mutual influence of infrastructure spending and economic growth.

Changes in infrastructure spending are generally related to changes in GDP, but this relationship seems not to be significant across the different provinces and cities in China due to the large grants provided by the central government and increasing foreign funds available for the regional development of infrastructure.[2] For instance, in 1994 more than one-third of the nation's total capital construction investment of state-owned units in the transportation, postal and telecommunication sectors came from the central government. The distribution of central government funds and foreign funds and decisions about where to invest have had a significant impact on the regional capacity to deliver infrastructure services to local economies.

The above observation suggests that the physical stock of infrastructure rather than provincial state investment data should be used to analyse the impact of infrastructure development on economic growth as 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 differing economic growth rates among provinces and cities. Indeed, there is even an advantage in using physical stock variables as this can avoid the tedious task of constructing capital stock estimates based on the perpetual inventory techniques, which is almost impossible in the case of Chinese data.

The impact of infrastructure development on economic growth can be clearly seen if correlation diagrams are drawn between changes in infrastructure provisions and in GDP. This makes it possible to analyse the effect of infrastructure development on economic growth at the margin. Figure 6 relates changes in GDP to changes in length of total traffic routes. Total traffic routes are the weighted average of the length of roads, railway lines and waterways.[3] It is evident from the figure that the growth of GDP is positively correlated with the growth of transport infrastructure.

Figure 6 Correlation between annual average growth rate (1990–94) of total traffic routes and that of GDP, thirty provinces and cities

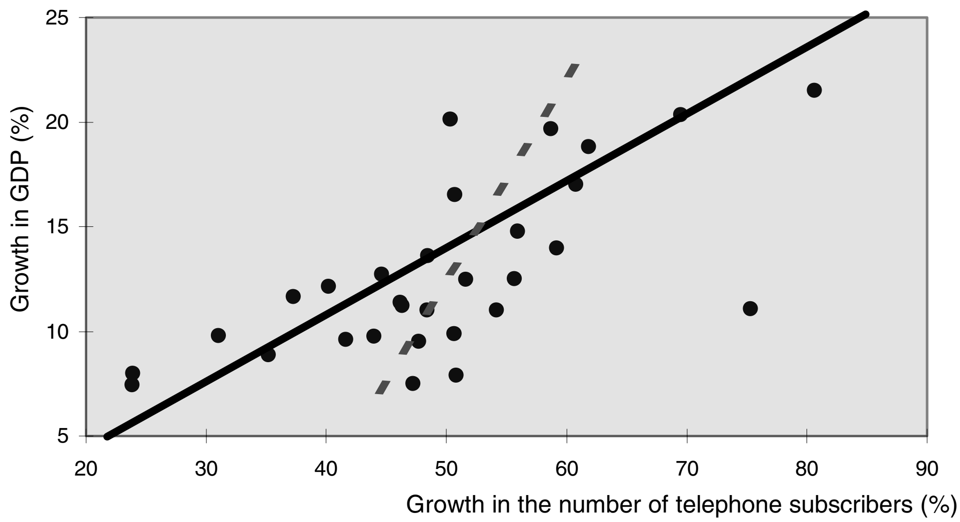


Source: *Statistical Yearbook of China*, 1991–95.

There is also a positive relationship between the growth of telecommunication services and economic growth (Figure 7). In fact, if a subset of observations is chosen, this relationship become even stronger, as indicated by the dotted line in the figure. This suggests that for some provinces and cities where the constraint of telecommunication services was severe, the payoffs of improving those services were even higher.

There are several ways in which one can rationalise the notion that infrastructure is a productive input, in the sense that the level of infrastructure development affects aggregate output for given levels of other inputs such as labour and capital. According to Meade (1952), infrastructure can be viewed as an input in the production process that contributes independently to output. Other arguments rest on the proposition that improved infrastructure facilitates the formation and integration of the domestic market and hence leads to better resource allocation and production efficiency. Increased infrastructure may also have the long-term effect of expanding the productive capacity of a region by increasing resources and enhancing the productivity of existing resources. Further, better infrastructure may increase a region's

Figure 7 Correlation between annual average growth rate (1990–94) of telephone subscribers and that of GDP, thirty provinces and cities



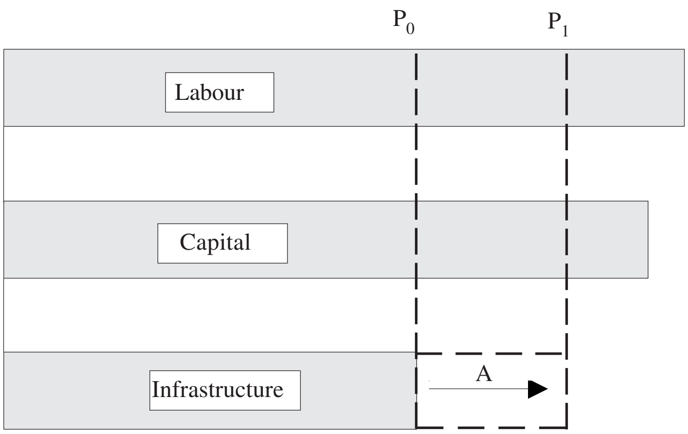
Note: Number of telephone subscribers is used as a proxy for telecommunication capacity since there has been basically no excess capacity.

Source: *Statistical Yearbook of China*, 1991–95.

capacity to attract investment from both home and abroad, the latter having proved an important stimulus to the Chinese economy and foreign trade.

The 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, as Figure 8 illustrates. Assume that there are only three inputs required for production — namely capital, labour and public capital (infrastructure). Also assume, for illustrative purpose only, a Leontief technology where the level of output is determined by the minimum input available for production. Further assume that one unit of output requires one unit of each input. Then, the production frontier is P_o, as shown in the figure. In this case, infrastructure clearly constitutes a bottleneck in the economy. However, if the stock of infrastructure can be increased by the amount of **A**, this will move the production frontier to P_1, which allows a fuller use of existing capital and labour resources. Such a case is obviously relevant to the recent Chinese growth experience, where, although there has been rapid infrastructure development in recent years, it has not been able to adequately meet China's economic growth. For instance, the coverage of China's inter-city transport networks is still one of the most sparse in the world: the total route (highways and railways) length per capita is similar to, or lower than, that of Brazil, India and Russia (the World Bank 1994). Transport shortage has also adversely affected 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.

Figure 8 Production frontier under infrastructure-constrained production



The model

The role of infrastructure development in economic growth is analysed in the framework of a production-function model adopted from Feder (1982), but infrastructure is treated here as being similar to a production input. We can then specify an augmented production function fairly simply as:

$$Y = f(L, K, X, G) \qquad (1)$$

where Y is real aggregate output, L is labour input, K represents input of capital, X measures exports,[4] and G is public infrastructure. It is easy to rewrite (1) in terms of growth rates. Taking total derivatives, and manipulating the terms slightly, we get the familiar expression:

$$\dot{Y} = b_o + b_1\dot{L} + b_2\dot{K} + b_3\dot{X} + b_4\dot{G} \qquad (2)$$

where a dot over a variable indicates its rate of growth and b_1, b_2 b_3, and b_4 are the elasticities of output with respect to L, K, X and G. Since $\dot{K}$, the growth rate of capital stock, is not easily obtained for China, equation (2) can be reformulated by replacing $\dot{K}$ with the more tractable variable $\Delta K/Y$, which approximates the investment–income ratio, as follows:

$$\dot{Y} = b_o + b_1\dot{L} + \frac{\partial Y}{\partial K} * \frac{K}{Y} * \frac{dK}{K} + b_3\dot{X} + b_4\dot{G} \qquad (2a)$$

or replacing dK by I,

$$\dot{Y} = b_o + b_1\dot{L} + b_2\frac{I}{Y} + b_3\dot{X} + b_4\dot{G} \qquad (2b)$$

where b_2 is the marginal physical product of capital.

Infrastructure variables to be included in equation (2b) are transportation and telecommunication services. These are important variables, as one is related to the flow of goods and the other to the flow of information, and both are central to the formation of an integrated market at the provincial or national level. Ideally, the power variable — another important component of economic infrastructure — could be included in the model, but the lack of data on power consumption prevents us from calculating the balance of demand and supply. The use of data on provincial electricity production would not capture the bottleneck effect caused by widespread power shortages in China, because of the interdependence on power supply of various provinces and cities. Therefore, the empirical model to be estimated becomes:

$$\dot{Y} = b_0 + b_1\dot{L} + b_2\frac{I}{Y} + b_3\dot{X} + \delta_1\dot{R} + \delta_2\dot{T} \quad (2c)$$

where *R* is the transportation variable and *T* is the telecommunication variable. If the model specification (2c) is reasonable, the estimated coefficient of $\dot{R}$ ($_1$) and $\dot{T}$ ($_2$) will indicate the direction and magnitude of the impact of infrastructure development on economic performance.

Data and estimation results

The empirical analysis here uses provincial data for 1990 to 1994 obtained from various issues of the *Statistical Yearbook of China*. Annual average growth rates were obtained using a geometric growth approach. All magnitudes are expressed in real terms, but the growth rates for exports are calculated on the basis of current US dollar prices.[5] The investment ratio is the simple average of investment/GDP for 1990–94. Data on the growth rates of GDP, labour input, export, transportation and telecommunication and on the investment ratio are reported in Appendix Table 1. The mean and standard deviation of these variables are shown in Table 2.

Table 2 Mean and standard deviation of the dependent and independent variables

Variables	Mean	Standard deviation
$\dot{Y}$	0.1274	0.0411
I/Y	0.3079	0.0780
	0.0190	0.0091
	0.1497	0.1095
	0.0217	0.0239
	0.4972	0.1292

The ordinary least squares (OLS) estimation method is applied to equation (2c). Since we are dealing with cross-sectional data, tests of heteroskedasticity were duly carried out. The results indicate that there was no heteroskedasticity problem in the dataset.

An attempt was made to include in the model a regional dummy variable (coastal versus inland region) which sought to capture the effect of policies on growth, but the dummy turned out to be highly correlated with the export variable, and thus created a problem of multicollinearity. Because the relative growth in exports reflected to a large extent the difference in policies, the dummy variable was dropped in the final estimation of the model.

Results from estimating both Feder's model and the modified model which includes infrastructure variables are presented in Table 3. In Feder's model, none of the coefficients is statistically significant. However, the situation changes when infrastructure variables are added to Feder's specification. The coefficient associated with *I/Y* become marginally significant at the 80 per cent confidence level. The coefficient for $\dot{L}$ remains insignificant, which may be due to the deficient labour statistics that were used.[6] Export growth exhibits a positive impact on

Table 3 OLS estimation of GDP function, 1990–94 (dependent variable = growth rate of GDP)

Independent variables	Feder's model		Modified model	
	Coefficient	t-ratio	Coefficient	t-ratio
I/Y (b_1)	0.1105	1.1253	0.1078	1.6529*
(b_2)	0.8893	0.8498	0.3202	0.5760
(b_3)	0.0991	0.0686	0.0875	1.9132**
(d_1)			0.4263	1.9930**
(d_2)			0.2115	5.5513***
Constant	0.0616	1.6134	-0.0393	-1.2568
Number of obs.	30		30	
R-square adjusted	0.0565		0.6072	
SSE	0.0414		0.0159	

Notes: * Statistical significance at the 80 per cent confidence level;
** statistical significance at the 90 per cent confidence level;
*** statistical significance at the 99 per cent confidence level.

economic growth, with its coefficient being significantly different from zero at the 90 per cent confidence level. Transportation and communication growth show positive and statistically significant effects on economic growth. Overall, the inclusion of infrastructure variables increases the explanatory power of the regression equation considerably.

The importance of infrastructure development for economic performance is clearly borne out in the above empirical results, which indicate that a 1 per cent improvement in the provision of transportation and telecommunication services would lead to an increase in output by 0.43 percent and 0.21 per cent respectively. Direct comparison of the results of this study with those for other countries is not possible due to differences in the measurement of infrastructure variables, but the magnitude of output elasticities in this study appears to be higher than that derived from country studies (Table 4). These results are consistent with the earlier speculation that the impact of infrastructure development on economic growth is more significant in an economy where there are bottlenecks caused by an under-developed infrastructure.

Table 4 Results from studies of infrastructure productivity

Sample	Output elasticity	Author/year	Infrastructure measure
Taiwan	0.24	Uchimura and Gao (1993)	Transportation, water and communication
Korea	0.19	Uchimura and Gao (1993)	Transportation, water and communication
Israel	0.31-0.44	Bragman and Marom (1993)	Transportation, power, water and sanitation
Mexico	0.05	Shah (1988, 1992)	Power, communication and transportation
Multicountry OECD	0.07	Canning and Fay (1993)	Transportation
Multicountry developing	0.07	Canning and Fay (1993)	Transportation
Multicountry developing	0.16	Easterly and Rebelo (1993)	Transportation and communication
Multi-provinces China	0.43 0.21	Present study	Transportation Telecommunication

Source: World Bank (1994, p. 15); Table 3 of this study.

A number of studies, such as the World Bank (1994), Gramlich (1994) and OECD (1993), have questioned the validity of previous research results, such as those listed in Table 4, suggesting that the results are simply too good to be credible. Their criticisms mainly include possible mis-specification of the model due to the omission of the relevant variables, mutual causality and spurious correlation associated with macroeconomic time series data. These criticisms, however, are less of a worry in the present study owing to several precautions that were taken at the beginning of the research. First, we adopted a broader specification of the production function which includes the export variable. Second, instead of using the state investment data, we used the infrastructure variables based on physical measurement, which are highly unlikely to be affected by current changes in output. Third, we used cross-sectional growth rates data to avoid a common trend or spurious correlation problem. All these add confidence to the statistical significance of the regression results.

Concluding remarks

This paper has attempted to provide a review of infrastructure development in China and to shed light on the extent to which the Chinese economy might benefit from infrastructure improvements in recent years. Based upon an augmented production function specification that includes labour, capital, export and infrastructure and which was estimated against cross-sectional provincial data, transportation and telecommunication growth is observed to exert a positive, large and significant impact on economic growth.

China has made a commitment to increase its investment in infrastructure in order to remove bottlenecks restricting economic development. Our results suggest that this will be highly rewarding in view of the present severe constraint of under-developed infrastructure on the economy. Continued improvement in infrastructure will not only lead to higher short-term growth but also to sustained growth.

The empirical results derived from the present study also have important implications for the achievement of balanced growth in China's regional economies. The performance of these economies depends on many factors, but infrastructure should prove to be among the more significant of these. Infrastructure could affect the efficiency of use of existing resources, export capabilities and investment decisions, all of which could impact on regional economic performance. Thus infrastructure development should continue to be an important component of any policy package designed to promote regional economic growth.

Regional capability to deliver infrastructure services is affected by the allocation of central government grants and thus needs careful planning if the government is to achieve balanced growth among its regional economies.

Foreign funds are another source of financing of infrastructure development in China. In the past, most foreign funds were in the form of loans from international financial institutions and foreign. The main reasons for low foreign direct investment in infrastructure are inadequate financial returns and the longer period required for cost recovery. Incentives are therefore needed if China is to attract more foreign investment in infrastructure.

Finally, it is worth noting that while this study has extended our understanding of the impact of infrastructure development on economic growth, other productive areas for further research remain. First, the variable of the power gap, when available, needs to be included in the expanded production function. This will reduce the chance of a mis-specified model and thus add further confidence to the empirical results. Second, more research is needed on the ways in which infrastructure development can be accelerated. Third, in view of the resource constraints on infrastructure development, research needs be undertaken into ways to make the provision of infrastructure more efficient.

Appendix Table 1 Investment ratio and growth rates, 1990–94 (per cent)

Provinces	GDP	Investment ratio	Labour	Export	Transportation	Communication
Beijing	11.67	43.65	1.37	30.10	4.34	37.28
Tianjin	11.03	38.91	1.59	12.24	0.62	48.40
Hebei	14.77	25.52	2.21	3.16	4.82	55.91
Shanxi	9.76	30.95	1.99	24.41	-0.88	44.00
Inner Mongolia	9.79	30.56	2.29	10.41	1.41	31.05
Liaoning	11.03	30.28	-0.98	-1.97	2.42	54.12
Jilin	11.25	27.96	1.86	22.72	1.76	46.33
Heilongjiang	7.50	25.11	1.60	26.91	-1.86	47.25
Shanghai	12.75	37.79	-0.02	15.79	4.11	44.61
Jiangsu	18.82	32.64	0.44	24.76	1.41	61.82
Zhejiang	19.69	34.77	1.48	30.84	5.06	58.66
Anhui	14.00	23.24	2.49	11.09	1.34	59.13
Fujian	20.36	26.85	3.57	28.59	1.22	69.50
Jiangxi	13.62	21.53	2.70	3.70	1.32	48.46
Shandong	16.54	27.40	2.39	17.49	7.21	50.67
Henan	12.50	25.58	2.65	7.02	3.79	51.61
Hubei	12.52	23.15	1.47	9.67	-0.87	55.63
Hunan	11.08	21.94	1.98	12.38	1.74	75.31
Guangdong	20.13	39.85	2.64	48.29	7.77	50.29
Guangxi	17.01	23.29	2.60	16.36	2.78	60.75
Hainan	21.50	51.02	2.52	-3.19	0.27	80.63
Sichuan	11.40	23.95	1.60	7.77	2.05	46.13
Guizhou	8.90	21.08	2.53	15.26	-1.72	35.20
Yunnan	9.91	26.35	2.41	11.81	3.65	50.61
Tibet	8.01	43.10	0.93	2.67	0.00	23.88
Shaanxi	9.53	27.64	2.24	15.42	0.84	47.72
Gansu	9.61	25.79	2.05	14.24	1.61	41.62
Qinghai	7.46	35.00	1.95	15.26	0.24	23.86
Ningxia	7.91	38.14	2.80	7.46	3.59	50.81
Xinjiang	12.16	40.57	1.77	10.19	4.95	40.20

Source: *Statistical Yearbook of China*, 1991–95.

Notes

1 For an excellent summary of these studies, refer to the World Bank (1994).

2 No statistically significant relationship is found between economic growth and infrastructure spending growth based on econometric analysis of Chinese data at the provincial level.

3 Weights are volumes of freight traffic by different transportation modes.

4 While X is not a proper argument of the production in that it is not a production input, it is intended to reflect those international factors that influence productivity but that are not captured in K and L. In a sense, X may be viewed as a systematic error terms affecting Y, the reasons for which are enumerated in Feder's work (1982).

5 Export data are based on provinces of origin. The estimation of real export growth rates is complicated by three factors: exchange rate, export prices and domestic prices. While the RMB yuan was devalued by 55 per cent against the US dollar during 1990–94, domestic prices rose by roughly the same magnitude during this period. Data on unit value of export were not available, though even if they had been, changes in export prices reflecting in part quality improvement. For this reason we have used export data based on current US dollars as a proxy for real changes.

6 There are three problems with the Chinese employment data: there were redundancies in the workforce, originating from the old planning system and especially for state-owned enterprises; Chinese data may fail to fully record the contract workers who migrated from rural areas into cities; and the number of employees cannot capture the improvement in workforce quality. All these could lead to an insignificant coefficient for labour in the growth equation.

References

Aschauer, D. A. (1989) ‘Is public expenditure productive?’, *Journal of Monetary Economics* 23: pp. 177–200.

Bragman, A. and A. Marom (1993) *Growth Factors in Israel’s Business Sector: 1958–1988*, Bank of Israel, Tel Aviv.

Canning, D. and M. Fay (1993) ‘The effect of transportation networks on economic growth’, Columbia University Working Paper China Statistics Bureau, New York.

China Statistics Bureau, *Statistical Yearbook of China*, Beijing.

Duffy-Deno, K. T. and R. W. Eberts (1991) ‘Public infrastructure and regional economic development: a simultaneous equations approach’, *Journal of Urban Economics* 30: pp. 329–43.

Easterly, W. and S. Rebelo (1993) ‘Fiscal policy and economic growth: an empirical investigation’, *Journal of Monetary Economics* 32(2): pp. 417–58.

Feder, G. (1982) ‘On exports and economic growth’, *Journal of Development Economics* 12: pp. 59–93.

Gramlich, E. M. (1994) ‘Infrastructure investment: a review essay’, *Journal of Economic Literature* 32: pp. 1176–1196.

Lu, T. (1995) ‘On infrastructure in economic development’, Working Papers of Graduate Studies No. 4/95, Chinese Academy of Social Sciences: pp. 51–7.

Meade, J. E. (1952) ‘External economies and diseconomies in a competitive situation’, *Economic Journal* 62: pp. 54–67.

OECD (1993) *Infrastructure Policies for the 1990s*, OECD, Paris.

Shah, A. (1988) ‘Public infrastructure and private sector profitability and productivity in Mexico’, Policy Planning and Research Working Paper No. 100, World Bank, Country Economics Department, Washington, DC.

—— (1992) ‘Dynamics of public infrastructure, industrial productivity and profitability’, *Review of Economics and Statistics* 74(1).

Uchimura, K. and H. Gao (1993) ‘The importance of infrastructure on economic development’, World Bank, Latin America and Caribbean Regional Office.

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

Zhao, X. (1995) ‘Power industry develops rapidly’, *Beijing Review*, 26 June–2 July: pp. 12–14.

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