CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

Understanding the relevance of infrastructure for growth has involved addressing three important questions. First, does an increase in infrastructure capital spur economic growth? If yes, then what are the channels through which the impact of increased infrastructure is felt in the economy? Second, what is the contribution of infrastructure to output and its impact on growth potential and how to quantify it? And thirdly, which sub sector of infrastructure matters more for growth and if there is a link with the stage of development the economy is in?

Theoretical papers have treated infrastructure (or public capital) as an additional input in an aggregate production function initially in an exogenous growth model framework (Arrow and Kurz, 1970) and eventually, in endogenous growth models such as those by Barro (1990). In the former approach, shocks to infrastructure are seen only to have a transitory effect with technological progress being the factor driving long-run growth. In an endogenous growth model, on the other hand, an increase in infrastructure stock can raise the steady-state income per-capita.

In most studies estimating the relationship between infrastructure and growth, the direct and indirect channels that are conventionally mentioned range from a simple productivity effect to its impact on private capital durability, enhancing ability of entrepreneurs to invest and access markets, reducing adjustment costs, to impact on human capital development – studies have tried to examine and verify the various ways in which infrastructure can result in growth. However, debates persist over the correct econometric modelling, on how to deal with issues of reverse causation, indicators to use for infrastructure (investment indicator or physical stock variable, selecting infrastructure sub-sectors that will serve as the best proxies). And because of these differences, quantitative assessments have resulted in wide ranging results. Bom and Ligthart (2009) report that in a sample of 67 studies for the period 1983-2008, the estimate of output elasticity of public capital ranged from -1.7 to +2.04 and most of the studies report positive estimates. But it is not possible to get a concrete idea on the
output elasticity just by going through literature as the results vary depending upon the time period studied, the type of infrastructure under consideration, the sample under consideration and the development stage of the countries/regions.

In this vein, the present review of literature looks mainly at macroeconomic literature linking infrastructure and economic growth. Focus is mainly on studies using a production function approach – at cross-country, national, regional and sectoral level – with public capital or investment or physical stock of infrastructure being the explanatory variable. Additionally, through the many direct and indirect channels, the impact of infrastructure is not just limited to growth, and infrastructure development can have varying impact on inequality as well. This review thus goes a step further and also reviews the existing literature for the impact of infrastructure on inequality.

2.2 Infrastructure and Economic Growth/Output

The impact of infrastructure on output was modelled first by Arrow and Kurz (1970) and since then different studies have tried to include either the stock of infrastructure or flow of infrastructure services as an additional input in the production function or have worked under the assumption that infrastructure is a gross complement for other inputs. The impact of infrastructure can be direct as well as indirect; however, the countervailing force comes in when the investment in infrastructure which is mostly financed by the government occurs through increasing taxation. This can crowd-out the private sector investments and capital generation which can offset the indirect impact of infrastructure on productivity. This was modelled by Barro (1990) in his endogenous growth framework where the welfare maximising level of productive expenditure is the one that maximizes the growth rate of the economy, and a way to achieve the same is when the share of productive government expenditure in GDP equals the elasticity of aggregate output with respect to the same variable – ‘Barro rule’ (Barro, 1990). If the productive expenditure is more than this level, then the additional taxation needed to finance this expenditure will divert non-infrastructure investment away and the growth is reduced. The paper by Futagami, Morita and Shibata (1993) extended the model by including both private and public capital and conclude that even though the growth maximising level of public investment is still equal to the elasticity of output with respect to public capital, its welfare maximising
level is lower. This can be attributed to the fact that public investment takes time to become productive and this results in additional sacrifice in current consumption for future consumption. The ensuing section reviews the empirical studies that have tried to estimate the impact of infrastructure on output and its growth.

Until the late 1980s little attention was paid by the economists on the role of infrastructure in either theoretical or empirical studies (Gramlich, 1994). Starting with the seminal work by Aschauer (1989), public capital (or infrastructure) formed an element in the aggregate production function. He examined the relation between aggregate productivity and stock and flow government spending variable 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 the empirical literature focusing on the technical issues such as not accounting for reverse causation, failure to control for other possible determinants of productivity growth, and econometric issues.

2.2.1 Cross-country studies
Various studies tried to explain, theoretically and empirically, why differences in income over time and across countries did not disappear as the neoclassical models of growth predicted. The idea that emerged from this literature is that economic growth is endogenous. That is, economic growth is influenced by decisions of economic agents, and is not merely the outcome of an exogenous process. Endogenous growth theory assigns a central role to capital formation, where capital is not just confined to physical capital, but includes human capital, infrastructure and knowledge capital (Barro and Sala-i-Martin, 1999). Initially, the econometric work on growth was dominated by cross-country regressions, in which growth of real per capita GDP is estimated by a catch-up variable, human capital, investment, and population factors like fertility and public capital as a separate explanatory variable.

Probably, the first study that included public capital in an empirical growth model was by Easterly and Rebelo (1993), who ran pooled regressions (using decade averages for the 1960s, 1970s and 1980s) of per capita growth on (sectoral) public investment and conditional variables (see Sturm et al, 1998 for a summary). The time period covered in this study is from 1970-88 and their dataset comprises observations on public investment for 36 countries in 1960’s, 108 in 1970’s and 119 countries in
1980’s. They found that the share of public investment in transport and communication infrastructure is correlated with growth. Likewise, Gwartney et al. (2004) consider 94 countries during the time period 1980-2000 and find a significant positive effect of public investment, although its coefficient is 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) explores empirically the relationship between infrastructure and economic growth by including the data of expenditure in infrastructure as a share of GDP in traditional growth cross-country regressions and find a negative growth impact of infrastructure expenditure in a sample of 76 countries. In addition, the paper elaborates 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. They postulate a model in which there are two types of government expenditure, productive and unproductive and the difference between the two is represented in the model by specifying how the shift in the mix between the two alters economy’s growth rate. The empirical analysis makes use of annual data on 43 developing countries from 1970-1990 to examine the link between components of government expenditure and economic growth. The pooled data include total central government expenditures for defense, education, health, transport and communication. They attribute their results to the fact that excessive amounts of transport and communication expenditures in those countries make them unproductive. Prichett (1996) suggested another explanation, arguing that public investment in developing countries is often used for 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. Sridhar and Sridhar (2005) investigate the simultaneous relationship between telecommunications and economic growth for 63 developing countries during 1990-2001 period using Three – Stage Least Square (3SLS) estimation thus endogenizing economic growth and telecom penetration and find significant impact of cellular services on national output, however the impact was much lower than for Organisation for Economic Co-operation and Development (OECD) countries.
2.2.2 Production function Approach

Starting with the seminal work by Aschauer (1989a), public capital formed an element in the aggregate production function. He examined the relation between aggregate productivity and stock and flow of government spending variable for the US economy for the time period 1949 to 1985 and concluded that non-military public capital stock is important for determining productivity. Using panel data and a specification in first differences, Evans and Karras (1994) find positive and significant coefficient of public capital when country or period effects are ignored. However, upon adding these, the coefficient of public capital loses its significance. Incorporating infrastructure into the production function as a third input with capital and labour has been the standard approach in determining the impact of infrastructure.

The usage of an aggregated Cobb-Douglas production function has been the common practice and the elasticity of output with respect to infrastructure is estimated using the production function in log-level or first difference or growth form (Aschauer, 1989b; Easterly and Rebelo, 1993; Sanchez-Robles, 1998). Some studies such as those by Canning and Bennathan (2000), Everaert and Heylen (2004) have used a trans-log function, which is more general than Cobb-Douglas function. The paper by Everaert and Heylen (2004) investigates the long-term output and labour market effects of public capital in Belgium within a broad model explaining private sector output and costs, private employment and capital formation, wage bargaining, price setting and aggregate demand. Model simulations show strong positive effects of public capital on private output and capital formation. Public capital and private employment, however, are found to be substitutes. In the paper by Charlot and Schmitt (1999) theoretical results from endogenous growth models (Barro, 1990) are used to examine the role of public infrastructure in regional growth in France. Production functions with three inputs (private capital and employment, public capital) are estimated from regionalised series of public and private sectors capital using panel data econometrics methods for the 22 regions of France for the period 1982-1993.

An important study by Calderon and Severn (2002) estimated the effect of various types of physical infrastructure on growth and inequality for over 100 countries and found that output elasticity of infrastructure was 0.16. Another
important cross-country study that made use of this approach by developing and estimating a structural model of infrastructure and growth was done by Esfahani and Ramirez (2002) for 78 countries for which complete data was available for three decades, 1965-75, 1975-85, and 1985-95. After accounting for the simultaneity between infrastructure and GDP, the impact of infrastructure on GDP growth turns out to be substantial, an exogenous 10% rise in GDP, say through an improvement in the terms of trade, could on average raise the telecoms growth rate by 0.43% and the power sector growth rate by 0.20%. These, in turn will stimulate further investment in the rest of the economy and, on average, add about 0.07% to the GDP growth rate. The study by Bonaglia et al (2000) addresses the issue of whether and by how much public capital can enhance economic performance. They have used Italian regional data for the period 1970-94 and find a positive contribution of infrastructure investments to TFP growth, output and cost reduction.

The recent literature tends to find smaller (and more plausible) effects than those reported in Aschauer and other earlier studies (Romp and de Haan, 2007). The elasticity reported by Garcia-Mila and Mc Guire (1992) are much lower than those reported by Aschauer. The mid-point estimate from recent studies of the elasticity of GDP with respect to public capital with a production function approach lies around 0.146 (Bom and Ligthart, 2009). Estimates from recent studies using broader country samples (e.g. Easterly and Serven 2003) are not very different.

2.2.2.1 Physical Infrastructure Indicators: Sub-sectoral Impact

In the empirical literature, the indicators that have been used to estimate the possible impact of infrastructure involve public capital stock, public investment as percent of GDP, investment in particular sub-sectors of infrastructure etc. However, these serve as proxies for infrastructure and often do not provide the true picture especially for developing countries where investment does not necessarily translate into infrastructure development and public capital includes more than just infrastructure. A number of empirical studies using various approaches also find that the output contribution of infrastructure when looking at infrastructure indicators specifically exceeds that of conventional public capital, which suggests the presence of externalities associated with infrastructure services. Here we review studies that have taken specific sub sectors of infrastructure indicators as explanatory variables.
Using panel data for a cross-section of countries, Canning (1999) and Canning and Bennathan (2000) estimate an aggregate production function that includes infrastructure capital for a panel of countries for the time period 1960 to 1990. Panel data cointegration methods used in estimation take account of the nonstationary nature of the data, are robust to reverse causation, and allow for different levels of productivity and different short-run business-cycle and multiplier relationships across countries. A Cobb-Douglas production function highlights a positive impact of public capital on regional growth, even after taking into account data-related effects and of possible simultaneity in determining regional output and regional public capital. Introduction of a trans-log form for evaluating region-specific elasticities shows that the positive effect of public capital increases with the regional wealth.

Amongst specific infrastructure sub-sectors, energy infrastructure appears to be of highest significance. In the studies reviewed by Garsous (2012), papers that focussed on energy sector as determinant of growth/output were in all likelihood to observe a robust and positive impact from this particular infrastructure sub sector than any other. Energy infrastructure also serves as an input into many of the other infrastructure sub-sectors as well, for example, electricity is needed to make the cellular towers transmit signals, in the construction of roads etc. Estache et al (2005) find output elasticity of the energy sector to be 0.5 in sub Saharan Africa and Hurlin (2006) found the elasticity to be 0.05 for a group of developing countries. Canning and Pedroni (1999) found that investments in electricity generating capacity had long run positive impact on growth for most countries in their sample.

Looking specifically at the transport infrastructure, the growth effects vary for developed and developing countries. They were found to be stronger for developing countries than for developed set of economies. The issues for developed countries’ transport infrastructure sector are of different nature – such as quality, dealing with bottlenecks – rather than just how many kilometres pf paved roads is built. Whereas, as reported by Buys et al (2006) and Estache and Fay (2010) constructing and expanding roads network is essential in many of the developing countries and specific regions within them, in order to just catch up with the rest. Cadot et al (1999, 2002) found the elasticity of transport infrastructure to be around 0.1 for France. Fernald (1999) concluded that between 1953 and 1989, in US, roads contributed about 1.4
percent per year to growth before 1973 and about 0.4 percent thereafter. The best results are however found for the telecommunication infrastructure and this could be because of ease of good quality data availability. Most studies have found a positive impact of an indicator of telecommunication availability, for example, see Roller and Waverman (2001); Kateja and Jha (2008) and Kaur and Malhotra (2014) specifically see the casual relationship of telecommunication and growth in India; see Chakraborty and Nandi, (2011) for a detailed review of literature on this topic. Study by Esfahani and Ramirez (2003) finds different output elasticity for telecommunication and power supply infrastructure in a sample of 75 countries. The output elasticity for telephones was in the range 0.078 and 0.095, and between 0.128 and 0.156 for power generation infrastructure. This indicates that the growth impact of different sub sectors of infrastructure vary for each infrastructure sub sector.

2.2.2.2 Problems with the production-function approach: Capturing Causality
A major drawback in using production function approach in estimating the impact of infrastructure is the potential for reverse causation. There exists a feedback from income to capital stock, making it difficult to identify the results of simple regression with income or Gross Domestic Product (GDP) as the dependent variable and infrastructure stock as one of the independent variable. There is also a potential feedback from income to the demand for infrastructure. Dealing with this problem has been at the heart of controversy over the infrastructure-growth relationship because causality is difficult to establish convincingly in growth regressions.

One way of dealing with this problem has been to derive an appropriate test in a manner that the direction of causality is determined. This has been done by Fernald (1999), his work uses data for 29 sectors in the US economy for the years 1953-89 and analyses the impact of changes in road growth on productivity. He concludes that if roads were endogenous, there would not be any particular relationship between an industry’s vehicle intensity and its relative productivity performance when road growth changes. Another study that follows this approach is by Canning and Pedroni (1999), they investigate the long run consequences of infrastructure provision on per capita income in a panel of countries over the period 1950-1992 and they derived a reduced form of a model in which public and private capital are financed out of available savings so that there is a growth maximising level of public capital. They
presented the series on per capita income and physical stock of infrastructure in the form of a dynamic error-correction model as they were individually non stationary and were cointegrated. This allowed them to test for restrictions in the model and decide on direction of causality. They observed that causality ran in both directions. Other important conclusions made in this study are that, on average, telephones and paved roads are supplied at growth maximising level, but some countries have too few, others too many.

Other approaches that have been followed to deal with the problem of reverse causality are estimating panel models, estimating simultaneous equation models and using instrumental variables. Canning and Bennathan (2000) have showed in their work that a panel data approach may solve the causality problem. By pooling the data across countries they were successful in identifying the long run production function relation. They found that for time period 1960 to 1990, the rates of return to both electricity generating capacity and paved roads are on a par with, or lower than, that on other forms of capital in most countries. However, in a limited number of countries we find evidence of very acute shortages of electricity generating capacity and paved roads, and large excess returns to infrastructure investment.

But the most intuitive way of dealing with the causality problem is to develop a simultaneous equations model. The basic steps consist of estimating two equations – one equation that links production to public capital or infrastructure and the second that links public capital to production. The main concern is the functional form of the second equation. Demetriades and Mamuneas (2000) have estimated a system of equations that makes use of an inter-temporal profit maximisation framework and applied the same on a pooled model for 12 OECD countries over 1972-91. The theoretical model developed by the authors involved producers who took publicly provided inputs at each point in time as given and then maximised present value of future profits to determine their optimal output and variable inputs. In the first stage, the firms decide on the optimal output and variable input demands, conditional on the availability of private and public capital stocks. In the second stage, firms choose the optimal level of capital inputs. They found that public capital has positive long run effect on both output supply and input demand. Another study that estimates a simultaneous equations model is by Esfahani and Ramirez (2003), who develop a
structural growth model that helps distinguish the reciprocal effects of infrastructure and the rest of the economy. They derived the infrastructure-output interaction as a recursive system that can be estimated simultaneously while solving the identification problem. The relationships between infrastructure and income are formulated as error-correction processes to account for the simultaneous effects of infrastructure innovations and responses to deviations from the steady state. Esfahani and Ramirez find that the contribution of infrastructure to GDP is substantial and, in general, exceeds the cost of providing them. The findings of Esfahani and Ramirez also shed light on the factors that shape a country’s response to its infrastructure needs. An interesting result in this respect is that private ownership of infrastructure and government credibility (low risk of contract repudiation) matter for infrastructure growth, but mainly in speeding up the rate of adjustment rather than the steady-state infrastructure–income ratios.

Finally, some studies have also made use of instrumental variable approach. The study by Calderon and Serven (2002) applies the instrumental variable method in which they have estimated a per capita Cobb Douglas production function for a panel of 101 countries for the period 1960-97. They simply use the lagged values as explanatory variables to solve for causality and estimate a per capita Cobb Douglas production function in first difference form (due to non-stationary data).

2.2.3 Cost function Approach

Production function approach has been criticised in literature as it violates standard marginal productivity theory (Duggal et al. 1999). Public capital when treated symmetric to labour and private capital assumes that the market determined per unit cost of infrastructure is known to the individual firm and can be used in calculating total cost. However, public capital is generally financed by the government through tax revenue or government debt implying that per unit costs of public capital is not market determined. Additionally, it is not necessarily true that the total cost of infrastructure to the firm is proportional to the amount it uses. There is also the possibility of government pricing inefficiencies that make it difficult to assume that public capital as a factor input is paid according to its marginal product. Some studies have tried to get past this violation by concentrating on the cost function approach which assumes that public capital is exogenously provided by the government as a
free input. These studies specify a cost function for the private sector and the motive of the firms is to produce a given level of output at minimum private cost. With the prices given to the firms, the only variables that they can control are the quantities of the private inputs. Alternatively, firms can choose to maximise profits given the output price and input prices. When firms optimise they take into account the environment in which they operate. One of these variables is the amount of public infrastructure capital available and it enters the cost or production function as an unpaid fixed input. There are many studies that have made use of this approach as it is less restrictive than the production-function approach and the advantages of this approach have been highlighted by Sturm et al. (1998). Moreno et al. (2003), Cohen and Morrison (2004), Bosca et al. (2000), Canaleta et al. (1998), Demetriades and Mamuneas (2000) are some of the studies that have used some form of cost function to empirically verify the role of infrastructure.

The main problem with the cost function approach is that the flexible functional form which is used to determine the impact of public capital requires data set that must contain considerable information. The data set has to be relatively large and must contain enough variability to deal with multicollinearity (Romp and De Haan, 2005). Most cost functions therefore use panel data which combine a time dimension with either a regional dimension or sectoral dimension.

In this regard specific mention is made to two of the studies that were interesting in their approach. Moreno et al. (2003) estimated cost function for 12 manufacturing sectors in Spanish regions during the period 1980-91 and concluded that the average cost elasticity of public capital is only -0.22. However, there is wide variety in the impact across both regions and industries that suggested that some sectors and regions did not benefit from public capital in some years. Industries such as electric machinery, food and drinks, and textiles have been sensitive to a rise in infrastructure, while the opposite applies to sectors like metallic and non-metallic minerals and chemistry. The other study was done by Cohen and Morrison (2004) that estimated the cost function using maximum likelihood techniques using data for 48 US states on prices and quantities of aggregate manufacturing output and inputs and public highway infrastructure for the period 1982-96. Manufacturing firms minimise short run costs by choosing a combination of inputs for given input prices, demand
(output) and capital for given technological and environmental conditions. The model distinguishes between intra- and inter-state effects of public infrastructure and for a given state the model includes the public infrastructure of that state as well as infrastructure in neighbouring states. The study found a significant contribution of public infrastructure to lowering manufacturing costs and recognised spatial linkages of infrastructure availability. Similarly, the study by Bosca et al (2000) tried to empirically examine the impact of infrastructure on cost and productivity performance of private productive sector of Spanish regions in the time period 1980-93. They used the dual approach based on cost function that recovers the usual parameters obtained with production function and concluded that infrastructure significantly helped reduce costs and enhanced productivity in almost every Spanish region.

The results from both cost function and production function studies indicate a relation between infrastructure capital and economic growth but there exists much heterogeneity across regions and industries/sectors. The above literature review provides an outline of the major line of work that exists on the topic at mainly international level. The next section takes a look at the literature that exists on India.

2.2.4 Review of Indian Studies
The patterns of growth of the group of developed countries and the group of developing nations have been found to be quite different. The above literature review mainly consisted of studies on developed nations. Our understanding of the determinants of growth in developing countries is still incomplete. In this vein, the role played by infrastructure in explaining growth in the Indian context will help enrich the literature and help in informed policymaking. This section briefly deals with the literature on the patterns and determinants of economic growth in major Indian states, infrastructure being one of the determinants.

2.2.4.1 Infrastructure and Economic Growth
The literature survey attempts to present the major studies conducted in India which establish the relationship between infrastructure and output growth. However, the unit of analysis varies in all these studies. There are studies that have tried to address the issue at an All-India level whereas, majority of studies are at State-level. Additionally, distinction is also made between those studies that have used indicators
for actual infrastructure provision and those that use infrastructure investment data as the explanatory variable. We begin thus, by presenting the studies at All-India level.

All-India Level

There is a dearth of literature that considers the role of infrastructure as a determinant of growth at an All-India level in a comprehensive manner. The study by Dash and Sahoo (2009) for time period 1970-2006 at All-India level is by far the most comprehensive study available in literature on the topic for India. They construct an index of infrastructure using Principal Component Analysis and take into account the time series properties of the data and test for unit root. Causality is tested between infrastructure and output growth and confirm that there exists uni-directional causality running from infrastructure to output growth. Following this, two stage least square estimation and Dynamic OLS estimation techniques are followed and they find the elasticity of infrastructure index with respect to output to lie between 0.4 and 0.5. However, this study has not taken into consideration financial infrastructure indicators which are significantly linked with economic growth (this has been shown by King and Levine, 1993; Demetriades and Hussein, 1996, Levine and Zervos, 1998; and at the same time, there have been studies that refute this relationship and that the role of financial development as determinant of economic growth is “over-stressed”. Some of these studies are those done by Sarkar, 2009; Lucas, 1988 and Fitzgerald, 2006). Dash and Sahoo (2009) stop at finding a positive and significant role played by infrastructure on aggregate output and does not talk about the importance of infrastructure for determining sectoral growth within India especially when bearing in mind the structural transformation occurring in India.

Looking specifically at the impact of transport infrastructure on economic growth of India is the study by Pradhan and Bagchi (2013) where they have applied Vector Error Correction Mechanism (VECM) to find the direction of causality between transport infrastructure and output growth between time-period 1970-2010. They have found there to exist bi-directional causality between road and economic growth and uni directional growth from railways infrastructure to economic growth. However, this study follows econometrically sound methodology but says nothing about the elasticity of infrastructure to output and stops short after pointing the direction of causality. It also excludes the other infrastructure indicators and only
considers land transport – road and railways – however, this is an important lacunae as the impact of different infrastructure indicators varies.

**State-level Studies – using physical indicators of infrastructure**

Upon moving from All India level studies to regional studies we find that the literature offers two kinds of studies - there are some studies that have included one or few infrastructure indicators along with other determinants of growth and the stress is not just on looking at the impact of infrastructure as a whole but include infrastructure indicator as representative for a state’s infrastructural development. This is problematic as it is not necessary that a state which is better developed in one kind of infrastructure will also be for other infrastructure sectors. Additionally, the impact of one indicator of infrastructure may vary from the others depending upon the structure of the economy in that state. The second set of studies includes several infrastructure indicators at state-level. They have developed infrastructure indices for different time points and estimate the impact of infrastructure.

Studies following the first approach were those by Kurian (2000), Ahluwalia (2000), Shand and Bhide (2000), Rao et al (1998) etc. 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), developmental and non-developmental revenue expenditure, disbursal of financial assistance for investment, indicators of physical infrastructure development and indicators of financial infrastructure amongst other variables. The paper pointed out that governmental effort during the 1950-80 achieved only partial success in mitigating regional disparities. It was argued in the paper that focussed investments in social and infrastructural sectors and decentralisation of decision making and financial powers would facilitate faster socio-economic development of the backward regions.

Where the above study was for pre reform period, Ahluwalia (2000) analysed the growth performance of 14 major Indian states in the post reform period 1991-92 to 1998-99 and compared it with the performance in the previous decade. The paper pointed that the dispersions of growth rates of states increased considerably in the post reform period: CV of growth rates increased from 15 percent in the 1980s to 27
percent in the 1990s. Growth accelerated in the richest states of Gujarat and Maharashtra, while it decelerated in the poorest states of Bihar, Uttar Pradesh and Orissa. Private investment rate, literacy rate, tele-density, proportion of villages electrified and per capita energy consumption were found to be individually correlated with SDP growth.

With the study by Shand and Bhide (2000) we get a comparative figures for both pre and post reform period. The determinants of growth for 15 major states of India over the period 1970-71 to 1995-96 are considered. They have used a comparative framework and presented data for each state on sectoral distribution of NSDP, its annual average growth rate and sectoral NSDP in constant (1980-81) prices for the periods 1971-80, 1981-90,1991-95 and 1992-95. The authors present rank correlation coefficients between NSDP growth rate and (i) alternative measures of size of the state (ii) relative sizes of sectors, (iii) life expectancy and literacy, and (iv) banking infrastructure and social expenditures. The results of the panel data regressions suggested that agricultural growth has positive impact on industrial growth and service sector growth. The importance of infrastructure has also been brought about, there being strong association of high growth rates of NSDP with provision of better transport and communications infrastructure, such as railways and roads, and provision of expanded services such as power, gas and water.

The studies mentioned above include a continuous time period analysis, Rao et al (1999) analysed the determinants of growth of per capita SDP with data for 14 major Indian states and estimated growth rates of per capita SDP from semi log trend equations for six different periods all ending in 1994-95. The growth rate was the dependent variable in the regression and the explanatory variables were initial level of per capita GDP, literacy rate in the initial year as a proxy for human capital stock, ratio of state government expenditure to SDP averaged for the period and adoption of technological changes in agriculture sector. A significantly positive coefficient on the initial income variable suggested β-divergence. Possible reasons for divergence were postulated by the authors and they found that skewed distribution of public expenditures attracted larger flows of investments to more affluent regions of the country. Thus, affirmative measures to correct imbalances in the spread of infrastructure were needed.
In a similar but exhaustive manner, the analysis by Nagaraj et al (2000) used panel data for 17 states including Assam, Himachal Pradesh, and Jammu and Kashmir, for the years 1960-94 and their growth regression included lagged per capita SDP, the share of agriculture, the relative price of agricultural and manufactured goods, several infrastructure indicators and fixed effects for states as explanatory variables. Their study used 14 indicators of infrastructure in the creation of infrastructure index. The estimation was done using Fixed effects and Two Stage Least Square estimation technique. The study tackles endogeneity issues by using Instrumental variable approach. The results of the study suggested that focusing investment efforts on physical infrastructure (electricity, irrigation and railways), social infrastructure (human development) would raise the overall effectiveness of public investment and raise growth with the elasticity of output with electricity to be around 0.15, 0.28 for roads, 0.18 for railways. 0.11 for number of bank branches. However, this study is dated and has not taken into account the fact that the series can have unit root and appropriate methodology is to be followed for the same. It also only talks about aggregate output and ignores the determinants of sectoral output growth.

All these studies differ in regard to the sample of states covered, period of analysis, and the explanatory variables used to represent the steady state in the growth regressions. While most of the studies have achieved some success in accounting for the differences in growth rate differences across states, they have not helped in reaching a consensus on convergence or divergence or in identifying the growth determinants (For reasons see Krishna, 2004). Additionally, the methodology followed by most of these studies is lacking and these need to be updated.

The above review of studies on India is only an introductory attempt and deals with patterns and determinants of growth for Indian states. But even from these few studies one can conclude that growth in different states of India has been characterised by instability and volatility. In this context, it will be worthwhile to extend the scope of the literature review on determinants of growth for India by exclusively looking at the patterns and impact of factors like infrastructure development among others (like - human development, capital flows like FDI, per capita bank credits, credit deposit ratios etc.) in explaining inter-state differences in
growth rate in India. Ghosh and De (1998) have tried to identify the role of infrastructure in regional development over the plan periods from 1971-72 till 1994-95. They tested the impact of public investment and physical infrastructure on both private investment behaviour and regional economic development using OLS regression. For this purpose, a physical infrastructure development indicator was formulated by them using the principal component analysis. The infrastructure variables that have been included are railway route length in kms per thousand square km of area, road length in kms per thousand square kms of area, per capita consumption of electricity in kwh, villages electrified as percentage of total number of villages in each state, gross irrigated area as percentage of gross cropped area, number of telephone lines per 100 persons. The results of their study are significantly conclusive for the time period studied and they conclude that there were increasing regional disparity in India and regional imbalances in physical infrastructure are responsible for rising income disparity across the states.

A similar study by the same authors titled Linkage between Infrastructure and Income among Indian States: A tale of rising disparity since Independence (2000) tried to find out the linkage between a composite index of infrastructure development and income across Indian states. The index was constructed using two different approaches (PCA and OLS) using ten infrastructural variables for four different years across 26 Indian states. The years are 1971-72, 1981-82, 1991-92 and 1994-95. In addition to the variables used in their earlier study mentioned above, number of post offices per thousand population, Government institutes per thousand population, number of hospital beds per thousand population, number of bank offices per ten thousand population and credit deposit ratio of nationalised banks in each state were added when computing the infrastructure development index. This study concluded that the rising inequality in ten important infrastructure facilities was responsible for widening income disparity. Planned disbursement of funds by the government had failed to cure this disparity.

Another study on the same lines by Ghosh and De (2004) tested the relationship of physical, social and financial infrastructure with per capita income across states. Three separate indices were created – Physical Infrastructure Development Index (PIDI), Social Infrastructure Development Index (SIDI) and
Financial Infrastructure Development Index (FIDI). They conclude that infrastructurally better endowed states have remained in the same position relative to their poorer counterparts and this sets limits to growth. However, these studies are dated and exclude the decade of 2000s. Additionally, they have considered only a few time points (4 time points for 3 decades) in their regression estimates and conducted separate regressions for each of the time points. Their equations are in levels and thus the interpretation of the results is a bit problematic as we do not obtain the contribution of infrastructure growth on output growth or elasticity of output with respect to infrastructure sectors.

The only study that we could trace that had tried to analyse the sectoral impact of infrastructure was by Ghosh (2011) which examined the importance of infrastructure in the development of secondary sector of the Indian economy at the state level. Six states were selected out of which three were more industrially developed and other three the least developed industrially between the time period 1995-2005. The conclusion from the study was that even though a few states had reached inflexion point in terms of physical infrastructure but other states will gain significantly from infrastructure development. However, the role of institutional and social factors was found to be more important for the less developed states.

There are several other studies that have highlighted the impact of infrastructure in India. Pradhan (2005, 2007) studies and confirms the contribution of infrastructure for Indian economy and its impact on availability and supply of inputs to production, market size and urbanisation in the economy. Recent study by Kaur and Ghuman (2009) looked at the pre and post reform periods and the infrastructure availability across 15 major states for three reference time points 1981-82, 1991-92 and 2001-02. Infrastructure index was constructed using 22 indicators of infrastructure and the states were then divided into three groups based on infrastructure development. They base their conclusion on convergence and divergence between states in terms of infrastructure development based on coefficient of range and variation. They conclude that states converged in terms of infrastructure availability during 1990s but a pattern of divergence was observed during the 1990s. Published work on role played by infrastructure in India and its regions include Shah (1970), Arunkumar (1993), Majumder (2003), Amin (1990), Dadibhavi (1991),
Tewari (1984), Das (1997), Joshi (1990), Alagh (1987), Gayathri (1997), Gowda (1997), Degaonkar (1996, 1998) and these studies confirm the positive role played by infrastructure in supporting growth and development. Several studies by Jayasheela (2007, 2008 and 2010) have looked at India’s power and health infrastructure in detail and identified the main areas of concerns. Patra and Acharya (2011) conclude that infrastructure development was important not just for regional economic growth but an important tool for reducing the level of poverty and unemployment.

In addition to these there are several studies that have looked at the development of infrastructure for a particular state in India for example; Kaur (2006) has studied the growth and infrastructure development pattern for Punjab; Majumder and Mukherjee (2005) apply a VAR framework to examine infrastructure and growth linkage for West Bengal; Basavaraj (2008) analyse the regional disparities and infrastructure development for Karnataka.

Possibly the only study in India that looks at the infrastructure development at the district level for the entire country has been by Majumder (2003) in which it was established that for the years 1971-72, 1981-82 and 1991-92 there existed substantial and significant positive associations between level of development and levels of infrastructure. When the districts were classified according to their level of development, infrastructure variables served as ‘discriminating variables’ and the association between infrastructure and development were positive for intermediate regions and insignificant for advanced regions and in lagging regions, social infrastructure was found to play an important role. These effects could play out in the form if increased earnings as evidenced in Manufacturing sector examined by Muthukrishnan (2011).

**State level studies – using infrastructure investment**

On a different line, Lall (1999) has tried to examine the relationship between public infrastructure investments and regional development in India. He concludes that leading, intermediate and lagging states are structurally different and infrastructure investments influence growth in these regions through different pathways. This study covers time period 1980-81 to 1993-94 and examines the development process of 15 states. Instead of using physical indicators of infrastructure, the dependent variables in the study are – public investments in economic infrastructure (transport, power,
telecom and irrigation); public investment in 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 linkage between economic infrastructure investments and regional economic growth and the relationship was often found to be negative. This could be due to the use of a simple uni-directional causal model that fails to capture the multiple impact path-potentials between infrastructure and growth or that it did not take deflate the investment data and fails to account for presence of unit roots in the data. However, the paper by Mishra, Narendra and Kar (2013) examines the linkages between infrastructure investments and economic growth for India for a ten year period from 1999-2009 and found infrastructure investment to have played a very important role in economic growth of India and exhibiting a very high rate of return.

In a similar vein, Bhanumurthy (2009) analyses a panel data comprising all the states in India for time period 1985-86 to 2005-06. Expenditure data on physical infrastructure (irrigation, energy, transport), social infrastructure (health, education, water and sanitation) was deflated using wholesale price index. Upon testing for panel unit root, the presence of cointegration was detected between the series following which a panel FMOLS was estimated. The estimation results find a negative impact of physical infrastructure expenditure when the regression equation did not include time dummies. Upon including the time dummies, they found a positive relationship with output. However, this study does not include other factors of production like labour and private capital and only measures the impact on aggregate economy.

### 2.3 Infrastructure and Total Factor Productivity

In recent years, a substantial research effort focused on estimating the contribution of infrastructure or public capital to the productivity of private factors of production and to economic growth. Quantitative assessments of the effects of public infrastructure capital on total factor productivity (TFP) began with the seminal work of Aschauer (1989) who, using annual time-series data for the USA, calculated that, holding constant private inputs, private GDP would increase permanently by more than one to one for every additional unit of non-defense public capital—in other words, that the annual marginal product of public capital is in excess of 100 percent. Aschauer's
results were based on a static production function estimated with yearly US data in levels. Subsequent research estimating production functions using pooled US state data in levels, disaggregating public capital into its main components, or using industry data also found similar effects, particularly for roads and highway capital.

The empirical literature dealing with the channels through which infrastructure affects productivity and/or output is reviewed in Straub (2008), Straub, Vellutini and Warlters (2008), Romp and de Haan (2007), Briceno et al (2004) and Gramlich (1994). Microeconomic studies conclude to a high impact of infrastructure on growth while others find negative or zero returns. The majority of studies, however, conclude that infrastructure matters for economic growth and production costs, but its impact is higher at lower levels of income. Romp and de Haan (2005), for instance, note that 32 of 39 OECD country studies found a positive effect of infrastructure on some combination of output, efficiency, productivity, private investment and employment. Of the remaining seven, three had inconclusive results and four found a negligible or negative impact of infrastructure. Romp and de Haan (2005) also review 12 developing country studies. Of these, nine find a significant positive impact of infrastructure on growth and productivity. The three that find no impact rely on public spending data (issues with such data have been mentioned earlier). Nevertheless, there is a lot of variance in the returns and elasticities reported by the various studies—which should not be a surprise since one cannot expect the effects of infrastructure on productivity to be positive and constant, over time or across countries.

Study by Dessus and Herrera (2000) estimates a production function and includes public capital in a simultaneous equation model to avoid endogeneity issues. It measures the impact of public capital on an index of TFP in the US and observes positive impact of the same. Similarly, Yeaple and Golub (2007) using data for 10 industrial sectors and a mix of developed and developing countries measure the impact of infrastructure variables – roads, telecommunication and power supply – on productivity using simultaneous equation model. Their results show that roads have a positive impact on productivity for almost all the sectors, whereas, the other two infrastructure sub sectors were significant for few of the sectors.
Indian studies

Amongst the Indian studies, there have been several studies on estimation and determinants of TFP. However, studies on impact of infrastructure on TFP at all India level are scant. The work by Hulten, Bennathan and Srinivasan (2006) explicitly looked at the externalities generated by infrastructure – national highways and electricity generating capacity - when looking at state-level TFP level differences in Organised manufacturing sector. Their study involved analysing Indian data for 20 years from 1972 to 1992 and it separates the direct effects of roads and electricity from indirect effects as measured by impact of infrastructure capacity on TFP growth and conclude that for the time period studied nearly half the growth of productivity in organised manufacturing sector can be explained by these two sectors. Recently, the working paper by Agarwalla (2011) has looked at the contribution of infrastructure in regional productivity in India using the growth accounting framework. The study covers 25 states in India from 1980-2006 and uses data for four main sectors of infrastructure services, education, health, transport and power. Many indicators are included in each sector and these are then used to develop 5 distinct indices of infrastructure availability. After computing the estimates of total factor productivity and infrastructure availability elasticity of output with respect to infrastructure availability was computed. Analysis of periods before and after the reforms shows significant changes in the impact of different infrastructure. Education infrastructure becomes increasingly important for productivity growth in the post reform period, whereas, contribution of transport infrastructure remains highest and significant in both the periods but there is a decline in their contribution in the latter period. Another working paper by Goel (2002) focussed on the productivity impact of infrastructure provision on registered manufacturing sector in India. The analysis in the paper was carried using the cost function approach and the cost elasticity of infrastructure inputs was computed for the manufacturing sector for the period 1965-1999. Twenty three different infrastructure variables were used at all India level and were aggregated using principal component analysis. The results indicate that infrastructure provision enhances the productivity in the manufacturing sector and lowers the cost of production.

In another study by Mitra et al (1998) State level estimation of Indian manufacturing Total Factor Productivity (TFP) and Technical Efficiency (TE) from
the estimation of production functions for 17 manufacturing industries from 1976 to 1992 was undertaken. Their analysis relates TFP and TE to the availability of infrastructure. According to them differences across States in manufacturing sector TFP and TE performance are accounted for, to a significant extent, by differences in infrastructure endowments. In a more recent attempt, Mitra, Sharma and Varoudakis (2011) estimate the impact of Core infrastructure sectors and ICT infrastructure sector on productivity for eight sub sectors of secondary sectors (chemical, Food and beverages, Machinery, Metal, Non-metallic mineral products, textile, Transport, Miscellaneous). Upon finding existence of cointegration between the series, system GMM and FMOLS estimation techniques were applied for estimation the elasticity of TFP index with infrastructure sectors. This study concludes that the elasticity of output with core infrastructure index was found to be 0.32 and with ICT infrastructure it was 0.12.

These studies have thus measured the contribution of infrastructure to output growth via measuring the spillover externality in the form of TFP growth. However, in Indian scenario we could not find a study that undertakes the same exercise at all India level for all the sectors while also testing for unit roots and presence of cointegration and thus using the appropriate methodology for estimation.

2.4 Infrastructure and Inequality
Infrastructure might be considered as a major facilitator of economic growth, however, when considering the impact of infrastructure in developing countries where weak governance, distorted public investment choices, and corruption are a reality, the benefits of infrastructural expansion that result in higher growth are not necessarily equally shared and could result in interregional or interpersonal income inequality. This section gives a quick overview of recent literature on the effects of infrastructure on inequality. The analysis of framework varies from time series models of the national economy to panel data based models consisting of countries and states/provinces. The various channels through which infrastructure can impact inequality and help reduce it have been highlighted in Estache, 2003; Gannon and Liu, 1997; Estache and Fay, 1995; Jacoby, 2000 amongst others. Essentially, infrastructure helps underdeveloped regions and disadvantaged individuals gain access to productive opportunities by helping connect to core economic activities.
Reduction in production and transaction costs through access to roads has been a key determinant of income convergence for the poorest regions in Argentina and Brazil (Estache and Fay, 1995).

In addition to the conventional channels through which infrastructure impacts the economy, literature has identified new channels like the impact of infrastructure development in improving human capital which then helps in increased job opportunities and productivity (for details see Brenneman and Kerf, 2002; Agenor and Moreno-Dodson, 2006). By investing in roads, for instance, governments may not only reduce production costs for the private sector and stimulate investment, but also improve education and health outcomes, by making it easier for individuals to attend school and seek health care. With their health improving, individuals become not only more productive, but they also tend to study more. In turn, a higher level of education makes individuals more aware of potential risks to their own health and that of their family members. Moreover, investment in infrastructure, by improving health and life expectancy, may reduce uncertainty about longevity and the risk of death, thereby increasing the propensity to save. As a result of these various effects, the impact of infrastructure on income and welfare is compounded.

For China, Fan, Zhang and Zhan (2002) using provincial data for 1970 to 1997 and simultaneous equation model documented the critical role of infrastructure development in raising growth levels and significantly reducing rural poverty and regional inequality. According to them this happened mainly because of the increased opportunity for rural non-farm employment that followed expansion of infrastructure. Recent study by Zheng and Kuroda (2013) on the role of two types of public infrastructure – transportation and knowledge infrastructure - in China’s regional inequality, growth and on industrial geography across 286 cities found that an improvement in transportation infrastructure reduced trade cost and increased growth and decreased income gap but at the expense of increasing industrial agglomeration between cities. However, for knowledge infrastructure it was suggested that it increases growth as well as decreases income gap and industrial agglomeration.

Taking into account the impact of both the quantity and quality of infrastructure on distribution of income Calderon and Chong (2004) provide evidence on the negative relation between both quantity and quality of infrastructure and
income inequality for time period 1960-97. They made use of cross-country and panel regression (using GMM dynamic methods to minimize endogeneity problems) and various types of infrastructure indices. Calderón and Servén (2005) in their study delved into both growth and the inequality aspects of infrastructure investment by providing an empirical evaluation of the impact of infrastructure development on economic growth and income distribution, using a large panel data set covering more than 100 countries and spanning 40 years (1960-2000). They concluded that availability and quality of infrastructure services for the poor in developing countries had a significant positive impact on their health and/or education and, hence, on income and welfare. Seneviratne and Sun (2013) studied the income distribution and infrastructure links for ASEAN-5 countries. They ran a set of pooled OLS regressions covering 76 advanced and emerging market economies for time period 1980-2010 and found that better infrastructure improved income distribution but the same could not be said for investment in infrastructure. The study suggests that infrastructure development can have double effects on poverty reduction and inclusive growth. For the ASEAN-5 countries, benefits of growth could be shared more evenly by removing infrastructure gaps.

But literature on this topic has not been unanimous in support of infrastructure development leading to a reduction in inequality. In the study by Brakman et al (2002) it was found that government spending on infrastructure has increased regional disparities within Europe. In a similar vein, for India, Banerjee (2004) and Banerjee and Somanathan (2007) have studied the impact of access to infrastructure services on distribution of income and they report that the two are positively related, i.e., the benefits of infrastructure services are accrued mostly by higher income groups as opposed to benefitting the poor. The study by Khandker and Koolwal (2007) found a limited distributional impact of building paved roads on income in rural Bangladesh.

The only study for India that we could trace, which takes a direct look at the impact of infrastructure on consumption inequality was by Majumder (2012). This study analyses the impact of infrastructure on poverty and inequality at district level using data from the NSS rounds of 1993-94 and 2004-05. The results from his study point that there has been increasing inequality along with physical infrastructure development however, expansion of regional infrastructural facilities enhances
average consumption level of the people and reduces the proportion of people living below poverty line. But his study did not take into consideration the impact of telecommunication infrastructure. Their regression estimates only included infrastructure indices as independent variables and ignored other possible determinants of inequality. The study is silent on whether the MPCE (marginal per capita expenditure) figures were deflated or not. Empirical investigation of impact of infrastructure on inequality (consumption) as measured by Gini coefficient calculated using the MPCE data provided by NSSO at state level in a panel data framework was hard to find.

However, there have been other studies looking at the impact of regional inequality such as the paper by Raychaudhari and De (2010) which made an attempt to understand the inter-linkages among infrastructure, trade openness and income inequality using a panel data of 14 Asia-Pacific countries spanning the period 1975 to 2006 and concluded that trade openness and infrastructure influence income inequality but the reverse is not necessarily true. Also, the effect of infrastructure development on trade is not found to be significant.

In India, a number of studies based on National Sample Survey (NSS) estimates of household consumption expenditure reveal mixed evidence on aggregate and regional trends. According to Bhalla (2003) both urban and rural Gini coefficients declined between 1993-94 and 1999-00. State-wide Gini coefficients were published by Government of India National Human Development Report (2001) for the years 1983, 1993-94 and 1999-2000. Amongst the 32 states and union territories seven states experienced an increase in rural inequality and fifteen states experienced an increase in urban inequality (Pal and Ghosh, 2007). Although, there have been many studies on this issue (Jha, 2004; Sen and Himanshu, 2005; Deaton and Dreze, 2002; Banerjee and Piketty, 2001), studies concentrating on the impact of infrastructure on inequality have been scarce.

Ghosh and De (2005) carried out a detailed study on the role of infrastructure on the inter-state inequality in India for the period 1970-71 to 1999-2000. They regressed the real per capita State GDP on several social, financial and physical infrastructure variables and found that inter-state disparity in per capita net State domestic product, physical, social and financial infrastructure facilities among Indian
States has been rising significantly during the past 25 years; and Physical and social infrastructure facilities have proved to be highly significant factors in determining the inter-state level of development. In Ghosh (2012) economic performance of 15 major states in India is investigated and convergence patterns examined. Accordingly regional divergence and convergence are explained with respect to differences in physical and social infrastructure, state level policy reforms, FDI and economic structure. An important result from this study was that by investing in physical and social infrastructure the states that showed poor economic growth performance could improve their growth performance.

2.5 Research Gaps

The above review of literature was mainly categorised based on three themes: impact of infrastructure on economic growth, its impact on total factor productivity and on economic inequality. This thesis addresses these 3 issues and is an attempt to take a comprehensive look at the macroeconomic impact of infrastructure on the economy in India. It differs from the existing Indian literature on the topic in the following manner.

All-India level studies undertaking the examination of impact of infrastructure on output growth have been few. Even amongst those that exist, the current study differs in the sense that it includes more infrastructure variables – particularly financial infrastructure variables along with physical and social infrastructure variables. The time period under consideration is that of more than 40 years (from 1970-71 to 2011-12) and the estimation methodology is such that the time series properties of the data are kept under consideration. Causality tests are undertaken to find out the direction of relationship between infrastructure and output based upon which appropriate estimation methodology which takes care of possible endogeneity issues has been applied. Additionally, this study estimates growth regression with infrastructure variables and other inputs to production - capital and labour. This is done for overall output (Net Domestic Product) as well as for secondary and tertiary sector to find the significance of infrastructure sectors in particular for these sectors and not aggregate NDP alone. This is an important digression from the existing literature as the drivers of growth for secondary and tertiary sector vary over time as has the structure of economy. Different infrastructure variables impact output growth.
in different ways and the impact of same infrastructure variable differs over time. For example, the impact of electricity/power sector on manufacturing sector output could be different than on services sector output. Thus it will be interesting to examine the relationship between infrastructure and sectoral output to identify which infrastructure sectors have played more important role in the growth of India’s secondary and service sector output growth over the last 40 years.

The unit of analysis for this study goes upto state-level and the time period under consideration is from 1980-81 to 2011-12. This thesis differs from existing several other state-level studies conducted in India as it is a panel data study involving 17 states for more than 30 year long period. The data used is annual data and not just a few time points (which has been the case for most other studies). It includes physical infrastructure variables as infrastructure indicators – physical, financial and social and not investment in infrastructure. This distinction is an important one because it is not necessary that infrastructure investment gets necessarily translated into actual creation of infrastructure. This is especially true for developing countries like India. Thus, it is better to rely on actual infrastructure stocks in existence across states in India. In addition, the methodology followed in this study involves testing for non-stationarity of data (both time series and panel data series) following which a cointegration test is conducted to find the nature of relationship between the series. This is succeeded by a causality testing based on VAR or VECM estimation technique following which estimation of output elasticity with respect to infrastructure variables is undertaken using appropriate regression technique.

An important point of departure for this study is that it engages with not just aggregate output and it’s growth but also takes into account the significance of infrastructure on secondary sector and tertiary sector output, across states in India for different time periods. Just as economic growth in India has seen changes in its trend, sectoral output growth have also varied over time with tertiary sector having a prominent share in aggregate output as well as in its growth. The changes in political and economic structure in the country were also followed by changes in infrastructural policies. This then is the basis for disaggregating the thirty year time period into different time period to examine if there are changes over time and across states in the impact of infrastructure indicators on sectoral output. This study differs
from many other studies on this topic by inclusion of control variables in the estimation of elasticity of output with infrastructure.

This study does not stop short at only examining the impact of infrastructure on output growth via its direct impact as a production input. Attempts have been sparse at studying the relationship between infrastructure and productivity growth at All-India level. Most studies have only tried to gauge the impact of infrastructure on manufacturing sector’s productivity growth. This study undertakes the estimation of relationship between index of infrastructure as well as infrastructure indicators on Total factor productivity in India in India. This study also makes an attempt to study the relationship at state level for organised manufacturing sector’s TFP growth. As an additional exercise, this study also considers the impact of infrastructure on 25 sub sectors of the economy to understand which of the sectors productivity levels get most affected by infrastructure development.

Additionally, an important research gap that has been identified is absence of a comprehensive study linking infrastructure development with consumption inequality across states in India. The relationship between infrastructure and inequality is not a clear cut one, because, even if infrastructure helps in economic growth and via its impact on growth helps reduce poverty, that does not necessarily translate into a reduction in inequality across regions or a reduction in interpersonal inequality. This thesis makes an attempt at estimating the nature of relationship in India and uses information on consumption expenditure provided by NSSO for the same. Alongside infrastructure, several control variables are also included that help explain inequality in India and this adds to the robustness of results.