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GROWTH AND INFRASTRUCTURE INVESTMENT IN INDIA: ACHIEVEMENTS, CHALLENGES, AND OPPORTUNITIES

ABSTRACT: *The paper analyses the recent scenario of infrastructure investment in India, with the recognition that inadequate infrastructure is one of the major constraints on India's ability to sustain high GDP growth. It conducts an overview of the trends in infrastructure investment from the 10th Five Year Plan onwards, and tries to examine the linkage between infrastructure and economic growth. The results exhibit a very high rate of return and also highlight that, since resource constraints will continue to limit public investment in infrastructure in other areas, Public Private Partnership (PPP) project-based development needs to be encouraged wherever feasible.*

KEY WORDS: *Infrastructure, economic growth, Public Private Partnership, Cobb-Douglas Production function and Principal Component Analysis (PCA)*

JEL CLASSIFICATION: H54, O16

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1. INTRODUCTION

The World Development Report (henceforth, WDR) 1994, published by the World Bank under the title "Infrastructure for Development", rightly states that "Infrastructure represents, if not the engine, then the "wheels" of economic activity. Infrastructure can deliver major benefits in economic growth, poverty alleviation and environmental sustainability - but only when it provides services that respond to effective demand and does so efficiently" (World Bank 1994: pp. 2,14). Moreover, the report mentions that the adequacy of infrastructure helps determine one country's success and another's failure, and emphasizes that the kind of infrastructure put in place determines whether growth does all that it can to reduce poverty.

Infrastructure, by definition the public stock of social and economic overhead capital because of its huge potential for improving the quality of life and its large scale impact on the aggregate economy, has been mentioned quite often in the early works of development economists such as Rosenstein-Rodan (1943), Lewis (1955), Hirschman (1958), Myrdal (1958), Hansen (1965), and others.

However the nineties saw unprecedented efforts at both academic and government levels to create awareness about increased infrastructure investment (Ghosh and De, 2005). The Conference held in June 1990 by the Federal Reserve Bank of Boston was perhaps the first of its kind in which all participants agreed that public capital investment plays an important role in enhancing both the quality of life and private economic activity. The works of Aschauer (1990), Munnell (1990), Gramlich (1990) and others on issues relating to the importance of infrastructure, its role in regional economic performance, the role of public infrastructure and its provisioning, etc., had been comprehensively dealt with by eminent academicians, researchers, and other stakeholders.

The World Development Report (WDR) 1994 asserts that a strong association exists between the availability of certain basic infrastructure and economic development measured in terms of GDP, with a caution that investment in infrastructure alone does not guarantee growth. This is corroborated by another recent study showing that the impact of infrastructure on output is difficult to pin down and the direction of causality hard to determine empirically. However, there is some evidence from annual and multi-year growth regressions that investment has positive effects that go beyond the impact to be expected from a larger capital stock (Sutherland et.al, 2009). The WDR 1994 estimates that infrastructure capacity grows step for step with economic output - a 1% increase

in the stock of infrastructure is associated with 1% increase in gross domestic product (GDP) across all countries. Similarly, as alluded, different infrastructure sectors have different effects on improving the quality of life and reducing poverty. In conjunction with this report, a seminal contribution by Gramlich (1994) paved the way for subsequent empirical studies at various national and regional levels (Ramirez, 2004; Lambrinidis, 2005; Dasgupta and Koji, 2006; Zou et al. 2008). These empirical studies show substantial variation in the estimates for different countries and contexts.

In this context it seems quite relevant to analyze these three interrelated issues - infrastructure investment, growth, and poverty - in the context of India, albeit some recent studies have also tried to address them in a different context (Ghosh and De, 1998, 2000; Lall, 1999; Thorat and Fan, 2007; Sahoo and Dash, 2009). The most important thing to mention at this juncture is that most of these studies have taken into account physical measures of infrastructure for analysis purposes, but the major limitation of this approach is that there is no simple way to aggregate the various measures of infrastructure. A further obvious shortcoming of physical measures is that they fail to capture the quality of the infrastructure, which may vary systematically across countries or regions. In some cases the efficiency of the use of existing infrastructure varies substantially across regions. As such, a straight comparison between two regions may be misleading without additional information.

Thus, the major point of departure of this paper is that it tries to address these issues with the recent availability of estimates of investment in infrastructure over a period of ten years. The organisation of the paper is as follows: Section II presents the trends and prospects of aggregate and sector-specific infrastructure development in India. Section III examines the linkages between infrastructure and growth. Finally, Section IV presents concluding observations.

2. INFRASTRUCTURE DEVELOPMENT IN INDIA

Ramping up investment in infrastructure is not only critical for India's growth and to sustain the country's battle against poverty but also to lay the foundations for stronger economic growth in the future. The Eleventh Plan emphasized the importance of investment in infrastructure for achieving a sustainable and inclusive growth of 9% to 10% in GDP over the next decade. The development of infrastructure is a central theme of the Government of India's 11th Five-Year Plan (2007–2012). The plan document states that "The fast growth of the economy in recent years has placed increasing stress on physical infrastructure

such as electricity, railways, roads, ports, airports, irrigation, and urban and rural water supply and sanitation, all of which already suffer from a substantial deficit from the past in terms of capacities as well as efficiencies in the delivery of critical infrastructure services. The pattern of inclusive growth of the economy projected for the Eleventh Plan, with GDP growth averaging 9 per cent per year can be achieved only if this infrastructure deficit can be overcome and adequate investment takes place to support higher growth and an improved quality of life for both urban and rural communities." (Government of India 2008a, 11th FYP-Vol.1: 254) (Infrastructure has been defined in the document to include electricity (including non-conventional energy), telecommunications, roads and bridges, railways, ports, airports, irrigation, water supply and sanitation, storage and gas distribution sectors).

With a projected GDP growth averaging 9% per year for the Eleventh Plan, the plan document estimates almost doubling infrastructure spending from its current 5% of GDP in 2006-07 to 9% by 2011-12 (terminal year of the Eleventh Plan). And, accordingly, the aggregate capital formation in infrastructure required to achieve India's targeted annual average growth in GDP would have to rise from Rs 259,839 crore in 2007–08 to Rs 574,096 crore in 2011–12 at constant 2006–07 prices. It estimates that investment to the tune of INR 20, 11,521 crore or $502.88 billion (at an exchange rate of Rs 40/$) is needed during the five-year period in various infrastructure sectors (Table 1) and, with 2006-07 as the base year, the total investment amounts to Rs 2,056,150 crore (Government of India 2008b). This level of investment amounts to an average of 7.6% of GDP during the Eleventh Plan as a whole. Between 2006-2007 and 2011-2012 public investment constituted around 70% of the total infrastructure investment and was 5.3% of GDP (Table 2).

Table 1: GCF in Infrastructure Based on Growth Targets (Top-down Estimates)

(at 2006–07 price)

	Year	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12
		Eleventh Plan Period					
1.	GDP at market prices (Rs crore)	4145810	4518933	4925637	5368944	5852149	6378843
2.	Rate of growth of GDP (%)	9.00	9.00	9.00	9.00	9.00	9.00
3.	GCF in infrastructure as % of GDP	5.00	5.75	6.50	7.25	8.00	9.00
4.	GCF in infrastructure (Rs crore)	207291	259839	320166	389248	468172	574096
5	GCF in infrastructure (US$ billion)	51.82	64.96	80.04	97.31	117.04	143.52
6	Total GCF in Eleventh Plan	Rs 2011521 crore or US$ 502.88 billion					

Source: CSO for estimates for 2006–07, and computations of the Planning Commission, cited in GoI (2008).

Table 2: Projected Investment as Percentage of GDP (Bottom-up Estimates)

(Rs crore at 2006–07 price)

Years	Base year (2006–07 of Tenth Plan) (BE/RE)	2007–08	2008–09	2009–10	2010–11	2011–12	Total Eleventh Plan
GDP	4145810	4518933	4925637	5368944	5852149	6378843	27044506
Public Investment	175388	192107	227327	273543	332355	411226	1436559
Private Investment	49858	78166	94252	115724	146762	184687	619591
Total investment	225246	270273	321579	389266	479117	595913	2056150
			Investment as Percentage of GDP				
Public	4.23	4.25	4.62	5.09	5.68	6.45	5.31
Private	1.20	1.73	1.91	2.16	2.51	2.89	2.29
Total	5.43	5.98	6.53	7.25	8.19	9.34	7.60

Source: CSO for estimates for 2006–07, and computations of the Planning Commission, cited in GoI (2008).

Further, the Eleventh Plan projections imply that 30% of the infrastructure needs will have to come from private investment in infrastructure in various forms, including Public Private Partnership (PPP) (Government of India, 2010a). Taking account of developments in the first two years the earlier projections for the entire Eleventh Plan period have been revised, and it is now estimated that the total investment in infrastructure in the Eleventh Plan will be Rs. 2,054,205 crore, which is comparable to the earlier estimates (Government of India, 2011). The details are shown in Table 3.

Table 3: Revised Projected Investment as Percentage of GDP

(Rs crore at 2006–07 prices)

Years	Tenth Plan (Actual)	Base Year of Eleventh Plan (2006–07) (Actual)	2007–08 (Actual)	2008–09 (Actual/ Estimated)	2009–10 (RE/BE/ Projected)	2010–11 (BE/ Projected)	2011–12 (Projected)	Total Eleventh Plan
GDP at market prices	1,78,40,877	42,83,979	47,17,187	50,03,545	53,63,800	57,92,904	63,14,265	2,71,91,700
Public investment	6,94,006	1,73,676	1,99,539	2,38,054	2,62,963	2,90,832	3,19,904	13,11,293
Private investment	2,25,220	70,819	1,04,268	1,21,138	1,39,866	1,69,227	2,08,413	7,42,912
Total investment	9,19,225	2,44,495	3,03,807	3,59,192	4,02,829	4,60,059	5,28,316	20,54,205
				Investment as percentage of GDP				
Public investment	3.89	4.05	4.23	4.76	4.90	5.02	5.07	4.82
Private investment	1.26	1.65	2.21	2.42	2.61	2.92	3.30	2.73
Total investment	5.15	5.71	6.44	7.18	7.51	7.94	8.37	7.55

Source: Government of India, 2011(b).

A number of initiatives were taken in the course of the Eleventh Plan to accelerate the pace of investment in infrastructure. The Committee on Infrastructure (COI) was constituted on August 31, 2004 under the chairmanship of the Prime Minister, and later, in July 2009, the COI was replaced by a Cabinet Committee

on Infrastructure (CCI) chaired by the Prime Minister to give further impetus to initiatives for infrastructure development. The CCI approves and reviews policies and projects across infrastructure sectors.

The government has taken several initiatives for streamlining and simplifying the appraisal and approval process for Public Private Partnership (PPP) projects in a transparent and competitive manner, including constitution of a Public Private Partnership Appraisal Committee (PPPAC) under the chairmanship of the Secretary, Department of Economic Affairs with the Secretary, Planning Commission as one of the members. The PPP proposals are appraised by the Planning Commission and approved by the PPPAC. The PPPAC conducts due diligence and a thorough scrutiny of the formulation, appraisal, and approval of PPP projects (Box 1).

Box-1
Structuring PPP Projects

PPP projects are based on long-term contracts and may involve delegation of governmental authority such as for toll collection, besides enabling private control over monopolistic services. The structuring of PPP contracts requires due diligence of a high order because of the complex nature of the partnerships and the need to protect the interests of the users as well as the exchequer. Inadequacies in the contracts/concessions can severely compromise the public exchequer and user interests besides leading to rent seeking and exposing PPP projects to public criticism. Badly structured contracts and inadequate regulation can often lead to windfall gains and rent seeking by the private investors. It is, therefore, important to ensure that PPPs are carefully structured for safeguarding user and government interests with a view to ensuring efficient services at competitive costs.

Source: Government of India, 2011(a).

Since then there have been perceptible impacts of this set of institutional arrangements on PPP-based development measures in India. A large number of PPP projects have been taken up in various infrastructure sectors, including roads, ports, airports, and urban infrastructure. In Table 4 a summary of PPP projects in the central and state sectors as on 31st March, 2011 shows that 1,965 projects, involving an investment of Rs.1,098,187 crore, are at various stages of awards and implementation. Out of these 432 projects with an investment of Rs 110,907 crore have been completed and 585 projects with an investment of Rs 376,827 crore are under implementation. Another 948 projects involving an investment of Rs 610,433 crore are in the pipeline. This clearly suggests that there are big prospects for infrastructure investment in India.

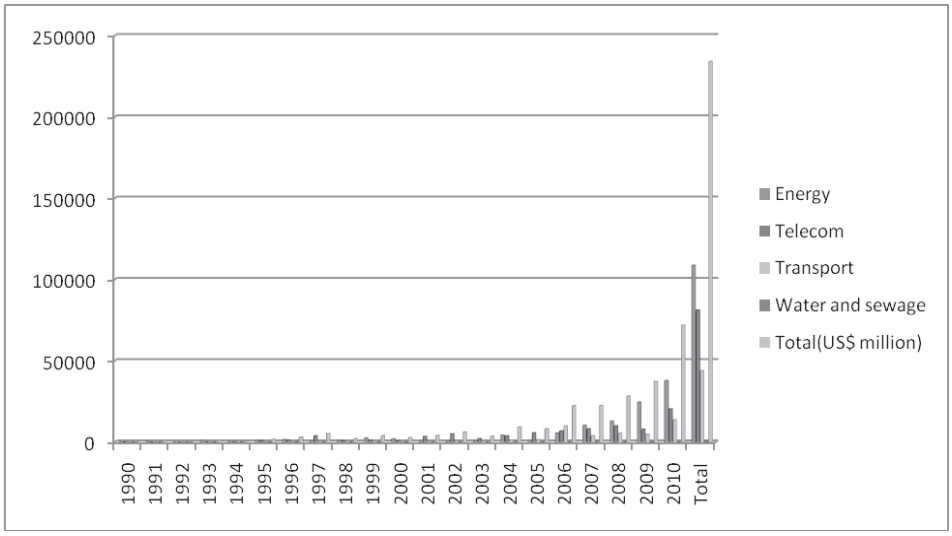
Table 4: PPP Projects in Central and State Sectors (as on March 31, 2011)

Sl. No.	Sector	Completed Projects		Projects Under Implementation		Projects in Pipeline		Total	
		No. of Projects	Projects Cost (Rs. crore)	No. of Projects	Projects Cost (Rs. crore)	No. of Projects	Projects Cost (Rs. crore)	No. of Projects	Projects Cost (Rs. crore)
(A) Central Sector									
1	National Highways	55	20,139	127	103,455	60	52,573	242	176,167
2	Major Ports	29	9,677	20	34,138	24	16,964	73	60,779
3	Airports	3	5,883	2	23,310	14	12,387	19	41,580
4	Railways	5	1,166	4	2,363	6	95,535	15	99,064
	Total (A)	**92**	**36,865**	**153**	**163,266**	**104**	**177,439**	**349**	**377,590**
(B) State Sector									
1	Roads	141	11,438	91	28,901	234	132,668	466	173,007
2	Non-Major Ports	20	26,964	40	55,853	25	41,073	85	123,890
3	Airports	2	4,957	7	4,571	9	4,265	18	13,793
4	Railways			1	500	3	312	4	812
5	Power	14	19,019	96	29,585	89	82,245	199	130,849
6	Urban Infra-structure	95	8,611	103	42,546	227	81,265	425	132,422
7	Other Sectors	68	3,053	94	51,605	257	91,166	419	145,824
	Total (B)	**340**	**74,042**	**432**	**213,561**	**844**	**432,994**	**1,616**	**720,597**
(C) Grand Total (A + B)		**432**	**110,907**	**585**	**376,827**	**948**	**610,433**	**1,965**	**1,098,187**

Source: http://infrastructure.gov.in/pppprojects/index.php (accessed on 14 September, 2012).

An upsurge in private participation in infrastructure investment in the primary sector is reflected in Graph 1, which shows that from 1990 till 2010 US$ 234, 204 million was invested in the creation of physical infrastructure, most particularly in the energy and telecom sectors. Moreover, it suggests that the country has been attracting more private investment in infrastructure since 2006. Concomitantly, recent studies also show that since 2006 India has had more success attracting private investment in infrastructure than any other developing country (Harris, 2008).

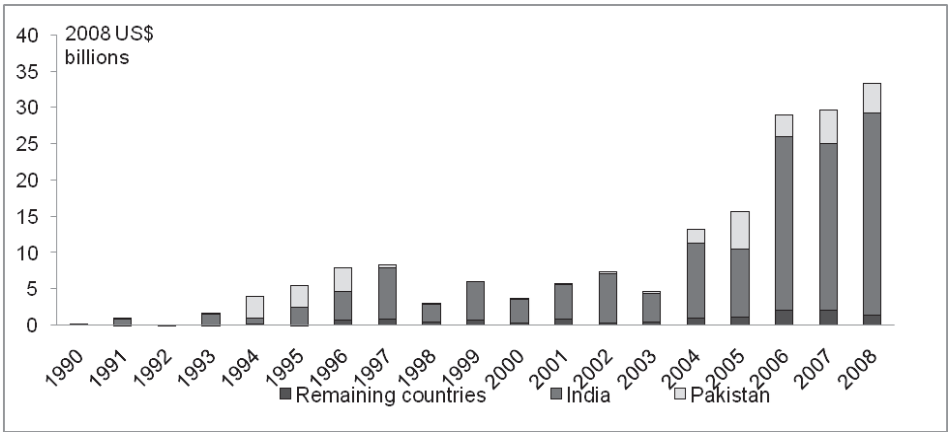
Figure 1: Total Investment in Projects by Primary Sector (US$ million)



Source: Private participation in Infrastructure Database http://ppi.worldbank.org/explore/ppi_exploreCountry.aspx?countryId=152 (accessed on 30 November, 2011).

In India private activity is vibrant, thanks to the many policies and programmes that the national and state governments have implemented to attract private investment into infrastructure sectors (Graph 2). India has now become the largest market for private participation in infrastructure in the developing world. The country implemented 94 new projects in 2010 and saw investment of US$71.9 billion in 2010, an 85% increase from 2009. That investment is the highest level that any developing country experienced in any given year in the entire 1990-2010 period. India alone accounted for 43% of the total investment in projects with private participation in developing countries in 2010. In 2010 India drove private activity in infrastructure in South Asia to a new peak for the fifth consecutive year. Long-standing policies in most other South Asian countries are beginning to bear fruit as well. However, in these South Asian countries private activity is sporadic and in many cases aims at easing crisis situations such as power outages (World Bank and PPIAF, 2011).

Figure 2: Investment Commitments to Infrastructure Projects with Private Participation in Main Recipients and Rest of Countries in South Asia, 1990–2008



Source: World Bank and PPIAF, PPI Project Database.

Nevertheless, delivering the infrastructure services needed to sustain and accelerate growth in South Asia remains a major challenge. Estimates suggest that closing the gap in service provision and meeting future needs will require infrastructure investment in the range of 7%–8% of GDP a year. The private sector can do more to help close the region's infrastructure service deficit.

In continuance with recognition that inadequate infrastructure is one of the major constraints on India's ability to sustain a high growth of GDP in the 11th FYP, the Approach Paper to the Twelfth Five Year Plan (Government of India, 2011c) states that "the plan must continue the thrust on accelerating the pace of investment in infrastructure, as this is critical for sustaining and accelerating growth". Further it admits that "in order to sustain and support the targeted growth in manufacturing, agriculture and services, larger investments in infrastructure is required and ….. provision of world-class infrastructure would not only be necessary for improving the competitiveness of the Indian economy but also for promoting inclusive growth and improving the quality of life of the common man" (Government of India, 2011a, 2011c).

A preliminary assessment suggests that investment in infrastructure during the Twelfth Plan (2012-17) would need to be in the order of about Rs.4,099,240 crore (US$ 1,025 billion) to achieve a share of 9.95% as a proportion of GDP, if the latter grows at a rate of 9% (Table 5).

Table 5: Projected Investment in Infrastructure during the Twelfth Five-Year Plan

(Rs crore at 2006–07 prices)

Year	Base Year (2011–12)	2012–13	2013–14	2014–15	2015–16	2016–17	Total 12th Plan
GDP at market prices (Rs crore)	63,14,265	68,82,549	75,01,978	81,77,156	89,13,100	97,15,280	4,11,90,064
Rate of growth of GDP (%)	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Infrastructure investment as % of GDP	8.37	9.00	9.50	9.90	10.30	10.70	9.95
Infrastructure investment (Rs crore)	5,28,316	6,19,429	7,12,688	8,09,538	9,18,049	10,39,535	40,99,240
Infrastructure investment (US$ billion) @ Rs 40/$	132.08	154.86	178.17	202.38	229.51	259.88	1,024.81

Source: GDP data for Tenth Plan, 2007-08 and 2008-09 are from CSO. GDP growth rates for 2009-10, 2010-11, and 2011-12 have been assumed as 7.2%, 8%, and 9% respectively, cited in Government of India, 2011(a).

Financing this level of investment will require larger outlays from the public sector, but this has to be coupled with a more than proportional rise in private investment. Private and PPP investment is estimated to have accounted for a little over 30% of total investment in infrastructure in the Eleventh Plan. This share may have to rise to 50% in the Twelfth Plan. Since investment in infrastructure has to increase as a percentage of GDP and about 50% of the investment is projected to be from the private sector, the institutional mechanisms for supporting such investment deserve strong support. The Finance Ministry has announced guidelines for establishing infrastructure debt funds.

3. INFRASTRUCTURE INVESTMENT – LINKS TO GROWTH AND THE ROLE OF PUBLIC POLICIES

3.1 The Model

In this section our objective is to examine the effects of infrastructure on overall growth and thereby sustained poverty reduction in the economy. There are many infrastructure variables that can be considered to determine the effect of infrastructure on growth. Since adding unimportant variables will add overhead to the analysis without any significant effect on the dependent variables, we need to identify which are the important variables.

In order to address the first research question, we use here an aggregate production function, which can be written in the form:

$$Q = A^{*} F(K, L, I) \quad (1)$$

where A* is the factor productivity represented by the state of technology, K is the stock of capital, L is the labour force, and I is the amount of infrastructure investment.

Using the Cobb-Douglas form

$$Q = A^{*} K^{\alpha} L^{\beta} I^{\delta} e^{u_t} \quad (2)$$

Now, writing (2) in logs gives:

$$\ln Q_t = \ln A^{*} + \alpha \ln K_t + \beta \ln L_t + \delta \ln I_t + u_t \quad (3)$$

Here the interpretation of production elasticities α, β & δ is tricky. If one assumes that labour and private capital are paid as per their productivities and finds $\delta>0$, $\alpha+\beta=1$ and $\alpha+\beta+\delta>1$, so that returns to scale are increasing.

It is also possible to use (2) to determine the rate of return on infrastructure investment. Differentiating Cobb-Douglas of (2) yields:

$$\delta = F_I I / Q \quad (4)$$

where F_I is the marginal product of infrastructure capital.

As far as second research question is concerned, Principal Component Analysis (PCA) technique has been used to discover the important sector-specific infrastructure investment.

3.2 Data Sources

Due to the fragility of the Indian database it is not possible to find, in particular, infrastructure investment data for a fair number of years. However, for a comparative analysis, data for all the variables or indicators have been taken since 1999-2000. Table 6 sums up the availability of data.

Table 6: Availability of Data

Variable	Source	Period
Labour force ('000)	Labour force participation rate (ILO estimates; by sex and age group)	1999 to 2008
GFCF in Infrastructure ****	Data for use of Deputy Chairman, Planning Commission, 18 May 2011	1999-2000 to 2008-2009
GDP at current prices	Central Statistical Office (CSO)	1999-2000 to 2008-2009
Gross Domestic Capital Formation	Central Statistical Office (CSO)	1999-2000 to 2008-2009

Note: **** GFCF in infrastructure includes GFCF in irrigation, electricity, gas, water supply and wind energy, ports etc., construction and Roads & Bridges, railways

The values of these parameters for the above-mentioned period is given below.

Table 7: Values of Selected Indicators

Year	**Labour force (crore)**	**GFCF in INFRA (Rs.in Crore)**	**GDPMP (Rs.in Crore)**	**Gross Domestic Capital Formation (Rs. in Crore)**	**Gross Domestic Capital Formation other than Infrastructure (Rs.in Crore)**
1999	40.14	88,521	1,802,801	429,430	340,909
2000	40.92	109,303	2,009,556	532,692	423,389
2001	42.06	116,950	2,164,262	538,525	421,575
2002	43.21	115,931	2,346,105	547,857	431,926
2003	44.38	123,940	2,526,888	650,323	526,383
2004	45.57	140,820	2,835,789	798,995	658,175
2005	46.77	182,603	3,242,209	1,064,041	881,438
2006	46.90	235,806	3,692,485	1,279,891	1,044,085
2007	47.00	275,111	4,293,672	1,531,568	1,256,457
2008	47.10	330,968	4,986,426	1,901,928	1,570,960

Source: Same as Table 6

3.3 Empirical Results

The regression result (from Table 8) can be put as:

$$LNGDP = \underset{(1.48)}{3.26} + \underset{(0.23)}{0.13}\ LNCAPITAL + \underset{(0.23)}{0.46}\ LNINFRA + \underset{(0.57)}{1.15}\ LNLF \quad (5)$$

Table 8: Linear Regression Results

Dependent Variable: LNGDP
Sample: 1999, 2008
Included observations: 10

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.262145	1.477943	2.207219	0.0694
LNCAPITAL	0.129654	0.226132	0.573356	0.5872
LNINFRA	0.460044	0.230836	1.992949	0.0933
LNLF	1.148501	0.565001	2.032744	0.0883
R-squared	0.992028	F-statistic		248.8712
Durbin-Watson stat	1.384301	Prob (F-statistic)		0.000001

Source: Same as Table 6
Note: LNLF represents the natural logarithmic value of labour force, LNINFRA represents the natural logarithmic value of infrastructure investment, LNCAPITAL represents the natural logarithmic value of capital formation in sectors other than infrastructure, and LNGDP represents the natural logarithmic value of GDP at current market prices.

Results show that the coefficient of infrastructure is positive (0.46) and also is statistically significant (at a 10% level), implying that a very high rate of return, even compared to other investment, might be due to its spill-over or externality effects.

Similarly, to assess which set of infrastructure parameters seems to be quite significant, PCA analysis has been used on the following variables:

1. Road Construction (Road)
2. Railways (Rail)
3. Electricity, Gas, Water supply (EGW)

4. Communications (Com)
5. Irrigation (irr)
6. Storage (strg)
7. Ports

Considering the above variables, an attempt is made to identify significant variables taking ten years and five years of data. The pattern that the variables follow in both the samples should be the same, indicating that all the variables follow the same pattern across time. The results from both analyses are discussed in detail below.

PCA requires that there should be some correlations greater than 0.30 between the variables of concern, which is satisfied as observed from the correlation matrix of variables in Table 9.

Table 9: Correlation Matrix (Ten years)

	Irr	Road	Rail	EGW	Com	Strg	Ports	Gdp
Irr	1.000	-0.262	0.500	0.532	0.677	0.081	0.753	0.744
Road	-0.262	1.000	0.084	0.194	0.017	0.640	-0.079	0.010
Rail	0500	0.084	1.000	0.281	0.736	0.370	0.734	0.742
EGW	0.532	0.194	0.281	1.000	0.144	0.241	0.694	0.783
Com	0.677	0.017	0.736	0.144	1.000	0.360	0.424	0.576
Strg	0.081	0.640	0.370	0.241	0.360	1.000	0.238	0.225
Ports	0.753	-0.079	0.734	0.694	0.424	0.238	1.000	0.890
Gdp	0.744	0.010	0.742	0.783	0.576	0.225	0.890	1.000

Source: Same as Table 6

It is already seen in the above regression analysis that infrastructure has a major impact on growth. The correlation matrix cannot quantify the impact of each of these parameters on growth: however the last column of Table 9 shows that each of the infrastructure parameters has a positive correlation with growth, and an increase in investment in each of these parameters will result in an increase in growth. Observing the positive correlations in the table it is evident that each of these sectors is interrelated, and an increase in growth because of an increase in investment in any particular sector might not be solely because of that sector. PCA enables us to transform this data into non-correlated data by creating eigenvectors from which we can avoid the problem of correlation in data.

A further analysis compares the change in GDP with the change in each of the parameters by calculating eigenvalues and corresponding eigenvectors. All the components whose eigenvalues are greater than 1.0 are significant. In both the samples there are three components having eigenvalues greater than 1.0 (Table 10), which explains more than 70% of the total variance of the data, when the criteria is only 60%. The higher the eigenvalue of a component the higher its importance, as it explains most of the variance in the data. The component loadings of each of the components are analyzed to see the individual importance of sectors, and the absolute value of the component loading of a sector explains its own importance to growth.

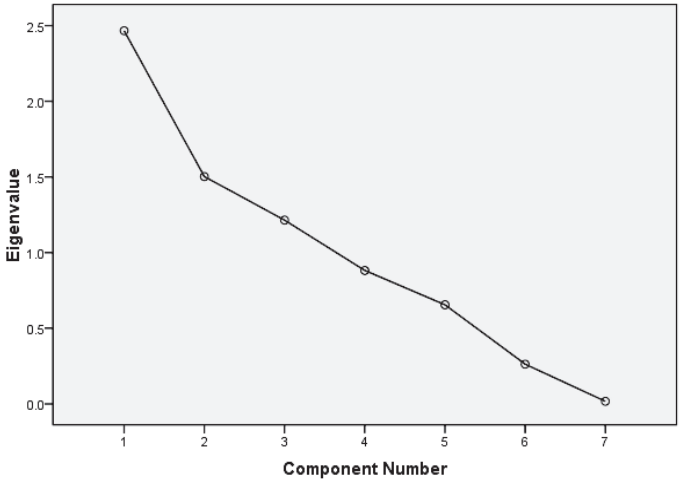
Table 10: Components (Ten years)

Component	Eigenvalue	Cumulative variance
1	2.466	35.233
2	1.502	56.694
3	1.215	74.046

Source: Same as Table 6

Figure 3 shows that the first component with higher eigenvalue and steep slope has more information about the significant parameters of growth, followed by the second and third components; all of which have eigenvalues of more than 1.0.

Figure 3: Screen Plot of Eigenvalues



Source: Same as Table 6

Finally we consider each of the components individually to identify the significance of each parameter. Table 11 shows all the components with the component loading values that explain the parameters' significance.

Table 11: Pattern matrix

	Component		
	1	2	3
Irr	-.956	-.113	-.151
EGW	.931	-.027	-.017
Rail	.619	-.066	-.578
Ports	.310	.766	.172
Strg	-.305	.717	-.023
Com	.072	.647	-.151
Road	.113	-.083	.915

Source: Same as Table 6

Looking at the first component, Irrigation (Irr), Electricity Gas and Water (EGW), and Railways (Rail) seem to be more significant. They all are moving together with higher values and so have a major impact on growth both individually and together. India is an agrarian economy and so it is evident that investment in the irrigation sector is very important, as supported by the results with the component loading value of 0.956, as are Electricity, Gas, and Water supply and Railways, which enable economic growth to drive forward and better communications in the industrial economy. However, Road Transportation and Water Transportation are also important as they facilitate well-established communications in the economy. This fact is evident by looking at the second and third components, where Road and Ports have component loadings of 0.915 and 0.766 in the third and second components, respectively. Considering all the components together, no infrastructure sector component appears to have less importance and an increase in investment in all components together can have a major impact on the growth of the economy.

4. RECENT CHALLENGES AND PROSPECTS

While the importance of infrastructure on economic development is well documented across countries/regions, as is being experienced in India, the Government of India recognizes that there is a significant deficit in the

availability of physical infrastructure across different sectors and that this is hindering economic development (Government of India, 2009). Sectors like telecommunications and airports are being transformed, while sectors like the highway system are being upgraded and expanded. Nevertheless, inefficient electricity distribution, not-so-transparent coal production, and the tardy pace of land acquisitions are still major hindrances to reaping benefits from infrastructure.

The Planning Commission of India, in its midterm review of the 11th Five-Year Plan, noted that India had a large deficit in infrastructure investment (Government of India, 2011b). As mentioned earlier, infrastructure investment needs to be close to 10% of GDP on a sustained basis for the next five years, 2012-2017. This massive investment target (a whopping $1 trillion) for developing the physical infrastructure, though not impossible, will nevertheless be tough to achieve through government budgetary support, and therefore needs private participation in financing. It may be recalled that private investment constituted around 30% of total infrastructure investment and was nearly 2.3% of GDP between 2007-2008 and 2011-2012 (Table 2). Private infrastructure financing in India, as in most other countries, faces a number of challenges. Private financing of infrastructure projects is not so lucrative, as these projects are complex capital-intensive, long-gestation projects that involve multiple risks, and investors have to be prepared for a long period of debt repayment and return on equity. Many financial institutions are limited in their ability to invest in very long-term illiquid assets (World Bank, 2006; IDFC, 2009).

5. CONCLUDING OBSERVATIONS

This paper analyses the recent scenario of infrastructure investment in India, with the recognition that inadequate infrastructure is one of the major constraints on India's ability to sustain high GDP growth. It surveys the trends in infrastructure investment from the 10th Five Year Plan (FYP) onwards and examines the linkage between infrastructure and economic growth. Due to data availability analysis is carried out on only 10 years' time-series data, by using an augmented Cobb-Douglas production function with infrastructure investment as one of the parameters. The results are quite striking. The basic conclusion that emerges from the paper is that infrastructure has a huge impact on national and local development. That it exhibits a very high rate of return, even compared to other investment, might be due to its spill-over or externality effects, and based on Principal Component Analysis (PCA) we found that infrastructure in seven

broad sectors, namely, road construction, railways, electricity gas and water supply, communications, irrigation, storage, and ports are complementary in nature and mutually reinforcing.

Several reform measures that have been taken to attract private investment in infrastructure through the PPP route have met with considerable success at both Central Government and State levels. A large number of PPP projects have taken off and many of them are currently operational, though progress is not even across the different sectors. In order to augment incentives for private infrastructure investment, the World Bank (2006) suggests the key ingredients of a successful PPP programme are:

- clear and stable policy and legal frameworks for PPPs that have broad support;
- competent and enabled institutions that can identify which projects are best done as PPPs and whether they are priorities, and then procure and properly monitor them;
- efficient oversight and dispute resolution procedures; and, of course,
- well developed financial markets, including a long-term corporate bond market.

PPP-based infrastructure development needs to be encouraged wherever feasible.

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