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Infrastructure Investment and the Indian Economy

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Abstract

The purpose of this paper is to investigate the growth effect of physical infrastructure investment in India. Using time-series data for the 1980-2014 period, this paper attempts to empirically test whether India's inefficient executions of infrastructure investment projects can impede its impressive economic growth potential. A simultaneous equation model is developed to address the problem of a bi-directional relationship between physical infrastructure investment and economic growth. The results find that the contribution of physical infrastructure investment to national economic growth is negative and statistically significant. Furthermore, the results also indicate that physical infrastructure investment in India is not keeping pace with its rapid economic growth.

JEL classification numbers: H50, H54, O40
Keywords: Infrastructure investment, economic growth, simultaneity, stationary

1. Introduction

India's civilization is one of the oldest civilizations in the world. India was responsible for one third of total world economic activity for most of the first millennium AD. However, India missed the industrial revolution and the opportunity to benefit from the industrial production technology that contributed to rapid economic growth in Japan, the United States and Western Europe. Thus, India lost its economic prominence in the last 200 years of the first millennium and for most of the second millennium because of the rise of Japan, the United States and Western Europe. After the independence from the Great Britain in 1947, India initially pursued a development strategy that heavily relied on the development of large public sector enterprises, strict regulations and tight control of the private sector and inward-oriented policies. India began to relax its tight grip on the private sector in the late 1980s, and its growth rate began to rise. However, India borrowed heavily in the international capital market leading to a major financial crisis. In 1991, faced with a severe balance of payment crisis India approached the International Monetary Fund for support. The IMF assistance was conditional on structural reforms including trade liberalization and a range of economic policy reforms in the industrial, financial and public sectors.

India's adoption of market-oriented economic reforms and trade liberalization policies in 1991 have transformed the country from a poor slow-growing country to a fast-growing middle-income country. India now has become the third-largest economy in the world in terms of purchasing power parity (PPP) surpassing Japan and trailing behind China and the United States. *IMF Survey* (2015) states, "The Indian economy is the bright spot in the global landscape, becoming one of the fastest-growing big emerging market economies in the world." However, India's limited infrastructure, which is extremely overstressed, may disrupt its optimistic growth prospects. Although the demand for infrastructure services is growing at an unprecedented rate, India's infrastructure has not been able

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to keep pace with the demand. Agarwal (2015) finds that India significantly trails behind other emerging countries in terms of both access to and quality of social infrastructure like education, health facilities and vocational training. India also lags behind other emerging countries in physical infrastructure. The author argues that India's poor social infrastructure may be one of the key reasons for India's very slow performance in eliminating poverty.

McKinsey & Company's 2009 report on India's infrastructure states, "India has set an ambitious target of investing USD 500 billion in infrastructure during the Eleventh Plan period. However, the country has consistently fallen short of meeting such targets over the last few years and early signs of implementation challenges are already visible. During the first two years of the eleventh plan, fewer infrastructure projects have been awarded than planned. We estimate that the average rate of awarding projects has been around 70 percent of the planned rate. Further, government data suggest that a majority of projects – close to 60 percent – are plagued by time and cost over-runs. If current trends continue over the Eleventh and Twelfth plan periods (2008 – 2017), McKinsey estimates suggest that India could suffer a GDP loss of USD 200 billion (around 10 percent of its GDP) in fiscal year 2017."

In the development literature, infrastructure investment has been suggested as an important factor for a high sustained rate of economic growth. Aschauer (1989) finds a strong positive effect of a "core" infrastructure of streets, highways, airports, mass transit, sewers, water systems, etc. on productivity. Following Aschauer's seminal work, a number of studies exploring the role of infrastructure investment in economic growth process have concluded that infrastructure investment is important for growth. For example, Munnell (1990) finds that infrastructure enhances productivity growth in the United States. Mitra et. al. (2002) examines the association between infrastructure investment and India's manufacturing industries' total factor productivity using annual data for the 1976-92 period for seventeen industries in fifteen Indian States. Their results indicate strong positive effects of infrastructure investment on manufacturing industries' total factor productivity. Using panel data for 96 countries, Canning and Fay (1993) find that transportation infrastructure has normal rates of return in developed countries, amazingly high rates of return in industrializing countries and moderate rates of return in underdeveloped countries. Fedderke and Bogetić (2009) discovers a strong positive effect of infrastructure investment on economic growth after controlling for the problem of likely endogeneity of infrastructure investment in estimation using panel data for South Africa over the 1970-2000 period.

Röller and Waverman (2001) estimate the impact of telecommunication infrastructure on economic performance for OECD countries and find positive growth effects of telecommunication infrastructure in OECD countries. They address the issue of simultaneity between telecommunication infrastructure and economic growth by jointly estimating a micromodel of supply and demand of telecommunication investment with a macro production equation. Calderón and Servén (2003) find a strong positive effect of the stock of infrastructure assets on Latin America's economic growth. Banerjee, Duflo and Qian (2012) explore the effect of access to transportation networks on regional economic consequences in China during the period of its fast growth. The results of their paper show moderate positive effects of access to transportation networks on per capita GDP levels across sectors. However, the authors did not find any growth effect of regional transportation investments. Ansar et al. (2016) argue in their paper that poorly managed infrastructure investments in China have contributed to the country's recent economic slowdown. The authors predict that China may experience an infrastructure-led financial and economic crisis unless it focusses on building a lower level of higher quality infrastructure.

In sum, previous studies have produced mixed results. Eberts (2009) reviews literature on highway investment and states, "Although researchers have devoted considerable time and effort exploring the contribution of highways to the economy, their studies vary so much by time period, methodology, and level of aggregation that is difficult to take that large body of research and come up with a general consensus." Gramlich (1994) in his survey of literature on infrastructure investment also underscores the problem of coming up with a general consensus on the contribution of infrastructure investment to economic growth.

The purpose of this paper is to examine the effect of physical infrastructure investment on India's economic growth using time-series data covering the span of 1980-2014. In particular, this paper attempts to empirically test whether India's inefficient implementations of infrastructure investment projects as suggested by McKinsey's 2009 report can impede its impressive economic growth potential. The relationship between economic growth and infrastructure investment is complex and likely to be bi-directional. Ordinary least squares estimates will be biased and inconsistent in the presence of simultaneity problem in regression models. Therefore, previous studies using single-equation models may have produced biased and inconsistent results. Note that a large number of studies point out that the results of early studies are likely to be subject to a severe simultaneity bias. The problem of simultaneity is, of course, best addressed using a simultaneous equation model (SEM). To the best of my knowledge, most previous studies have not employed a SEM to estimate the growth effect of physical infrastructure investment. This paper, thus, uses a SEM to address the issue of simultaneity between physical infrastructure investment and economic growth.

2. The Model

In an effort to specify a regression model to empirically test the growth effect of infrastructure investment in India, this paper begins with the well-known *sources of growth* equation derived in a conventional manner from the neoclassical production function. For example, defining Y, A, K and L as the real gross domestic product, total factor productivity, capital stock, and labor force, respectively, the neoclassical production function is often written in the following familiar Cobb-Douglas form:

$$Y = AK^{\alpha} L^{1-\alpha}. \tag{1}$$

Converting equation (1) into natural logs and differentiating with respect to time yields,

$$\dot{Y} = \dot{A} + \alpha\dot{K} + (1-\alpha)\dot{L} \quad , \tag{2}$$

where $\dot{Y}$, $\dot{A}$, $\dot{K}$ and $\dot{L}$ are the growth rates of real GDP, total factor productivity, capital, and labor force, respectively. α and $1\text{-}\alpha$ are the relative shares of capital and labor.

This paper can empirically test the relationship between economic growth and infrastructure investment based on equation (2), the basic sources of growth equation, by adding the share of infrastructure investment and replacing *Gr(K)* by the share of gross investment excluding physical infrastructure in GDP in equation (2). Specifically, this paper specifies the following regression model.

$$Gr(Y) = a_o + a_1(I_o/Y) + a_2 Gr(L) + a_3(I_{INF}/Y) \quad , \tag{3}$$

where *Gr(Y)* and *Gr(L)* are the growth rates of real gross domestic product, and labor force, respectively. I_o/Y , and I_{INF}/Y are the shares of gross investment excluding physical infrastructure investment and gross physical infrastructure investment in GDP, respectively. In equation (3) investment in physical infrastructure includes transportation, storage and communication. Physical infrastructure investment in this paper includes all components of physical infrastructure except energy. Data are not available for energy for the period of this study.

To minimize the omitted variable bias, this paper adds a dummy variable that measures the growth effect of 1991 trade liberalization policies adopted in India. Note that the vast empirical literature that widely supports the hypothesis, all other things equal, that international trade has a positive effect on economic growth is summarized by Edward (1998) and Baldwin (2004), among others. Since an inward-oriented economy like the Indian economy is not likely to respond immediately to the reversal of protectionist policies, this paper chooses to include a dummy variable,

D_{Trade}, for the years 1999 and onward to capture the effects of trade liberalization policies on economic growth in India. Adding the trade liberalization dummy variable to equation (3) yields,

$$Gr(Y) = a_o + a_1(I_o/Y) + a_2 Gr(POP) + a_3(I_{INF}/Y) + a_4 D_{Trade} \; . \tag{4}$$

Note that this paper uses the growth rate of population, *Gr(POP),* in place of the growth rate of labor, *Gr(L),* because labor force data for India are only available since 1990. Population growth rate is often used in place of labor force growth in studies on economic growth in developing countries because the official labor force data seldom reflect the true supply of formal and informal labor in developing countries.

Note that this paper also uses the share of gross investment excluding physical infrastructure investment, I_o/Y, and the share of physical infrastructure investment in GDP, I_{INF}/Y, in place of the growth rates of capital stock excluding physical infrastructure and physical infrastructure capital stock, respectively. These substitutions are made because actual capital stock data are not available for physical infrastructure. In practice, researchers generally use the ratio of gross investment to output in place of the growth rate of capital stock because researchers often do not have reliable estimates of actual capital stock.

2.1 Dealing with the Simultaneity Bias

The relationship between economic growth and infrastructure investment is complex. The coefficient estimates of equation (4) would most likely be biased and inconsistent due to the presence of likely simultaneity between *Gr(Y)* and I_{INF}/Y. Note that when a country begins to grow rapidly, it always runs into an infrastructure constraint. Therefore, the demand for physical infrastructure investment is likely to increase rapidly with economic growth. For example, India's demand for infrastructure investment has been growing at an extraordinary pace since economic growth has picked up. Note that many infrastructure projects experienced losses from excess capacity in India during economic slowdown after 2008. Thus, economic growth may influence physical infrastructure investment as much as physical infrastructure investment may influence economic growth. Note that there have been many studies [e.g. Calderón and Servén (2003, 2004), Röller and Waverman (2001), Frutos et. al. (1998) and Fedderke and Bogetić (2009) just to cite a few] that confirm the presence of simultaneity between economic growth and infrastructure investment.

There might also exist a reverse relationship running from economic growth to the share of gross investment excluding physical infrastructure in GDP, I_o/Y. A number of researchers - Hongyu, Park and Siqi (2002) among them - using time-series data, find that economic growth stimulates both housing and non-housing investment. As mentioned earlier, the issue of simultaneity is best addressed using a SEM. Therefore, the following SEM that explicitly specifies several hypothesized simultaneous relationships is constructed in this paper.

$$\begin{aligned} Gr(Y) &= a_o + a_1(I_o/Y) + a_2 Gr(POP) + a_3(I_{INF}/Y) + a_4 D_{Trade} + t + \varepsilon_1 \\ I_{INF}/Y &= b_o + b_1 Gr(Y) + b_2 Gr(POP) + b_3 D_{Trade} + b_4 R_{int} + t + \varepsilon_2 \\ I_o/Y &= c_o + c_1 Gr(Y) + c_2(I_{INF}/Y) + c_3 R_{int} + c_4 D_{Trade} + t + \varepsilon_3 \end{aligned} \tag{5}$$

In addition to those variables introduced earlier, R_{int} is the real interest rate. Equation (4) is the first equation of the SEM. The second equation of model (5), which explains I_{INF}/Y , is inspired by Borcherding, Ferris and Garzoni (2004) and Canning and Fay (1993). The second equation specifies that physical infrastructure investment share depends on economic growth, the growth rate of population, trade openness, and the real interest rate. As explained earlier in this paper, robust economic growth is likely to increase the demand for physical infrastructure investment. Thus, the second equation in model (5) addresses the issue of simultaneity between *Gr(Y)* and I_{INF}/Y . The third equation for the ratio of investment to output is developed following Sprout and Weaver (1993) and Esfahani (1991) and it addresses the issue of simultaneity between *Gr(Y)* and I_o/Y. ε_1, ε_2 and ε_3 are stochastic error terms with zero mean and finite variance.

3. Data

Model (5) is estimated using time-series data for the 1980-2014 period. The Appendix provides a detailed description of variables and data sources. Note that some of the time-series variables in model (5) may be nonstationary. Regressions involving independent nonstationary variables tend to generate "spurious" results, that is, conventional time-series tests are biased toward finding a significant relationship among variables in levels when in fact none exists[2]. The standard method for detecting nonstationary behavior in a time-series is to test for the presence of a unit root. Testing can be extended to incorporate the prospect of a deterministic trend as well as the stochastic type of trend represented by a unit root. A number of tests can be found in Said and Dickey (1984), Kwiatkowski et. al. (1992), Perron (1988), Phillips (1987), and Phillips and Perron (1988). The PP test is applied to detect the existence of unit roots in the variables in model (5). The test assumes the null hypothesis of a unit root.

Table 1 reports our unit root test results. The test results confirm the presence of a unit root only in I_{INF}/Y . All other variables are found to be stationary. A common method of dealing with the presence of unit roots is to take first differences of the variables prior to estimating a model containing them and so the variable I_{INF}/Y is differenced. The differenced form of I_{INF}/Y then is analyzed with the PP test and found to be stationary. I_{INF}/Y is thus entered into the model in its first differenced form. A time trend, t, is included in each equation to capture the effect of a potential deterministic trend in the variables estimated in levels.

Table 1: Stationarity Tests

Variables	**PP Test**
Gr(Y)	-5.24**
I_o/Y	-4.33**
Gr(POP)	-3.72**
I_{INF}/Y	-0.79
R_{int}	-4.82**

Notes: ** significant at the 5 percent level.
The critical value for the PP test with constant and trend at the 5 percent significance level is -3.43

4. Estimating the Simultaneous Equation model

Model (5) is estimated by the three-stage least squares (3SLS). Table 2 reports the complete 3SLS estimates of model (5). In the first equation, explaining economic growth, the variable I_{INF}/Y has a negative and significant coefficient. This finding of a negative growth effect of infrastructure

[2] Known as the spurious regression problem, it was popularized and studied extensively by Granger and Newbold.

investment in India supports the prediction of McKinsey's 2009 report, which states that delays in the implementations of infrastructure projects may result in a GDP loss of USD 200 billion. Note that Agarwal (2015) also indicates that although recently delays in clearance and land acquisitions are declining, the implementations of infrastructure projects in India still face major challenges that may slow down India's optimistic growth potential. The coefficient estimate of the variable I_o/Y is positive and significant. The coefficient on the 1991 trade liberalization dummy variable, D_{Trade}, is positive and significant. This finding shows that India's 1991 market-oriented economic reforms and trade liberalization indeed have played a major role in spurring economic growth in India.

In the second equation that explains the share of physical infrastructure investment in GDP, I_{INF}/Y, the coefficient on economic growth, *Gr(Y)*, is negative and significant. The statistically significant coefficient on *Gr(Y)* confirms a bi-directional relationship between *Gr(Y)* and I_{INF}/Y ; the use of a simultaneous equation model in this paper is thus justified. The negative coefficient implies that the income elasticity of infrastructure investment is less than one. In other words, economic growth results in a less than proportionate increase in physical infrastructure investment. This finding supports the evidence that in India infrastructure investment is not keeping pace with its rapid economic growth. The trade openness dummy variable is positive and significant reflecting the fact that globalization further increases the demand for physical infrastructure investment. The growth rate of population and the real interest rate have the expected signs but none of them is significant.

Table 2: Estimated Equations

Equation 1	**Equation 2**	**Equation 3**
Gr(Y)	$\boldsymbol{I_{INF}/Y}$	$\boldsymbol{I_o/Y}$
$0.13(I_o\|Y)$ (1.85)*	-0.41E-01 Gr(Y) (-5.04)**	0.52Gr(Y) (1.38)
17.62Gr(POP) (1.29)	1.09Gr(POP) (1.38)	$-1.04R_{int}$ (-2.61)**
$-13.35(I_{INF}\|Y)$ (-5.34)**	$0.19D_{Trade}$ (2.61)**	$6.07(I_{INF}\|Y)$ (0.92)
$3.18D_{Trade}$ (2.38)**	$-0.33\text{E-}02R_{int}$ (-0.32)	$-3.25D_{Trade}$ (-1.03)
0.64t (1.36)	0.43E-01t (1.57)	0.33t (1.97)**
-39.90 (-1.17)	-2.45 (-1.27)	19.19 (4.30)**

Notes: t-ratios are in parentheses, E indicates scientific notation;
** - significant at the 5 percent level;
* - significant at the 10 percent level;

In the third equation explaining I_o/Y, the share of gross investment excluding physical infrastructure investment, the coefficient on *Gr(Y)* is positive but not significant implying no bi-directional relationship between *Gr(Y)* and I_o/Y. The coefficient on the real interest rate is significant and negative. All other variables in equation (3) are not significant.

Since the estimation results do not indicate that there exists a bi-directional relationship between economic growth, *Gr(Y)*, and the share of gross investment excluding physical infrastructure investment in GDP, I_o/Y, model (5) is estimated without the third equation that explains I_o/Y. Table

3 reports the results. The results show that the exclusion of the equation for I_o/Y has changed neither the sign nor the significance of the growth effect of the share of physical infrastructure investment in GDP confirming the robustness of the relationship between economic growth and physical infrastructure investment in India. Note that the results also indicate that there exists simultaneity between *Gr(Y)* and I_{INF}/Y .

Table 3: Estimated Equations

Equation 1	**Equation 2**
Gr(Y)	$\boldsymbol{I_{INF}/Y}$
0.59E-01$(I_o\|Y)$ (0.86)	-0.41E-01Gr(Y) (-5.09)**
15.23Gr(POP) (1.11)	0.94Gr(POP) (1.18)
-13.13$(I_{INF}\|Y)$ (-5.24)**	0.19D_{Trade} (2.55)**
2.87D_{Trade} (2.14)**	-0.97E-03R_{int} (-0.92E-01)
0.59t (1.25)	0.38E-01t (1.39)
-33.12 (-0.96)	-2.08 (-1.08)

Notes: t-ratios are in parentheses, E indicates scientific notation;
** - significant at the 5 percent level;
* - significant at the 10 percent level;

5. Summary and Conclusions

This paper examines the growth effect of physical infrastructure investment in India using time-series data for the 1980-2014 period. Particularly, this paper attempts to test empirically whether India's inefficient implementations of infrastructure investment projects leading to cost and time over-runs may impede India's optimistic economic growth potential. In order to address the problem of simultaneity between economic growth and the share of physical infrastructure investment, this paper employs a simultaneous equation model to explore the growth effect of physical infrastructure investment. To the best of my knowledge, previous studies have not used a simultaneous equation model to test the relationship between infrastructure investment and economic growth in India.

The results show that physical infrastructure investment has a negative and significant effect on economic growth in India. This finding is supported by 2009 McKinsey estimates that indicate that the negative growth effect of large time and cost over-runs of Indian infrastructure projects is substantially large. In addition, a number of studies – Agarwal (2015), and Laksmanan (2008) among others – also indicate that persistent cost and time over-runs of infrastructure investment projects may prevent Indian economy to achieve its optimistic growth potential. According to the Indian ministry of statistics and program implementation, only twenty-five percent of all India's infrastructure projects succeed in meeting project deadlines.

Additionally, the results also show that the relationship between economic growth and physical infrastructure investment is bi-directional which justifies the use of a simultaneous equation model in this study. As mentioned earlier in this paper, to the best of my knowledge, previous studies have not employed a SEM to estimate the growth effect of physical infrastructure investment in India. Therefore, previous studies using single-equation models may have produced biased and inconsistent results. The estimation of a simultaneous equation model also reveals other interesting results. Notably, trade liberalization has a positive and significant effect on the share of physical infrastructure investment in GDP. In other words, economic globalization increases the demand for physical infrastructure investment. Furthermore, the results also show that India's adoption of trade liberalization policies has contributed to its economic transformation of a poor slow-growing economy to a fast-growing middle-income economy.

In sum, while no single econometric method provides a definitive proof of a relationship, the findings of this paper show that bottlenecks in India's infrastructure investment pose risk to its economic growth. High-quality infrastructure is crucial for promoting economic growth and development. Note, according to the recent government data, the current administration in India has made some progress in improving the efficiency of the executions of infrastructure projects. The data show that as of January 2016, both time and cost over-runs have declined. However, Beniwal (2016) states that "bad debts, weak global demand and difficulties in pushing through key reforms threaten to hobble the world's fastest-growing major economy." Aiyar (2016) also indicates that although infrastructure problems are slowly declining, major challenges persist. The findings of this paper underscore that to sustain and enhance India's optimistic economic growth potential, major efforts need to be made to upgrade the institutional mechanism for faster delivery of high-quality infrastructure.

References

Ansar, A., Flyvbjerg, B., Budzier, A., and Lunn, D. (2016) Does Infrastructure Investment Lead to Economic Growth or Economic Fragility? Evidence from China. Oxford Review of Economic Policy, 32, 360-390.

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

Agrawal, P. (2015) Infrastructure in India: Challenges and the Way Ahead. IEG Working Paper Number 350. http://www.iegindia.org/upload/publication/Workpap/wp350.pdf.

Aiyar, S. (2016) Twenty-Five Years of Indian Economic Reform: A Story of Private-Sector Success, Government Failure, and Institutional Weakness. Cato Institute Policy Analysis, No. 803. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2877918.

Baldwin, R.E. (2004) Openness and growth: What's the Empirical Relationship?. In: R.E Baldwin and L.A. Winters, Eds., Challenges to Globalization, Chicago, University of Chicago Press.

Banerjee, A.V., Duflo, E., and Qian, N. (2012) On the Road: Access to Transportation Infrastructure and Economic Growth in China. MIT Department of Economics Working Paper Number 12-06. https://dx.doi.org/10.2139/ssrn.2018637

Beniwal, V. (2016) Good News for Modi: Only a third of India Projects Delayed. Bloomberg. https://www.bloomberg.com/news/articles/2016-04-08/good-news-for-modi-only-a-third-of-india-projects-now-delayed

Borcherding T.E., Ferris, J.S. and Garzoni, A. (2004) Growth in the Real Size of Government since 1970. In: J. Backhaus and R.E. Wagner, Eds., Handbook of Public Finance, Hingham, Ma: Kluwer Academic Press, 77-108.

Canning D. and Fay, M. (1993) The Effect of Transportation Networks on Economic Growth. Colombia University Academic Commons. https://doi.org/10.7916/D80K2H4N

Calderón, C., and Servén, L. (2003) The Output Cost of Latin America's Infrastructure Gap. In: W. Easterly and L. Servén, Eds., The Limits of Stabilization: Infrastructure, Public Deficits, and Growth in Latin America, Standford University Press and the World Bank, 119-138.

Calderón, C., and Servén, L. (2004) The Effects of Infrastructure Development on Growth and Income Distribution. Policy Research Working Paper; No. 3400. World Bank, Washington, D.C., @ World Bank. https://openknowledge.worldbank.org/handle/10986/14136 License: CC By 3.0 IGO.

Eberts, R.W. (2009) Understanding the Contribution of Highway Investment to National Economic Growth: Comments on Mamuneas's study, Prepared for the Federal Highway Administration, Department of Transportation. http://research.upjohn.org/reports/115

Edwards, S. (1998) Openness, Productivity and Growth: What do We Really know? The Economic Journal, 108, 383-398.

Esfahani, H. S. (1991). Exports, imports, and economic growth in semi-industrialized countries. Journal of Development Economics, 35: 93-116.

Fedderke, J.W., and Bogetić, Ž. (2009) Infrastructure and Growth in South Africa: Direct and Indirect Productivity Impacts of 19 Infrastructure Measures. World Development, 37, 1522 - 1539.

Frutos, R.F., Gracia-Díez, M., and Pérez, T. (1998). Public Capital Stock and Economic Growth: An Analysis of the Spanish Economy. Applied Economics, 30, 985-994.

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

Granger, C. and Newbold, P. (1974) Spurious Regression in Econometrics. Journal of Econometrics, 2, 111-120.

Government of India, Ministry of Statistics and Program Implementation. http://mospi.nic.in/

Hongyu, L., Park, Y. W. and Siqi, Z. (2002) The Interaction between Housing Investment and Economic Growth in China. International Real Estate Review, 5, 40-60.

IMF Survey (March 11) India's Economic Picture Brighter, but Investment, Structural Reforms Key. https://www.imf.org/en/News/Articles/2015/09/28/04/53/socar031115a

Kwiatkowski ,D., Phillips, P.C.B., Schmidt, P. and Shin, Y. (1992) Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root. Journal of Econometrics, 54, 159-178.

Laksmanan, L. (2008) Public-Private Partnership in Indian Infrastructure Development: Issues and Options. Reserve Bank of India Occasional Papers, 29, 37-77.

McKinsey & Company. (2009) Building India: Accelerating Infrastructure Projects. A Report. http://www.academia.edu/19624430/Building_India-Accelerating_infrastructure_projects

Mitra, A, Varoudakis, A. and Véganzonès-Varoudkis, M. (2002) Productivity and Technical Efficiency in Indian States' Manufacturing: The Role of Infrastructure. Economic Development and Cultural Change, 2002, 395-426.

Munnell, A.H. (1990) Why has Productivity Growth Declined? Productivity and Public Investment. New England Economic Review, January/February 1990, 3-22.

Perron, P. (1988) Trends and Random Walks in Macroeconomic Time Series: Further Evidence from a New Approach. Journal of Economic Dynamics and Control, 12, 297-332.

Phillips, P.C.B. (1987) Time-Series Regression with a Unit Root. Econometrica, 55, 277-301.

Phillips, P.C.B. and Perron, P. (1988) Testing for a Unit Root in Time-Series Regression. Biometrika, 75, 335-346.

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

Said, S.E., and Dickey, D.A. (1984) Testing for Unit Roots in Autoregressive-Moving Average Models of Unknown Order. Biometrica, 71, 599-608.

Sprout, R. V. A. and Weaver, J.H. (1993). Exports and economic growth in a simultaneous-equations model. Journal of Developing Areas 27, 289-306.

Appendix: Variable List and Data Sources

Y	Real GDP – United Nation
Gr(Y)	Growth rate of real GDP – derived.
POP	Population – World Bank.
Gr(POP)	Growth rate of population – derived.
I	Gross investment – United Nation
I_{INF}	Gross physical infrastructure investment – United Nations
I_o	Gross investment excluding infrastructure – derived
R_{int}	Real interest rate - World Bank