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The Infrastructure-Output Nexus: Regional Experience from India

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THE INFRASTRUCTURE-OUTPUT NEXUS: REGIONAL EXPERIENCE FROM INDIA

Sumedha Bajar*

Abstract

Infrastructure plays an important role to support development and growth. In recent years, India has come to enjoy the reputation of a rapidly developing nation. In order to ensure that nothing hinders this growth process or its continuance, it is important to identify the major bottlenecks to growth and the channels through which they operate. In this paper, attempts are made to establish the nexus between per capita NSDP in India and infrastructure availability in India's 17 major States. The main conclusions that can be drawn are that considerable regional disparities exist in terms of per capita net State domestic product (PCNSDP) from 1981 to 2010 and these disparities have increased over the years even though the initially poorer States have been growing at faster rate. After grouping the states into three categories, it was observed that the poor States had poorly developed infrastructure whereas the richer States had relatively better infrastructure. However, there is evidence of increase in infrastructure growth in the poor states after the economic reforms of 1991even though their level still remained considerably lesser than that of the rich states. The panel data estimation reveals that physical infrastructure variables did not have a uniform influence on output. The relationship did not just differ for aggregate output and, secondary and tertiary sector outputs; there was a distinct difference in the impact infrastructure had on the same sector for different time periods. This paper is part of on-going research aimed at comprehensive empirical work exclusive to India to help identify the role of infrastructure development.

JEL codes: H54, O11, L92, L94, L96,O53
Keywords: Physical Infrastructure, Output (NSDP), Economic Growth, India

Introduction

Achieving balanced economic growth amongst the Indian states has been a persistent aim of the Indian Government and the planners since Independence. Economic policies that promoted economic growth with equity and minimised inter-regional disparities formed the major thrust of the planning process. However, despite having common political institutions and national economic policies, these objectives were not realised and considerable inter-state disparities endure in India (Nair, 1993; Cashin and Sahay, 1996; Nagaraj *et al*, 2000 and Rao, Shand and Kalirajan, 1999).

Although, India's growth performance during the first years of Independence had been lacklustre (the term 'Hindu rate of growth' was disparagingly used to refer to the modest growth rate experienced during this period), this pattern started showing a change in the 1980s with partial liberalisation of the economy and, more so, with the wide-ranging reforms that followed the balance of payment crisis in 1991. The gross domestic product (GDP) grew at an average of 5 per cent in the 1980s and increased further in the 1990s to touch 9 per cent in the second half of the 2000s.

Even with these rapidly evolving changes at the national level, regional inequalities remained obstinate. In 1980-81, an average citizen of Punjab was four times richer than the average citizen of Bihar. The situation has not changed much since. In 2009-10 the per capita income level in Bihar (the poorest state in India) was one-fourth of that in Maharashtra (the richest state) and one-third of that in Punjab. Interestingly, Maharashtra which had 8 per cent of total national population contributed 16 per

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cent of the aggregate net state domestic product (NSDP) in 2009-10, while Bihar with more than 10 per cent of population contributed only 4.5 per cent. Rising regional inequalities can have several repercussions on both economic and political stability in the country (Nagaraj *et al*, 2000).

While reducing inter-state disparities in growth and income remains the avowed objective of Indian planning for balanced regional development, reducing the real interest rate in the economy and ensuring long run sustainable growth by reducing the fiscal deficit is of utmost importance to both the regional and national economy. The present system of fiscal federalism mandates increased transfers from the central government to the less developed states making it even harder to reduce the federal deficit. Thus, achieving balanced growth and reducing regional disparities is a major challenge faced by the Indian government.

In view of the above discussion, it becomes important to understand the determinants of the development of sub-national regions. The literature points to various set of strategies through which the objective of balanced regional development can be accomplished. Infrastructure provision is seen as a particularly important instrument for promoting regional development in which the governments can play an important role due to the public goods nature of infrastructure facilities. Services provided by infrastructure – power, transport and telecommunication – are considered fundamental to economic activity by serving as intermediate inputs in the production process. Furthermore, infrastructure availability enhances long run growth by facilitating market transactions and creating positive externalities among firms or industries that influence their choice of location (Jumenez, 1995).

In this context, an examination of the precise economic relation of infrastructure and output with respect to the Indian states would be of great use to policy makers and researchers. This study analyses a panel of 17 major Indian states over the period of 1980 to 2010. The focus in this paper is on physical capital stocks in network sectors: transport (roads and railways) and non-transport (electricity, telecommunications). All these sectors can be expected to have network externalities and large economies of scale. The study begins the analysis by using basic descriptive statistics followed by panel econometric techniques.

The remainder of the paper is structured as follows: A brief review of literature presented in Section 2 serves to position this paper. An overview of inequalities in per capita income and growth performance of Indian states is presented in Section 3 besides a summary of the development of infrastructure at the state-level. Section 4 presents the empirical results obtained that focus on the nature and strength of the relationship between infrastructure and per capita Net State Domestic Product (PCNSDP). The final section offers the concluding remarks.

Brief Review of Literature

Until the late 1980s, little attention was paid by the economists to the role of infrastructure in theoretical and empirical studies (Gramlich, 1994). Starting with the seminal work by Aschauer (1989), public capital (or infrastructure) was an element in the aggregate production function. He examined the relation between aggregate productivity and government spending variables for the US economy for the time period 1949 to 1985 and concluded that non-military public capital stock yields very high returns (in the range of 60-100 per cent per annum). This sparked off a debate in empirical studies focussing

on the technical issues such as the form of the production function used amongst others. In a study that included public capital in an empirical cross country growth model, Easterly and Rebelo (1993), ran pooled regressions (using decade averages for the 1960s, 1970s and 1980s) of per capita growth on (sectorial) public investment and conditional variables for 36 countries (Sturm *et al*, 1998 for a summary). They found that the share of public investment in transport and communication infrastructure is correlated with growth. Likewise, Gwartney *et al* (2004) considered 94 countries during 1980 to 2000 and found a significant positive effect of public investment, although its coefficient was always smaller than that of private investment. However, other studies using the public investment share of GDP as regressor report different results. For instance, Sanchez-Robles (1998) explored empirically the relationship between infrastructure and economic growth by including the data of expenditure on infrastructure as a share of GDP in traditional growth cross-country regressions and found a negative growth impact of infrastructure expenditure in a sample of 76 countries. In addition, the paper elaborates on some new indicators of investment in infrastructure employing physical units of infrastructure. Devarajan *et al* (1996) report evidence for 43 developing countries, indicating that the share of total government expenditure (consumption plus investment) has no significant effect on economic growth. Their empirical analysis makes use of annual data of 43 developing countries from 1970 to 1990 to examine the link between components of government expenditure and economic growth. Devarajan *et al.,* attribute their results to the fact that excessive expenditure on transport and communication in those countries make them unproductive. Prichett (1996) had another explanation – public investment in developing countries is often made in unproductive projects. As a consequence, the share of public investment in GDP can be a poor measure of the actual increase in economically productive public capital.

Some of the important studies that used the Cobb Douglas or trans log production function with different types of infrastructure as separate factors of production alongside private physical capital and labour at the cross country or national level were by Easterly and Rebelo (1993), Everaert and Heylen (2004) Bonaglia *et al* (2000), Cadot *et al* (1999), Canning (1999), Canning and Bennathan (2000), Charlot and Schmitt (1999)Calderon and Severn (2002), Esfahani and Ramirez (2002) and report output elasticity of infrastructure between 0.1 and 0.2. More recently, Egert *et al* (2009) found that investment in network infrastructure boosted long-term economic growth in OECD countries. This paper is especially important because it considers the time-series properties of data and concludes that the contribution of infrastructure to long run output levels and growth are not homogenous across countries and sectors and over time.

The patterns of growth of the group of developed countries and the group of developing nations have been found to be quite different. The study by Straub and Hagiwara (2010) presented the state of infrastructure in developing Asian countries and applied two approaches – growth regressions and growth accounting – to understand the link between infrastructure, growth and productivity. They found that the growth rate of infrastructure stocks had a positive and significant impact on average growth rates of per capita GDP in these countries while the impact on productivity was inconclusive.

While Income differentials between countries are extremely large, income differentials within regions of a given country can also be significant. In case of India, Nair's (1983) pioneering analysis

covered 14 major states of India and found that the inter-state disparities in per capita NSDP, as measured by coefficient of variation (CV), had declined from 1950-51 to 1964-65, but increased between 1964-65 and 1976-77. Dandekar (1993) claimed that the inter-state economic disparity increased over time. A study by Mathur (2001) reported a steep acceleration in the coefficient of variation of per capita incomes in the post-reform period of 1991 to 1996. A comparative analysis of 15 major states in respect of a variety of indicators was attempted by Kurian (2000). His study also drew attention to inter-state disparities by presenting data for states on demographic characteristics, poverty ratio, magnitude and structure of State Domestic Product (SDP), development and non-development revenue expenditure, indicators of physical infrastructure development and indicators of financial infrastructure and other variables.

A large part of mainstream economic research on infrastructure (as mentioned above) has concluded that the impact on growth is substantial and significant. In this context, it will be worthwhile to look at Indian states and consider the patterns and impact of factors like infrastructure development in explaining inter-state differences in growth rate in India. In this review the more recent and relevant studies are presented for the sake of brevity. Ghosh and De (1998, 2000 and 2004) tried to identify the role of infrastructure in regional development. They tested the impact of public investment and physical infrastructure on both private investment behaviour and regional economic development using OLS regression. The results of their study are significantly conclusive for the time period studied and they conclude that regional disparity in India was increasing and regional imbalances in physical infrastructure were responsible for rising income disparity across the states.

Other Studies that found positive and significant impact of infrastructure index on regional output and output growth are Patra and Acharya (2011) Nagar and Basu (2002), Majumder (2004), Ghosh (2012) etc. Patra and Acharya (2011) examined the spatial disparities in infrastructure facilities across 16 major states and the impact on regional economic growth and poverty for the year 2002-03 using correlation matrix and path regression. Indices of infrastructure development were computed using the principal component analysis for the period 1999-91 to 1996-97 by Nagar and Basu (2002) and from 1970-71 to 1990-91 by Majumder (2004). The study by Majumder made use of district as a unit of analysis using discriminant analysis concluded that infrastructure variables can be discriminating when districts were classified according to the level of development. Association between infrastructure and development was found significantly positive in intermediate regions but insignificant in advanced regions. It was found that social infrastructure was more important in lagging regions. Kaur and Ghuman (2009) examined the extent and determinants of inter-state disparities in socio-economic infrastructure during the pre and post reform period and used 22 indicators of infrastructure for 15 major Indian states. The states were classified into 3 categories based on infrastructure development. The main conclusion from the study was that states in India converged in terms of infrastructure during the 1980s and diverged during the 1990s. Infrastructure disparities were the highest within the less developed states and relative ranking of states in terms of infrastructure development remained more or less the same for the three reference periods – 1981-82, 1991-92 and 2001-02.

The study by Nagaraj, Varoudakis and Veganzones (2000) examined the growth performance of Indian states during 1970-94. They started by grouping the states according to differences in the

availability of physical, social and economic infrastructure using the principal component analysis and assessed the contribution of various infrastructure indicators to growth using the PCA and the techniques of panel data estimation. The instrumental variable estimation technique was applied to tackle the endogeneity issue in the provision of infrastructure. This study finds persistent income inequalities amongst states due to differences in structure of production, infrastructure endowments and state specific fixed effects in growth regression.

On a different line, Lall (1999) tried to examine the relationship between public infrastructure investments and regional development in India. This study covers the period 1980-81 to 1993-94 and examines the development process of 15 states and concludes that leading, intermediate and lagging states are structurally different and infrastructure investments influence growth in these regions through different pathways. Instead of using physical indicators of infrastructure, the dependent variables in the study are – public investments in economic infrastructure (transport, power, telecom and irrigation) and social infrastructure (education, water supply and sanitation, medical and public health), private investment and private employment. A common result that emerged across all states is that investments in social infrastructure have positive effects on regional growth. This study failed to show any positive link between economic infrastructure investments and regional economic growth. Another interesting study by the same author (after developing a theoretical model that incorporated both private and public infrastructure investments) concluded that expenditure in transport and communication infrastructure was a significant contributor to regional growth and the benefits were higher in lagging states. The positive benefits accruing from these investments came not from individual states alone but also the positive externalities from network expenditure made by neighbouring states (Lall, 2007). The impact of regional infrastructure investment on regional income across 17 states at four different points in time – 1970-71, 1980-81, 1990-91 and 1997-98 – was undertaken by Kumar (2002).

In the following two sections after providing evidence for the existence of regional disparities in income in India, the identification of the role played by infrastructure endowment in improving per capita income level and its growth in Indian states from 1980-81 to 2009-10 was attempted.

Economic Features of Indian States and Regional Disparities

There are big disparities in economic development and growth performance between states in India. Understanding these is of paramount importance when trying to determine the factors accounting for long-term growth trends in India. Attention is called to inequalities in real per capita Net State Domestic Product (in 2004-05 prices) and analysis is presented in the Sub-Section B. The present study intends to examine the effect of infrastructure on the output of a state. For this purpose, certain infrastructure variables were selected as indicators of infrastructure development and their trend analysed over time and across states in Sub-Section C. Most of these indicators are either absolutely controlled by the government or are regulated either by central or state government. It must be noted that supply of infrastructure is a stock available over discrete time points.

A. Data, Coverage of States and Time Period

India is a union of 28 states and 7 union territories but the analysis in this paper is confined to 17 major states – Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. These 17 states account for about 90 per cent of the national net domestic product, 92 per cent of national gross fixed capital formation (GFCF) and 93.5 per cent of total labour force in 2009-10 and are therefore representative.

For the purpose of this paper, data series for PCNSDP, PCNSDP in the secondary sector and PCNSDP in the tertiary sector in 2004-05 constant prices was created for these 17 Indian states. This data was obtained from the Central Statistical Organisation (under MOSPI, Government of India) website. The state-wise and sector-wise worker's data was compiled from NSSO rounds on Employment and Unemployment for 1987, 1993, 1999-00, 2003 (sector wise distribution of workers) and 2009-10. The total number of workers from NSSO survey conducted in 1977 and 1983 were used for the period 1981 to 1987. These two surveys only provided per thousand distribution of working population and the sector-wise distribution of this working population was not available. To tackle this, the state-wise share of primary workers available in Bansil (1990) for 1981 was obtained used to project the share between 1981 (Bansil, 1990) and 1987 (available in NSS Report) using the growth rate between the two periods. This share was to compute the primary working population from the total working population calculated since 1981. In order to calculate the population of secondary and tertiary workers the remaining workers (apart from primary workers) share in 1981 was distributed between these two sectors according to their proportion in the 1987 NSS survey. Then the same procedure was adopted to work out the working population of the secondary and tertiary sectors. However, the workers data series could not be computed for Assam and Jammu and Kashmir due to unavailability of data.

Data for state-wise outstanding credit of Scheduled Commercial Banks was compiled from the annual publication of the Reserve Bank of India titled "Basic Statistical Returns of SCBs in India". This series is available from 1980 to 2010 except for 1989 for which data could not be obtained. Disaggregated data is available under the section *State and Bank Group-wise Classification of Outstanding Credit of SCB According to Occupation*. This data was used to compile the total and sectorial shares of credit and deflated using the GDP deflator to obtain a useable series.

Data for electricity consumption (kWh per capita), surfaced road density (km of surfaced road per 1000 sq. km of geographical area), rail density (km of rail length per 1000 sq km of geographical area), teledensity (per 10,000 people), number of schools, primary health centres and community health centres (all figures in per 1,00,000 population) was compiled from the Statistical Abstract of India, CMIE, database on infrastructure and the respective government departments.

In order to understand the impact of infrastructure on different regions in India, the states were grouped as High income, Medium income and Low income states for each of the three periods. The basis for this stratification was - states with average PCNSDP above (National average PCNDP – 0.5* (standard deviation of national income)) were classified as high income; those with less were categorised as Low income and states with average PCNSDP between the two ranges were in the Middle-income category. (See Appendix for the list of states in each category for the three periods).

Income dummies were created for these categories and their interaction with infrastructure variables estimated. This exercise was undertaken to understand the differential impact of infrastructure on income/output, if any, depending upon whether the region is a high income or low income region.

Time period

The basic strategy employed in this paper is to divide the entire time into three decades – 1980-1989, 1990-1999 and 2000-10 – and to discern the impact of infrastructure variables on the levels of PCNSDP in the respective periods.

The decision to divide the time period into three phases was policy inspired. These three decades are characterised by stark differences in terms of the infrastructure development policies shaped, in large part, by the changing political priorities of governments in each decade (Lall and Rastogi, 2007). In the beginning of the 1980s, following the second oil crisis, concentration was mainly on rural India and the Sixth Five Year Plan (FYP) was characterised by massive public investment in rural roads, ground water irrigation and a system of procurement prices. Rural electrification did not mean electrification of rural households but grid extensions were provided to farms to meet the demand for irrigation. There was great politicisation of fiscal policy and it was the era of larger government and public spending. The entry of Rajiv Gandhi in 1984 was characterised by two noteworthy features with respect to infrastructure development. The development of the telecommunication sector acquired significance and attracted huge investments. The Centre for Development of Telematics was established in 1987 to cultivate and improve India's telecom sector and help it catch up with the rest of the world thus setting the stage to launch the Indian IT industry during the 1990s. Secondly, the development of infrastructure for ground water irrigation and electricity supply for irrigation purposes continued. However, the financial situation of State Electricity Boards deteriorated and there appeared chronic shortages of power for commercial and urban use. The development of critical transportation and urban infrastructure continued to be neglected.

In the post-1991 period, the emphasis was on fiscal consolidation. Investment in infrastructure became a major casualty when the aim of central government was to reduce fiscal deficit from 8.4 per cent of GDP in 1990-91 to 5 per cent 1992-93. The decline in infrastructure spending and putting on hold almost all infrastructure projects should have adversely affected GDP growth but marked improvement in targeting of infrastructure spending and telecom-related reforms propelled productivity. Until 1994, telecom was a government monopoly. The National Telecom Policy (1994 and 1999) helped liberalise the sector and recognise its importance as component of infrastructure. The second half of the 1990s saw an upsurge in recognition of the shortages in infrastructure that were surfacing. The *India Infrastructure Report* (NCAER 1995) was the first of its kind and many recommendations found their way into government policies. The *World Development Report* (World Bank, 1994) drew the attention of policymakers to the initiatives followed globally to induce greater private sector participation in infrastructure development. It would later become part of many of the policies crafted by Indian policymakers. With the Ninth FYP debate over private sector participation entering into infrastructure sector was initiated and steps taken to encourage the same and there was an emergence of a strategic

focus on infrastructure policy. It also emphasised the disproportionate reliance on congested national highways compared to railways.

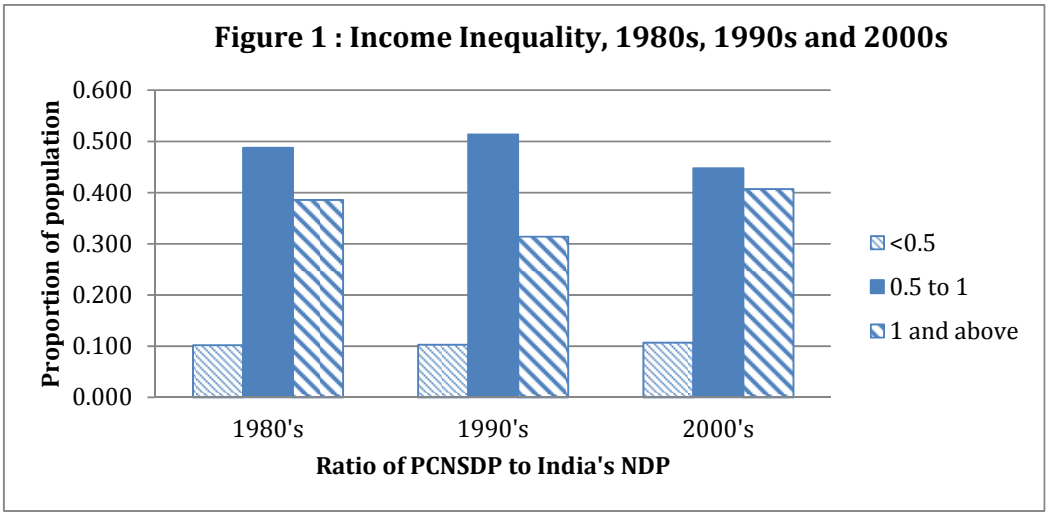
The decade of the 2000s saw the above mentioned policy suggestions and initiatives take shape. There was targeted spending on national highways network and build-out of Golden Quadrilateral and related North-South and East-West road corridors under the Tenth FYP. Policies to create enabling conditions for private sector financing of infrastructural projects were initiated. With the Electricity Act of 2003, the policy framework brought private investment in the sector. In order to provide direction to the effort and prioritise infrastructure development, especially, public-private partnerships (PPP), the government constituted a Committee on Infrastructure (CoI) in August 2004 under the chairmanship of the Prime Minister. The objectives of the CoI included initiating policies that would ensure time-bound creation of excellent infrastructure, delivering services matching international standards, developing structures that maximise the role of PPPs and monitoring the progress of key infrastructure projects to realise established targets. The Eleventh FYP envisaged stepping up the gross capital formation in infrastructure from 5 per cent to 9 per cent of GDP. Despite the emphasis on PPP by plan documents, the response of the private sector has been lukewarm. Several reasons have been highlighted, such as overlapping of regulatory jurisdiction, improper design, bidding transparency issues, project costs, time overruns etc.

Thus, it can be gauged that each of the three decades of 1980s, 1990s and 2000s were characterised by different policy focus, infrastructure policies pursued and development of various infrastructure sectors. This then becomes the motivation to divide the entire time period into three phases.

B. Regional Disparity in per capita NSDP

There is a vast body of literature dealing with economic growth and its pattern in Indian states (Nair, 1983; Roy Choudhary, 1993; Cashin and Sahay, 1996; Rao, Shand and Kalirajan, 1999; Das and Barua, 1996; Mathur, 2001; Kurain, 2000, to name a few). In this section, data from 1981 to 2010 has been selected and state-wise disparities in PCNSDP and growth rate in the above-mentioned 17 states computed. A single time trend will not adequately characterise the evolution of PCNSDP over time because instability and phases in growth rates over time is a reality in India.

The portion of India's population living with per capita NDP less than half the aggregate per capita NDP for India has increased marginally from 10.2 per cent in the 1980s to 10.7 per cent in the 2000s (assuming all households within a state are the same). Interestingly, the proportion of India's population that earned more than half but less than the aggregate per capita NDP for India first increased in the 1990s and then fell below the 1980s level (49% in 1980s to 51 % in 1999s to 44% in 2000s). Almost the same set of states are in this category for all the three decades – Uttar Pradesh, Madhya Pradesh, Orissa, Rajasthan and West Bengal, with the exception of Andhra Pradesh that saw an improvement in its NSDP. It led to the exit of Andhra Pradesh from this group in the decade of 2000s, which is significant, as it constitutes around 7 per cent of the population in India. The states that earned more than the aggregate India's PCNDP have remained consistent – Gujarat, Haryana, Punjab, Maharashtra, Tamil Nadu, Karnataka, Kerala



Source: Author's calculation

It is important to realise that states like Uttar Pradesh, Madhya Pradesh, Bihar and Rajasthan with a large population base seem to perform badly in per capita terms. In 2009-10, Uttar Pradesh produced 9.15 per cent of India's NSDP (following Maharashtra's contribution), but almost 17 per cent of India's population live in this state and it brings the per capita NSDP of the state down to second lowest in the country (following Bihar). Whereas, states like Punjab, Haryana and Kerala that are considered the rich states of India contribute 3 to 4 per cent of India's NDP but have low population base thus raising their per capita income. Table 1A in the appendix provides the trend in growth in NSDP and population growth rates for the three decades of 1980s, 1990s and 2000s as well as for the overall time period (1980-2010). Maharashtra (highly industrialised state) had the highest NSDP growth rate for the entire period. In the 1980s, Haryana, Maharashtra and Punjab had high NSDP growth rates. The success story of Punjab and Haryana in this period rests mainly on the high growth of agricultural output productivity. The situation changed drastically after the 1991 reforms and the opening up of the economy had adverse impact on the growth of the agricultural sector in India after the mid-1990s (Chand and Parapurrathu, 2012) leading to a big drop in NSDP growth rate and ranking for Punjab and Haryana. Surprisingly, Bihar grew at close to 10 per cent in the 1990s and the trend continued in the 2000s as well. The growth of Bihar is primarily from a lower base and supported mainly by the construction sector. The huge growth in construction activities was largely propelled by public investment in the last few years which included construction of roads, bridges and government buildings. Majority of the growth is occurring in the tertiary sector whereas agriculture and allied sectors, on which about 80 per cent of the state's population depends, have registered very low growth rates.

It is gathered from the above analysis that the growth pattern of the 17 major states has been quite diverse. Next, an attempt is made to group the states based on their average level of PCNSDP and trend in growth rate of NSDP for the three periods – 1980s, 1990s and 2000s into poor/middle income/rich states and low/middle/high growth states (Table 1). Across the entire period Punjab, Haryana, Maharashtra, Himachal Pradesh, Gujarat, Kerala and Tamil Nadu are the high-income states

and remain so in each of the three decades except for Tamil Nadu in the 1980s. Bihar, Madhya Pradesh, Uttar Pradesh, Orissa, Rajasthan and Assam are the poorer states in India and have lower growth rates. Interestingly, Punjab and Haryana, which were in the high income, high growth category fared badly in the 1990s and recorded low growth (but remain in high income) category, whereas Kerala, Karnataka, West Bengal and Madhya Pradesh improved their growth records. States that fared better in terms of growth rate in the 1990s compared to their performance in the 1980s are Bihar, Madhya Pradesh, Karnataka, Gujarat and Maharashtra. Some interesting results that can be seen are that in the 1990s, Madhya Pradesh and Bihar recorded high growth even if they remain in the low-income group. West Bengal fell to the low/poor income category with high growth rate. States that remained in the high growth, high income group in 1990s and 2000s are Maharashtra and Gujarat, and amongst the low income states, Uttar Pradesh continued with its low growth performance.

As a first step towards achieving a better understanding of the differences or similarities among the states with respect to their economic performance (for the purposes of this paper, PCNSDP), is to look at the development in the infrastructure sector in the various states. The availability and status of infrastructure is considered as an important pre-condition for a region to develop and grow and thus serves as a mechanism to reduce differences in cross-regional per capita incomes within the national economy.

Table 1: Classification of States based on Income and Growth

Growth 1981 to 1990	**PC Income in 1980-81**		
	Poor	**Medium**	**Rich**
Low	MP,	WB, AS	KER, JK
Medium	Bih, UP, RJ, AP	OR, KAR, GJ	HP, MAH
High		TN	HR, PJ
Growth 1991 to 2000	**PC Income 1990-91**		
Low	OR,UP	AS, JK	PJ, HR
Medium		RJ, AP	
High	Bih, MP, WB	KAR, KER,TN	HP, MAH, GJ
Growth 2001-10	**PC Income 2000-01**		
Low	UP, MP, AS, RJ	JK	PJ
Medium	Bih,	WB, KAR	HP,
High	OR	AP,	GJ, KER, TN, MAH, HR

Note: *States are classified as rich if their average PCNSDP is more than (India's mean PCNDP+0.5(stddev)), poor if it is less than (India's mean PCNDP-0.5(stddev)), and middle income if it lies in between. **A state is said to have high (or low) growth rate if the NSDP trend growth rate for the state is more (or less) than 0.5*(India's trend NDP growth rate) for that time period. In this table, AP– Andhra Pradesh, AS-Assam, Bih– Bihar, GJ – Gujarat, HR – Haryana, HP- Himachal Pradesh, JK – Jammu & Kashmir, KAR – Karnataka, KER – Kerala, MP - Madhya Pradesh, MAH – Maharashtra, OR – Orissa, PJ – Punjab, RJ – Rajasthan, TN- Tamil Nadu, UP – Uttar Pradesh, WB – West Bengal. Source: Author's calculations

C. Comparison of Infrastructure facilities across Indian states.

The major economic variables used for this study are Net State Domestic Product (and PCNSDP) and physical infrastructural variables - per capita electricity consumption (KwH), Road density (km of surfaced road per 1000 sq. km of geographical area), Rail density (km of rail length per 1000 sq km of geographical area) and Tele-density (per 10000 population).

In Table 2, state-wise trend in growth rate of PCNSDP and availability of infrastructure variables has been calculated. We observe that the initially poor states of Bihar, MP, Rajasthan, UP, Orissa and Assam had a very high growth rate for electricity consumption in the 1980s (Table 2ii). This is mainly because of the low base they started off with. The richer states like Punjab, Gujarat, Haryana and Maharashtra had per capita electricity consumption as high as 300 KwH, 224 KwH, 200KwH and 225 KwH, respectively, in 1981 whereas that of Bihar was 54, MP 88, Rajasthan 87, Orissa 95 and UP 74 KwH and it was far below the national average (Data available upon request).

Similarly, road density in these initially poor states was considerably below the national average in all the three decades. In fact, the gap between road density of the rich and poor states was so high that the average road density of poor states in 2001-10 was still lower than that of the rich states in 1981-90 (see Tables 3i and 3ii). Rail density was high to begin with in Bihar and UP as the British left a well-developed railway system in these states. However, an increase in rail density in MP, Rajasthan, Orissa and Assam was observed as new rail routes were laid to improve access to natural resources in these states.

Amongst the rich income states, Haryana, Punjab and Tamil Nadu had the highest PCNSDP growth rates in the decade of 1981-90 and were also the best endowed with infrastructure facilities (Table 2i). Punjab had the highest road density (757 sq km) followed by Tamil Nadu (736 sq km) and Haryana had the fourth highest road density during the period of 1981-90. These states also had the highest per capita electricity consumption and a significant trend growth rate of more than 5 per cent was registered by them despite the relatively wide base that already existed (See Table 2i).

The other two rich income states, Maharashtra and Gujarat also had higher infrastructure availability in the beginning of the period under consideration (1980-81). They continued to build upon it and electricity consumption increased at 7.4 per cent in Gujarat and 7 per cent in Maharashtra in the period 1981-90. Consumption kept growing at the rate of 4 to 5 per cent even in 1990s and 2000s. These states also succeeded in building up their roads infrastructure with highest trend growth rate in road density recorded in 1980s. By 2010, road density of Maharashtra (1091 sq km) and Gujarat (719 sq km) was quite high but was still below that of Kerala (state with highest road density of 2839 per 1000 sq km in 2010), Punjab, West Bengal and Tamil Nadu.

Another interesting feature that the data indicates is that for all the three categories – rich, poor and middle income states –growth rate of electricity consumption was higher in the decade of 1980s than in 1990s (except for Kerala and West Bengal) and it picked up again in 2000s. For roads network, rich states had a higher trend growth rate in the 1980s and 2000s than in 1990s, but for both poor and middle-income states, the trend growth rate of road density has been steadily rising and was highest in the 2000s indicating that continuous attempts were made to catch up with the rich states (exceptions are Orissa and Andhra Pradesh). However, despite this consistently increasing growth rate

in road density, the average road density in the poor income states (except UP) in 2001-10 was still lower than the average road density of the rich states in 1981-90, which indicates the scale of catching up that these states have to do.

The performance of middle-income states was only slightly better than that of poor income states. Both electricity consumption and rail density average growth rate was worst in 1990s. Average per capita electricity consumption and road density was always between that of rich and poor income states in all the three decades. However, rail density of most of the middle income states was lower than the rail density in poorer states and the rail density of poor income states was not much lower than that of the rich income states.

Table 2i: Trend growth rate of PCNSDP and infrastructure variables in the Rich income states

	PCNSDP			Elec			Road			Rail			Tele	
State	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1991-00	2001-10
Haryana	3.72	2.25	6.98	5.73	1.91	7.37	2.12	0.98	3.95	-0.35	0.55	-0.29	20.16	35.64
Punjab	3.49	2.48	4.11	9.85	4.44	5.50	2.07	2.88	4.01	0.13	-0.23	0.22	22.21	30.62
Tamil Nadu	3.46	5.25	7.69	6.38	5.25	6.73	2.11	-1.98	2.76	0.38	0.56	-0.36	21.84	33.88
Maharashtra	3.21	4.71	8.28	7.04	3.94	4.91	6.38	3.68	3.87	0.35	-0.02	0.32	15.13	25.60
Gujarat	2.77	6.00	8.53	7.42	6.56	5.83	6.16	4.51	1.23	-0.39	0.07	-0.50	16.38	31.90
HP	2.67	4.43	5.16	12.74	6.89	12.86	6.16	4.37	3.34	0.24	0.16	1.20	25.84	35.24
Kerala	1.14	4.83	7.16	4.45	4.87	3.58	3.62	3.19	10.04	0.51	0.43	0.00	22.00	30.46
Mean	2.92	4.28	6.84	7.66	4.84	6.68	4.09	2.52	4.17	0.13	0.22	0.09	20.51	31.91

Table 2ii: Trend growth rate of PCNSDP and infrastructure variables in the poor income states

	PCNSDP			Elec			Road			Rail			Tele	
State	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1991-00	2001-10
Assam	1.10	0.33	3.20	8.51	0.16	5.44	2.51	2.53	10.50	0.95	0.05	-0.78	21.44	44.78
Bihar	2.53	7.84	5.60	8.17	2.81	6.54	0.82	0.95	9.85	0.65	-0.24	0.92	19.15	45.73
MP	1.17	7.68	4.23	10.38	4.99	6.75	3.99	0.50	4.84	0.56	-0.05	0.21	16.36	37.61
Orissa	2.92	2.38	7.43	8.47	1.95	8.10	1.85	17.16	0.59	0.28	2.04	0.47	21.59	44.38
Rajasthan	3.22	4.03	4.98	10.35	5.51	6.72	5.52	4.56	8.31	0.27	0.28	-0.22	21.44	42.71
UP	2.40	2.32	3.70	9.11	1.73	2.99	3.27	5.90	5.61	0.20	0.00	0.18	19.95	42.88
Mean	2.22	4.10	4.86	9.16	2.86	6.09	2.99	5.27	6.62	0.48	0.35	0.13	19.99	43.01

Table 2iii: Trend growth rate of PCNSDP and infrastructure variables in the middle income states

	PCNSDP			elec			road			rail			tele	
STATE	1981-90	1991-200	2001-10	1981-90	1991-200	2001-10	1981-90	1991-200	2001-10	1981-90	1991-200	2001-10	1991-200	2001-10
Andhra Prade	3.03	3.69	7.09	10.14	4.79	6.66	2.78	4.38	2.65	0.26	0.09	0.04	22.21	35.16
J&K	-0.60	1.72	3.67	9.71	5.05	9.99	1.31	3.58	6.46	1.09	0.63	13.63	14.46	54.23
Karnataka	3.18	5.38	6.55	6.52	3.13	7.36	2.86	2.27	4.74	0.97	-0.50	0.28	19.79	35.68
West Bengal	2.33	5.04	5.25	3.52	4.36	7.07	1.01	5.92	7.54	0.16	-0.40	0.73	13.62	44.96
Mean	1.99	3.96	5.64	7.47	4.33	7.77	1.99	4.04	5.35	0.62	-0.05	3.67	17.52	42.51

Source: Author's calculations

Telecommunication revolution is evident in India from the sheer trend growth rate figures for all states – rich, poor or middle income – especially in the period 2000-10. However, even in this case, it

was the rich states that had better tele-density to begin with followed by the middle income and poor income states. On an average the poorer states had a higher growth rate (average 43% for poor income and 32% for the rich income states), followed by the middle-income group. Nevertheless, average tele-density was much higher in the richer states.

Table 3i : Average PCNSDP and infrastructure availabilty in the Rich states: 1981-90, 1991-00, 2001-10

	PCNSDP			Elec			Road			Rail			Tele	
State	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1991-00	2001-10
Punjab	20512.8	26981.6	35214.5	436.7	750.6	1350.3	756.7	945.1	921.8	42.7	42.1	42.1	2.6	31.3
Haryana	18756.5	25811.5	40610.8	262.5	485.3	1045.1	492.3	570.1	674.0	33.1	34.2	35.3	1.6	20.6
Maharashtra	16180.5	25773.9	40686.0	298.7	503.3	893.7	338.6	626.0	716.6	17.2	17.7	18.0	3.0	19.0
Gujarat	14637.7	22145.1	34743.2	298.3	643.9	1278.4	271.8	409.9	670.0	28.4	27.1	26.7	2.0	22.0
HP	14443.1	20479.8	33753.5	117.4	269.0	805.7	95.7	254.5	303.2	4.6	4.8	5.1	2.0	26.8
Kerala	13474.8	19986.1	34022.6	127.6	235.0	419.3	670.6	1086.6	2482.4	23.8	26.8	27.0	2.6	30.5
Tamil Nadu	12978.7	20819.9	33954.3	217.6	423.5	943.3	735.9	921.9	1076.0	30.5	31.3	31.8	2.6	31.3
Mean	15854.88	23142.56	36140.70	251.25	472.94	962.26	480.21	687.72	977.72	25.76	26.28	26.57	2.35	25.94

Table 3ii : Average PCNSDP and infrastructure availabilty in the poor states: 1981-90, 1991-00, 2001-10

	PCNSDP			Elec			Road			Rail			Tele	
State	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1981-90	1991-00	2001-10	1991-00	2001-10
Assam	13223.8	14503.7	17085.5	50.5	97.3	168.3	113.2	145.8	307.5	28.7	30.8	30.7	0.5	9.1
Bihar	4779.4	7628.5	10938.1	80.1	129.5	213.1	169.2	190.4	313.9	32.3	30.2	30.8	0.3	7.2
MP	7526.2	12616.8	17338.3	147.4	330.2	621.7	140.5	223.0	287.8	13.3	13.4	13.7	0.8	9.7
Orissa	10986.9	12385.4	18400.9	135.2	317.5	649.3	114.5	330.3	230.1	12.9	13.8	15.0	0.6	10.7
Rajasthan	9915.7	14848.4	19655.2	132.5	278.2	588.7	132.2	217.0	335.2	16.5	17.2	17.0	1.0	15.8
UP	9298.8	12057.1	15059.6	108.9	190.0	343.8	262.8	448.9	719.8	30.6	30.3	30.4	0.6	10.7
Mean	9288.5	12340.0	16412.9	109.1	223.8	430.8	155.4	259.2	365.7	22.4	22.6	22.9	0.6	10.6

Table 3iii : Average PCNSDP and infrastructure availabilty in the middle income states: 1981-90, 1991-00, 2001-10

	PCNSDP			Elec			Road			Rail			Tele	
State	1981-90	1991-200(	2001-10	1981-90	1991-20(	2001-10	1981-90	1991-20(	2001-10	1981-90	1991-20(	2001-10	1991-20(	2001-10
Jammu & Kash	16732.5	18155.1	22409.2	128.1	220.8	684.8	33.4	38.1	64.2	0.3	0.4	0.7	0.8	14.6
Karnataka	12362.0	18730.9	29639.5	188.8	342.7	706.9	375.5	501.2	742.5	16.7	15.9	15.8	1.8	22.8
Andhra Prades	11254.6	16445.9	27720.8	165.1	346.5	759.5	240.6	361.2	481.3	17.5	18.5	18.9	1.2	19.0
West Bengal	10651.2	14939.8	23841.0	122.0	179.9	395.1	295.3	444.5	657.6	42.1	42.6	43.2	0.8	9.6
Mean	12750.1	17067.9	25902.6	151.0	272.5	636.6	236.2	336.3	486.4	19.2	19.3	19.7	1.1	16.5

Source: Author's calculation

In order to understand better the relation between infrastructure and PCNSDP, panel data techniques were applied. It must be mentioned that the analysis has not yet entered into the gamut of growth models but is simply trying to see the impact of infrastructure variables on growth of per capita NSDP across Indian states.

Econometric Analysis

The basic equation estimated throughout this paper assumes infrastructure to be an additional factor of production. To start with, the following relationship needs to be estimated:

1) $\ln(Y) = \ln(A) + \alpha\ln(K) + \beta\ln(L) + \gamma\ln(G)$

Where Y is output (State Domestic Product), K is private capital, L is labour and G is stock of infrastructure. All the variables are in logs.

But in this paper we estimate the following equation using panel of 17 Indian states for the time period 1980-2011:

2) $\ln(y) = \ln(a) + \beta\ln(w) + \gamma\ln(Credit) + a_1\ln(El) + a_2\ln(RR) + a_3\ln(Tele) + a_4\ln(Schl) + a_5\ln(Health)$

Where, ln(y) = log of per capita net state domestic product; ln(w) = log of worker to population ratio; ln(Credit) = log of per capita credit disbursed by all Scheduled Commercial Banks; ln(El) = log of per capita electricity consumption; ln(R) = log of density of surfaced road per 1000 sq km (Alternatively, the variable ln(RR) = log of density of total density of surface transport and includes surfaced road and rail density was used with similar results. Results not shown in the paper but available upon request); ln(Tele) = log of tele-density per 10,000 people. In order to augment the model, human capital is treated as an additional factor of production and has been included as number of schools per 10,0000 population and number of health centres per 10,0000 population (ln(schl) and (ln(health).

Empirical Results

In order to present coherently the results from panel data analysis, they have been segregated and presented for 1980-90, 1990-2000 and 2000-10 periods. Regressions were run using pooled OLS, fixed effects and random effects but only the more econometrically correct results are shown (based on Hausman test between fixed and random effect and Breusch Pagan test between random effect and pooled OLS).

A) Aggregate Output and Infrastructure

- For the period 1980-89, we found significant and positive impact of physical infrastructure – electricity – even after correcting for heteroskedasticity and serial autocorrelation. Electricity has a huge impact on output and one percentage increase in electricity consumption increases output by 0.14 per cent. The elasticity for transport infrastructure was not high and 1 per cent increase results in 0.10 per cent increase in output. However, this was not found to be significant.
- Adding human capital in the form of number of schools and health centres shows that number of schools was negative and significant, whereas, the elasticity for health centres was 0.08 and significant (Table 4, Column 1). The lack of effect of schools and health centres does not mean that government-provided educational and health services have no effect on productivity (the channel through which they impact output). The results may perhaps suggest that the stock of buildings devoted to education may not be the best indicator of the quality of educational services. Another reason could be that even if physical capital was a good measure of service quality, labour might migrate, thus the state that provides the educational services may not be the one that reaps the benefit.

- For the 1990-99 period, the equation added variable for telecommunication infrastructure (Table 4, Column 2). The impact of electricity infrastructure increased and was positive and significant. The contribution of the transport infrastructure declined and was not significant. The elasticity of tele-density was around 0.12 indicating an increasingly important role played by this sector in output generation.
- The results for the period 2000-2010 indicate that only tele-density was important for output generation. However, we find that for the first time the worker-population ratio had a negative sign. The reason for the same as highlighted in some studies is that in this period, especially in the latter half of the decade, employment growth rate was very low whereas output was increasing at a higher rate. The service sector, whose share in the total output has been increasing steadily, saw high employment generation in this period but it was not commensurate with its output growth leading to a decline in employment elasticity, especially since 2004-05. The primary sector and, in some years even the manufacturing sector, actually registered negative employment elasticity (Papola and Sahu, 2012). All these reasons substantiate the results obtained for worker-population ratio.
- Another noteworthy observation that can be made from this table is the insignificant and negative contribution of transport infrastructure for this period. One interpretation for this could be that investment decisions may be politically driven and depart from efficiency criterion resulting in over accumulation of stock and negative returns or the infrastructure exists but its quality is dubious and so it may not have the expected impact on output. In this case, adding a proxy for usage of infrastructure like number of vehicles per kilometre of road could capture the benefits from the extension and the quality of the network.

B) Sectoral output and Infrastructure

In this section, the relation between the per capita NSDP from the secondary or tertiary sectors and various infrastructure sectors is presented. The secondary sector includes manufacturing, construction, electricity, gas and water supply and mining and quarrying. The tertiary sector comprises transport, storage and communication, trade, hotels and restaurants, banking and insurance, real estate, ownership of dwellings and business services, public administration and other services.

- Starting with 1980-89 period for both secondary and tertiary sectors, the per capita net state domestic product Hausman test suggests the use of fixed effects model. Hetersokedasticity and first order autocorrelation is a problem and to correct for the same, Driscaoll and Kraay standard errors were used (Hoechle, 2007).The elasticity for electricity consumption (0.24) is significant and almost the same for both PCNSDP of the secondary and tertiary sectors. However, the transport infrastructure elasticity is higher and significant for the services sector than for the secondary sector (Tables 5 and 6, column 1).
- For human capital, it was found that schools had a significant and positive contribution to output for the services sector whereas it was negative and not significant for the secondary sector's output. The health infrastructure indicator showed a positive and significant elasticity to output for both the sectors as it did for the overall NSDP per capita.

- In the 1990s, electricity contributed the highest to secondary sector's PCNSDP than in any other period or any other sector. The mid-1990s also witnessed the highest growth in the manufacturing sector's output.
- The tele-density elasticity was significant for the secondary sector as well as the tertiary sector and, as expected, the elasticity was higher for the latter. Amongst the social infrastructure this is the only decade in which number of schools had a positive and significant relation with the output of the secondary sector. Elasticity of the health infrastructure was highest for this decade for the secondary sector. Thus in terms of human capital infrastructure the decade of 1990s had the highest elasticity with respect to output.
- The results for the 2000s for the secondary sector suggest that only teledensity contributed significantly to its output whereas, transport and electricity infrastructure seem to have made a negative contribution and it was not significant.
- The services sector's output was positive but showed decreasing elasticity with electricity over the three periods. Tele-density also had positive significant but decreasing elasticity with output from 0.23 to 0.13 (Table 6). As expected, the elasticity of tele-density in the service sector output was the highest and highly significant. Health infrastructure however showed a negative and significant elasticity with services output in the 1990s and 2000s.

C) Income effect of infrastructure.

Next, we test the income effects by interacting the infrastructure indicators with dummies for income/output – high, low and medium income.

- The income classification and its interaction with specific infrastructure variables indicate that the impact of road infrastructure indicators in the 1980s was lower in low-income states. For both high and low-income regions the interaction with electricity was negative with significant impact (Table 7 Column 1)
- In the 1990s, we observe that although the impact of infrastructure was almost the same for both the high and low-income regions, it was insignificant (Table 7 column 2).
- In the 2000s, high-income regions had a significantly positive impact from telecom infrastructure but low-income regions had negative impact from infrastructure on output even for telecommunication (Table 7, Column 3).

Overall, this exercise showed that no clear differences emerged from the differences in infrastructure availability and different income regions except for the telecommunication sector. Most of the interaction dummies were not significant.

Table 4: Dependent variable: ln (PCNSDP)

Independent variables	(1)	(2)	(3)
	FE (Robust) 1980-89	FE(Robust) 1990-99	FE(Robust) 2009-10
Constant	9.7 (1.00)***	4.77 (1.12)***	6.18 (1.3)***
LnCredit	0.05 (0.02)	0.14 (0.01)***	0.25 (0.07)***
Ln(W/P)	0.37 (0.14)***	0.32 (0.11)***	-0.39 (0.16)***
Ln(elec)	0.14 (0.06)***	0.40 (0.08)***	0.03 (0.06)
Ln(road)	0.10 (0.10)	0.08 (0.10)	-0.06 (0.09)
Ln(tele)		0.12 (0.02)***	0.10 (0.04)***
Ln(School)	-0.44 (0.21)**	0.16 (0.07)***	-0.05 (0.74)
Ln(health)	0.08 (0.02)***	-0.11 (0.10)*	-0.03 (0.06)
Observations	120	151	150
R^2	0.56	0.85	0.91
Hausman test	0.05	0.000	0.000
F-statistic	72.2(0.000)	57.2(0.00)	0.000
Breusch-Pagan			
Modified Wald	0.00	0.000	0.000
Test for serial AC	0.99	0.20	0.18

Numbers in parenthesis below the coefficient estimates are standard errors. p values for the null hypothesis of the usual diagnostic tests are also reported in parenthesis. *,** and *** indicate that the variable is significant at 10, 5 and 1 per cent level. Dependent variable is the log of per capita NSDP; or log of per capita secondary sector NSDP; or log of per capita tertiary sector NSDP Andln(w/p) = log of worker population ratio; ln(credit) =log of per capita credit given by SCBs; ln(elec) = log of per capita electricity consumption; ln(road) = log of road density per thousand sq km area; ln(tele) = log of teledensity per ten thousand people; ln(school) = log of number of school per 100000 population, ln(health) = log of number of health centres per 100000 population. Hausman test to decide between fixed effect and random effect. Modified Wald Test for heteroskedasticty: the null of homoskedasticty and Wooldridge test for first order serial autocorrelation: the null of no autocorrelation

Table 5: Dependent Variable: ln (Secondary PCNSDP)

Independent variables	(1)	(2)	(3)
	FE (Discoll and Kraay) 1980-89	Random Effect 1990-99	FE (Discoll and Kraay) 2000-10
Constant	5.23 (1.09)***	1.00 (0.94)***	6.88 (0.83)***
Ln PCSec Credit	0.03 (0.06)	0.27 (0.12)***	0.17 (0.05)***
Ln(W/P)	0.03 (0.15)	0.03 (0.01)**	0.15 (0.02)***
Ln(elec)	0.24 (0.10)**	0.69 (0.09)***	-0.01 (0.07)
Ln(road)	0.19 (0.13)	0.16 (0.09)**	-0.17 (0.06)
Ln(Tele)		0.08 (0.02)***	0.16 (0.01)***
Ln(School)	-0.04 (0.13)	0.24 (0.08)***	-0.04 (0.07)
Ln(health)	0.07 (0.02)***	0.18 (0.09)**	-0.13 (0.1)
Observations	119	150	149
R^2	0.63	0.79	0.87
Hausman test	0.000***	0.70	0.000***
Breusch Pagan		0.000***	
F-statistic	0.000***	0.000***	0.000***
Modified Wald	0.000***		0.000***
Test for serial AC	0.000***	0.60	0.000***

Table 6: Dependent Variable: ln (Tertiary PCNSDP)

Independent variables	(1)	(2)	(3)
	FE (Driscall) 1980-89	Random Effects 1990-99	FE (Driscall) 2000-10
Constant	2.99 (1.2)***	5.04 (0.52)***	5.73 (0.44)***
Ln(W/P)	0.16 (0.03)***	0.27 (0.08)***	-0.02 (0.07)
Ln(PCserv Credit)	0.04 (0.02)**	0.11 (0.03)***	0.22 (0.04)***
Ln(elec)	0.25 (0.03)***	0.17 (0.04)***	0.08 (0.03)***
Ln(road)	0.26 (0.08)***	0.08 (0.05)	0.02 (0.05)
Ln(Tele)		0.23 (0.01)***	0.13 (0.01)***
Ln(School)	0.36 (0.17)*	0.12 (0.06)***	-0.07 (0.06)
Ln(health)	0.08 (0.02)***	-0.12 (0.06)***	-0.09 (0.02)***
Observations	119	150	149
R^2	0.85	0.91	0.93
Hausman test	0.000	0.55	0.05
Breusch Pagan		0.000	
F-statistic	0.000	0.000	0.000
Modified Wald	0.000		0.000
Test for serial AC	0.04	0.001	0.005

Table 7: Physical Infrastructure Stocks and Per Capita NSDP, Output / Income Dummies Interaction Dependent Variable: ln (PCNSDP)

Variable	(1)	(2)	(3)
	RE (1980-89)	RE (1990-99)	RE (2000-10)
Constant	6.81 (0.50)***	4.92 (0.76)***	6.60 (0.44)***
Ln(W/P)	0.19 (0.15)	0.24 (0.10)***	-0.44 (0.10)***
Ln(PC Credit)	0.11 (0.04)*	0.19 (0.03)***	0.16 (0.03)***
Ln(elec)	0.49 (0.13)***	0.02 (0.30)	0.12 (0.06)***
Ln(road)	-0.19 (0.11)*	0.39 (0.32)	-0.09 (0.06)
Ln(tele)		0.07 (0.03)***	0.11 (0.02)***
HI*elec	-0.30 (0.13)***	0.36 (0.31)	-0.13 (0.06)***
LI*elec	-0.28 (0.13)***	0.30 (0.31)	0.03 (0.06)
HI*road	0.27 (0.11)***	-0.35 (0.31)	0.08 (0.06)
LI*road	0.23 (0.11)***	-0.27 (0.31)	-0.08 (0.07)
HI*Tele		0.05 (0.03)	0.06 (0.01)***
LI*Tele		0.04 (0.03)	-0.009 (0.01)
Observation	120	151	149
Rsquared	0.49	0.84	0.93
Breusch-Pagan	0.000	0.000	0.000

Numbers in parenthesis below the coefficient estimates are standard errors. P values for the null hypothesis of the usual diagnostic tests are also reported in parenthesis. *,** and *** indicate that the variable is significant at 10, 5 and 1 per cent level. Dependent variable is the log of per capita NSDP; log of per capita secondary sector NSDP; or log of per capita tertiary sector NSDP Andln(w/p) = log of worker population ratio; ln(credit) =log of per capita credit given by SCBs;ln(elec) = log of per capita electricity consumption; ln(road) = log of road density per thousand sq km area; ln(tele) = log of teledensity per ten thousand people; ln(school) = log of number of school per 100000 population, ln(health) = log of number of health centres per 100000 population. HI = high income, LI = low income.

Conclusion

In this paper, an attempt is made to provide an empirical evaluation of the impact of infrastructure development – measured by stocks of individual physical infrastructure – on economic output across 17 Indian states in the period between 1980 and 2010. The main conclusions drawn from analysing the raw data were that the initially rich states were also the ones best endowed with infrastructure facilities – roads, electricity, railways and telecommunication infrastructure. These states also continued to

remain in the rich income category in the decade 2001-10 with average PCNSDP much above India's average PCNSDP. These states managed to grow in terms of their infrastructure endowments, which is noteworthy considering that these states had a relatively wider base to begin with. This can also imply that although infrastructure facilities were better developed in these states compared to the poor or middle-income states, but in absolute terms, there was huge scope for development and with an increase in availability of infrastructure, these states continued to increase their PCNSDP.

Second, poor income states like Bihar, Madhya Pradesh and Orissa improved their growth performance in the later decades, mainly due to the low base they started off with, and managed to increase their infrastructure endowments (some of these states were the worst endowed states in the country). The trend growth rate of electricity, road and even tele-density was amongst the highest for most of these initially poor states but they still lag way behind the richer states in income and infrastructure availability.

Third, after the econometric analysis, we found that physical infrastructure variables did not have a uniform influence on output. The relationship not just differed for aggregate output, secondary and tertiary sector output; there was also distinct difference in the impact of infrastructure on the same sector for different periods. For aggregate PCNSDP we observed positive and significant elasticity of electricity and health infrastructure variables but negative for schools. However, transport infrastructure was not significant throughout the three time periods. Elasticity of electricity was highest during the 1990s and number of schools had a positive elasticity with output. Electricity had the highest elasticity for the secondary sector's output in the 1990s and teledensity had highest elasticity for the services sector during the same period. The impact of social infrastructure – education and health – also showed a similar pattern. Where education infrastructure had a significant contribution to secondary sector output, only in the 1990s, for tertiary sector, it had positive elasticity in the 1980s and 1990s.

Infrastructure variables, like roads, that play a major role in determining the output have insignificant and even negative elasticity with output indicating towards the quality of infrastructure argument and using a usage indicator for this sector. When different regions were interacted with infrastructure variables, we found that although high-income regions might have an edge over the low-income regions, the results were not conclusive.

However, these results do not point to any uniform relationship between infrastructure availability and output. This possibly entails the fact that infrastructure development in the country has not been uniform and has seen cycles of infrastructure build-up corresponding to maybe a different political-economy era in each decade. The focus of the corresponding Five-Year Plans was shaped largely by the changing political priorities of the government.

An important question that needs further examination is that even as growth rates in real infrastructure development have declined, output growth rates have tended to accelerate. This could be due to two possible reasons. First, the build-up of infrastructure stock upto 1990-91 was sufficient to support the growth surge that occurred. Second, in the post-1991 reforms period the drivers of growth changed and were more significant than the declining growth of infrastructure availability.

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Appendix

Table 1A: Trend growth rate - NSDP and Population

TREND RATE	1981-10		981-90		1991-2000		2001-10	
	NSDP	Pop	NSDP	Pop	NSDP	Pop	NSDP	Pop
INDIA NDP	5.76	1.93	4.79	2.16	6.40	1.99	7.67	1.53
ANDHRA PRADESH	6.18	1.57	5.29	2.19	5.27	1.53	8.26	1.09
ASSAM	3.16	1.83	3.26	2.14	2.20	1.86	4.68	1.43
BIHAR Tot	6.53	2.15	4.75	2.17	10.22	2.21	6.89	1.72
GUJARAT	6.45	1.90	4.84	2.02	7.99	1.88	10.24	1.58
HARYANA	6.38	2.37	6.27	2.46	4.71	2.41	8.94	1.84
HIMACHAL PRADESH	6.13	1.77	4.54	1.82	6.21	1.70	6.95	1.70
JAMMU & KASHMIR	3.95	2.45	1.96	2.57	4.65	2.88	5.20	1.48
KARNATAKA	6.15	1.61	5.27	2.03	7.08	1.62	7.83	1.20
KERALA	5.69	1.03	2.58	1.42	5.86	0.98	8.09	0.86
MP Total	6.45	2.11	3.58	2.38	9.81	1.98	6.80	1.92
MAHARASHTRA	6.83	2.05	5.58	2.29	6.89	2.08	9.95	1.55
ORISSA	4.29	1.54	4.79	1.82	4.03	1.61	8.61	1.10
PUNJAB	4.73	1.88	5.44	1.88	4.44	1.91	6.00	1.82
RAJASTHAN	5.99	2.37	5.94	2.64	6.53	2.40	6.97	1.89
TAMIL NADU	6.08	1.13	5.00	1.48	6.41	1.11	8.56	0.81
UP TOTAL	4.50	1.97	4.79	2.33	4.27	1.68	6.27	1.94
WEST BENGAL	5.89	1.74	4.59	2.20	6.86	1.74	6.45	1.14

Source: Author's calculations

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