Growth and Non-Traded Sectors: The Scope of India's Infrastructure

Avik Chakrabarti*

ABSTRACT

This paper examines the links between economic growth and non-traded sectors, with a focus on infrastructure, in an effort to assess the role of infrastructure in the growth of a developing economy such as India. Results from multivariate heterogeneous panel cointegration analyses of annual data on 78 economies over the period 1961-2000 lead to the following inferences. The panel estimates confirm a) a significant and robust positive association between growth and infrastructure and b) a significantly higher correlation between growth and infrastructure for the developing economies relative to the developed economies. As such, sustained expansion of investment in and improved performance of her infrastructure sectors is likely to aid the growth of a country like India wherer institutional capabilities and organizational reforms that lend credibility and effectiveness to government policy are likely to complement her growth momentum through expanded infrastructure investment.

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* Associate Professor, Department of Economics, University of Wisconsin-Milwaukee.
Mailing Address: 816 Bolton Hall, Department of Economics, College of Letters and Science, University of Wisconsin-Milwaukee, P.O. Box 413, WI 53201, U.S.A.
E-mail: chakra@uwm.edu

"*Our growth potential will be realized only if we can ensure that our infrastructure does not become a severe handicap*." Dr. Manmohan Singh, October 08, 2006.

1. Introduction

The significance of non-traded sectors, discovered by Ohlin (1929) in his criticism of Keynes' (1929) views on the German transfer problem[1] and subsequently illuminated by many prominent economists, continues to draw our attention even in today's increasingly integrating world. There exists a host of services (e.g. infrastructure, education, health, utilities etc.) that are not traded across the borders, either because they simply cannot be traded or because barriers (economic and/or political) to trade are prohibitive. Services liberalization offers a potential source of welfare gain as the performance of service sectors and policies affecting their performance are likely to have important consequences for trade volumes, the distributional effects of trade, and economy-wide growth.[2] With this backdrop, in this paper, I will focus on the incentives and constraints that India's infrastructure seemingly projects on her growth prospects.[3]

The rest of the paper is organized as follows. In the next section, I discuss the economics of non-traded sectors with emphasis on infrastructure services. Section 3 outlines the evolution and current state of India's infrastructure vis-à-vis the rest of the

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[1] Keynes and Ohlin agreed that a transfer would inevitably result in a re-allocation of resources between the traded and non-traded sectors. However, Keynes had argued that the presence of non-traded sectors would shift resources away from the non-traded sector into the exporting sector to exacerbate further the donor's terms of trade deterioration as a result of a transfer. Ohlin, in contrast, saw no reason for a movement in the terms of trade and expected only opposing changes in the prices of traded sectors relative to those of non-traded sectors for the donor and recipient.

[2] The competitiveness of firms in open economies is determined in part by access to low-cost and high-quality services. One of the stylized facts of economic development is that the share of services in GDP and employment rises as per capita incomes increase. In the lowest-income countries, services generate about 35 percent of GDP. This rises to over 70 percent of national income and employment in OECD countries.

[3] Ianchovichina and Kacker (2005) forecast that the largest real per capita GDP growth dividend, for countries (including India) that together account for nearly 80% of the developing world's GDP, is likely to come from sustained improvement in infrastructure.

world. In section 4, I describe the data used for analyses, explain the econometric method, and report the results. Section 5 concludes.

2. The Economics of Non-traded Sectors

The services of non-traded sectors must have their markets cleared locally, and in this respect, differ fundamentally from traded sectors for which local excess demand or supplies can be accommodated in the world markets. Services that are traded internationally can be provided in another country at some cost. In principle, therefore, the providers from different countries compete with each other in such traded sectors. In contrast, non-traded services have to be provided locally and do not involve competition among international providers. In addition, non-traded services such as infrastructure — including telecommunications, electricity, water and sewerage, natural gas, and transportation — reflect some unique economic characteristics, which make them a natural target for government intervention yet render them difficult to regulate in the public interest. These features[4] include a) extensive economies of scale and scope that generally lead to market concentration and inhibit competition; b) large sunk costs relative to fixed and variable costs; and c) services deemed essential to a broad range of users, making their provision and pricing politically sensitive.

While there is no denying the fact that “it was all in Marshall”, traditional economic theory postulated growth as a function of increases in the quantity and productivity of primary inputs with negligible role to non-traded services. The significance of non-traded services in the growth and development of an economy, that has increasingly become evident in international data, was originally captured in the pioneering works by Baumol

[4] See also Spiller and Savedoff (1999).

(1967) and Fuchs (1968). An important economic characteristic of many such services is their "facilitating" (i.e. supporting finer specialization) role. Francois (1990) demonstrated that the growth of intermediation services is an important determinant of overall economic growth and development as much of this intermediation activity facilitates transactions through space (transport, telecommunications etc.).

Several empirical studies have investigated the linkages between services, services liberalization, and economic growth. Empirical explorations of the effects of infrastructure on growth have been characterized by ambiguous (countervailing signs) results with little robustness[5]. A number of explanations of the contradictory findings have been proposed. These range from the crowd-out of private by public sector investment, non-linearities generating the possibility of infrastructure overprovision, simultaneity between infrastructure provision and growth, and the possibility of multiple channels of influence between infrastructure and productivity improvements.[6]

Aschauer (1989a, 1989b), Easterly and Rebelo (1993), Canning et al. (1994), Sanchez-Robles (1998) have found high returns to infrastructure investment. Among relatively recent contributions, Fink *et al*. (2003) assessed the impact of policy reform in telecommunications on sectoral performance using a panel data set for 86 developing countries across Africa, Asia, the Middle East, Latin America and the Caribbean over the period 1985 to 1999. They observed that both privatization and competition led to significant improvements in performance, but that a comprehensive reform program, involving both of these policies supported by an independent regulator, produced the largest gains. Esfahani and Ramirez (2003) provide cross-country estimates reflecting

[5] See Munnell (1992), Tatom (1993) and Gramlich (1994).
[6] See Fedderke and Bogetic (2006).

that the contribution of infrastructure services to GDP is substantial and, in general, exceeds the cost of provision of those services. Mattoo *et al*. (2006) reported that controlling for other determinants of growth, countries with open telecommunications sectors grew, on average, about 1 percentage point faster than other countries. Fully liberalizing the telecommunications sectors was associated with an average growth rate above that of other countries. Eschenbach and Hoekman (2006) investigated the impact of changes in services policy, including liberalization, on economic performance over this period for a sample of 20 transition economies during 1990–2004. They found that changes in policies towards infrastructure services, including telecommunications, power and transport, are statistically significant explanatory variables for the post-1990 economic performance of the transition economies in the sample. Arnold *et al*. (2006a) analyzed the effects of allowing foreign providers greater access to services industries on the productivity of manufacturing industries relying on services inputs. The results, based on firm-level data from the Czech Republic for the period 1998–2003, show a positive relationship between FDI in services and the performance of domestic firms in manufacturing. They conclude that the presence of foreign services providers as the measure of services policy is the most robust services variable affecting firm performance, measured by Total Factor Productivity (TFP). In a related firm-level study focusing on Africa that uses data from over 1,000 firms in 10 sub-Saharan African economies, Arnold *et al*. (2006b) found a statistically significant positive relationship between firm performance and the performance of service input industries for which data was collected through enterprise surveys (including access to communications and electricity). Fedderke and Bogetic (2006) analyzed a panel data of South African industries during 1970–2000 to conclude that the impact of infrastructure capital on growth is not only positive, but of economically meaningful magnitudes.

3. The Global Positioning of India's Infrastructure

For much of the 20th century, India, like most countries, relied on government ownership and regulation to promote socially equitable access to infrastructure services using mechanisms such as non-exploitive pricing, nondiscriminatory coverage, and universal service. Reflecting infrastructure's strategic importance and concerns about monopoly power, it was widely believed that these sectors could not be entrusted to the signals, motivations, and penalties of free markets. In addition, most governments were convinced that state resources were required to finance large investments in service coverage. Infrastructure's enormous economic importance, a desire to protect the public interest in industries supplying essential services, and concerns about private monopoly power led governments to conclude that control over these services could not be entrusted to the motivations and penalties of free markets. But in recent decades this consensus has changed, resulting in far reaching restructuring, privatization, and other reforms of crucial infrastructure sectors and services.

During the 1950s vertically integrated, state-owned infrastructure became the industry model for electricity, telecommunications, water, natural gas, and railways and other transportation services. Since the early 1980s, however, the monolithic model has proven increasingly unsuited to dramatically changing conditions in both industrial and developing countries. As a result there has been a worldwide reassessment, led by the examples set by the U.S., U.K. and the E.U., of public policies for infrastructure. In a globalized economy, poorly performing state-owned infrastructure providers were increasingly seen as constraining economic growth and undermining international competitiveness. Developing countries simply could not continue to absorb the fiscal burden of these enterprises. It became evident to policymakers that the problems of public enterprises could be solved only by implementing radical structural changes and realigning the roles of the government and the private sector. Proponents of deregulation argued that unleashing competition among service providers would lower inflation and restore productivity growth. At the same time, concerns about the energy crises and environmental protection facilitated the introduction of economically efficient pricing, which was expected to discourage wasteful consumption.[7]

As such, balancing the roles of the private[8] and public sectors (which presumes an effective legal and regulatory framework, strong political will demonstrated by a clear government commitment for a long-term partnership, transparency in the procurement bidding process, a positive lending environment and guaranteed cost recovery) has become an integral part of nearly every infrastructure reform program around the globe. India's Prime Minister Dr. Manmohan Singh has recently (2006) confirmed his government's commitment to developing infrastructure in India through the use of public-private partnerships (PPPs)[9]: "It is imperative that we explore avenues for increasing investment in infrastructure through a combination of public investment,

[7] See also Joskow and Noll (1994), Noll (1999) and Kahn (2001).

[8] See Chakrabarti and Heywood (2004) for a spatial model in which a foreign firm and local government behave strategically in setting a local equity requirement. Contrary to simple intuition, larger equity requirements may increase economic efficiency but this conclusion is highly sensitive to the vertical structure of the foreign firm. When the foreign firm has monopoly power in both foreign (upstream) and domestic (downstream) markets the optimal equity requirement is zero. Surprisingly, the introduction of domestic competition upstream causes the government to adopt an LER which lowers economic efficiency.

[9] One variant of PPPs is a "build-operate-transfer" arrangement in which the private company operates a toll road or other facility until it has recovered its investment and made a profit, then turns it over to the government. In other cases, the builder gets a partial capital subsidy from the government. An example is the new 62-mile, six-lane expressway that replaced a potholed stretch of National Highway 8 from Jaipur in the Rajasthan desert to Bombay. The project, led by Larsen & Toubro Ltd. and Hyderabad's GVK Industries, cost $141 million, with $49 million provided by the government.

public-private partnerships and occasionally, exclusive private investments wherever feasible. … Among these, the PPP approach is best suited for the infrastructure sector."[10]

India experienced an economic growth of 9.3 per cent for the first quarter of the 2006–07 fiscal year.[11] In comparison, the figures released by the Ministry of Commerce & Industry on the growth of core infrastructure industries in May 2006–07 recorded a slowdown in production. India's current state of infrastructure reveals many weak links that threaten to hobble its economic growth. For instance, Indian cities currently contribute as much as 70% of her GDP and over 500 million people are expected to live in urban India by 2020. However, about 15% of the urbanites do not have access to safe drinking water and about 50% are not covered by sanitary facilities. The Central Public Health Engineering (CPHEEO) has estimated the requirement of funds for 100 percent coverage of the urban population under safe water supply and sanitation services by the year 2021 at US$ 41.16 billion. Estimates by Rail India Technical and Economic Services (RITES) indicate that the amount required for urban transport infrastructure

[10] There are several issues confronting a complete transfer of financing infrastructure from the public to the private sector. First, the ability of the private sector to respond to the needs of low-income households is limited given the profit-oriented nature of the former. Without some form of targeted subsidies, the poor will barely have access to basic infrastructure. Second, financing infrastructure is often a long-term process when compared with other sectors of the economy. Consequently, the private sector may be unwilling to undertake such risk, as the long gestation period may adversely affect returns on investment. Third, the private sector does not adequately account for externalities associated with infrastructures except when government financing is involved. As such, the public sector is likely to continue to be a major player in the provision of infrastructure. See also Fox (1994).

[11] Out of the 17 industry sectors, 8 sectors have posted higher growth in production. These sectors include other manufacturing industries (32.3%), basic metal and alloy industries (20.5%), transport equipment (22.0%), machinery and equipments (15.4%), non-metallic mineral products (15.1%), paper products (12.0%), rubber plastic petroleum and coal products (8.7%) and man made textile products (7.3%). Of the remaining 9 industry sectors, growth fell in 4 sectors namely beverages and tobacco, cotton textiles, textile products and chemical products while the other 5 sectors wood, leather, jute, food products and metal products registered negative growth. All of the use based industry categories, the capital goods, basic goods and intermediates achieved higher growth rates of 22.9%, 8.8% and 9.1% respectively compared to the growth rates registered in the corresponding quarter of the last fiscal year. While there has been a sharp slowdown in the production of consumer non-durables since the beginning of 2006-07, higher growth in production could be seen in the consumer durables category during the first three months of the current fiscal year.

investment in cities with population 100,000 or more during the next 20 years would be of the order of US$ 49.28 billion.

India's infrastructure has been subject to chronic underinvestment causing significant deterioration in service quality and seriously undermining providers' ability to respond to new demands and expand service. Compared with China's infrastructure spending of 20% of its GDP, India currently spends only about 6%. It is not surprising that Dr. Shankar Acharya, former Chief Economic Adviser to the Government of India, is convinced that that India is yet to be in "China's league": electricity production in China is nearly 3 times higher than in India; ton-kilometres of freight hauled on railways is about 4.5 times greater; air-freight ton-kilometres flown in China is nearly 10 times higher; container traffic shipped through ports is an astonishing 16 times more in China.[12] In order for India to maintain its current growth momentum, the Confederation of Indian Industry (CII) estimates that the nation calls for US$330 billion of investment on infrastructure over the next five to seven years.

In a recent (2006) interview, Dr. Montek Singh Ahluwalia, Deputy Chairman of India's Planning Commission, anticipated that resources can flow into India's infrastructure in the form of foreign direct investment (FDI) or from domestic savings or through market borrowings. If the nation reflects the right environment, all the domestic investment can be absorbed in infrastructure, which will make room for FDI in other sectors and vice-versa. Hence, he pointed toward the need for two distinct yet related

[12] There are reasons for some to believe that India is likely to emerge as a more fertile ground for investment than China: India is a functioning democracy with respect for property rights and the rule of law; India is now emerging on the global stage and playing classic balance of power politics; India's capital markets are better organized than China's; and India is a relatively youthful nation with half of its population under 25 years of age.

kinds of policies: the general policies that will make India an attractive destination for investment[13] and another, more specific, one for infrastructure.

4. Data, Estimation and Results

I employ recently developed techniques of multivariate heterogeneous panel cointegration analyses to capture the association between growth and infrastructure. The data set used in this analysis contains annual observations spanning 78 countries over the period from 1961 to 2000 and is extracted from the World Development Indicators (WDI), 2005 and Penn World Tables 5.6. Summers and Heston's (1991) Penn World Table summary assessments of the quality of countries' data are used to identify countries with the lowest quality (D-graded) data.

The first step in applying any cointegration technique is to test for non-stationarity in the data. For this the cross-sectionally augmented Im-Pesaran-Shin (*CIPS*) panel unit-root test[14], based on the simple averages of the individual cross sectionally augmented Dickey-Fuller statistics, is used. The main advantages of this approach are a) it incorporates potential cross-section dependence; and b) it allows (since it does not directly pool the autoregressive parameter in the unit root regression) for the possibility of heterogeneous coefficients of the autoregressive parameters under the alternative hypothesis that the process does not contain a unit root. To use the *CIPS* test the following equations are estimated:

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[13] See Chakrabarti (1999, 2001, 2003) on a host-country perspective on the determinants and spatial distribution of FDI in a strategic environment.

[14] See Pesaran (2005). The CIPS test statistic is a generalization of the IPS test statistic, originally proposed by Im, Pesaran, and Shin (2003), that incorporates potential cross-section dependence. Chang (2002) had proposed a non-linear instrumental variable approach to deal with the cross section dependence of a general form and established that the individual Dickey-Fuller (DF) or the Augmented Dickey-Fuller (ADF) statistics are asymptotically independent when an integrable function of the lagged dependent variables are used as instruments. In this paper I have chosen not to implement this test since it can be shown, using Monte Carlo techniques, that Chang's test is grossly over-sized for moderate degrees of cross section dependence even when the sample contains relatively small number of countries.

(1A) $$\Delta Y_{it} = \mu_{1i} + \lambda_{1i} Y_{i,t-1} + \theta_{1i} f_{1t} + \varepsilon_{1it}$$

(1B) $$\Delta X_{it} = \mu_{2i} + \lambda_{2i} X_{i,t-1} + \theta_{2i} f_{2t} + \varepsilon_{2it}$$

$$(i = 1,2,...,N;\ t = 1,2,\ldots,T)$$

where Y is the residual[15] per capita GDP growth rate and X is the proxy for infrastructure (measured by the number of telephone mainlines per capita in a country[16]), f_t is the unobserved common effect proxied by a linear combination of the current and lagged cross-sectional averages of the dependent variable and ε_{it} is the individual-specific (idiosyncratic) error.

The null hypothesis ($\lambda_i = 0, \forall i = 1,2,...,N$) of a unit root is then tested (against the alternative hypothesis: $\lambda_i < 0$, $i = 1,2,...,N_1$ and $\lambda_i = 0$, $i = N_1 + 1, N_1 + 2,..., N$) using the *CIPS* statistic:

$$CIPS(N,T) = \frac{1}{N}\sum_{i=1}^{N} t_i(N,T)$$

where $t_i(N,T)$ is the cross-sectionally augmented Dickey-Fuller test statistic for the *i*-th country. In the next step γ is estimated from the following equation and the null of no cointegration is tested:

[15] The residual is obtained from regressing per-capita GDP growth rate on education, financial depth, openness, government burden and inflation. Education is measured as the ratio of total secondary enrollment to the population 25 years or older. Financial depth is computed as the ratio of M2 to GDP. Openness is the residual of a regression of the log of the trade (exports and imports) to GDP ratio on the logs of area and population, and dummies for oil exporting and landlocked countries. Government burden is measured with the ratio of government consumption to GDP. There is a host of other variables (political instability, life expectancy at birth, distance from the equator, shares of primary products in GDP and financial depth) that have appeared in the empirical studies as determinants of growth but turned out to be statistically insignificant in our regression.

[16] Telecommunications services offer a source of natural experiment for infrastructure since they have historically been provided through government monopolies and been an important source of state revenue. As a result of changes in telecommunications technologies the "natural monopoly" argument for state ownership or control has been eroded, and many countries now allow competition, but often restrictions are maintained on ownership and access to networks. The inferences are not sensitive to alternative proxies of infrastructure, such as power, energy, and transport facilities. See Table 4 for the current state of India's telecommunication network.

(2) $$Y_{it} = \alpha_i + \beta_t + \gamma X_{it} + e_{it} \qquad (i = 1,2,...,N;\ t = 1,2,\ldots,T)$$

where α_i represents any idiosyncratic fixed effect that differs across countries, β_t represents any effect common to all countries and e_{it} is the error term capturing unmeasured shocks.

[Table 1 here]

Table 1 reports results from the *CIPS* panel unit root tests for each variable. It provides evidence that both per capita GDP growth rate and the proxy for infrastructure suffer from non-stationarity: the null hypothesis of a unit root cannot be rejected consistently.

Cointegration tests and Fully Modified Ordinary Least Squares (FMOLS)[17] estimation techniques for heterogeneous panels, developed recently by Pedroni (1999, 2000), are employed due to several distinct advantages.[18] First, it combines information from the time series dimension with that obtained from the cross section of units making inference about the existence of cointegration more efficient than pure time series-based tests given their well-known power deficiencies. Second, it provides efficient estimation of a long-run relation among variables even in cases where consideration of the time-dimension alone would lead to the regression being characterized as spurious. This has been discussed by Phillips and Moon (1999), Engel and Granger (1987) and Granger and Newbold (1986). Third, it allows (using the asymptotic properties of non-stationary panels) for considerable heterogeneity[19] among individual members of the panel,

[17] The panel FMOLS estimation technique applied in this paper is outlined in the technical appendix.
[18] It is well known that standard OLS or 2SLS results can suffer from 'spurious regression' problems when data are non-stationary.
[19] Inferences can be made regarding common long run relationships that are asymptotically invariant to considerable degree of short run heterogeneity prevalent in the dynamics. In particular, two key sources of heterogeneity are captured in this analysis. One source of heterogeneity manifests itself in the familiar fixed

including heterogeneity in the long-run cointegrating vectors as well as in the dynamics associated with short-run deviations from these cointegrating vectors. Fourth, the method simultaneously corrects for serial correlation, endogeneity and sample bias (asymptotically).

Table 2 presents the results from panel cointegration tests of the null of no cointegration among the variables. The rows report the computed values of the panel test statistics, following Pedroni (1999), that are classified into two categories: within-dimension and between-dimension. Rows labeled "within-dimension" report the computed value of the statistics based on estimators that effectively pool the autoregressive coefficient across different countries for the unit root tests on the estimated residuals. Rows labeled "between-dimension" report the computed value of the statistics based on estimators that average individually estimated coefficients for each country. The statistics are calculated "without time dummies" as well as "with time dummies" where the latter is intended to pick up any common disturbances affecting all countries in the panel.

[Table 2 here]

The asymptotic distribution of each of the statistics is normal with zero mean and unit variance. Under the alternative hypothesis the variance ratio statistic diverges to positive infinity and consequently the right tail of the normal distribution is used to reject the null hypothesis. Each of the other statistics diverges to negative infinity under the alternative hypothesis and consequently the left tail of the normal distribution is used to reject the

effects form. These reflect differences in mean levels among the variables of different countries in the panel and are modeled by including country specific intercepts. The second source of heterogeneity comes from differences in the way countries respond to short run deviations from equilibrium cointegrating vectors that develop in response to stochastic disturbances. This is modeled by allowing the associated serial correlation properties of the error processes to vary across sectors.

null hypothesis. Clearly per capita GDP growth rate and the proxy for infrastructure are cointegrated: the null of no cointegration is rejected at 1% level using any of the test statistics with or without the inclusion of time dummies.

Table 3 reports results from Fully Modified Ordinary Least Squares (FMOLS) estimation of equation (2).[20] The calculated value of the *t*-statistic, under the null hypothesis that a coefficient is zero, is provided within parentheses.

The first row of the table presents results for the full panel of 78 countries. Row 2 presents results for the largest balanced panel contained in the sample. Row 3 reports results from a panel that excludes major oil-producing countries because the bulk of their recorded investment is in the extraction of existing resources (not value added). To address the issue of potential data quality problems row 4 presents results obtained after excluding the countries with the poorest data from the sample. Specifically, only countries that are assigned a grade better than "D", on the Penn World Table's summary assessments of the quality of countries' data, are included. Rows 5 and 6 report results separately for OECD and non-OECD economies.

[Table 3 here]

The following inferences are drawn from the table. First, the panel estimates exhibit a significant positive association (ranging from 0.41 to 0.73) between per capita GDP growth rate and the proxy for infrastructure. This is consistent with most of the earlier findings. The estimated coefficient is even stronger for the select group of countries that pass the test of the Penn World Table's summary assessments of data quality as well as for the group of non-oil-producing countries. The estimates do not differ significantly

[20] The estimates are strikingly similar with and without time dummies. The results are reported from estimation with time dummies in order to allow potential cross-sectional dependencies.

from that of the balanced panel. Second, the growth-infrastructure association is higher for the group of non-OECD countries than the OECD countries. The hypothesis that the estimated correlations are equal for the two groups is rejected (the t-statistic is 8.71) in favor of the alternative hypothesis that the estimated association is significantly higher for OECD countries, at 1% level of significance. Finally, the possibility of cross-sectional dependency, which is particularly relevant for the growth-infrastructure relationship, has been incorporated in this analysis by employing the *CIPS* panel unit root test by Pesaran (2005) and in the form of including common time dummies in the panel cointegration and the FMOLS estimation techniques. It may be noted that while the inclusion of common time dummies captures a broad class of cross-sectional dependencies (such as, if growth or infrastructure tends to be driven by a common disturbance) there are likely to be other forms of dependency that time dummies can not control. In particular, if there are dynamic feedback effects that exist between the variables of different countries, these can not be controlled for simply by using time dummies. It is worthwhile to note though that, based on the strong evidence from the individual country test results, a relatively simple method of inference can be used to conclude if the results are sensitive to the likely presence of other such forms of cross-sectional dependencies. To see this, note that according to the Bonferroni inequality constraint, the marginal significance level, P, for a rejection of the null hypothesis applied to a panel of N countries is such that $P \leq \sum_{i=1}^{N} p_i$, where p_i is the marginal significance level of the tests applied to the individual members of the panel: $p_i = \frac{P}{N}$ can be used as a criterion to set the rejection level, in which case we require $p_i \leq 0.003$ for any one member of our sample to reject the null as applied to the panel as a whole at the 10% level. Following Maddala and Wu (1999), this type of test does not rely on the independence of the individual tests, and is thus invariant to the presence of any form of cross sectional dependency. For the normal distribution, absolute values of the *t*-statistic in excess of 4.0 are sufficient for $p_i \leq 0.003$. In our sample, the individual FMOLS tests produce 43 such cases, leading to the conclusion that no degree of cross-sectional dependency would be sufficient to overturn the key inferences of this analysis.

5. Conclusion

It is evident that a developing economy like India is likely to gain from sustained expansion of investment in and improved performance of her infrastructure sectors. Institutional capabilities and organizational reforms that lend credibility and effectiveness to government policy are likely to complement her growth momentum through expanded infrastructure investment. In particular, the high rates of urban growth experienced in India will require significant investments in infrastructure if cities are to perform their various production and service activities in a manner consistent with the principles of sustainable development. With Indian cities being at the forefront of socioeconomic transformation and given the backlog and state of deficient infrastructure characterizing these cities, increasing the level of investment in infrastructure should be a major policy thrust.

However, it is crucial for the policy-makers of the "world's fastest growing, free market democracy" to distinguish the "hypes" from the "facts" in order to guard the nation from missing her shot at converting global interest into investment, jobs and development. Reforms should be directed toward drawing resources into expanding, modernizing, and improving infrastructure facilities and services. Fair competition should be promoted by lowering entry barriers and giving entrants access to network infrastructure. Innovations must be facilitated by focusing on goals to be achieved and giving operators and investors the leeway to introduce more efficient technologies and innovative service arrangements. At the same time, it is necessary to recognize that infrastructure is critical for growth through expansion of production and trade but absent adequate complementary investments, infrastructure alone is not likely to build the "road" for moving jobs to people in a world where people increasingly keep moving to jobs. Finally, it is important not to overlook the pressing needs for designing and effectively implementing adequate governance mechanisms, the conspicuous absence of which continues to draw media and political attention, to compensate those adversely affected by the transformation of infrastructural services.

Technical Appendix

Fully Modified Ordinary Least Squared (FMOLS) Estimation: The panel FMOLS technique, developed by Pedroni (2000), is a method for estimating and testing hypotheses for cointegrating vectors in a dynamic time series panel. It augments the conventional panel Ordinary Least Squares (OLS) technique by applying the same principle underlying the semi-parametric correction for the OLS estimator used by Phillips and Hansen (1990) to develop the time series FMOLS estimator. The panel FMOLS estimator is essentially the simple average of the time series FMOLS estimates. The same is true for the *t*-statistic.

Let *y* be the dependent variable and *x* be the vector of *m* explanatory variable(s). The panel FMOLS technique involves the following steps:

1. Construct $(y_{it} - \bar{y}_t)$ and $(x_{it} - \bar{x}_t)$ where $\bar{y}_t = \frac{1}{N}\sum_{i=1}^{N} y_{it}$ and $\bar{x}_t = \frac{1}{N}\sum_{i=1}^{N} x_{it}$.
2. Estimate $y_{it} = \alpha_i + \beta_t + \gamma x_{it} + e_{it}$ (i = 1,2,...,N; t = 1,2,…,T) where α_i represents any idiosyncratic fixed effect that differs across countries, β_t represents any effect common to all countries and e_{it} is the error term capturing unmeasured shocks.
3. Use the estimated residuals ($\mu_{it} = y_{it} - \hat{y}_{it}$) from step 2 and the differences of each regressor ($\varepsilon_{it} = x_{it} - \bar{x}_t$) to construct a vector error series $\xi_{it} = [\mu_{it} \quad \varepsilon'_{it}]'$.
4. Apply the Newey-West (1987) long run covariance matrix estimator to the vector ξ_{it} to generate long run covariance matrix Ω_i and the auto-covariance matrix Γ_i .
5. Construct matrix L_i by applying Cholesky triangularization to Ω_i .
6. Construct an estimate of the standard contemporaneous covariance matrix Ω_i^0 for the elements of ξ_{it} , similarly partitioned.
7. Let Ω_{11i} be the far upper right scalar element and Ω_{22i} be the lower $m \times m$ partition of the $(m+1)\times(m+1)$ long run covariance matrix Ω_i ; Ω_{21i} corresponds to the remaining *m* elements in the column below Ω_{11i}. The same mapping applies to the partitions of the $(m+1)\times(m+1)$ auto-covariance matrix Γ_i . A superscript '0' is used when a covariance or auto-covariance is "contemporaneous". Construct a serial correlation correction term λ_i as $\hat{\lambda}_i = \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^0 - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}\left(\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^0\right)$.

8. Construct $y_{it}^{*} = (y_{it} - \bar{y}_i) - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta x_{it}$ where $\bar{y}_i = \frac{1}{T} \sum_{t=1}^{T} y_{it}$.

9. Construct the cross-product terms between y_{it}^{*} and $(x_{it} - \bar{x}_i)$ where $\bar{x}_i = \frac{1}{T} \sum_{t=1}^{T} x_{it}$.

10. The panel FMOLS estimator is given by: $\hat{\gamma} = \dfrac{\sum_{i=1}^{N} \frac{1}{\hat{L}_{11i}\hat{L}_{22i}} \left(\sum_{t=1}^{T} (x_{it} - \bar{x}_i) y_{it}^{*} - T\hat{\lambda}_i \right)}{\left(\sum_{i=1}^{N} \frac{1}{\hat{L}_{22i}^{2}} \sum_{t=1}^{T} (x_{it} - \bar{x}_i)^2 \right)}$.

    The *t*-statistic is given by: $t = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} \frac{1}{\hat{L}_{11i} \sqrt{\left(\sum_{t=1}^{T} (x_{it} - \bar{x}_i)^2 \right)}} \left(\sum_{t=1}^{T} (x_{it} - \bar{x}_i) y_{it}^{*} - T\hat{\lambda}_i \right)$.

In sum, this FMOLS technique allows for considerable heterogeneity across individual members of the panel. In addition to producing asymptotically unbiased estimators, it also produces nuisance parameter free standard normal distributions.

Table 1: Panel Unit Root (*CIPS*) Test

Variable	p =1	p =2	p =3	p =4
Y	– 3.392	– 3.811	– 2.821	– 2.801
X	– 3.963	– 3.248	– 2.872	– 2.441

Notes:

(i) All statistics are based on AR(p) specifications in the level of the variables with $p \leq 4$, for the largest balanced panel contained in the sample.

(ii) The critical values are – 2.19 for 1%, – 2.08 for 5%, and – 2.02 for 10%, levels of significance.

Table 2: Panel Cointegration Tests

Test Statistic	Without time dummies	With time dummies
within-dimension		
variance ratio statistic	9.17	5.88
rho statistic	- 9.80	- 6.94
Phillips Perron *t*-statistic	- 9.07	- 8.07
ADF *t*-statistic	- 10.20	- 10.32
between-dimension		
rho statistic	- 8.21	- 8.25
Phillips Perron *t*-statistic	- 8.44	- 9.93
ADF *t*-statistic	- 11.97	- 11.90

Notes:

(i) The *within*-dimension test statistics are based on estimators that effectively pool the autoregressive coefficient across different members for the unit root tests on the estimated residuals.

(ii) The *between*-dimension test statistics are based on estimators that average the individually estimated coefficients for each country.

(iii) The first of the four statistics is a type of non-parametric variance ratio statistic. The second is a panel analogue of the Phillips and Perron (1988) rho-statistic. The third is a panel analogue of the Phillips and Perron (1988) *t*-statistic. The fourth is a panel analogue of the Dickey-Fuller *t*-statistic.

(iv) The asymptotic distribution of each of the four statistics is normal with zero mean and unit variance. As such the standard normal table provides the critical values.

Table 3. Fully Modified Ordinary Least Squares (FMOLS) Estimates

Panel	Estimate
I. Full (78 countries; 1961-2000)	0.44
	(24.58)
II. Largest Balanced Panel Contained in the Sample (46 countries; 1961-1998)	0.41
	(19.65)
III. Non-oil-producing (55 countries; 1961-2000)	0.43
	(34.28)
IV. Non-D-graded (66 countries; 1961-2000)	0.59
	(33.04)
V. OECD (20 countries; 1961-2000	0.57
	(24.04)
VI. Non-OECD (58 countries; 1961-2000)	0.73
	(17.02)

Notes:

(i) The calculated values of the *t*-statistic are indicated within parenthesis.
(ii) The asymptotic distribution of the *t*-statistic is normal with zero mean and unit variance. As such the standard normal table provides the critical values.

Table 4: Growth of India's telecommunication network (in million)

	Fixed line (including WLL fixed)	Cellular mobile phones (including WLL mobile)	Total phones
1996-97	14.5	0.3	14.9
1997-98	17.8 (3.3)	0.9 (0.5)	18.7 (3.8)
1998-99	21.6 (3.8)	1.2 (0.3)	22.8 (4.2)
1999-00	26.8 (5.2)	1.9 (0.7)	28.7 (5.8)
2000-01	33.0 (6.2)	3.6 (1.7)	36.6 (7.9)
2001-02	39.1 (6.2)	6.4 (2.9)	45.6 (9.0)
2002-03	41.5 (2.4)	13.0 (6.6)	54.5 (8.9)
2003-04	42.6 (1.1)	33.6(20.6)	76.2(21.7)
2004-05	45.9 (3.3)	52.2(18.6)	98.1(21.9)
2005-06	46.7(0.8)	93.04(40.8)	139.8(41.7)
2006-07 (Apr-July)	47.4(0.6)	111.2(18.2)	158.6(18.8)

Source: Telecom Regulatory Authority of India