JOURNAL OF ECONOMIC DEVELOPMENT
Volume 37, Number 1, March 2012

CHINA'S GROWTH STORY: THE ROLE OF PHYSICAL AND SOCIAL INFRASTRUCTURE

PRAVAKAR SAHOO[a], RANJAN KUMAR DASH[b] AND GEETHANJALI NATARAJ[c*]

[a]*Institute of Economic Growth, India*
[b]*Indian Council for Research on International Economic Relations, India*
[c]*National Council of Applied Economic Research, India*

The paper investigates the role of infrastructure in promoting economic growth in China using ARDL and GMM techniques for the period 1975 to 2007. In this context, an attempt is made to understand growth accounting equations to investigate the impact of infrastructure development on output. Overall, the results reveal that infrastructure stock, labour force, public and private investment play an important role in economic growth in China. More importantly, the study finds that Infrastructure development in China has significant positive contribution to growth than both private and public investment. Further, there is unidirectional causality from infrastructure development to output growth justifying China's high spending on infrastructure development since the early nineties. The experience from China suggests that it is necessary to design an economic policy that improves the physical infrastructure as well as human capital formation for sustainable economic growth in developing countries.

Keywords: China, Infrastructure Development, Investment, Output Growth
JEL classification: H4, H54, L9, O1

1. INTRODUCTION

China is the fastest growing country in the world for last few decades and accounts for nearly one fifth of the world population. Economic growth in China increased from 7.5% during 1970 to 1999 to over 10% per annum between 1999 to 2008. This has attracted many scholars to examine the major determinates of growth in China. Over the last two decades, academic research has devoted considerable attention to the role of trade and Foreign Direct Investment (FDI) in promoting growth. However, the role of

[*] We thank an anonymous referee for very useful and constructive comments. However, the usual disclaimer applies.

infrastructure and human capital development has been neglected. Therefore, this paper offers an empirical assessment of the impact of infrastructure and human capital development on growth in the case of China.

The role of infrastructure in enhancing economic development has been well documented both in the academic literature and in the policy debate (Aschauer, 1989; Munnell, 1990; World Bank, 1994; Calderon and Serven, 2003; Estache, 2006; Sahoo, 2006; Sahoo and Dash, 2010; and 2011). More recently, increasing attention has also been paid to the impact of infrastructure on poverty and inequality (World Bank, 2006). Further, it has been found that social infrastructure such as education, health, and housing are essential to promote better utilization of physical infrastructure and human resources, thereby leading to higher economic growth and improving quality of life (Hall and Jones, 1999).

Over the past two decades, one of the defining features of China's growth has been investment led growth supported by domestic savings. China's sustained high economic growth and increased competitiveness has been underpinned by a massive development of physical infrastructure (Chatterjee, 2005; Stephane *et al*., 2007). The open economic policy made it possible for the inflow of foreign direct investment (FDI) mainly to the manufacturing sector. Cheap labour and better than adequate infrastructure were important pre-requisites that led to a successful the export-led growth strategy. With seemingly unlimited supply of cheap labour from the rural sector, public investment in infrastructure became the keystone in the strategy. A major focus by the government at all levels on infrastructure thus ensued.[1]

Though infrastructure development certainly helped export-led economic growth in China, the Chinese economy started showing signs of overheating in recent years because of basic infrastructure constraints. Clearly, there is an increasing gap between the potential demand and the available supply of infrastructure to sustain high growth. Given the importance of infrastructure development for sustainable economic growth and poverty reduction in China, the present study examines the output elasticity of infrastructure development in China for the period 1970-2008.[2] Unlike cross section or panel data studies on large number of countries where each country may not be a representative sample, the present study is country specific focusing on China.[3] This study extends previous literature in several dimensions: it encompasses different core infrastructure sectors, considers both the quantity and quality of infrastructure, and accounts for their potential endogeneity and spurious correlation due to non-stationarity

[1] Infrastructure development is one of the major determinants of FDI inflows, see Sahoo (2006).

[2] Our analysis is motivated by seminal work of Aschauer (1989) and Canning and Pedroni (2004) on the contribution of infrastructure development to the level and growth of aggregate output and productivity.

[3] There have been few studies examining different aspects of the role of infrastructure for economic growth at province level in case of China, however, there is no detailed study examining this issue at macro level (see the section- review of literature).

of the data. Further, previous literature on the growth effects of infrastructure has focused on one single infrastructure sector/indicators or public expenditure/ infrastructure investment as proxy for infrastructure[4] where as the present study develops a composite index of a stock of leading physical infrastructure indicators to examine the impact of infrastructure development on output growth. In addition to this, the present paper also provides the direction of causality between infrastructure and growth which is more relevant for policy implication.

Rest of the paper is structured as follows: In section 2, we briefly discuss infrastructure development in China. Section 3 presents review of literature. Section 4 deals with theoretical framework, construction of the Infrastructure Index and data sources. Section 5 analyses the empirical results. Finally, conclusions and policy implications are presented in section 6.

2. INFRASTRUCTURE IN CHINA

2.1. Macro-Economic Overview of China

Since 1978, China has pursued a policy of gradual transition from a centrally planned to a market-based economy coupled with an "open door" policy that has involved substantial liberalization of its international trade and investment regimes. This strategy has delivered sustained and high economic growth averaging about 10 per cent annually between 1978 to 2008. In recent years, the Chinese economy has been well placed with high capital formation; buoyant international trade, surplus in external sector and robust FDI inflows (see Table 1). The sustained economic growth in China is mainly driven by a continuous rise in domestic savings and gross domestic capital formation. China's savings and investment rates are 50% and 44 % of GDP respectively, highest among the developing countries. However, China's dependence on export-led growth has led to decline in its growth rate since 2008 due to in fall external demand owing to the global economic crisis.[5] However, unlike other WTO members, China in general resisted a protectionist response to the effects of the global economic crisis and maintained its long term strategy of opening up its economy to international trade and FDI. The Chinese government responded to the crisis with a large economic stimulus

[4] Public expenditure/infrastructure investment as proxy for infrastructure development may not be right given the lack of governance and poor outcomes of infrastructure investment in developing countries like China.

[5] In 2009, China's exports fell by 16 per cent and its imports fell by 11 percent, reflecting the high import intensity of its manufacturing export sector. Real GDP growth declined from 9.6 percent in 2008 to a year-on-year rate of 6.2 percent in the first quarter of 2009, the lowest rate in more than a decade. (TPR of WTO, China, 2009)

package designed to boost domestic demand by investing in infrastructure and public services to help sustain economic growth.

Table 1. Select Macro Economic Indicators (1990-2008)

	1990	1995	2000	2005	2008
GDP (at constant 2000 price US$ billion)	445	793	1198	1893	2603
GDP per capita (at constant 2000 price US$)	392	658	949	1452	1964
Gross capital Formation (as % of GDP)	36.1	41.9	35.1	44	44.4
Current account balance as % of GDP	3.4	0.2	1.7	7.2	9.8
Growth of exports of goods and services	5.2	6.4	30.6	21.2	-9.6
Growth of imports of goods and services	-16.1	7.5	24.5	11.2	-13.2
FDI, Net inflows (% of GDP)	1	4.9	3.2	3.5	3.4
Forex Reserves in Months of Imports	8.5	6.3	7.4	13.5	18.2
Total external debt (US$ billion)	55.3	118	146	284	378

Source: World Development Indicator, World Bank CD-ROM, 2009.

2.2. Infrastructure Development in China

Over the past two decades one of the defining features of China's growth has been investment led growth supported by domestic savings and foreign direct investment. It is not investment per se that has been driving the current boom, but the investment in infrastructure, which is around 14% of GDP, has played an important role (see Table 2). China's sustained high economic growth and increased competitiveness has been underpinned by a massive development of infrastructure, particularly in nineties.

Table 2. Infrastructure Spending in China (in percent of GDP)

	1998	2006
Power and Gas	2.3	3.6
Transport	2.4	5.2
Drinking Water	0.2	0.3
Irrigation	0.4	3.5
Telecom	0.4	0.8
Other rural infrastructure	-	1.0
Total Spending	5.7	14.4

Source: China Statistical Yearbook, various issues.

The bulk of infrastructure financing in China comes from three broad channels. These are direct budget investment from fiscal resources, borrowing and market based financing. Direct budget expenditures on urban infrastructure include spending at the central, provincial and local levels from fiscal resources. Because urban infrastructure is also a local (sub-provincial) responsibility, a vast majority of spending is done by local governments. A second source of direct public financing is off-budget fees. These fees are generally arbitrary fees levied on such items as construction permits and various authorizations for domestic and international business operations (see Table 3). Nonetheless, they provided a source of unrestricted local income that often was invested for infrastructure development. Third, the financing gap created by the decline in direct budgetary spending on infrastructure was filled in by borrowing and market based financing. Since most of the banks were state-owned, they were encouraged, as a national policy, to lend for infrastructure projects and urban infrastructure development.

However, financing of infrastructure in China from the state and central budget has been declining steadily as sub-national governments have gained more and more autonomy in the decision making process. Provincial and local governments have turned aggressively to alternate ways for raising resources to finance infrastructure development. As a result, the overwhelming proportion of resources for investment comes from the 'self raised and other funds' of local governments and other allied bodies. These funds comprising largely of a combination of enterprise retained earnings and extra budgetary revenues of different kinds, accounted for 75% of the total investment financing in 2006. The extent of private and foreign investment in infrastructure development has been very little. FDI inflows into infrastructure have been very modest -with the FDI accounting for less than 2% of the capital funds invested in infrastructure in 2006.[6]

Table 3. Sources of Investment financing (as a percent of total)

	1995	2006
State Budget Allocations	3	4
Domestic Loans	20	20
Self-Raised funds & Other	66	72
Foreign Funds	11	4
Total	100	100

Source: China Statistical Yearbook, 2007, and State Statistical Bureau, 1996.

Infrastructure service provision is currently dominated by government departments and state owned enterprises in developing countries like China and India. The reason for

[6] One of the reasons for limited private sector participation in the development of infrastructure is that the NDRC has retained centralized control on planning while decentralizing responsibility for building of infrastructure on local government. The high level of political risk and lack of certainty on tariff regulation has discouraged private infrastructure investment.

China's better performance is because of its ability to get reasonable returns, profitability, and implementation ability (Table 4). Unlike in India where bureaucracy operates in a framework that does not encourage risk-taking (Nataraj, 2007), Chinese state owned enterprises are actively encouraged to deliver results and take risks.[7] In China, the incentives between government and bureaucracy, and by extension, the management of state owned enterprises seem aligned - the politicization of the government machinery turns out to be a good thing and effective for delivering results.[8]

Table 4. Comparative Analysis of the Physical Indicators of Infrastructure

	China	India
Consumption per capita (KWh, 2006)	2041	503
Road Network ('000 kms), 2000-2006	3357	3316
Coastal Ports - Port Container Traffic (TEU), 2006	84686	6190
Civil Aviation: Registered carrier departures worldwide ('000), 2006	1543	454
Railways ('000 kms), 2000-2006	62.2	63.46

Source: China Statistical Yearbook, various issues, China Highway and Water Transport Statistics Yearbook, 2006.

When the East Asian countries were fighting economic crisis in 1997/98, the Chinese government implemented a fiscal stimulus program under which the Central Government provided transfers to local governments and introduced the issuance of state debt to fund infrastructure. This is also in sharp contrast to other East Asian countries where investment infrastructure fell sharply in the aftermath of the Asian Crisis. Infrastructure led fixed capital formation more than doubled from 5.7% of GDP in 1998 to over 14% in 2006, and the share of infrastructure in total investment ballooned to almost one-third of gross capital formation in 2006. The emergence of China as the world factory would not be possible without a range of new economic infrastructure services in place.

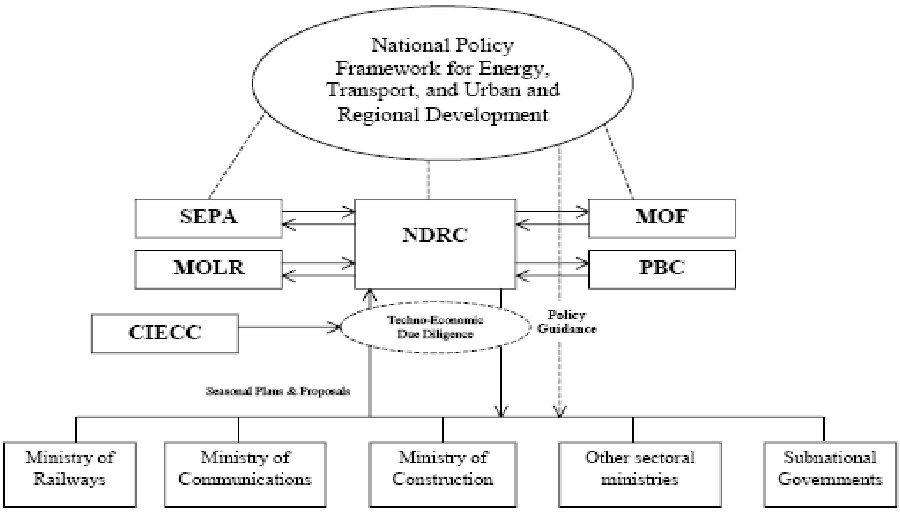
There are a number of players in the infrastructure policy making and planning processes at the central level. The organizational structure for infrastructure development in China is very systematic and dynamic (see Fig. 1). The planning system for infrastructure development consists of socioeconomic planning and sectoral planning at all levels of government, and urban planning at the municipal level. The time frames

[7] Further, governments in a representative democracy like India are subject to huge populist pressures often leading to overstaffing or becoming vehicles for political patronage rather than effective suppliers.

[8] While in India, the relationship between the government and the bureaucracy seems more contentious. The politicization of the bureaucracy is a corrosive phenomenon that undermines professionalism and performance.

for socioeconomic and sectoral plans include long-term, medium-term (i.e., five-year) and annual plans. Urban master plan usually covers a time span of 20 years. The National Development and Reform Commission (NDRC, formerly National Planning Commission) are at the core of the planning machinery and formulate economic development strategies, five-year plans and annual plans. It organizes and coordinates the implementation of plans for infrastructure development across states.[9]

Overall, China has been successful in developing its infrastructure to improve the competitiveness of its economy in general, particularly in the manufacturing sector and attract huge foreign direct investment. In this backdrop, it would be useful to examine the contribution of infrastructure development and the role of public and private investment in infrastructure to economic growth in China.



Source: Planning and Policy Coordination in China's Infrastructure Development

Figure 1. Institutional Setup for Planning at the Central Level

[9] This leadership role in implementation is needed, because the actual implementation functions rest with a number of line ministries and lower level governments and because of the sheer size of China, its institutions pose high risk and things could easily go out of control. In addition to its planning and implementation role, NDRC is part of the top policy making mechanism. Along with the Development Research Center of the State Council, NDRC serves as one of the primary think tanks on development policy issues for the CPC and the State Council. At the same time, it carries out its planning and policy coordination functions under the national policy framework set up by the CPC.

3. BRIEF REVIEW OF LITERATURE

The empirical research on role of infrastructure in economic growth started after the seminal work by Aschauer (1989) where he argued that public expenditure is most productive, and the slowdown of the U.S productivity was related to the decrease in public infrastructure investment. Day (1991) develops a theoretical model to show that improvement in infrastructure to population leads to growth and moderate economic instability. Subsequently, Munnell (1990), Garcia-Mila and McGuire (1992), Uchimura and Gao (1993), found high output elasticity of public infrastructure investment though comparatively lower than Aschauer. Criticizing these earlier studies, there has been a flurry of empirical tests on the link between infrastructure and economic growth using variety of data, empirical methods and infrastructure measures (both quantity and quality) and controlling other variables affecting growth.[10] For example, Sturm *et al.* (1998) show that the literature contained a relatively wide range of estimates of output elasticity of public investment in infrastructure viz., with a marginal product of public capital that is much higher than that of private capital (Aschauer, 1989; Khan and Reinhart, 1990); roughly equal to that of private capital (Munnell, 1990); well below that of private capital (Eberts, 1986); and negative contribution of public investment (Hulten and Schwab, 1991; Deverajan, Swaroop and Zou, 1996; and Prichett, 1996). Similarly, Hulten (1997) and Canning and Pedroni (2004) show that optimal and efficient use of infrastructure is important for growth. Rioja (2001) has developed a general equilibrium model of a small open economy to study the effects of public infrastructure on output, private investment and welfare for three Latin American countries: Brazil, Mexico, and Peru. Results show that infrastructure can have positive effects on output, private investment and welfare. However, raising public infrastructure investment past a certain threshold can be detrimental. In a recent study, Pereira and Pihno (2011) examine the impact of public investment on long-term output for the period 1980-2003 for 12 European countries. The results reveal that productive public investment has strong positive effect on growth for eight of the twelve euro area countries. The industry specific and country specific study by Pereeira and Andraz (2007), finds that public investment has a positive effect on both private inputs as well as on private output and that it affects labor productivity positively u for eighteen industries in the Portuguese economy. The wide range of estimates makes the results of these studies almost irrelevant from a policy perspective (see Table 5). However, the study by Romp and De Haan (2007) summarizes earlier studies and suggests that public capital may, under specific circumstances, raise income per capita in general. However, most of the studies find positive long-run effect of infrastructure on output, productivity, or their growth rate using physical indicators of infrastructure stocks, but results are mixed or even

[10] Infrastructure development is measured in terms of physical stocks, spending flows, or capital stocks constructed accumulating the latter.

negative among the growth studies using measures of public capital stocks or infrastructure spending flows (Straub, 2007). There are also studies like by Bose and Haque (2005) which evaluates the direction of causality between public investment in the transport and communication sector and economic growth for a set of 32 developing countries. The analysis suggests one way feedback from growth to investment in the transport and communication sector and not vice-versa. Further, However, Huang (2006) shows that public expenditure including investment in infrastructure always does not lead to economic growth.

Table 5. Estimates of Output Elasticity of Infrastructure Indicators

Country/Region	Author	OEI*	Infrastructure Measure
USA	Aschauer (1989)	0.39	Public Capital
USA	Munnell (1990)	0.34	Public Capital
Mexico	Shah (1992)	0.05	Transport, Water and com.
Taiwan	Uchimura and Gao (1993)	0.24	Transport, Water and com.
Korea	Uchimura and Gao (1993)	0.19	Transport, Water and com.
DCs	Easterly and Rabelo (1993)	0.16	Transport and communication
USA	Gracia Milla *et al.* (1996)	0	Public Capital
LDCs	Devarajan *et al.* (1996)	negative	Transport and communication
Canada	Wylie (1996)	0.31	Public Capital
Cross Country	Canning (2004)	-0.23 to 0.22	Road, Telephone, and Electricity
Cross country	Calderón & Servén (2003)	0.16	Transportation, Communication
Cross country	Esfahani and Ramíres (2003)	0.12	Power and Telephones
South Africa	Fedderke, Perkins and Luiz (2006)	-0.06 to 0.20	Physical capital stock
India	Sahoo and Dash (2009)	0.24 to 0.35	Physical capital stock
South Asia	Sahoo and Dash (2011)	0.18 to 0.22	Physical capital stock

Note: * OEI implies Output Elasticity of Infrastructure.

Source: Authors' compilation.

Studies on the role of infrastructure in China's success story are few and most of them are at state level using panel data analysis. Démurger (2001) examines the role of infrastructure in growth performance across 24 provinces in China and concludes that infrastructure endowment along with reforms openness and geographical location account significantly for observed differences in growth performance across provinces. Further, the results reveal that transport facilities are a key differentiating factor in explaining the growth gap. Similarly, Jalan and Ravallion (2002) find that increase in road density has a significant positive effect on the consumption expenditure of rural farm households in poor regions of China. Fan and Chan-Kang (2004) estimated the effect of quality of roads on growth and poverty reduction in China by using provincial-level data for 1982-1999. Contrary to usual findings, the study finds that the impact of investment in lower quality roads is 4 times higher than that of high quality roads both in rural and urban areas. On the other hand, Ding and Haynes (2004) find a positive and statistically significant impact of telecommunications infrastructure (both fixed and mobile) on regional economic growth in China for the period 1986-2002. The results are robust even after controlling for investment, population growth, initial levels of GDP per capita, and lagged growth. Further, Shiu and Lam (2003) found that real GDP and electricity consumption for China have long term equilibrium relations and there is unidirectional Granger causality running from electricity consumption to real GDP.

On the issue of human capital, studies by Mankiw, Romer, and Weil (1992) and Barro (1991) have shown that accumulation of human capital improves economic growth through many channels and externalities. Lucas (1988) was one of the first authors that considered human capital as an alternative to technological process to improve growth. Social infrastructure such as education, health, and housing is essential to promote better utilization of physical infrastructure and human resources, thereby leading to higher economic growth and improving quality of life (Hall and Jones, 1999).

Overall, the brief review suggests that the effect of public capital or infrastructure differs across countries, regions, and sectors depending upon quantity and quality of the capital stock and infrastructure development. A further source of variation is the theoretical framework used in the analysis. In this context, we examine the contribution of infrastructure and human capital to economic growth in China at macro level.

4. THEORETICAL FRAMEWORK, INFRASTRUCTURE INDEX AND DATA SOURCES

Existing empirical studies on the contribution of infrastructure to economic growth are essentially based on the production function framework and closely related to a literature concerned with the macroeconomic role of productive public expenditure. Arrow and Kurz (1970) were the first to provide a formal analysis of the effects of public capital on output. Assuming a generalized Cobb-Douglas production and extending the neoclassical growth model to include infrastructure stock/public capital as an additional input of the production function along with private capital and labour, the production function is written as follows:

$$Y_t = t(K_t(pvt/pub), LF_t, I_t), \tag{1}$$

where Y_t is real gross output produced in an economy using inputs such as private and public capital $(K_t(pvt/pub))$, labour force (LF_t) and supporting infrastructure stock (I_t). This generalised form of (Eq. 1) is open to the possibility of constant returns to scale as suggested by Solow-type models (Solow, 1956). On the other hand, the model also admits the possibility of constant or increasing returns to capital-in this case disaggregated into private and public capital-as suggested by some endogenous growth theorists (Romer, 1987). The possibility of a long-run impact of infrastructure on income depends on whether the data are generated by a neoclassical growth model or an endogenous growth model. In the exogenous growth model wherein technical progress drives long-run growth, shocks to the infrastructure stock can only have transitory effects. However, shocks to infrastructure can raise the steady-state income per capita in an endogenous growth model. Besides, social capital and human capital are also important for economic growth (Lucass, 1988; Barro, 1991).[11] Higher public expenditure on social infrastructure induces more literacy, better health and manpower skill, which leads to higher productivity and growth. In order to assess the impact of human capital on growth, we consider public expenditure on health and education.[12] Finally, we estimate the following equations to empirically examine the impact of infrastructure stock on output in China,

$$LnGDP_t = \alpha_i + \delta_i t + \beta_1 \ln K_t (pvt / pub) + \beta_2 \ln LF_t + \beta_3 \ln Index_t + \beta_4 \ln HE_t + e_t \text{ ,(2)}$$

where GDP is gross domestic product, $Kpvt_t$ is domestic private investment; $Kpub_t$ is domestic public investment; LF_t is total labour force; $Index_t$ is infrastructure index and HE_t is per capita expenditure on health and education. The expected sign of (β_1, β_2, β_3, and β_4) is > 0.

Infrastructure Index

Measuring infrastructure development is critical since infrastructure development is a multi-dimensional concept, comprising many services that range from communication to health services. But most of the empirical studies that examine the impact of infrastructure on growth use variety of definitions of infrastructure development such as public investment/expenditure or some indicators of physical infrastructure. However, it is important to mention here that omitting important indicators of infrastructure is likely to lead to invalid inferences owing to omitted variable biases. To overcome this problem, we develop a composite index of major infrastructure indicators to examine the impact of infrastructure development on growth. Principal Component Analysis (PCA) is used to create the infrastructure index by taking six major infrastructure indicators such as (1) Per capita Electricity Power consumption; (2) Per capita Energy use (kg of oil

[11] Mankiw, Romer and Weil (1992) state that: "particularly for the developing countries, investment in human capital also becomes more quantitatively important when a more open trading environment and a better public infrastructure are in place."

[12] Since it is difficult to get compatible and reliable time series data on social indicators, we have considered public expenditure on health and education.

equivalent); (3) Telephone line (both fixed and mobiles) per 1000 population; (4) Rail Density per 1000 Population; (5) Air Transport, freight million tons per kilometer; and (6) Paved road as percentage of total road. Therefore, our infrastructure index is mixed of both quality and quantity.

The Eigen values and respective variance of these factors are as given in Table 6. The first factor or principal component has an Eigen value larger than one and explains over two thirds of the total variance. There is a large difference between the Eigen values and variance explained by the first and the next principal component. Hence, we choose the first principal component for making composite index representing the combined variance of different aspects of infrastructure captured by the six variables. The factor loadings for each of the five original variables are given in Table 7.

Table 6. Eigen values and Variance Explained by Principal Components

Principal Components	Eigen Values	% of Variance	Cumulative Variance
1	4.936	0.836	0.869
2	0.915	0.146	0.958
3	0.110	0.036	0.995
4	0.019	0.003	0.998
5	0.012	0.001	0.999
6	0.002	0.0003	1.00

Table 7. Factor Loadings of Original Values

Infrastructure Variables	Factor Loadings
Electricity Power consumption (per capita)	0.442
Energy use (kg of oil equivalent per capita)	0.439
Telephone Density	0.391
Rail Density (Population)	0.445
Air Transport, freight	0.430
Paved road as % of total road	0.277

Data Source

Annual data on Gross Domestic Product, public expenditure on health and education, infant mortality rate, and total labour force are taken from World Development Indicators CD-ROM, World Bank, 2009. Data on Private and public investment are taken from International Financial Corporation (IFC). These variables have been taken in real terms by dividing GDP deflator (base 1999-2000=100). Labour force is taken according to the ILO definition of the economically active population that includes both the employed and the unemployed. Six Infrastructure variables used for constructing infrastructure index are compiled from various issues of World Development Indicators. The study period is 1975-2007.

5. ECONOMETRIC ANALYSIS

The empirical research evaluating the impact of infrastructure on output growth always comes across the problem of endogeneity. It has been debatable whether infrastructure development leads to increase in productivity, competitiveness and thereby output growth or output growth necessitates overall infrastructure development. Given this reverse causality and possibility of more than one endogenous variable, we use[13] Autoregressive-distributed lag model (ARDL) developed by Pesaran *et al*. (2001) and Generalised Methods of Moments (GMM) developed by Hansen (1982). The error correction version of the ARDL model of Eq. (2) is formulated as follows:

$$\begin{aligned}\Delta \ln GDP_t = \alpha_0 &+ \sum_{i=1}^{p} \beta_{1i} \Delta \ln GDP_{t-i} + \sum_{i=1}^{p} \beta_{2i} \Delta \ln LF_{t-i} + \sum_{i=1}^{p} \beta_{3i} \Delta \ln Kpvt_{t-i} \\ &+ \sum_{i=1}^{p} \beta_{4i} \Delta \ln Kpub_t + \sum_{i=1}^{p} \beta_{5i} \Delta \ln Index_{t-i} + \sum_{i=1}^{p} \beta_{6i} \Delta \ln HE_{t-i} \\ &+ \beta_{7i} \ln GDP_{t-i} + \beta_8 \ln Kpvt_{t-i} + \beta_8 \ln Kpub_{t-i} + \beta_9 \ln LF_{t-i} \\ &+ \beta_{10} \ln Index_{t-i} + \beta_{11} \ln HE_{t-i} + u_t .\end{aligned} \tag{3}$$

The existence of the long run relationship is confirmed with the help of an F-test that tests for existence of cointegration. The null hypothesis (H_0) in the equation is $\beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = 0$, which means the non-existence of the long run relationship. The ARDL approach compute two sets of critical values for a given significance level. One set assumes that all variables are I(0) and the other set assumes they are all I(1). If the computed F-statistic exceeds the upper critical bounds value, then the H0 (null hypothesis) is rejected. If the F-statistic falls into the bounds, then the test becomes inconclusive.

Granger Causality: The Vector Error Correction (VECM) Procedure

Our next step is to ascertain the direction of causality between infrastructure development and output. If all the variables are found to be integrated of order one, vector error correction procedure can be used to see the direction of causality between

[13] We have not given ARDL and GMM in details as these methodologies have been well established by now. However, we can produce detail methodology section if requested.

output and infrastructure development in China. The general model for Granger causality for I(1) (see Engle and Granger, 1987) variables are given as:

$$\Delta Y_t = \lambda + \sum_{i=1}^{p-1} \alpha_i \Delta Y_{t-i} + \sum_{j=1}^{p-1} \beta_j \Delta X_{t-j} + \Theta(Y - \kappa X)_{t-1} + U_t, \quad (4)$$

$$\Delta X_t = \tau + \sum_{i=1}^{p-1} \gamma_i \Delta Y_{t-i} + \sum_{j=1}^{p-1} \delta_j \Delta X_{t-j} + \Phi(Y - \kappa X)_{t-1} + U_t, \quad (5)$$

where the lagged ECM term $(Y - \kappa X)_{t-1}$ are the lagged residuals from the co-integrating relation between *Y* and *X*. As Engle and Granger (1987) have argued, failure to include the ECM term will lead to mis-specified models which can lead to erroneous conclusions about the direction of causality. Thus, if Y_t and X_t are I(1) and cointegrated, Granger causality tests can be carried out using (4) and (5). However, there are now two sources of causation of Y_t by X_t, either through the lagged dynamic terms ΔX_t if all the β_i are not equal to zero, or through the lagged ECM term if θ is non-zero (the latter is also the test of weak exogeneity of *Y*). Similarly, X_t is Granger caused by Y_t either through the lagged dynamic terms ΔX_t if all the γ_i are not equal to zero, or through the lagged ECM term if Φ is non-zero.

6. EMPIRICAL RESULTS

The augmented Dickey-Fuller test is used to test for the existence of unit roots and determine the order of integration of the variables. As reported in Table 8, all variables are non-stationary in levels but stationary at first difference[14] [integrated of order one, or I(1)]. Since all variables are integrated of same order [I(1)], next we use autoregressive-distributed lag ARDL method developed by Pesaran *et al*. (2001) to find out long-run relationship among the relevant variables. The results reveal that F-statistic ($F = 9.43$) exceeds the upper bound critical value (4.35) at the 5% levels[15] establishing long-run relationship between GDP and other relevant variables. Similarly,

[14] We also use Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests for stationarity and results reveal that all variables are I(1). Results are available on request.

[15] The relevant critical value bounds are obtained from Table C1.iii (with an unrestricted intercept and no trend; with three regressors) in Pesaran *et al*. (2001). They are 2.72-3.77 at 90%, and 3.23- 4.35 at 95%. ** denotes above the 95% upper bound. The order of ARDL (2, 0, 2, 0, 1) is selected on the basis of Akike Information Criteria (AIC).

the null of no cointegration is rejected ($F = 5.87$) when infrastructure index is selected as the dependent variable. Thus, the null of non-existence of stable long-run relationship is rejected.

Table 8. ADF Unit root Test

Variables	Level		First Difference	Result
	Without Trend	With Trend	Without Trend	
LnGDP	0.34	-1.94	-4.01*	I(1)
LnLF	-2.11	-2.54	-6.78*	I(1)
LnGDIpvt	-1.54	-2.51	-3.54*	I(1)
LnGDIpub	0.54	-1.98	-4.07*	I(1)
LnIndex	1.34	-1.38	-3.57*	I(1)
LnHE	-0.98	-2.05	-3.12**	I(1)

Notes: * and ** represent statistical significance at the 1 percent and 5 percent level, respectively. AIC criterion is used to choose the optimal lag length.

Next we proceed to estimate long-run elasticites by using ARDL and GMM procedures. Various specifications of Equation (2) were estimated using annual data for China during 1975-2007 and reported in Table 9. The GMM estimator is based on the assumption that the error terms are not serially correlated and that the explanatory variables are weakly exogenous or not correlated with future realisations of the error terms under which the following moment condition holds:

$$E[y_{t-s}.(e_t - e_{t-1})] = 0\,; \quad E[x_{t-s}.(e_t - e_{t-1})] = 0\,; \text{ for } \; s \geq 2; t = 3,...,T\,,$$

where y_t is dependent variable, x_t is explanatory variables, e error term and s is number of lags of explanatory variables considered as instruments (see Equation (2)). To deal with endogeneity, we need suitable instruments. However, empirical researchers find it difficult to find a good instrumental variable for an endogenous explanatory variable. Apart from internal instruments (lags of explanatory variables), infant mortality rate is also considered as an instrument and exogenous variable. The test for strength of instruments has been conducted to ensure the robustness of coefficients.

It is clear that all the coefficients show the expected sign and are statistically significant. First we started with the estimation of Equation (2) without infrastructure index (Column 1 of Table 9). Then we substituted public investment with infrastructure index (Column 2). Finally, we estimated Equation (2) with all the variables as specified in Equation (2) to test whether this has any different implications. It can be seen that the various equations have a relatively high degree of explanatory power as measured by their adjusted coefficients of determination, and more importantly, the DW-statistics suggest that serial correlation is not a problem in the sample data.

Table 9. Long-run Coefficients (Dependent log of Real GDP)

Variables	Long-run Coefficients (ARDL)			Long-run Coefficients (GMM)		
	1	2	3	4	5	6
Constant	0.46	0.67	2.34*	-3.22**	-3.18	-2.06
	(1.12)	(1.21)	(2.43)	(-4.64)	(-1.08)	(-1.51)
LnIndex	-	0.33**	0.28**	-	0.36**	0.34*
		(2.92)	(3.15)		(2.92)	(2.63)
LnKpvt	0.17*	0.20*	0.15*	0.21*	0.17*	0.16*
	(2.54)	(2.21)	(2.10)	(2.34)	(2.11)	(2.47)
LnKpub	0.21*	-	0.18*	0.19*		0.17**
	(2.73)		(2.28)	(2.66)		(2.95)
LnHE	0.39**	0.54**	0.48**	0.62**	0.53**	0.41**
	(3.20)	(6.44)	(3.98)	(6.81)	(4.48)	(3.06)
LnLF	0.34	0.45	0.79	1.31	1.51	1.14
	(1.38)	(0.92)	(1.15)	(1.34)	(1.58)	(1.20)
Order of ARDL	ARDL	ARDL	ARDL			
(AIC)	(2,0,1,0,1)	(2,0,1,1,0)	(1,0,2,1,2,0)			
Adj.R^2				0.85	0.89	0.94
D-W stat.				1.44	1.76	1.62
F-stat. at first stage				45.67	43.23	49.3
P-value				(0.00)	(0.00)	(0.00)
Hansen J stat.				0.15	0.11	0.06
P-value				(0.77)	(0.85)	(0.99)

Notes: ** and * denotes significance at the 1 and 5 percent level respectively. The optimal lag length of ARDL coefficients are selected by using AIC. Instruments list for GMM estimation: Index (-1), LF (-1), HE (-2), Kpvt (-2) and Infant Mortality rate (-1).

First, we present ARDL result of estimation of long-run coefficients of individual variables.[16] In particular, we are interested in whether innovations to infrastructure stocks have a long run effect on GDP. As noted earlier, our strategy involves estimation of an infrastructure-augmented income regression. As expected, the coefficients of private investment, public investment, expenditure on health and education are positive and significant, indicating statistically significant positive impact on GDP. The long-run elasticity of both private investment and public investment varies between 0.15 to 0.21. More importantly, the coefficient of infrastructure varies between 0.28-0.33. However,

[16] Diagnostic tests are checked to ensure that it is the best model and there is no misspecification bias in the model. The diagnostic tests include: the test of serial autocorrelation (LM), heteroscedasticity (ARCH test), omitted variables/functional form (Ramsey Reset).

the elasticity of infrastructure index is higher than total private investment and public investment which is discussed later in the paper. The coefficient of expenditure on health and education is around 0.60 which is higher than elasticity of infrastructure index. We also estimated Equation (2) using GMM estimation procedure. The estimated long-run coefficients of variables by GMM methodology indicate a significant positive contribution of infrastructure development to growth along with private investment and human capital. The long-run elasticity of both private investment and public investment are not very different from ARDL estimation. Therefore, it is clear from these results that the output elasticity of infrastructure varies between 0.28-0.36 percent for China.

As mentioned earlier the magnitude of output elasticity of infrastructure is higher than output elasticity of private investment or public investment. This is because all components of public investment or private investment are not expected to affect long-run economic growth in the same way. Some of them are or may be unproductive (Khan and Kumar, 1997; Al-Faris, 2002). In other words, investment in physical capital for instance is far more important for macroeconomic performance than public or private consumption. Apart from the direct multiplier effect, resulting from all types of government expenditure, public infrastructure is an important input in the private sector production process, affecting both output and productivity. They not only enlarge the capital stock of a nation but also enable a more efficient use of the existing stock (Munnell, 1990).

Overall, the results reveal that (i) Infrastructure development in China has significant positive contribution to growth; (ii) human capital such as expenditure on health and education contributes substantially to economic growth. The long-run elasticity of individual infrastructure indicators varies between 0.09 to 0.16. Infrastructure facilities such as energy use, electricity power consumption, rail and air transport are the most important infrastructure having maximum contribution to growth (see Table 10). Our results are comparable to findings of (Easterly and Rabelo, 1993; Calderón & Servén, 2003; Esfahani and Ramíres, 2003; Kamps, 2006).

Table 10. Long-run Elasticities of Individual Infrastructure Indicators

Infrastructure Indicators	ARDL 2	GMM 5
Electricity Power consumption (per capita)	0.15	0.16
Energy use (kg of oil equivalent per capita)	0.15	0.16
Telephone Density	0.13	0.14
Rail Density (Population)	0.15	0.16
Air Transport, freight	0.14	0.16
Paved road as % of total road	0.09	0.10

Notes: The long run coefficients of the individual infrastructure indicators are calculated by multiplying the infrastructure index coefficient in specification 2 of ARDL and 2 of GMM estimations with the factor loading of the individual infrastructure indicator.

Since the problem of reverse causality is discussed in the empirical literature extensively, we look at the direction of feedback between infrastructure index, private investment and real GDP by using VECM procedure, given that we have only 33 observations. The results are reported in Table 11. The first section of the table, with $\Delta \ln GDP$ (or growth of real output) as the dependent variable tests the null hypothesis that growth of GDP is not caused by lags of $\Delta \ln Index$ (growth of infrastructure index) in the short run or by the ECM term which tests long run causality. Both the coefficients of lags of $\Delta \ln Index$ and the lagged ECM term are significant at the 5 percent level rejecting the null of no Granger causality from infrastructure to output. On the other hand, both short-run coefficients ($\Delta \ln GDP$) or of the lagged ECM term is not significant establishing no causality from GDP to infrastructure development (index). Therefore, we conclude that there exists one-way causality from infrastructure stocks to GDP. Similarly, results also indicate that there exists two-way causality (mostly through laggard ECM terms) between GDP and private investment. Therefore, the implication of this result is that infrastructure development has led to economic growth in China. On the other hand higher investment leads to higher output and higher output in turn leads to higher investment.

Table 11. Causality between Real GDP, Infrastructure and Private Investment

Causality between GDP and Infrastructure			
Dependent Variable	$\sum_{j=1}^{p} \ln\Delta Index_{t-j}$	$\sum_{j=1}^{p} \ln\Delta GDP_{t-j}$	Lagged ECM term
	$\sum \beta_i = 0$: F-stat (p-value)	$\sum \beta_i = 0$: F-stat (p-value)	$\Theta = 0$: t-stat (p-value)
$\Delta \ln GDP$	4.32* (0.045)	-	-2.55* (0.03)
$\Delta \ln Index$		0.78 (0.57)	0.42 (0.76)
Causality between GDP and Private Investment			
	$\sum_{j=1}^{p} \ln\Delta GDIpvt_{t-j}$	$\sum_{j=1}^{p} \ln\Delta GDP_{t-j}$	Lagged ECM term
$\Delta \ln GDP$	0.98 (0.43)	-	-2.47* (0.034)
$\Delta \ln GDIpvt$		1.45 (0.27)	-3.32** (0.00)

Notes: ** denotes significance a 1 per cent level, * denotes significance a 5 per cent level. Optimal lag is selected on the basis of Akaike Information Criterion (AIC).

To examine further the role of infrastructure in economic growth, we have also analysed the dynamic relationship among these variables within the vector auto regression (VAR) framework by conducting variance decompositions tests for the forecast errors at different time horizons. The results are presented in Table 12. The results show that the variance of growth of GDP is largely explained by its own shock (41 percent for time horizon of 10 years) and infrastructure growth (34 percent). Remaining 24 percent is explained by growth of private investment. Therefore, the forecast errors variance decompositions analysis corroborates the previous causality analysis.

Table 12. Decomposition of Ten-year Forecast Error Variance (%)

Percent of Forecast Error Variance in (years)	Growth of GDP	Growth in Infrastructure	Growth of Private Investment
1	100.00	0.00	0.00
2	70.15	17.10	12.75
4	52.07	19.00	28.93
4	49.23	27.48	23.29
5	50.90	24.20	24.90
6	49.95	28.34	21.71
7	48.25	27.47	24.28
8	46.28	28.19	25.53
9	45.25	32.17	22.58
10	41.35	34.30	24.35

Note: Order of the VAR is 2 selected on the basis of AIC criteria.

7. CONCLUDING REMARKS AND POLICY IMPLICATIONS

In this study, we investigate the role of infrastructure in promoting economic growth in China after controlling for other important variables such as investment (both private and public), labour force, and human capital for the period 1975 to 2007. Overall, the results reveal that investment, infrastructure stock, and human capital play an important role in economic growth in China. Further, the causality analysis shows that there is unidirectional causality from infrastructure development to output growth and bi-directional causality between output and public investment.

From a policy perspective, the study suggests that infrastructure development contributes positively to economic growth in China. In this context, China's aggressive investment (around 15% of GDP) on infrastructure is justified to sustain growth and minimise the impact of global financial crisis. The contribution of investment to growth reflects the investment-led growth strategy followed by China. Most importantly the investment in human capital (health and education) is most crucial for growth in China. The results in case of China suggest that it is necessary to design an economic policy that improves the human capital formation as well as physical infrastructure for sustainable economic growth in developing countries. The results justify why China has been heavily spending on infrastructure (both physical and social infrastructure) development since early nineties.

REFERENCES

Al-Faris, A.F. (2002), “Public Expenditure and Economic Growth in the Gulf Cooperation Council Countries,” *Applied Economics*, 34(9), 1187-1195.

Arrow, K., and M. Kurz (1970), *Public Investment: The Rate of Return and Optimal Fiscal Policy*, Johns Hopkins.

Aschauer, D.A. (1989), “Is Public Expenditure Productive?” *Journal of Monetary Economics*, 23, 177-200.

Barro, R. (1991), “Economic Growth in a Cross Section of Countries,” *Quarterly Journal of Economics*, 106, 407-443.

Bose, N., and M.E. Haque (2005), “Causality between Public Investment in Transport and Communication and Economic Growth,” *Journal of Economic Development*, 30(1), 95-106.

Calderón, C., and L. Servén (2003), “The Output Cost of Latin America’s Infrastructure Gap,” in Easterly, W., and L. Servén, ed., *The Limits of Stabilization: Infrastructure, Public Deficits, and Growth in Latin America*, Stanford University Press.

Canning, D., and P. Pedroni (2004), *The Effect of Infrastructure on Long-Run Economic Growth*, mimeo, Harvard University.

Chatterjee, S. (2005), “Poverty Reduction Strategies: Lessons from the Asian and Pacific Region on Inclusive Development,” *Asian Development Review*, 22, 12-44.

Dash, R.K., and P. Sahoo (2010), “Economic Growth in India: Role of Physical and Human Infrastructure,” *Journal of Economic Policy Reforms*, 13(4), 409-420.

Day, H.R. (1991), “Infrastructure, External Diseconomies and Turbulent Economic Growth,” *Journal of Economic Development*, 16(2), 7-23.

Demurger, S. (2001), “Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China**?**” *Journal of Comparative Economics*, 29(1), 95-117.

Devarajan, S., V. Swaroop, and H.F. Zou (1996), “The Composition of Public Expenditure and Economic Growth,” *Journal of Monetary Economics*, 37, 313-344.

Ding L., and K.E. Haynes (2006), “The Role of Infrastructure in Regional Economic Growth: The Case of Telecommunications in China,” *Australasian Journal of Regional Studies*, 12(3), 165-187.

Easterly, W., and S. Rebelo (1993), “Fiscal Policy and Economic Growth,” *Journal of Monetary Economics*, 32, 417-458.

Eberts, R.W. (1986), “Estimating the Contribution of Urban Public Infrastructure to Regional Growth,” Federal Reserve Bank of Cleveland, Working Paper, 8610.

Engle, R.F., and C.W.J. Granger (1987), “Cointegration and Error Correction:

Representation, Estimation and Testing," *Econometrica*, 55, 251-276.

Esfahani, H.S., and M.T. Ramirez (2003), "Institutions, Infrastructure and Economic Growth," *Journal of Development Economics*, 70, 443-477.

Estache, A. (2006), *Infrastructure: A Survey of Recent and Upcoming Issues*, The World Bank, Washington D.C.

Fan, S., and C. Kang-Chan (2004), *Road Development, Economic Growth and Poverty Reduction in China*, International Food Policy Research Institute, mimeo.

Fernald, J. (1999), "Assessing the Link between Public Capital and Productivity," *American Economic Review*, 89, 619-638.

Garcia-Mila, T., T.J. McGuire, and R.H. Porter (1996), "The Effect of Public Capital in State Level Production Functions Reconsidered," *Review of Economics and Statistics*, 78, 177-180.

Global Competitiveness Report (Various Years), *World Economic Forum*, Switzerland.

Gramlich, E. (1994), "Infrastructure Investment: A Review Essay," *Journal of Economic Literature*, 32, 1176-1196.

Hansen, L.P. (1982), "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica*, 50, 1029-1054.

Huang, C. (2006), "Government Expenditures in China and Taiwan: Do They follow Wagner's Law?" *Journal of Economic Development*, 31(2), 139-148.

Holtz-Eakin, Douglas, and A.E. Schwartz (1995), "Infrastructure in a Structural Model of Economic Growth," *Regional Science and Urban Economics*, 25, 131-151.

Hulten, C.R. (1997), "Infrastructure Capital & Economic Growth: How Well You Use It Maybe Muchmore Important Than How Much You Have," NBER Working Paper, 5847, National Bureau of Economic Research, USA.

Hulten, C.R., and R.M. Schwab (1991), *Is There Too Little Public Capital?: Infrastructure and Economic Growth*, American Enterprise Institute for Public Policy Research.

Jalan, J., and M. Ravallion (2002), "Geographic Poverty Traps? A Micro Model of Consumption Growth in Rural China," *Journal of Applied Econometrics*, 17(4), 329-346.

Jones, S. (2004), *Background Paper: Contribution of Infrastructure to Growth and Poverty Reduction in East Asia and the Pacific*, Oxford Policy Management.

_____ (2006), "Infrastructure Challenges in East and South Asia, Promoting Growth, Ending Poverty," *IDS Bulletin*, 37, 28-44.

Kamps, C. (2006), "New Estimates of Government Net Capital Stocks for 22 OECD Countries 1960-2001," IMF Working Paper, 04/67.

Khan, M.S., and M.S. Kumar (1997), "Public and Private Investment and The Growth Process in Developing Countries," *Oxford Bulletin of Economics and Statistics*, 59(1), 69-88.

Liu, Z. (2005), "Planning and Policy Coordination in China's Infrastructure Development," a background paper prepared for East Asia and Pacific Infrastructure Flagship Study Commissioned by ADB-JBIC-Worldbank, World Bank, Washington

D.C., USA.

Lucas, R. (1988), "On the Mechanics of Economic Development," *Journal of Monetary Economics*, 22, 3-42.

Mankiw, N., D.R. Gregory, and D. Weil (1992), "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, 107(2), 407-438.

Munnell, A.H. (1990), "Why has Productivity Growth Declined? Productivity and Public Investment," *New England Economic Review*, Federal Reserve Bank of Boston, 3-22.

_____ (1992), "Infrastructure Investment and Economic Growth," *Journal of Economic Perspectives*, 6, 189-198.

Nataraj, G. (2007), "Infrastructure Challenges in South Asia: The Role of Public-Private Partnerships," ADBI Discussion Paper, 80, Tokyo.

Pereira, A.M., and J.M. Andraz (2007), "Public Investment in Transportation Infrastructures and Industry Performance in Portugal," *Journal of Economic Development*, 32(1), 1-20.

Pereira, A.M., and M.F. Pinho (2011), "Public Investment, Economic Performance and Budgetary Consolidation: Var Evidence for The first 12 Euro Countries," *Journal of Economic Development*, 36(1), 1-20.

Pesaran, M.H., and Y. Shin (1998), "An Autoregressive Distributed Lag Modeling Approach to Cointegration Analysis," in S. Strom, eds., *The Econometrics and Economic Theory in the 20th Century*, Cambridge, Cambridge University Press.

Pesaran, M.H., Y. Shin, and R.J. Smith (2001), "Bounds Testing Approaches to the Analysis of Level Relationships," *Journal of Applied Econometrics*, 16**,** 289-326.

Pritchett, L. (1996), "Mind Your P's and Q's," World Bank Policy Research Paper, 1660, Washington D.C.: The World Bank.

Rioja, F.K. (2001), "Growth, Welfare, and Public Infrastructure: A General Equilibrium Analysis of Latin American Economies," *Journal of Economic Development*, 26(2), 119-130.

Roller, L.H., and L. Waverman (2001), "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach," *American Economic Review*, 91, 909-923.

Romer, P.M. (1987a), "Crazy Explanations for Productivity Slowdown," in S. Fischer, ed., *NBER Macroeconomics Annual*, MIT Press, Cambridge, 163-202.

Romp, W., and J. de Haan (2007), "Public Capital and Economic Growth: A Critical Survey," *Perspektiven der Wirtschaftspoliti*, 8, 6-52.

Sahoo, P. (2006), "FDI in South Asia: Trends, Policy, Impact and Determinants," Asian Development Bank Institute, Discussion Paper, 56, Tokyo.

Sahoo, P., and R.K. Dash (2009), "Infrastructure Development and Economic Growth in India," *Journal of the Asia Pacific Economy*, 14(4), 351-365.

_____ (2010), "Economic Growth in India: Role of Physical and Human Infrastructure," *Journal of Economic Policy Reforms*, 13(4), 409-420.

_____ (2011), "Economic Growth in South Asia: Role of Infrastructure," *The Journal of*

International Trade and Economic Development, 15(2), 1-36.

Stéphane, S., C. Vellutin, and M. Warlters (2007), "Infrastructure and Economic Growth in East Asia," The World Bank Policy Research, Working Paper, 4589.

Sturm, J.E., G.H. Kuper, and J. de Haan (1998), "Modelling Government Investment and Economic Growth on a Macro Level: A Review," in Brakman, S., H. van Ees, and S.K. Kuipers, eds., *Market Behaviour and Macroeconomic Modelling*, MacMillan Press Ltd, London, UK.

Uchimura, K., and H. Gao (1993), *The Importance of Infrastructure on Economic Development*, Latin America and Caribbean Regional Office, World Bank, Washington D.C.

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

_____ (2006), *World Development Report: Equity and Development*, Washington D.C., The World Bank.

Mailing Address: Pravakar Sahoo, Institute of Economic Growth (IEG), Delhi University, Delhi- 11007, India. Fax: 91-11-2766-7410. E-mail: pravakar@iegindia.org.

Received August 8, 2011, Revised January 25, 2012, Accepted February 2, 2012.