Public Infrastructure Investment, Economic Growth and Fiscal Sustainability in India: An Empirical Analysis

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CERTIFICATE

This is to certify that the thesis entitled **Public Infrastructure Investment, Economic Growth and Fiscal Sustainability in India: An Empirical Analysis,** submitted by Mr.Varun Chotia, ID No. 2012PHXF403P for the award of Ph.D. degree of the institute embodies original work done by him under my supervision.

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ABSTRACT

The interlinked aspects of Public Infrastructure Investment, Economic Growth and Fiscal Sustainability have been of great importance in terms of the proper functioning of any developing economy, like India.

The importance of Infrastructure is well established with a general agreement being developed across the world that Infrastructure has a direct and positive correlation with the economic growth and development of a nation. Post liberalization era, the focus on infrastructure development has been increasing continuously. From a growth enhancing point of view, Infrastructure sector has emerged as one of the most significant sectors in recent years. The investment in infrastructure as a percentage of Gross Domestic Product (GDP) has increased from 4.9 per cent in 2002-03 to approximately 7.2 per cent in 2011-12 and is estimated to further increase up to 10 per cent by 2016-17. The share of bank funding in financing the Infrastructure sector increased from 3.74 per cent in 2002 to around 10.40 per cent in 2015. It is also predicted that augmented spending on infrastructure would reach United States Dollar (USD) 19 billion during the 12^{th} five year plan period i.e Financial Year (FY) 2012-17.

Based on the review of literature, three major research gaps were identified. Firstly, till date very few studies had been conducted in India, analyzing the relationship between Public Infrastructure Investment and economic growth, particularly from a state level point of view. Secondly, there was insufficiency of research works which had explored and suggested the best mode of infrastructure financing for India's major Infrastructure sectors. Also, the aspect of determining the major determinants of attracting any Public Private Partnership (PPP) in India was largely untouched. Thirdly, the vital relationship between debt and economic growth needed evaluation, particularly from an Indian context. Also, measurement

of fiscal sustainability and estimation of a threshold value of debt/GDP ratio for Indian states still remained relatively unexplored and required its due attention. Therefore, three major research issues relevant to us for this study were: understanding the relationship between Public Infrastructure Investment and Economic growth for India, Issues pertaining to Infrastructure Financing, and finally the interlinkages between debt, economic growth and fiscal sustainability issue for Indian economy.

To capture the essence of the critical relationship between Public infrastructure investment and economic growth for India, a sectoral analysis was performed for the twenty eight Indian states, excluding Telangana. For all the states, Public Investment data was taken for six major sub sectors falling under overall Infrastructure sector: Transport, Education, Sports, Art and Culture, Medical and Public Health, Water supply and sanitation, Irrigation, Energy/Power. Further, time series econometric techniques such as Im, Pesaran and Shin (IPS) (2003) panel unit root test and Westerlund (2007) panel cointegration were employed in order to examine this panel data set for twenty eight Indian states. Moving on to the issue of Infrastructure Financing, two research problems were addressed. Firstly, it was examined that which mode of infrastructure financing (either public financing, private financing or the PPP mode) was the preferred one for major infrastructure sectors of India. To achieve this objective, the historical trends of each mode of infrastructure financing were evaluated over the last two decades for the major sectors falling under the Infrastructure sector i.e Transport, Telecommunication (Telecom), Energy, Water and Sewerage. Further for these sectors individually as well as for the aggregate scenario, the preferred mode of financing in terms of having the maximum positive impact on India's economic growth was estimated using the Structural Vector Autoregression (SVAR) model. For the second research problem, the study focused on the PPP mode of infrastructure financing and estimated the important determinants of attracting any PPP in India. To test and estimate the possible determinants of

PPPs in infrastructure in India, eight research hypotheses were framed and tested using techniques like Poisson regression, Negative Binomial regression and Tobit regression. For our third and final research objective, firstly we examined the dynamic relationship between debt and economic growth for India. Following this, a fiscal sustainability index was calculated for the twenty eight Indian states, excluding Telangana, signifying each state's fiscal stance. Finally, Pareto principle and decision tree algorithm were used to calculate an optimal value of debt/GDP ratio above which it can be concluded that any state economy of India becomes fiscally unsustainable.

Based on the empirical findings, the following conclusions were derived. For the first research objective, the presence of cointegration was confirmed and hence long-run equilibrium relationship existed among the seven variables used for studying this objective i.e. Per Capita Gross State Domestic Product (PCGSDP) and Public Investment in Transport (PTRANS); Public Investment in Education, Sports, Art and Culture (PEDU); Public Investment in Medical and Public Health (PMED); Public Investment in Water supply and sanitation (PDW); Public Investment in Irrigation (PIRRI); Public Investment in Energy/Power (PENG). Further, the causality analysis was carried out which suggested a short-run bi-directional causality relationship between PTRANS and PCGSDP. Various causal relationships were also inferred among these seven variables of our study. The findings from the analysis suggest that economic policies should address each of the cointegrated/interlinked sectors of Infrastructure simultaneously with investment being the top most priority in order to achieve higher economic development. From a policy recommendation point of view, the empirical framework can help to estimate the short- and long-run elasticities of Public Investment in these major Infrastructure sectors. Further, these elasticities can be used to calibrate the developed models and generate scenarios telling how

openness policies might stimulate businesses to adopt different types of investment options (like PPPs etc.) so as to maximize growth prospects.

The empirical analysis performed under second research objective achieved two major purposes. Firstly, Private mode of infrastructure financing was seen to be the most preferred one for sectors – Roads, Telecommunication (Telecom) and Energy while Public Private Partnership (PPP) mode was preferred for the Seaports sector. For Energy sector, Private mode of investment has witnessed an overall increasing trend since liberalization of Indian Economy with its growth further triggered by Electricity Act 2003, National Tariff Policy 2006 and more recently by the New Hydro Policy of 2008. For Roads sector, the National Highways Act 1956 was amended in June 1995 to facilitate private participation in road infrastructure projects. The Seaports sector has witnessed significant private participation particularly after 1996 which could be attributed to the fact that in 1996, the port sector was opened for private sector participation. For Telecom sector, the New Telecom Policy (NTP) was announced in 1999 post which the private investment started pouring in.

Further, based on the findings of examining which mode of infrastructure financing has a maximum positive impact on the overall GDP of our nation, it was concluded that Private mode of investment in Roads, Energy, Telecom while PPP mode for Seaports were observed to have maximum positive impact on GDP. For Energy sector, the Impulse Response functions suggested that an increase in Private investment in energy sector led to an increase in GDP in the short term. However, in the long run the increase was mitigated. Hence, the Indian government needs to focus on long-term measures like reducing dependence on any one source of imported energy, exploiting native fossil fuel or renewable energy resources, and cutting down the overall demand through energy conservation measures. For Roads sector, the Impulse Response functions obtained for the Indian economy clearly indicated

that private investment in the roads sector had a maximum positive effect on GDP in short run as well as long run. Transport infrastructure is one of key ingredients to fuel economic growth and Roads are the lifeline of transportation in our country. For Seaports sector, the Impulse Response functions clearly suggested that PPP investment in the seaports sector had the maximum positive effect on GDP in short run as well as in the long run. The Indian ports and shipping industry plays a crucial role in sustaining growth in the country's trade and commerce as around 95 percent of India's trading by volume and 70 percent by value is done through maritime transport. Therefore, investment in the seaports sector is directly linked to boosting of Indian economy. For the Telecom Sector, the Impulse Response functions pointed out that an increase in Private investment in Telecom sector led to an increase in GDP in the short term. However, in the long run the increase was marginal and not a significant one. This may be due to the fact that still there is a tremendous opportunity for future growth in the Telecom industry. Hence, the amount of investment going in presently might only be used up in trying to sustain the existing demand and not ultimately getting transferred into exerting a positive impact on the economy. The rural areas are still underpenetrated and their demand is huge. Further as per the empirical analysis for overall Infrastructure scenario constituting of Roads, Seaports, Telecom and Energy sectors, PPP mode of infrastructure financing came out to be the most significant one in terms of having the maximum positive impact on GDP of India. Hence, the study was taken ahead to focus exclusively on the PPP mode of infrastructure financing by estimating the significant determinants of attracting any PPP in India.

From the empirical evidences, it was concluded that the major determinants of a successful PPP in India are hard government constraints, market conditions, political factors and institutional quality. The empirical findings suggested that for India, a higher Cash deficit with huge government debt tends to attract more number of PPP projects. Further, the results

imply that stable market conditions reflected in sufficient gross savings and a rising GDP per capita ultimately lead to more number of PPP projects in India. Also in terms of political factors, Voice and Accountability, Political Stability and Regulatory Quality are indeed responsible and play a crucial role for the private sector in terms of making decisions regarding involvement of the PPP mode for financing Infrastructure. Finally, Institutional quality via freedom from corruption index (FCI) cannot be ignored and it also holds its significance in determining PPP projects in India. Ultimately, there is evidence in favour of all the channels except the macroeconomic factors.

In the next step, the investment aspect for PPPs was examined. The results of this analysis indicated that soft governmental constraints, market conditions and effectiveness of government prove to be decisive in terms of impacting the PPP investment (total cost of PPP projects). More specifically, a country with a large population and large demand, receiving net inflows from equity securities and having an effective and credible government attracts more investment in PPP.

For the third research objective, the dynamic relationship between debt and economic growth for India was empirically examined, by looking at this relationship from the investment point of view. From the results, it was concluded that public debt makes a significant positive contribution to economic growth directly as well as indirectly via investment. An increase in level of public debt, all else being equal, would appear to stimulate the rate of investment over the course of time and, in turn, indirectly increase economic growth, hence supporting the argument that public debt has an indirect effect on economic growth through its beneficial impact on investment.

The subject of fiscal sustainability was analyzed with an aim of calculating the threshold value of debt. The time period of 2002-03 to 2013-14 was considered to construct an

indicator which measures fiscal sustainability for twenty eight Indian states, excluding Telangana. This indicator was named as Sustainability Gap. Based on the calculations, Arunachal Pradesh, Chattisgarh, Goa, Haryana, Himachal Pradesh, Manipur, Odisha, Punjab, Rajasthan and Uttar Pradesh came out to be the top performing states on grounds of fiscal sustainability.

Chhattisgarh although an underdeveloped but a resource-rich state, seems to be surprise entry in the list of top performers. This relatively new and small mineral-rich state is able to stand out because of a revenue surplus budget and low interest payment burden. In terms of interest payment as a proportion of the state gross domestic product, apart from Chhattisgarh, Goa and Odisha also have the least interest costs which benefits them a lot and that is why both of these states also find themselves in the list of Top performers. Small states like Arunachal Pradesh, Himachal Pradesh and Manipur also are performing well because of high revenue receipts and low expenditure.

States like Gujarat and Maharashtra perform decent owing to higher capital expenditure spending and greater reliance on self-generating taxes. States like Jharkhand, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, and Karnataka perform poorly because of a poor revenue balance. These states do not have sufficient revenue receipts to meet their expenditure. The extra burden of interest payments on past debt also makes them vulnerable and they lie in the poor performers' category.

Moving ahead, a threshold value of debt was calculated suggesting that if a particular Indian state's debt is above this value, its fiscal position represents instability and ultimately India's fiscal sustainability will be at threat. Based on the empirical findings, three levels of conditions were identified, each predicting the fiscal sustainability for a state economy and at

the same time also suggesting an optimal value of debt which the Indian states should not breach.

The first level gave the condition based on the fiscal deficit indicator. Fiscal deficit is one of the most important indicators whenever we discuss fiscal sustainability. There should be a particular value of fiscal deficit which the governments should take as a benchmark and should not cross it. The empirical findings suggested that the threshold value of fiscal deficit should not cross -3.62 (as a % of GDP), with the negative sign implying that it is a deficit. Till this fiscal deficit value of -3.62 %, it is being predicted that the economy remains fiscally sustainable. This result is almost equal to the fiscal deficit target of -3.9 (% of GDP) set by Government of India for the year 2015-16.

The second level gave the condition based on the combination of two indicators: Fiscal deficit and debt-GDP ratio. The empirical findings concluded with the condition that if fiscal deficit crosses -3.62 and debt-GDP ratio is more than 69.45% then the economy becomes fiscally unsustainable. If fiscal deficit does not cross -3.62, and debt-GDP ratio is also less than 69.45%, then the economy remains fiscally sustainable. Here, by including the debt-GDP ratio at the second level, the optimal level of debt for India was predicted as 69.45%.

The third and final condition was based on the combination of three macroeconomic indicators: Fiscal deficit, debt-GDP ratio and growth rate. After reaching out at the above two conditions using fiscal deficit and then debt-GDP ratio, growth rate was included just to expand the analysis and have a much more wider and realistic view in terms of examining this issue of fiscal sustainability. Therefore, from the empirical findings it was concluded that if fiscal deficit of a particular Indian state does not cross -3.62 with its debt-GDP ratio being less than 69.45% and growth rate greater than 13.48%, then the state economy remains fiscally sustainable.

This study is a pioneering work in the field of Indian Infrastructure sector which holds a prominent edge in terms of its contribution to GDP. Though there have been studies which have examined the different aspects of the role of infrastructure in terms of achieving economic growth, however, insufficiency of research work remains when it comes to specifically examine the Public Infrastructure Investment and economic growth relationship for India, particularly from a state level point of view. This thesis specifically contributes in this regard. The studies focusing on India's Infrastructure sector have ignored the issue of Infrastructure Financing. This study takes up this issue and explores and suggests the best mode of infrastructure financing for India's major Infrastructure sectors. The aspect of determining the major determinants of attracting any PPP project in India is also a unique contribution of this thesis to the existing work. This thesis contributes to the literature by analyzing the issue of fiscal sustainability for Indian states and constructing a measure to assess the same. Empirical work on estimating a threshold value of debt-GDP ratio for Indian states and ultimately India needs to be enriched. This work provides empirical evidence on that front also.

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List of Abbreviations

ADF : Augmented Dickey Fuller

AIC : Akaike's Information Criterion

AIIMS : All India Institute of Medical Science

APEC : Asia-Pacific Economic Cooperation forum

BOP : Balance of Payments

BOT : Build–operate–transfer

BWA : Broadband Wireless Access

CE_i : Capital Expenditure for year i

CR_i : Capital Receipts for year i

CAGR : Compounded Annual Growth Rate

CCI : Cabinet Committee on Infrastructure

CCoI : Cabinet Committee on Infrastructure of the Planning Commission

C-D : Cobb-Douglas

CDPQ : Caisse de depot et placement du Quebec

CGEE : Computable general equilibrium

CII : Confederation of Indian Industry

CPI : Consumer Price Index

CSO : Central Statistics Office

D : Public debt to GDP ratio

D_{ai} : Actual debt at year i

D_{ei} : Expected debt at year i

DDUGJY : Deen Dayal Upadhyay Gram Jyoti Yojana

DEA : Department of Economic Affairs

DF : Dickey Fuller

DG : Director General

DIPP : Department of Industrial Policy and Promotion

DOD : Disbursed and outstanding debt

E_i : Total Expenditure at year i

ECM : Error Correction Model

EOC : Economic Overhead Capital

EPC : Engineering, Procurement, Construction

FCI : Freedom from Corruption

FDI : Foreign Direct Investment

FI : Fiscally Improving

FICCI : Federation of Indian Chamber of Commerce and Industry

FUS : Fiscally Unsustainable

FY : Financial Year

G20 : Group of Twenty

GCF : Gross Capital formation

GDP : Gross Domestic Product

GER : Gross Enrollment Ratio

GFS : Gross Domestic Savings

GMM : Generalized Method of Moments

GNI : Gross National Income

GRPV : Grid Connected Rooftop Solar Photovoltaic

GSDP : Gross State Domestic Product

GTE : Government Trading Enterprises

GW : Gigawatt

HQIC : Hannan and Quinn information criterion

I : Investment ratio (total investment, as a % of GDP)

$I_{\_PPPEG}$: Investment in Energy sector by PPP mode of financing

$I_{\_PPPR}$: Investment in Roads sector by PPP mode of financing

$I_{\_PPPSP}$: Investment in Seaports sector by PPP mode of financing

$I_{\_PPPT}$: Investment in Aggregate scenario by PPP mode of financing

$I_{\_PPPTC}$: Investment in Telecom sector by PPP mode of financing

$I_{\_PUBEG}$: Investment in Energy sector by Public mode of financing

$I_{\_PUBR}$: Investment in Roads sector by Public mode of financing

$I_{\_PUBSP}$: Investment in Seaports sector by Public mode of financing

$I_{\_PUBT}$: Investment in Aggregate scenario by Public financing

$I_{\_PUBTC}$: Investment in Telecom sector by Public mode of financing

$I_{\_PVTEG}$: Investment in Energy sector by Private mode of financing

$I_{\_PVTR}$: Investment in Roads sector by Private mode of financing

$I_{\_PVTSP}$: Investment in Seaports sector by Private mode of financing

$I_{\_PVTT}$: Investment in Aggregate scenario by Private financing

$I_{\_PVTTC}$: Investment in Telecom sector by Private mode of financing

ICF : Freedom from Corruption

ID3 : Iterative Dichotomiser 3

IDFC : Infrastructure Development Finance Corporation Ltd.

IIFCL : India Infrastructure Finance Company Ltd.

IL&FS : Infrastructure Leasing & Financial Services

IMF : International Monetary Fund

INR : Indian Rupees

IPDS : Integrated Power Development Scheme

IPO : Initial public offering

IPS : Im, Pesaran and Shin

IR : Indian Railways

ITR : Interest rate

IRDA : Insurance Regulatory and Development Authority

IRFs : Impulse Response functions

ISP	: Internet Service Provider
JNNURM	: Jawaharlal Nehru National Urban Renewal Mission
L	: Natural logarithm of the variable
LAC	: Latin America and the Caribbean
LNG	: Liquefied Natural Gas
LTE	: Long Term Evolution
M	: Money supply
MDB	: Multilateral development banks
MNP	: Mobile Number Portability
MoRTH	: Ministry of Road Transport and Highways
MOSPI	: Ministry of Statistics and Programme Implementation
MRTS	: Mass Rapid Transit System
MW	: Megawatt
NCRI	: National Council of Rural Institutes
NDB	: National Development Banks
NHAI	: National Highway Authority of India
NHDP	: National Highway Development Project
NMDP	: National Maritime Development Program
NP-NPSE	: National Programme of Nutritional Support to Primary Education
NTP	: New Telecom Policy
NTPC	: National Thermal Power Corporation
OC	: Overhead Capital
ODA	: Official Development Assistance
OECD	: Organization for Economic Co-operation and Development
OLS	: Ordinary Least Squares
PCGSDP	: Per Capita Gross State Domestic Product
PDW	: Public Investment in Water supply and sanitation

PEDU : Public Investment in Education, Sports, Art and Culture

PENG : Public Investment in Energy/Power

PFRDA : Home-Pension Fund Regulatory and Development Authority

PIRRI : Public Investment in Irrigation

PMED : Public Investment in Medical and Public Health

PPI : Private Participation in Infrastructure

PPP : Public Private Partnership

PTRANS : Public Investment in Transport

r : Interest rate on debt (risk free rate of return)

R_i : Total Receipts at year i

RE_i : Revenue expenditure for year i

RR_i : Revenue Receipts for year i

R&D : Research and Development

R&M : Renovation and Modernization

RBI : Reserve Bank of India

RMSA : Rashtriya Madhyamik Shiksha Abhiyan

RTE : Right of Children to Free and Compulsory Education

SG_i : Sustainability Gap

SBI : State Bank of India

SBIC : Schwarz's Bayesian information criterion

SCINS : Standing Committee on Infrastructure Statistics

SEBI : Securities and Exchange Board of India

SEZ : Special Economic Zone

SNGs : Sub national governments

SOC : Social Overhead Capital

SVAR : Structural Vector Autoregression

T : International trade in real terms as a percentage of GDP

TC : Telecom Commission

Telecom : Telecommunication

TFC : Telecom Finance Corporation

TFP : Total Factor Productivity

TWh : Terawatt-Hour

UK : United Kingdom

US : United States

USD : United States Dollar

VAR : Vector Autoregression

VECM : Vector Error Correction Model

WGI : Worldwide Governance Indicators

WiMAX : Worldwide Interoperability for Microwave Access

Y_t : Per capita Gross Domestic Product

Y_{rt} : Real Gross Domestic Product growth rate year on year

Δ : First difference of the variable

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The interlinkages between Public Infrastructure Investment, Economic Growth and Fiscal Sustainability hold great importance for any developing economy, like India. These three interrelated aspects are highly crucial in terms of the proper functioning of an economy and that is why it becomes all the more important to analyze these interrelationships with special focus on India. The subsequent paragraphs give a brief introduction about the importance of these interlinked issues.

The significance of Infrastructure is widely acknowledged with a general consensus being developed across the globe that development of Infrastructure is a reflection of how well the economy is performing and that Infrastructure has a direct and positive correlation with the economic growth and development of the nation. Availability of adequate infrastructural set up leads to rapid industrialization and at the same time improves the quality of life of the people. The importance of Infrastructure can be ascertained from the fact that it includes the whole spectrum of key sectors such as roads, railways, Telecommunication (Telecom), shipping, civil aviation, energy/ power generation and transmission etc. Adequate infrastructure facilities in each of these sectors become an absolute necessity for achieving sustainable economic growth and development. It can be said that Infrastructure facilities act as wheels of development without which the economy cannot function proficiently. A strong infrastructural foundation holds the key for a fast growing economy like India, which requires infrastructure of world class stature. This world class infrastructure will act as a magnet for pulling additional investment into our economy and hence, providing it with a competitive edge.

While the importance of infrastructure is recognized and established, investment in Infrastructure becomes a prime factor to achieve fast and sustained economic growth. The

governments all across the world including India have recognized this principal need of boosting up the public investment levels. Several factors like matching up with the ever increasing pace of urbanization and the allied infrastructure demands, taking due advantage of various technological changes or cutting down on our nation's carbon footprint, are behind this recent change. Public Infrastructure Investment plays an important role in terms of achieving important policy goals of government like poverty reduction, responding to approaching demographic trends, in particular the ever increasing urbanization etc. Therefore, it becomes all the more important to investigate the interlinkages between Public Infrastructure Investment and Economic Growth for India, particularly from a state level point of view.

For Investing in Public Infrastructure, capital is required and that is where the subject of Infrastructure financing comes in. Focus needs to be given in terms of suggesting the best mode of financing among Public financing, Private financing or Public Private Partnerships (PPPs) for major sectors of India's Infrastructure, so that policymakers can efficiently design and develop economic policies. Further, specific focus needs to be given on assessing the importance of PPPs and the viability of PPPs as an option of Infrastructure financing. For this, it becomes very crucial to examine the fact that what are the major factors that determine the PPPs involvement in India.

However, if the Indian government is unable to generate the required amounts of funds via different modes of Infrastructure financing, then they have to resort to taking debt and that is where the concerns of fiscal sustainability come in. If the economy is burdened by a high debt stock, then a significant portion of the tax revenue is used for repaying the interest payments incurring on public debt, leading to fewer resources being left for public investment. If the amount of debt taken goes into alarming zones, then it may have a detrimental effect on the economic growth of India's economy and that is when this issue of

fiscal sustainability for our economy gains importance. Therefore, three major research issues relevant for this study are: understanding the relationship between Public Infrastructure Investment and Economic growth for India, Issues pertaining to Infrastructure Financing and finally the interlinkages between debt, economic growth and fiscal sustainability issue for Indian economy.

1.2 PUBLIC INFRASTRUCTURE INVESTMENT, ECONOMIC GROWTH AND FISCAL SUSTAINABILITY: BRIEF REVIEW OF LITERATURE AND RELEVANCE OF RESEARCH

As discussed in above section, three major issues relevant to this study and need attention are:

- Relationship between Public Infrastructure Investment and Economic growth
- Issue of Infrastructure Financing
- Interlinkages between Debt, Economic growth and Fiscal Sustainability

For each of these issues, a brief overview of literature helps in identifying the research problem and ultimately the research objectives.

1.2.1 Relationship between Public Infrastructure Investment and Economic growth

Public Infrastructure Investment is a critical input for economic growth and there is a need for a substantial increase in the Infrastructure Investment, particularly in nations like India where there is urgent need to bring the current existing Infrastructure levels to world class standards. As India continues to grow and develop, there is increasing interest in elucidating this dynamic relationship between Public Infrastructure Investment and economic growth more comprehensively.

Considerable efforts have been made in the gone by decades focusing towards the theoretical and empirical estimation of the contribution of Public Infrastructure Investment to economic

growth. The whole argument on assessing the impact of public infrastructure investment on economic development was revived by Aschauer (1989) who had observed that the major reason behind the slowdown in United States (US) productivity growth in the 1970s and 1980s was due to the decreasing rates of public investment spending. Aaron (1990) examined US public capital stock time series data from 1951-1985 and explained that public capital has a positive effect on output. However, Hulten and Schwab (1991) using US public capital stock data from 1949-1985, estimated that there are insignificant impacts of public capital on output. Results from another study by Tatom (1991) got insignificant effects of public capital on output. Contrary to it, Nourzad and Vriese (1995) did analysis on US from 1949-1987 and confirmed the fact that there happens to be significant positive effects of public capital on output.

In recent times, Calderon and Serven (2011) concluded that curtailing the infrastructure spending decreased the long term growth by approximately 3 percentage points a year in Argentina and Brazil and by 1.5 to 2 percentage points per year in Mexico, Chile and Peru. From an Indian context, Elhance and Lakshamanan (1988) made use of both physical and social infrastructures to show that the mitigations in production costs in manufacturing occur because of investing in infrastructure. Datt and Ravallion (1988) concluded that Indian states which are possessed with better infrastructure and human resources, usually have observed higher growth rates and more rapid poverty reduction. Sahoo and Saxena (1999) estimated that infrastructure sub sectors like transport, electricity, gas, water supply and communication facilities have a significant positive effect on economic growth with increasing returns to scale.

Though there have been studies which have analyzed the different aspects of the role of infrastructure in terms of achieving economic growth; however, there is still insufficiency of

research works when it comes to particularly analyze the Public Infrastructure Investment and economic growth relationship for India, specifically from a state level point of view. Hence, it becomes vital that a state level study of India is carried out in order to examine this relationship between Public infrastructure investment and economic growth for the Indian states.

1.2.2 Issue of Infrastructure Financing

For several developing economies around the globe including India, the current as well as future infrastructure requirements are increasing and this is creating trouble for governments as they are unable to finance these rising needs, given the fiscal constraints prevalent in those particular nations. This leads us to the question that whether private sector financing can play a greater role or not in funding infrastructure.

Historically, the public sector used to assert that they only possess the capabilities of providing access of basic infrastructure services to the poor and needy ones. However, these claims have been discarded because of the continuous letdown by public sector. On a similar note, Clarke and Wallsten (2002) highlighted the insufficiency of public provision of infrastructure services in fulfilling the increasing demand for many nations around the world. Simultaneously, many projects which had the involvement of private sector displayed substantial superior quantity, efficiency gains and giving benefits for the poor (Mukhopadhyay, 2004).

The importance of private participation in financing of infrastructure was emphasized by Shirley (2002) who concluded that private participation in water and sanitation leads to overall domestic welfare benefits of United States Dollar (USD) 1.4 billion in Buenos Aires and USD 23 million in Guinea. Kikeri and Nellis (2002) through their study on various economies said that fiscal gain was yet another improvement brought by privatization to the

government. Under Private financing, the option of PPPs is also gaining importance. Over the past decade, the use of PPPs has grown almost five times (PWC, 2010), with the rising popularity of PPPs in many developed, developing and emerging nations (English, 2005; Guasch, Laffont, & Straub, 2008; Yang, Hou, & Wang, 2013).

However, there still exists a lack of research in terms of examining the different modes (Public, Private and PPP) of investing/financing major sectors of Infrastructure, and then suggesting the best mode of financing. Hence, it becomes important that a study needs to be carried out which determines the preferred mode of infrastructure financing for India's major Infrastructure sectors. The discussion above clearly states that the rise of PPPs as an option of Infrastructure financing is quite evident, and that is why it becomes important to investigate the major determinants of attracting PPPs in India.

1.2.3 Interlinkages between Debt, Economic growth and Fiscal Sustainability

Moving ahead, it is well known that any government which is incapable of generating the required amounts of funds for financing Infrastructure has to resort to taking debt. During this process, the issue of high debt burdens and the related hazardous effects on development aspects cannot be ignored. This is of deep worry to the researchers and policymakers around the world (Scharlarek & Ramon-Ballester, 2005; Cecherita & Rother, 2010).

Pattillo, Poirson and Ricci (2002) considered a large panel dataset of 93 developing countries over the time period of 1969-1998 and estimated that the effect of external debt on per-capita Gross Domestic Product (GDP) growth is negative for net present value of debt levels above 35-40 per cent of GDP. Makin (2005) did one study for Indonesia and estimated that debt levels of above 38 per cent of GDP will be damaging to Indonesia's economic growth. The relationship between public debt and economic growth could also be based on the viewpoint that it is the low economic growth that forces high levels of debt

(Reinhart, Reinhart, & Rogoff, 2012). In other words, the observed correlation between debt and growth could possibly be due to a third factor. Therefore, we can say that particular focus needs to be given in terms of investigating the dynamic relationship between India's debt levels and economic growth.

From the available literature on this topic, it can be observed that there exists an optimal value of debt above which public debt becomes negatively correlated with economic growth. Studies from Smyth and Hsing (1995) & Cohen (1997) confirmed the same view and concluded that the relationship between debt and economic growth is non-linear and that this relationship is distinguished by the fact that there is a particular threshold value above which the debt starts having a negative impact on economic growth. Smyth and Hsing (1995) concluded that the optimal debt ratio that maximizes US growth is about 40 per cent of GDP. This optimal debt/GDP ratio can be viewed as an indicator that maximizes social welfare and economic growth without cutting down on the private investments or increasing sovereign credit risks or raising overall development costs (Blanchard, 1983; Stein, 2004; Alfaro & Kanczuk, 2006; Rochet, 2006). Basically, an optimal debt/GDP can be seen as one that is in sync with fiscal sustainability of an economy. Hence, under the debt growth dynamics for India, there are not many studies which have measured the fiscal sustainability of the Indian states by estimating a threshold value of debt/GDP ratio above which the fiscal stance becomes unsustainable for a state economy and eventually India.

1.3 OBJECTIVES OF THE RESEARCH

Based on the above review of literature, the following research objectives were formulated:

- To understand and analyze the vital relationship between Public infrastructure investment and economic growth for Indian states.
- To understand the concept of Infrastructure financing issue and in particular test that which mode of infrastructure financing among Public financing, Private financing or the PPP is most preferred for India's major Infrastructure sectors. Further, to examine and estimate the important determinants of attracting any PPP in India.
- To firstly analyze the critical relationship between debt and economic growth for India and secondly, based on the nature of relationship what is the optimal value of debt till every Indian state can go and at the same time their fiscal sustainability is maintained.

1.4 RESEARCH APPROACH: AN OVERVIEW

To achieve the above mentioned objectives, appropriate research techniques will be used which have been discussed below in brief.

i. For first research objective, the relationship between Public infrastructure investment and economic growth will be examined by using relevant time series econometric techniques like Im, Pesaran and Shin (IPS) (2003) unit root test for panel data and panel cointegration tests developed by Westerlund (2007) and Persyn and Westerlund (2008). The aim is to analyze a panel data set for twenty eight Indian states, excluding Telangana, as it was formed recently and there is no data available for it. For all the states, Public Investment data will be taken for the period 1999–2000 to 2014-15 for six major sub sectors falling under overall Infrastructure sector: Transport, Education,

Sports, Art and Culture, Medical and Public Health, Water supply and sanitation, Irrigation, Energy/Power.

ii. For second research objective, two research problems will be addressed. Firstly, based on the data availability, the historical trends of each mode of infrastructure financing (Public, Private, and PPP) will be examined over the last two decades for the major sectors falling under the Infrastructure sector i.e Transport, Telecom, Energy, Water and Sewerage. The considered time period of analysis is 1995 to 2014. Further for these sectors individually as well as the aggregate scenario, Structural Vector Autoregression model (SVAR) model will be employed in order to estimate the preferred mode of financing by analyzing the impact of Public, Private and PPP mode of investment on India's economic growth for the considered time period. For the second issue, focus will be put on the PPP mode of infrastructure financing and estimate the important determinants of attracting any PPP in India. Relevant research hypotheses will be framed and tested for estimation purpose by using techniques like Poisson regression, Negative binomial regression and Tobit regression. For this analysis, the time frame from 1990 to 2015 will be considered.

iii. For third and final research objective, again two major research issues will be addressed. Firstly, the dynamic relationship between debt and economic growth for India will be investigated by empirically testing for the indirect effect of public debt on economic growth via investment aspect. For this purpose multiple regression analysis will be used and the considered time period is 1991-92 to 2014-15. Secondly, focus is on the fiscal sustainability issue and calculating a fiscal sustainability index for the twenty eight Indian states excluding Telangana, signifying each state's fiscal stance. The time period of analysis is from 2002-03 to 2013-14. Further, Pareto principle and decision tree

algorithm will be used, in order to calculate an optimal value of debt/GDP ratio above which we will conclude that an Indian state's economy becomes fiscally unsustainable.

1.5 SCHEME OF CHAPTERIZATION

The thesis comprises of six chapters. Chapter 1 provides an Introduction to the thesis and discusses in brief the research objectives based on literature review. Next is the Chapter 2 which gives an overview of India's Infrastructure sector. It includes all the relevant issues like classification of Infrastructure sector, composition of overall Infrastructure sector of India, detailed profiles of the important sub-sectors constituting Infrastructure sector, the risks and challenges faced by this sector and finally the growth prospects of India's Infrastructure sector. Chapter 3 gives a detailed review of literature on Infrastructure sector and related issues based on which the research gaps are identified. Chapter 4 describes the research methodology for carrying out the empirical work of this thesis. It covers research process, research framework formulated under each of the research objectives and an overview of the research techniques chosen for carrying out the empirical work on the framed research objectives. Chapter 5 presents and discusses the empirical findings of this thesis. This chapter is segregated in three broad parts. The first part presents all the empirical results and findings of IPS (2003) test for stationarity, Westerlund-based panel cointegration tests and the short run causality test results, used for investigating the relationship between Public Infrastructure Investment and economic growth for a panel data set of twenty eight Indian states. The second part covers the results of the empirical analysis where firstly the historical trends of each mode of infrastructure financing (Public, Private and PPP) for the major sectors falling under the Infrastructure sector i.e Roads, Seaports, Telecom and Energy have been examined. The results of the empirical analysis pertaining to the impact of Public, Private and PPP mode of infrastructure financing on economic growth is also discussed in

the second part. Secondly, the results of eight research hypotheses framed for examining and estimating the significant determinants of attracting any PPP in India are presented in the second part. In third part, the relationship between debt and economic growth for India has been examined and the results of this analysis are presented. Further, the calculations of fiscal sustainability indicator for Indian states along with estimation of an optimal value of debt till which India's fiscal sustainability is maintained are discussed and presented in this third part of Chapter 5. A summary of the key findings with respect to the empirical results obtained in the previous chapter is discussed in Chapter 6. This chapter also gives conclusions and Recommendations of the thesis, the limitations of the research, specific contributions of the thesis and suggests future scope of work.

CHAPTER 2

INDIA'S INFRASTRUCTURE SECTOR: AN OVERVIEW

2.1 INTRODUCTION

The whole world has seen the rise of Indian economy as one of the fastest growing economies and a major global force to be reckoned with. Certain sectors like manufacturing and services have enhanced India's economic growth process which has led to a wave of positive sentiments, both inside the nation as well as abroad. With the boost in investment as well as the support of strong macroeconomic essentials, the future prospects of India's economy are positive and clearly upbeat. Going by what economic experts and policymakers have to say, India can tap its full potential as a major economic power, if it is to focus on one fundamental exercise i.e improve its infrastructural facilities which are currently not adequate enough to suffice for the ever increasing demands of the economy. Failure to improve the infrastructure levels will surely constrain India's growth momentum.

For any nation, development of Infrastructure is a reflection of how well the economy is performing. Infrastructure has a direct and positive correlation with the economic growth and development of the nation. Being a fast growing economy, India has always understood the importance of infrastructure sector and that is why this sector has been of paramount importance to the government. Gulati (2011) understood the importance of infrastructure and pointed out that the contribution of infrastructure sector to India's Gross Domestic Product (GDP) was approximately around 8 per cent in 2012 and it is expected to rise to 10 per cent by 2017 in order to sustain the growth targets. Indian infrastructure sector is positioned well in terms of taking the lead role and therefore presents numerous investment opportunities for foreign investors across the globe.

Therefore, it becomes all the more important to present an overview of India's Infrastructure sector and understand in detail about its classification and composition. Also the profiles, trends and growth prospects of all the different sub-sectors of India's Infrastructure sector

need to looked at. With these objectives in mind, this chapter has been organized in the following manner. Section 2.2 provides an insight into the different ways in which infrastructure has been classified in the literature. Section 2.3 elaborates on the composition of Infrastructure sector followed by Section 2.4 that gives a brief overview of the profiles of the major sub-sectors of Infrastructure. Section 2.5 discusses the recent growth shown by India's infrastructure sector while Section 2.6 highlights the risks and challenges faced by the sector. Finally, the growth prospects are covered in Section 2.7 and in the end the conclusions of the chapter are presented in Section 2.8.

2.2 CLASSIFICATION OF INFRASTRUCTURE

This section discusses about the different ways in which infrastructure has been categorized in the literature by various authors.

- **Personal, institutional and material infrastructures:** Starting off, this particular classification was given by Jochimsen (1966) where he made distinction between material, personal and institutional infrastructures. *Personal infrastructure* refers to "the number and qualities of people in the market economy characterized by the division of labour with reference to their abilities to contribute to increase the level and degree of integration of economic activities" (Jochimsen, 1966, p. 133). A good example to refer to personal infrastructure is given by *human capital* which is defined by Organization for Economic Co-operation and Development (OECD) as the knowledge, proficiency, skills and characteristics embodied in individuals that aid the creation of personal, social and economic well-being" (Healy & Cote, 2001, p. 18).

  Institutional infrastructure: Institutional infrastructure determines the framework within which economic agents may formulate their own economic plans and execute them in co-operation with others" (Jochimsen, 1966, p.117). The institutional infrastructure can

be regarded as the real execution of the norms in the "institutional basis" of the market economy (Buhr, 2003).

Material infrastructure: Provided an economic arrangement, material infrastructure is basically categorized by two prime attributes: i) fulfillment of economic and social needs ii) mass production. The first attribute highlights the completion of essential needs of human life. Based on this inference, material infrastructures can also be rewritten in other way as those goods and services which are able to quench the needs of economic agents from physical and social requirements of human beings. For example, the need for drinking water is catered to by the subsequent supply of water accumulated, let's suppose, in a reservoir which, acting as a capital good, is a specific type of material infrastructure.

- **Economic and Social infrastructures:** Hansen (1965) in his research made a distinction of dividing infrastructure into two major categories - *economic* and *social.* According to Hansen (1965), this point of view named infrastructure as local public Overhead Capital (OC) and divided it into two major components, "Social Overhead Capital (SOC) and "Economic Overhead Capital (EOC)". All those items or sectors which mainly support the productive activities and bring about a movement of economic goods in a direct manner are classified under the category of EOC. SOC sectors or items may also increase productivity, but they do so in an indirect manner compared to EOC and hence come under the category of SOC. Thus, *Economic infrastructures* directly advocate for productive economic activities and consist of roads, highways, airports, naval transport, gas networks, sewer networks, electricity networks, networks for water distribution, aqueducts, irrigation plant and structures etc. On the other side *Social infrastructures* are those sectors which are basically established to aid in social comfort and security and to increase the economic productivity. SOC consists of schools, hospitals, sport structures,

green fields and areas, structures for public safety, plants of waste disposal etc (Hansen, 1965).

- **Core and not-core infrastructures:** This classification includes the *core* infrastructure which contains roads and highways, airports, public transport, electric and gas networks, network for water distribution and sewer networks (Aschauer 1989). The *not-core* infrastructures are referred to as residual components (Aschauer (1989). A similar kind of categorization is employed in Mastromarco and Woitek (2006) where they divide the public capital into *core* and *not core* components. On similar lines, Sturm, Jacobs, and Groote (1995) in their research work distinguished infrastructure into *Basic and Complementary infrastructure.* Basic infrastructure consists of main railways, roads, canals, harbours and docks, the electromagnetic telegraph, drainage, dikes, and land reclamation as compared to *complementary* infrastructure category which refers to light railways, tramways, gas, electricity, water supply, and local telephone networks.

- **Network and Nucleus infrastructures**: Biehl (1991) classified infrastructure into *network infrastructures* and *nucleus infrastructures*. Network infrastructure, as the name suggests, refers to roads, railroads, water highways, networks of communication, systems for energy and water provisioning. These network infrastructures are those sectors whose use corresponds with the territorial unity in which the infrastructure is present and there is a sense of 'mobility'. On the other hand, the nucleus infrastructures include schools, hospitals and museums, which are relatively described by a certain degree of immobility, indivisibility, non-interchangeability and similar kind of features.

2.2.1 Infrastructure Classification: The Indian Prospective

Looking at the Indian prospective, the concept of Infrastructure was comprehensively discoursed by the Rangarajan Commission while they were analyzing the statistical system of India. The Rangarajan Commission in their 2001 report pointed out to the importance of infrastructure saying that Infrastructure holds the key in determining the accessibility of inputs which are central to a plethora of productive activities. The non-availability of these inputs determined by infrastructure can act as a stern restraint on the productive ability of the economy. The commission in this report also said that Infrastructure is a significant input for both industrial as well as economic development of a nation.

Infrastructure, according to Rangarajan Commission, typically possesses long-lived engineering structures. The commission designated six significant characteristics for a sector to be identified as an infrastructure sub-sectors, viz. (a) natural monopoly; (b) non-tradability of output; (c) bestowing externalities on society; (d) high-sunk costs or asset specificity; (e) non-rivalness (up to congestion limits) in consumption; and, (f) possibility of price exclusion. Based on these six features, the commission in their 2001 report suggested that the following sub-sectors were eligible to be considered under Infrastructure sub-sectors heading: *Railway tracks, signaling system, stations; Roads, bridges; Runaways and other airport facilities; Transmission and distribution of electricity; Telephone lines, telecommunications (telecom) network; Pipelines for water, crude oil, slurry, etc.; Waterways, port facilities; Canal networks for irrigation; Sanitation or sewerage.* However, after considering features like high-sunk costs or asset specificity, non-rivalness in consumption, and possibility of price exclusion only, the commission recommended that following subsectors may be included so as to extend the above list and at the same time align with the existing idea of infrastructure: *Rolling stock on railways; Vehicles; Aircrafts;*

Power generating plants; Production of crude oil, purification of water; Ships and other vessels.

2.3 COMPOSITION OF INFRASTRUCTURE SECTOR

The composition of Infrastructure sector has always remained an intriguing issue with everyone who has thought about the question of which all sub sectors constitute this important and broad Infrastructure sector. Recognizing the complexities of this issue pertaining to Infrastructure sector's composition, different commissions/committees have been formed which have defined infrastructure as per their respective recommendations. Below mentioned are the details corresponding to all these commissions/committees:

- **Cabinet Committee on Infrastructure (CCI)**: The CCI committee led by Prime Minister was constituted on July 6, 2009. It replaced the Committee on Infrastructure which was established on 31st August, 2004 under the Chairmanship of Prime Minister. The main job of CCI was to review and approve policies and supervise the making and implementation of various programmes and projects across infrastructure sectors. The secretariat for Infrastructure in the Planning Commission (now removed and replaced by 'Niti Aaayog' by the Narendra Modi led Government of India) felt the utmost necessity to define infrastructure and its coverage from the prospect of policy formulation, focusing on sectoral targets and ensuring consistency and comparability in the data collection process done by varied agencies. To cater this need, the CCI reviewed the various definitions of infrastructure as used by different organizations like Rangarajan Commission, Reserve Bank of India (RBI), Income Tax Department, Dr. Rakesh Mohan Committee Report (1996), Insurance Regulatory and Development Authority (IRDA), Economic Survey, World Bank and finally recognized the following list of sectors to be mentioned under infrastructure:

i. Electricity (including generation, transmission and distribution) and R&M (Renovation and Modernization) of Power stations;
ii. Non-conventional energy (including wind energy and solar energy);
iii. Water supply and sanitation (including solid waste management, drainage and sewerage) and street lighting
iv. Telecom
v. Road and bridges
vi. Ports
vii. Inland waterways
viii. Airports
ix. Railways (including rolling stock and mass transit system)
x. Irrigation (including watershed development)
xi. Storage
xii. Oil and gas pipeline networks

- **Ministry of Finance, Department of Economic Affairs:** Conforming to the advocacy of Prime Minister's office, The Ministry of Finance, Department of Economic Affairs wrote a concept paper in order to determine and finalize on the uniformity of the definition of infrastructure, thereby guiding on the selection of sub sectors to be categorized under infrastructure. This concept paper directed 'Infrastructure' as an indispensable input for the economy to function properly. The framework created by Rangarajan Commission was used and ultimately the list given earlier by Rangarajan Commission was further expanded by including sectors that deserved their involvement on grounds of their contribution in achieving economic development or their capability to donate towards human capital. Finally, the opinion of concerned Ministries and Departments, relevant regulatory bodies like RBI, Securities and Exchange Board of India (SEBI), IRDA, Home-Pension Fund

Regulatory and Development Authority (PFRDA) and other stakeholders like Confederation of Indian Industry (CII) and Federation of Indian Chamber of Commerce and Industry (FICCI) were also taken before finalizing the list of sub sectors. The identified infrastructure sub-sectors were classified broadly under five major categories: Transport; Energy; Water and Sanitation; Communication; Social and Commercial Infrastructure.

It was further suggested that in future any particular sub-sector which may be recognized as an infrastructure sub-sector will be categorized under one of these five categories. For example, watershed will be categorized under water and sanitation classification, agro industries will be categorized under social/commercial infrastructure classification, only if included in future.

The list of infrastructure sub sectors, thus recommended is given in the Table 2.1.

Table 2.1: Classification of Infrastructure sub-sectors as per Ministry of Finance, Department of Economic Affairs

Category	Infrastructure sub-sectors
Transport	Roads and bridges; Ports; Inland waterways; Airports; Railway Track, tunnels. viaducts, bridges; Urban Public Transport(except rolling stock in case of urban road transport)
Energy	Electricity – Generation, Transmission and Distribution; Oil pipelines; Oil/Gas/Liquefied Natural Gas(LNG) storage facility; Gas pipelines
Water & Sanitation	Solid Waste Management; Water supply pipelines; Water treatment plants; Sewage collection, treatment and disposal system; Irrigation (dams, channels, embankments etc.); Storm Water Drainage System
Communication	Telecom(Fixed network); Telecom towers
Social and Commercial Infrastructure	Education Institutions(capital stock); Hospitals(capital stock); Three-star or higher category classified hotels located outside cities with population of more than 1 million; Common infrastructure for industrial parks, Special Economic Zone (SEZ), tourism facilities and agriculture markets; Fertilizer(Capital investment); Post harvest storage infrastructure for agriculture and horticultural produce including cold storage; Terminal markets; Soil-testing laboratories; Cold chain

- **Standing Committee on Infrastructure Statistics (SCINS):** SCINS was formed by Central Statistics Office (CSO) under the Chairmanship of DG (Director General), CSO and representatives from the Secretariat of the Cabinet Committee on Infrastructure of the Planning Commission (CCoI), Ministry of Finance, RBI, Department of Industrial Policy and Promotion (DIPP) and other subject matter Ministries. The main points for this Standing Committee to focus upon were:

  i. To standardize definitions, concepts and methodology for collection and analysis of Infrastructure statistics
  ii. To describe the coverage and scope of infrastructure statistics and recommend transformations regularly
  iii. To propose enhancement in Infrastructure statistics particularly in line with the international practices, suggestions given by other expert committees and at the same time to meet the domestic requirements of policy makers.

  The Standing Committee finalized the coverage of sectors and sub sectors classified under infrastructure as given in the Table 2.2.

- **Dr. Rakesh Mohan Committee Report (1996) and the CSO:** Dr. Rakesh Mohan Committee in "The India Infrastructure Report" took Electricity, gas, water supply, telecom, roads, industrial parks, railways, ports, airports, urban infrastructure, and storage as sub sectors of infrastructure. Excluding the industrial parks and urban infrastructure, all the other sub-sectors were also taken by CSO in their composition of overall infrastructure sector.

Table 2.2: Classification of Infrastructure sub-sectors as per SCINS

Infrastructure Sector	Sub sector	Coverage
1. Transport	Road transport	Roads and bridges, Tunnels, Motor vehicles
	Rail transport	Railways,Signalling,communications systems, Rail yards,Stations,Rolling stock
	Inland water transport	Inland waterways, Inland water vessels
	Sea and coastal transport	Seaports, Ships and other vessels
	Air transport	Airports, Air crafts
2. Energy/ Power	Electricity (Thermal, Hydro, Nuclear)	Generation plants, wind mills, transmission and distribution lines, electric substations, Coal Reserves, Coal fields/mines, Coal washeries
	Petroleum and Natural gas	Oil and gas pipeline networks Distribution terminals, Gas fields/wells, Refineries
3. Drinking Water Supply, Sanitation	Drinking water supply	Water supply pipelines, filtration and treatment plants
	Sanitation	Sewage treatment plants, Drainage pipelines, On site sanitation facilities, Landfills, Incinerators
4. Irrigation	Irrigation	Major and minor irrigation structures, Command area, Irrigation canals, Reservoirs, Water shed development
5. Communication	Telecom	Telephone network (landlines, mobile), Internet servers, Communication satellites, Cable television network
	Postal communication	Postal network, Courier mail service
6. Storage	Storage	Food grain Storages, Cold Storages, Warehouses

- **Dr. C. Rangarajan Commission's Notion of Infrastructure (2001):** The National Statistical Commission headed by Dr. C. Rangarajan tried to classify infrastructure based on certain characteristics. The Rangarajan Commission specified six characteristics of infrastructure sectors, (a) Natural monopoly, (b) High-sunk costs, (c) Non-tradability of output (d) Non-rivalness (up to congestion limits) in consumption, (e) Possibility of price exclusion, and (f) Bestowing externalities on society. Based on these characteristics

(excluding b, d and e) the Commission proposed to include the following things in infrastructure at the first stage:

i. Railway tracks, signalling system, stations
ii. Roads, bridges, runways and other airport facilities
iii. T&D of electricity
iv. Telephone lines, Telecom network
v. Pipelines for water, crude oil, slurry, waterways, port facilities
vi. Canal networks for irrigation, sanitation or sewerage.

Further, the Commission suggested that if the features (b), (d) and (e) are also included, then the above list of infrastructure sectors can be extended to take into account the following in the second stage:

vii. Rolling stock on railways
viii. Vehicles, aircrafts
ix. Power generating plants
x. Production of crude oil, purification of water
xi. Ships and other vessels.

However, the Rangarajan Commission also suggested that as per the characteristics recommended by them for identifying infrastructure, the range of infrastructure activities should ultimately be decided by the Ministry of Statistics and Programme Implementation (MOSPI).

- **RBI circular on definition of Infrastructure**: According to RBI, a credit facility is taken as "infrastructure lending" to a borrower company involved in developing, operating and maintaining any infrastructure facility, which is a project in any of the below mentioned sectors, or any infrastructure facility of the same nature :

i. A road, including toll road, a bridge or a rail system;
ii. A highway project and other activities being a significant part of the highway project;
iii. A port, airport, inland waterway or inland port;
iv. A water supply project, irrigation project, water treatment system, sanitation and sewerage system or solid waste management system;
v. Telecom services whether basic or cellular, including radio paging, domestic satellite service (i.e. a satellite owned and operated by an Indian company for imparting telecom service), network of trunking, broadband network and internet services;
vi. An industrial park or special economic zone;
vii. Generation as well as distribution of power;
viii. Transmission or distribution of power by creating a network of new transmission or distribution lines;
ix. Construction relating to projects involving agro-processing and supply of inputs to agriculture;
x. Construction for protection and storage of processed agro-products, perishable goods such as fruits, vegetables and flowers including testing facilities for quality;
xi. Establishment of educational institutions and hospitals;
xii. Any other infrastructure facility of similar nature.

For raising external commercial borrowings funds, the RBI has defined infrastructure to include (i) power, (ii) telecom, (iii) railways, (iv) roads including bridges, (v) sea port and airport, (vi) industrial parks and (vii) urban infrastructure (water supply, sanitation and sewage projects) via their circular dated 2nd July, 2007.

- **IRDA:** The IRDA, Registration of Indian Insurance Companies in its Second Amendment Regulations, 2008 defined infrastructure to include the following sectors:

i. A road, including toll road, a bridges or a rail system.

ii. A highway projects including other activities which are being essential to the highway project.

iii. A port, airport, inland waterways or inland port.

iv. A water supply project, irrigation project, water treatment system, sanitation and sewerage system or solid waste management system.

v. Telecom services, whether basic or cellular, including radio paging, domestic satellite services (i.e. a satellite owned and operated by an Indian company for providing telecom services), network of trunking, broadband network and internet services.

vi. An industrial park or special economic zone.

vii. Generation and distribution of power.

viii. Transmission or distribution of power by creating a network of new transmission or distribution lines.

ix. Construction relating to projects involving agro-processing and donation of inputs to agriculture.

x. Construction for safeguarding and storage of processed agro-products, perishable goods such as fruits, vegetables and flowers including testing facilities for quality.

xi. Establishment of educational institutions and hospitals.

xii. Any other public facility similar to this as may be notified by the Authority in this behalf in the Official Gazette.

- **Income Tax Department**: For an infrastructure company, Section 80-IA of the Income Tax allows withdrawal of 100 per cent profit from its income during the initial 5 years of running and then 30 per cent withdrawal of profit from income during the next 5 years. For this reason, infrastructure covers electricity, water supply, sewerage, telecom, roads & bridges, ports, airports, railways, irrigation, storage (at ports) and industrial parks/SEZ.

- **Economic Survey**: The Economic Survey takes power, urban services, telecom, posts, roads, ports, civil aviation, and railways under the term infrastructure.

- **Decision of the Empowered Sub-Committee of the Committee on Infrastructure**: The Empowered Sub-Committee of the Committee on Infrastructure in its meetings held on 11th January, 2008 and 2nd April 2008, respectively under the chairmanship of Deputy Chairman, Planning Commission had a discourse and finally a consensus was made to include the following in the broad definition of infrastructure:

  i. Electricity (including generation, transmission and distribution) and R&M of power stations,
  ii. Non-Conventional Energy (including wind energy and solar energy),
  iii. Water supply and sanitation (including solid waste management, drainage and sewerage) and street lighting,
  iv. Telecom,
  v. Roads & bridges,
  vi. Ports,
  vii. Inland waterways,
  viii. Airports,
  ix. Railways (including rolling stock and mass transit system),
  x. Irrigation (including watershed development),
  xi. Storage,
  xii. Oil and gas pipeline networks.

2.4 PROFILE OF SUB-SECTORS OF INFRASTRUCTURE

The section below gives a brief profile about the major sub-sectors of Infrastructure.

2.4.1 Roads

In FY16, India had the second largest road network in the world, with a total length of approximately 5.23 million kilometers. This road network is used to transport over 64.5 per cent of all goods across the country and 85.9 per cent of total passenger traffic. The road and bridges infrastructure value was 11 billion USD (United States Dollar) in 2014 and it is expected to increase up to 19.2 billion USD in FY 17 (Financial Year 2017). The infrastructure investment in this sector is expected to rise to 11.61 billion USD in FY 15-16 (Financial year 2015 to Financial year 2016). The National highways are expected to touch the length of 100,000 kilometres by the end of the 2017 from 97,135 kilometres in FY 15. Along with these features, the road sector has many advantages which make it one of the most significant sub sectors of Indian Infrastructure. Some of the advantages of Roads sector and reasons behind them are given below:

- **Robust Demand**: There is enough robust demand for road sector. Higher connectivity between different cities, towns and villages has resulted in a sharp rise in road traffic over the recent years. Also, the increase in automobiles and freight movement demands a strong road network.
- **Attractive Prospects**: The Roads and bridge infrastructure industry is approximated to be of worth 19.2 billion USD by FY17. After the Lok Sabha elections of 2014, the Central government led by Narendra Modi has fast tracked around 24 roads and highways projects.
- **Rising Investments:** With the Government of India setting a target to develop a total of 66,117 kilometers of roads, the Infrastructure expenditure in road infrastructure sector is

estimated at 1 trillion USD over FY13–17. There is also an increasing participation of private sector through the Public-Private Partnerships (PPPs).

- **Policy Support**: Road infrastructure has always received policy support from the government. This sector has always been getting strong budgetary support since the beginning. In terms of other policy supports, all the financial institutions have got government's approval to raise money for this sector through tax free bonds. Also, 100 per cent Foreign Direct Investment (FDI) is permissible under automatic route based on applicable laws and regulations.

The Road infrastructure sector can be further divided into three categories:

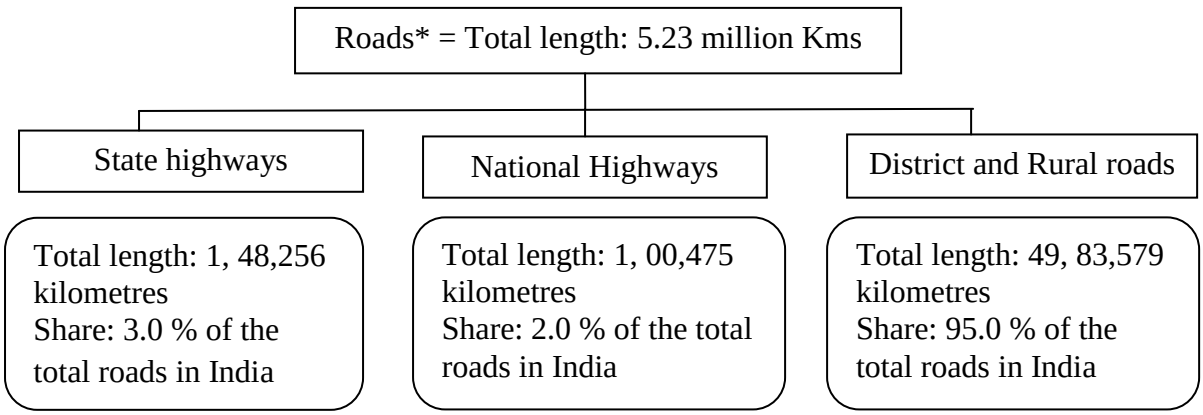


Figure 2.1: Classification of Road Infrastructure Sector

Note: *Data as of FY16

Source: Road Sector Report – October 2016, retrieved from http://www.ibef.org/industry/roads-india.aspx

2.4.1.1 Prominent Trends in Road Sector

As discussed above, the current government is focused to bring a strong momentum in the expansion of roadways. This is evident from the fact that projects worth 32.69 billion USD have been granted through PPP mode as on March 2015. Under the 12th five year plan (FY 2012-2017), the government aims to construct 20 kilometres of national highways per day, implying construction of 7,300 kilometres per year. The size of national highway is also approximated to grow from 97,135 kilometres as on FY15 to 100,000 kilometres by end of

FY17. Programmes like 'Bharat Nirman', Jawaharlal Nehru National Urban Renewal Mission (JNNURM) have been designed in order to achieve nationwide rural connectivity. Also the value of total roads and bridges infrastructure is estimated to grow at a Compounded Annual Growth Rate (CAGR) of 13.6 per cent over FY 09-17 to reach at 19.2 billion USD.

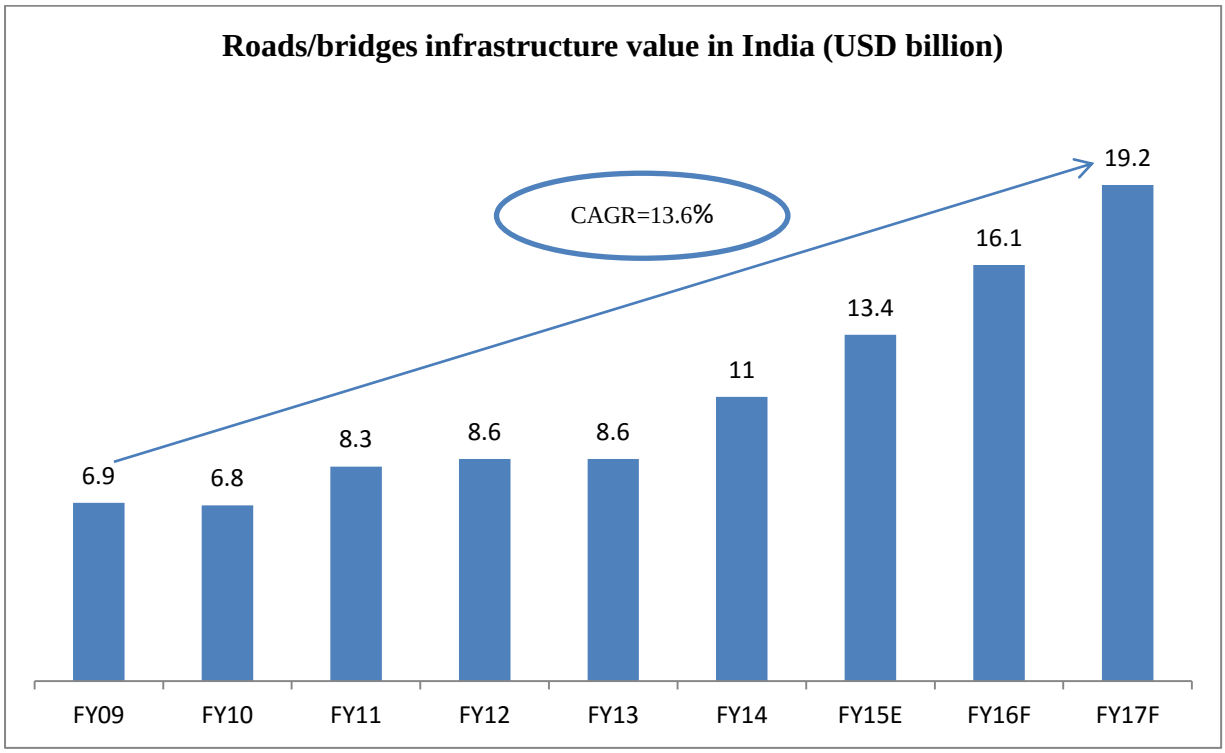


Figure 2.2: CAGR growth of Roads/bridges infrastructure value

Source: Road sector report – October 2016, retrieved from http://www.ibef.org/industry/roads-india.aspx
Note: E- Estimate, F –Forecast

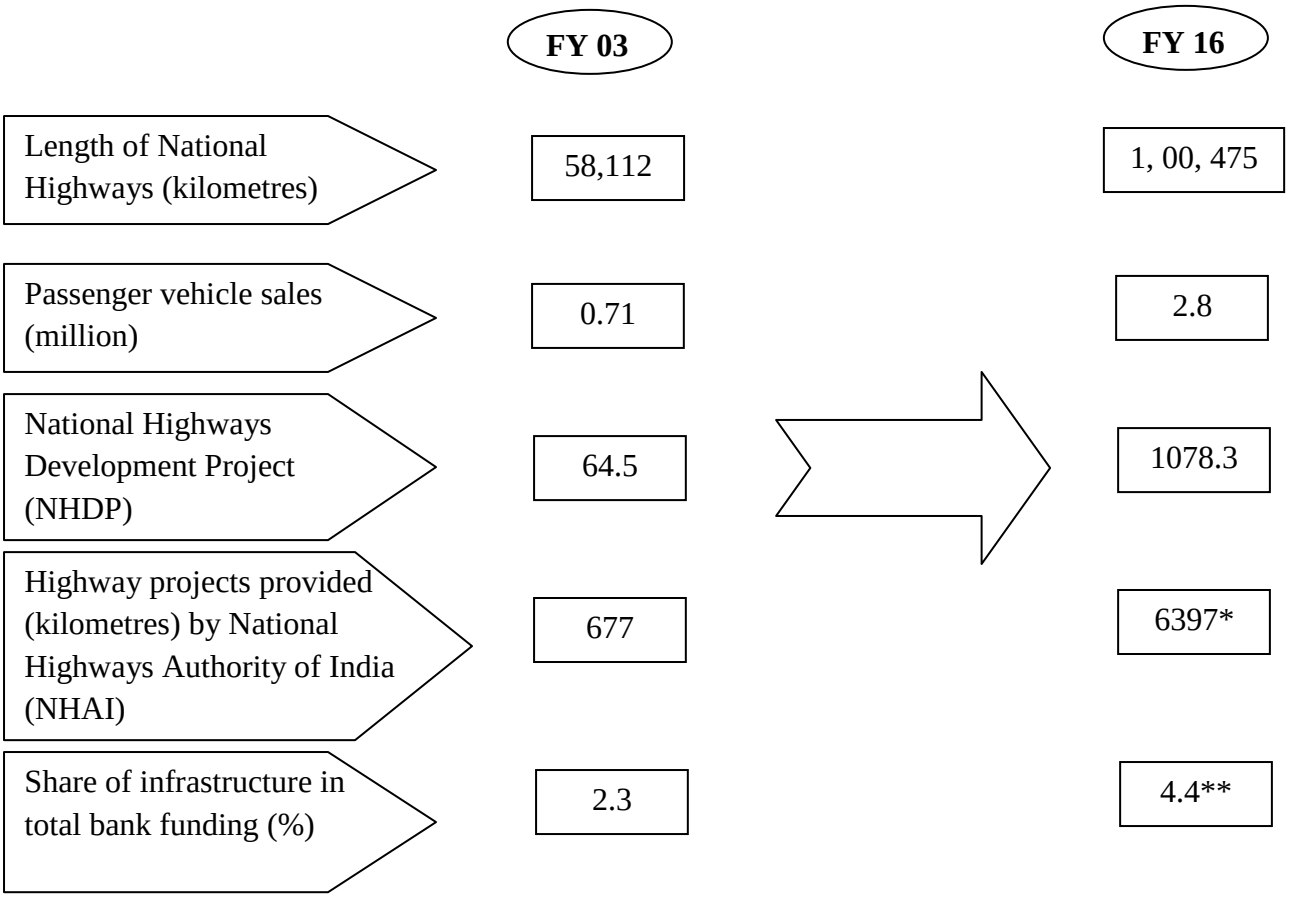


Figure 2.3: Growth of Road Infrastructure Sector

Source*:* Source: Road sector report – October 2016, retrieved from http://www.ibef.org/industry/roads-india.aspx
Notes: *: FY16 till December 2015, **: FY17 till May 2016

2.4.2 Railways

The Indian Railways (IR) is a departmental undertaking of the Government of India, which possesses and handles a majority of India's rail transport. It is managed by Ministry of Railways. The India railways network is third largest in the world, with a route network of approximately 64,600 kilometers spanning across 7,712 stations and carrying over 30 million passengers daily. As of FY15, Indian Railways operates more than 19000 trains on a daily basis with 2.4 lakh wagons, 63,870 coaches and 9,549 locomotives. From a

commercial point of view, 1101 million tonnes of freight was transported with the help of trains in FY15 and is estimated to rise to 1,186 million tonnes in FY16. The railways sector also has many advantages which make it one of the most important and essential sub sectors of Indian Infrastructure. Some of the advantages of Railways sector and reasons behind them are given below:

- **Increasing Demand**: Growing urbanization and increasing incomes (both urban and rural) are major driving factors of growth in terms of the passenger segment. The rising industrialization across the nation has been increasing freight traffic over the past decade or so.
- **Tempting Opportunities**: Freight traffic is expected to rise in a considerable manner on the back of growing investments and higher private sector participation. Also, the initiation of numerous metro rail projects across many cities augurs well for this sector.
- **Greater Investments:** The Government of India plans to invest heavily in order to upgrade the already existing railways infrastructure. Based on these lines, the private investment in Mass Rapid Transit System (MRTS) is estimated to rise from 13 per cent to 42 per cent during 2012-17.
- **Policy Support**: The government has expanded the role of PPPs and now their scope is beyond offering maintenance and other supporting roles. Also, 100 per cent FDI is permissible now after the approval of the Indian government.

The Indian Railways infrastructure sector can be further divided into two major segments:

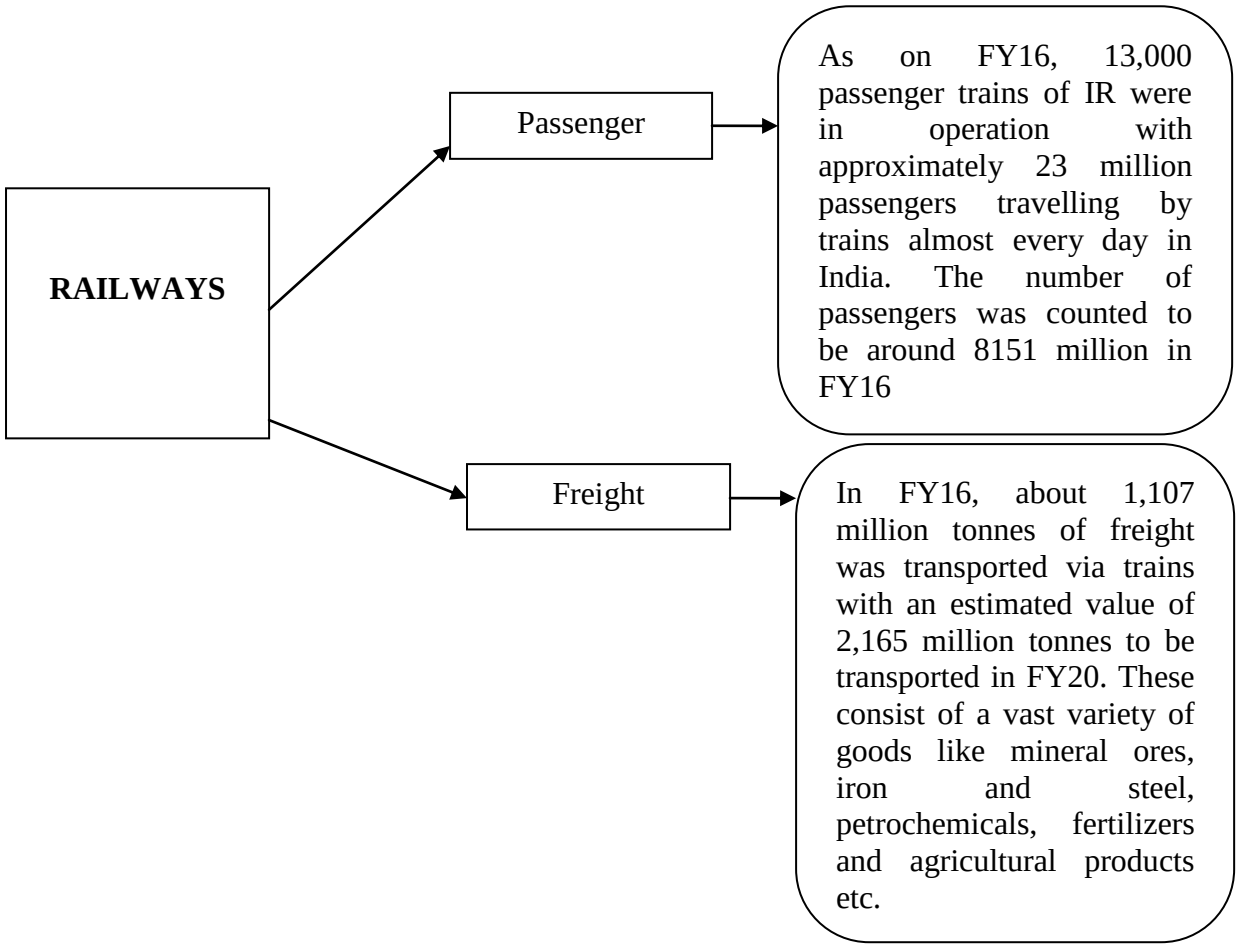


Figure 2.4: Classification of Indian Railways sector

Source: Railways sector report – November 2016, retrieved from http://www.ibef.org/industry/indian-railways.aspx

2.4.2.1 Prominent Trends in Railways Sector

The Indian railways sector is witnessing a fast increase in demand for urban mass transportation systems in the country. To fulfill this increasing demand, numerous metro rail projects have been either started or are in progress so as to improve connectivity within cities. Also in 2015, e- ticketing scheme has been introduced in order to offer 7,200 tickets per minute as compared to the current capacity of 2000. In terms of international investment, many subsidiaries of foreign companies are being set up to tackle the huge demand offered

by IR. Another notable trend is the increasing focus on introducing high speed trains projects.

With this view, IR has plans to build seven high-speed rail corridors with a futuristic view of providing rapid rail connectivity across the nation. Hence, a budget of 17 million USD has been provisioned for this High Speed project. The trains in this regard will be having the capacity to run at a speed of upto 350 kilometer per hour. Another focus is to look for cost effective options so as to increase the current running speed to 160–200 km per hour on existing routes such as Delhi–Chandigarh and Delhi–Agra.

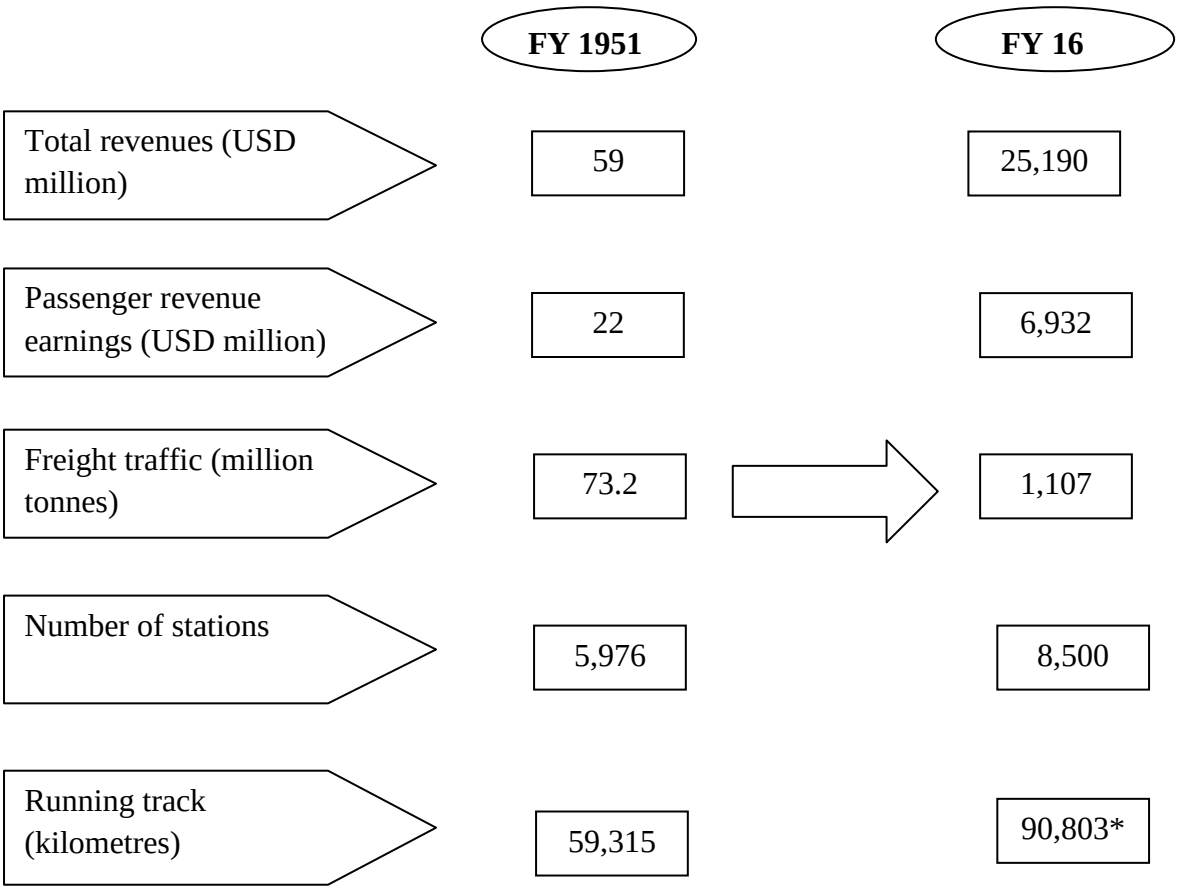


Figure 2.5: Growth of Railways Sector

Source: Railways sector report – November 2016, retrieved from http://www.ibef.org/industry/indian-railways.aspx
Note : * - Data for FY15

In terms of revenue growth also, Indian railways has seen a strong upward trend with revenues increasing at a CAGR of 6.4 per cent during FY 07-16 to reach at 25.2 billion USD in FY 16. The positive sentiment is expected to increase even further in the future with an estimation that revenues would expand at a CAGR of 9.07 per cent during FY 07-20E (Financial year 2007 to Financial year 2020 Expected) and touch a value of 44.5 million USD by 2020.

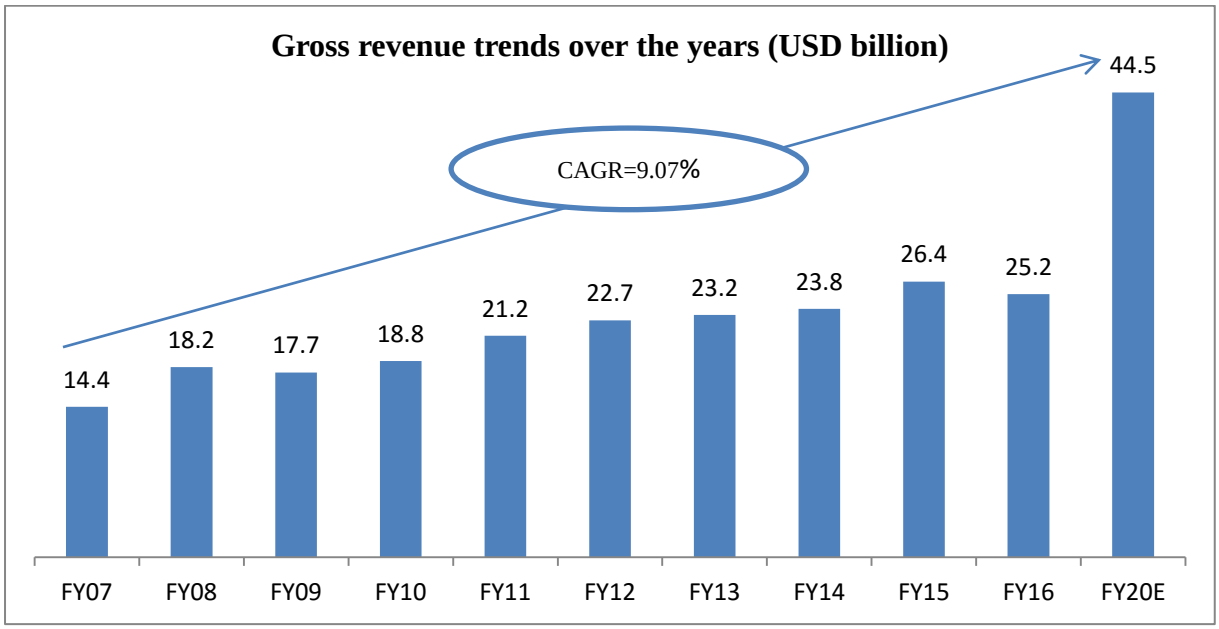


Figure 2.6: CAGR growth of gross revenue for Indian Railways

Source: Railways sector report – November 2016, retrieved from http://www.ibef.org/industry/indian-railways.aspx
Note: E –Estimates

2.4.3 Power

With production of 1,278.91 TWh (Terawatt-Hour) in 2015, India was the third largest producer and fourth largest consumer of electricity in the world. Also, it is ranked at fifth position in terms of installed capacity rankings around the world. The government has big expansion plans for the power sector. It has set targets of capacity addition of 88.5 Gigawatt (GW) under the 12th five year plan and around 100 GW under the 13th five year plan (2017-22). Renewable energy capacity additions to 30 GW are also set as one of the targets which

have to be achieved by 2017. In addition to this, the government plans to make 250 billion USD worth of investment in the power sector during the 12th five year plan.

The power sector has many advantages which make it one of the most significant sub sectors of Indian Infrastructure. Some of these advantages and reasons behind them are discussed below:

- **Growing Demand**: The rising industrialization is boosting demand for electricity in a significant way. The increasing population and per capita usage also adds impetus to the growing demand for electricity. With this backdrop, the power consumption is expected to rise from 1174.07 TWh in 2015 to 1894.7 TWh in 2022.
- **Striking Opportunities:** Ambitious projects and rising investments across the value chain make way for lot of attractive opportunities in the power sector. Also, the future scope of diversification into renewable sources of energy also pushes the growth avenues to a higher and a fairly attractive level.
- **Higher Investments:** The Power sector also has witnessed an upsurge in terms of FDI inflows over the past decade or so. Total FDI inflows in this sector rose to 10.48 billion USD during the time period April 2000 to March 2016 which itself accounted for 4 per cent of the overall FDI inflow in India. Also, there has been a sanctioning of investment for 7 new transmission systems that includes strengthening of national grid etc.
- **Policy Support**: The government has given permission for 100 per cent FDI under the automatic route in the power segment and renewable energy. Further, schemes such as Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY) and Integrated Power Development Scheme (IPDS) have already been put into practice for rural and urban areas respectively.

The Power sector can be further divided based on the sources of power with their respective shares in total installed capacity:

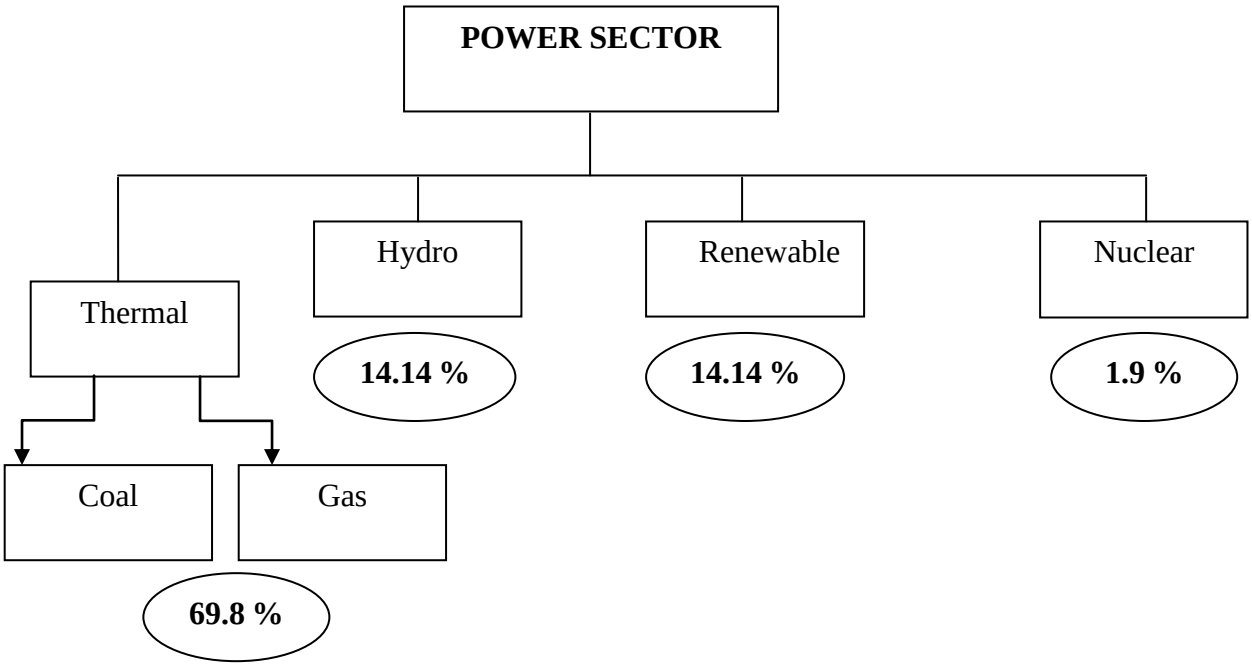


Figure 2.7: Classification of Power sector (based on sources of power)

Source: Power sector report – November 2016, retrieved from http://www.ibef.org/industry/power-sector-india.aspx

2.4.3.1 Noteworthy Trends in Power Sector

The Indian power sector has massive potential for hydropower with a large envelop of rivers and water bodies. The 12th five year plan also includes increasing the current hydro power generating capacity of India from 41.63 GW to nearly 70 GW by the end of FY17 as one of major objectives. Coming to the renewable sources of energy, projects like the Jawaharlal Nehru National Solar Mission plan to produce 20,000 Megawatt (MW) of solar power by 2022 are there in the pipeline. There are also other plans to setup four solar power plans of 1 GW each across the nation. All this has resulted in creating a positive wave among the foreign investors who want to invest in India and tap its growing potential. From the nuclear energy context, India has one of the world's largest reserves of Thorium and hence contains a massive potential in nuclear energy. Presently, India has 5.78 GW of net electricity

generation capacity by putting the nuclear fuels (across 20 reactors) into use and intends to raise it to 45 GW by 2020. We should also take into account the huge reserves of thermal power for India. At the end of 2014, total coal reserves of India were estimated to be 301.56 billion tonnes, out of which 60.6 billion tonnes were proven reserves. Also, India's proven natural gas reserves stood at approximately 1.4 trillion cubic metres.

Power Generation has also increased at a rapid pace over the past few years. Electricity production in India was estimated to be 1107.8 TWh in FY 16 which is around 5.64 per cent growth over the previous fiscal. The electricity production had a CAGR of 6.21 per cent over FY 10-16.

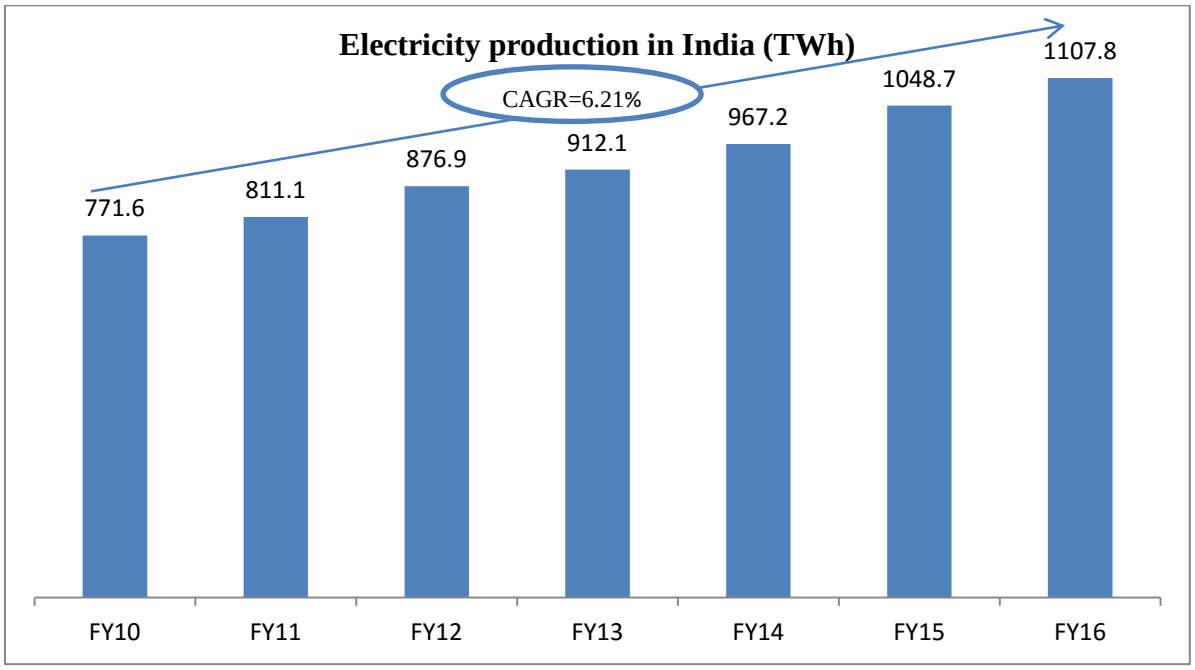


Figure 2.8: Electricity Production in India over the past years

Source: Power sector report – November 2016, retrieved from http://www.ibef.org/industry/power-sector-india.aspx

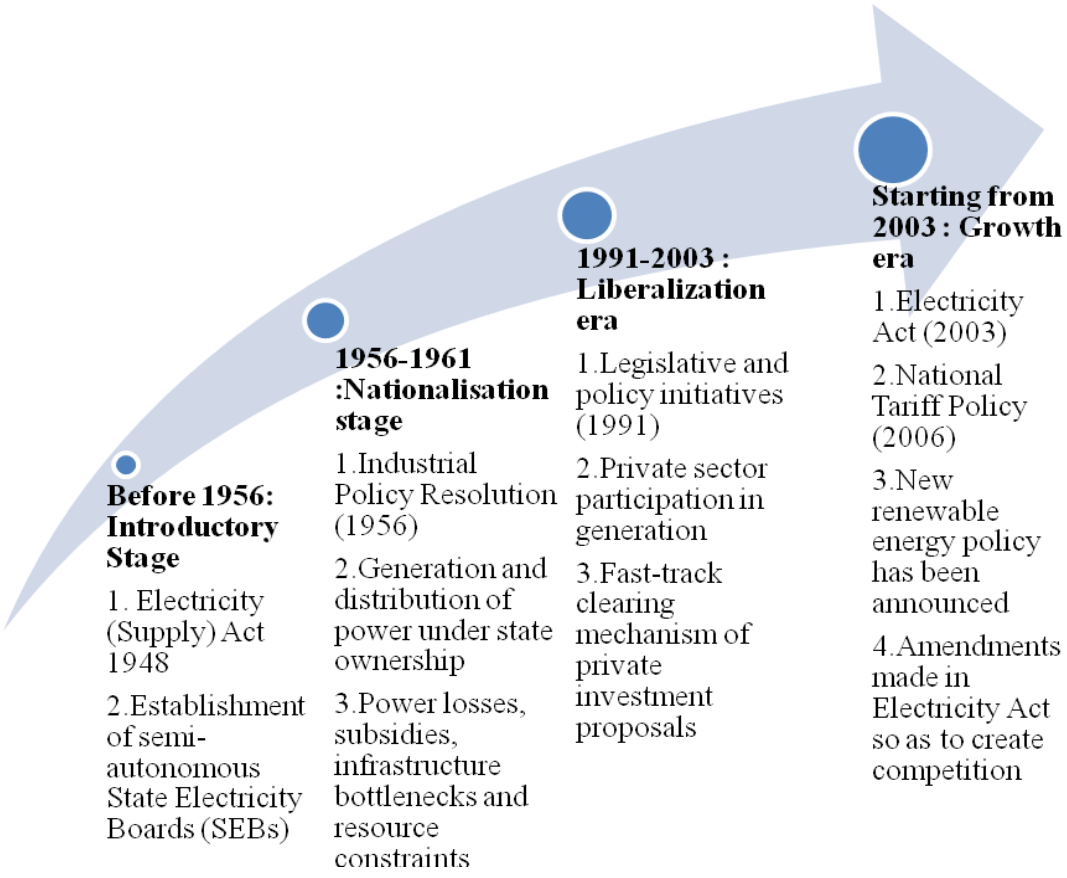


Figure 2.9: Evolution of Power Sector over the past decades

Source: Power Sector Report–November 2016, retrieved from http://www.ibef.org/industry/power-sector-india.aspx

2.4.4 Telecom Sector

India has the second largest Telecom network in the world with a subscriber base of almost 1058.86 million as on March 2016. It also had third highest number of internet users in 2016 with 342.65 million internet subscriptions as of March 2016. Mobile based internet has an extensive reach in India with every seven out of eight users availing internet services from their respective mobile phones. Teledensity is also growing both in rural as well as urban areas recently. Urban teledensity was estimated at 154.01 per cent with rural teledensity at 51.37 per cent as of March 2016.

Some of the advantages of Telecom sector and reasons behind them are discussed below:

- **Rising Demand**: Majority of the Indian population live in rural areas. Therefore, rural market presents itself as a key growth driver in the coming years.
- **Growing Opportunities:** There are lots of attractive opportunities in this sector as Telecom penetration in India's rural market is estimated to increase upto 70 per cent by 2017 from 51.37 per cent as of March 2016. Also, government of India has launched Digital India program which links all the sectors such as healthcare, retail, etc. via internet.
- **High Ratings:** The Telecom sector of India is highly ranked as India is one of the leaders in Telecom infrastructure when compared to its peers in the west and from Asia.
- **Policy Support**: The government is committed in its endeavors to change India into a global Telecom hub. A practical regulatory support has also helped in this regard. The National Telecom Policy 2012 that calls for unified licensing, full Mobile Number Portability (MNP) and free roaming is just one example of it

The Telecom market is classified into three segments:

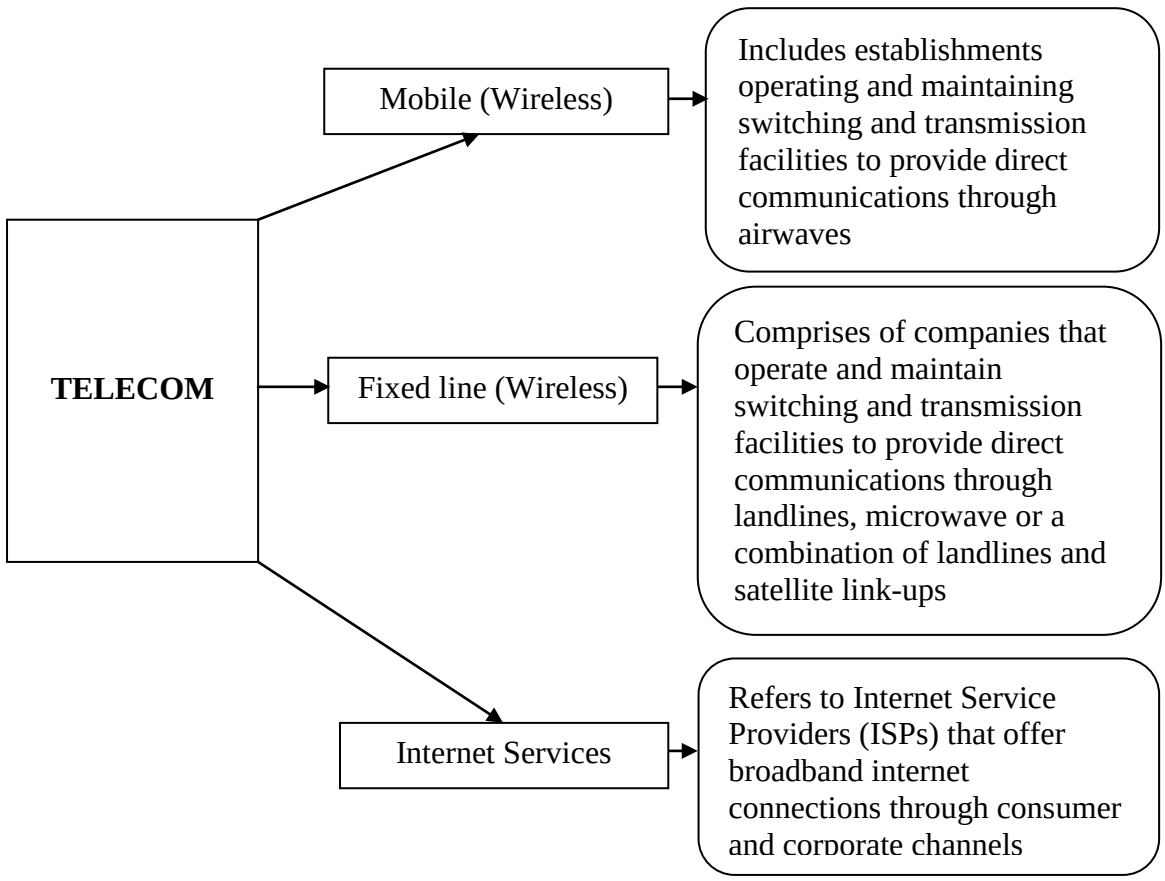


Figure 2.10: Classification of Telecom Sector

Source: Telecommunication sectoral presentation – November 2016, retrieved from http://www.ibef.org/industry/indian-telecommunications-industry-analysis-presentation#

2.4.4.1 Trends in Telecom Sector

The 'green telecom' concept is one of the most notable trends which we cannot miss while discussing the Telecom sector. The 'green telecom' is focused at mitigating the carbon footprint of Telecom industry through lower energy consumption. The government's Universal Service Obligation Fund plans to focus on those 62, 443 villages in India which are still uncovered and would be endowed with village telephone facility with subsidy support. Some other important developments related to this sector include Broadband Wireless Access (BWA) technologies like Worldwide Interoperability for Microwave Access (WiMAX) and Long Term Evolution (LTE). WiMAX is estimated to have acquired

nearly 8 to 10 million subscribers. Reliance Jio, the only operator which attained 4G spectrums in all 22 Telecom circles of India, has its plans to provide its 4G LTE services in 800 Indian cities by end of 2016. The Telecom Commission (TC) is going to establish a Telecom Finance Corporation (TFC) which can channelize funds for Telecom projects at competitive rates and ultimately make way for investments in the sector. The Indian government has also put in a proposition to invest around 32.2 billion USD in order to focus on local research and manufacturing of Telecom products. Indian Telecom sector's revenue growth has risen at the rate of 10.7 per cent to reach at 71.2 billion USD in FY14 as compared to 64.3 billion USD in FY13. The wireless and wireline revenue also increased at a CAGR of 8.91 per cent to reach a figure of 38.8 billion USD over FY06-14. The revenues from Telecom equipment is also estimated to reach 19 billion USD in FY15 and further rise to 30 billion USD in FY20.

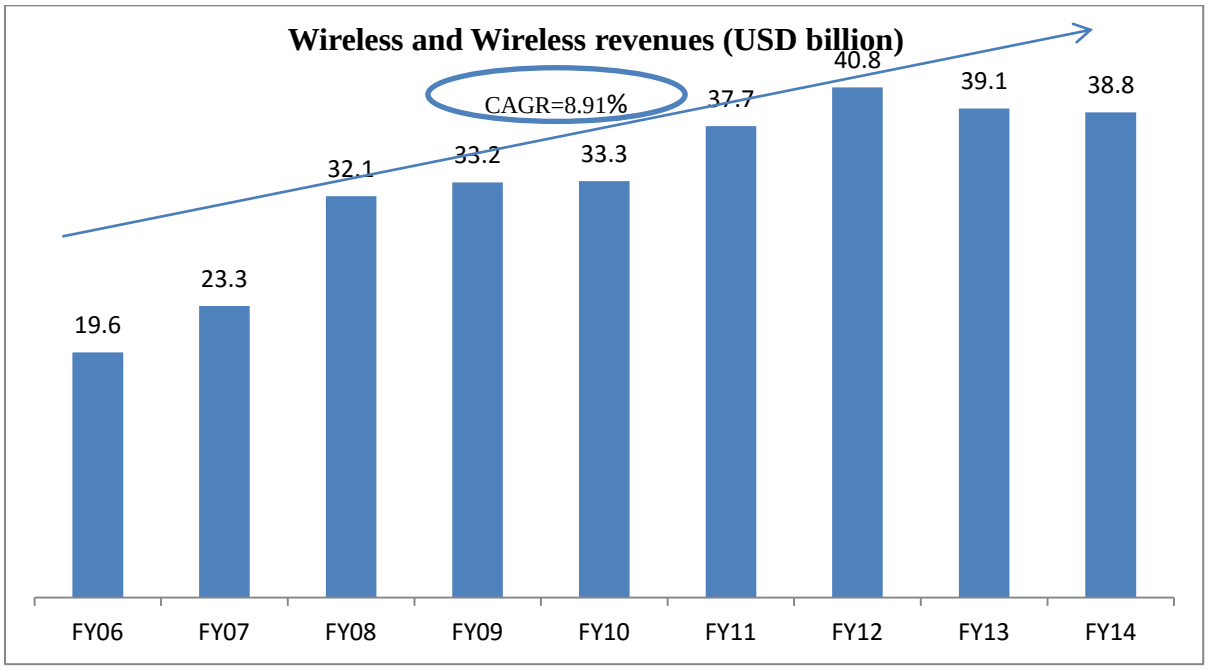


Figure 2.11: Growth of Wireless and Wireline Revenues in India

Source: Telecommunication sectoral presentation – November 2016, retrieved from http://www.ibef.org/industry/indian-telecommunications-industry-analysis-presentation#

2.4.5 Education Sector

As of 2015, India had the largest higher education segment in the world with approximately 48,116 colleges and institutions possessing student strength of 30.1 million. It is also the third largest in the world as far as education enrollment is concerned with more than 21.5 million enrollments every year. The higher education sector in India is estimated to grow upto 37.8 billion USD by 2020 from 10.1 billion USD in 2010. In the 12^{th} five year plan also, the government intends to offer a budgetary support of 74.4 billion USD to the education sector.

The education sector undoubtedly has numerous advantages which make it one of the most important sub sectors of Indian Infrastructure which we cannot overlook. Certain advantages of Education sector and reasons behind them are discussed below:

- **Robust Demand**: There is a massive demand supply gap in the education sector. Due to the enormous demand for education, there is still an additional requirement of 200000 schools, 35000 colleges and 700 universities.
- **Competitive Advantage:** India's Education sector has a huge competitive advantage as it contains the largest young population in the world i.e 500 million for age bracket of 5 - 24 years. Also, with a literacy of 74 per cent as compared to the world average of 84 per cent India's education sector offers an attractive opportunity for private players to tap this hidden potential.
- **Higher Investments:** The Education sector witnessed an upsurge in terms of FDI inflows over the past decade or so. Even after this increase, there is still an estimated investment of 200 billion USD required by the government to achieve its target of 30 per cent Gross Enrollment Ratio (GER) for the higher education segment by 2020.
- **Policy Support**: 100 per cent FDI is allowed in education sector under the automatic route. Further to liberalize the sector, government has started initiatives like National

Accreditation Regulatory Authority Bill for Higher Education and the Foreign Educational Institutions Bill.

The Educational landscape in India can be depicted with the figure given below:

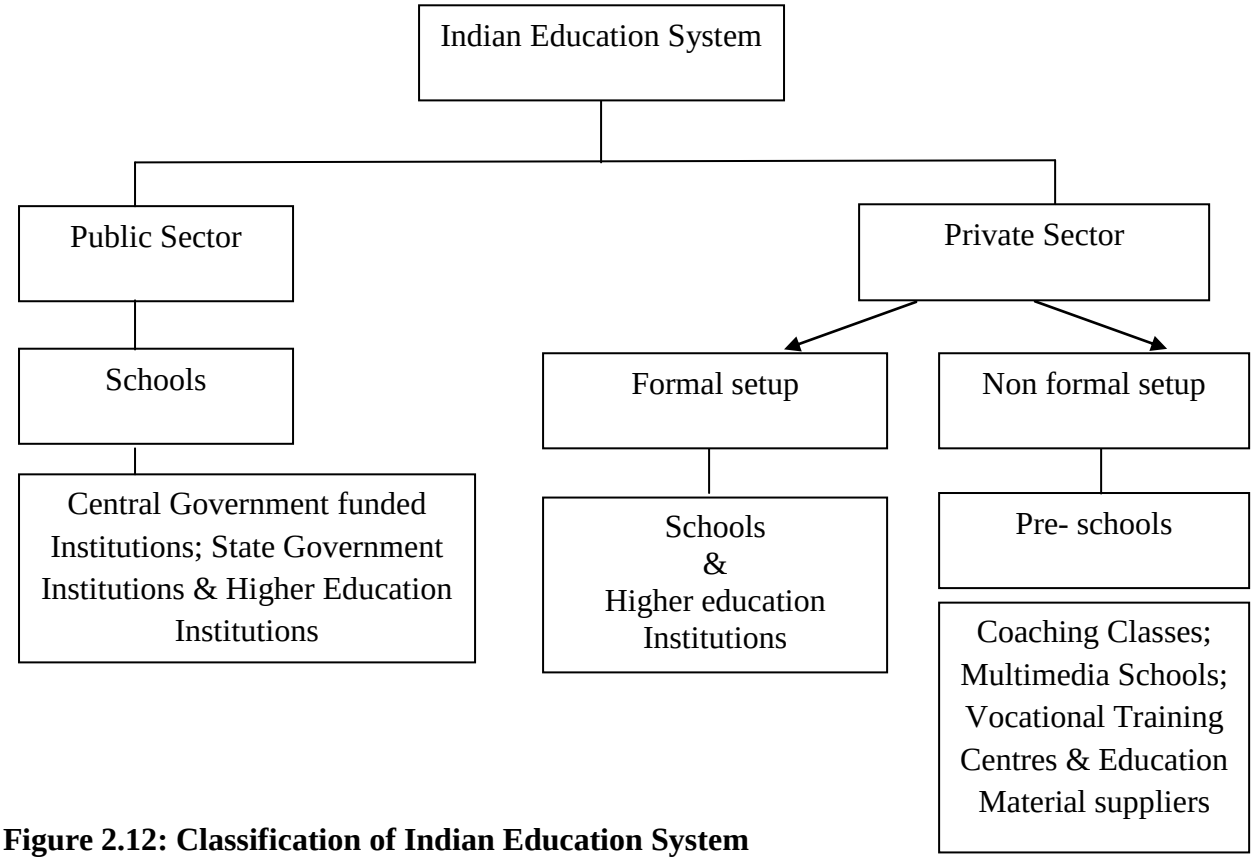


Figure 2.12: Classification of Indian Education System

Source: Education sectoral report – October 2016, retrieved from http://www.ibef.org/industry/education-sector-india.aspx

2.4.5.1 Notable Trends in Education Sector

Many operating models like a blend of franchisee and owned schools are employed by various private players to guarantee their economic feasibility. Also with the growing awareness, majority of Indian private players in this sector are collaborating with international brands to offer international standard quality education. Schools are also investing heavily in information and multimedia education technologies to give best education to their students. The numbers of recognized educational institutions have increased from 7,485 in 2011 to 7,906 in 2014. Moving on to higher education segment,

various Indian universities and colleges have signed joint venture agreements with international universities so as to offer top-world class education to their students and ultimately meet their growing demands of international exposure. Several private institutions have either adopted or planning to adopt multi city campus model in order to expand their operations and tap the potential market of tier 2 and tier 3 cities.

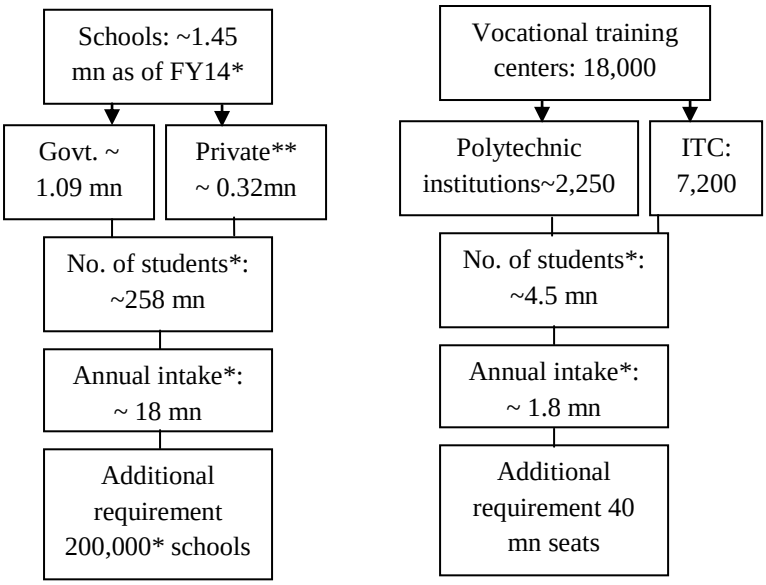


Figure 2.13: Schooling & Vocational Training Infrastructure in India

Source: Education sectoral report – October 2016, retrieved from http://www.ibef.org/industry/education-sector-india.aspx
Notes: ^ Provisional, * In FY12, ** Recognized

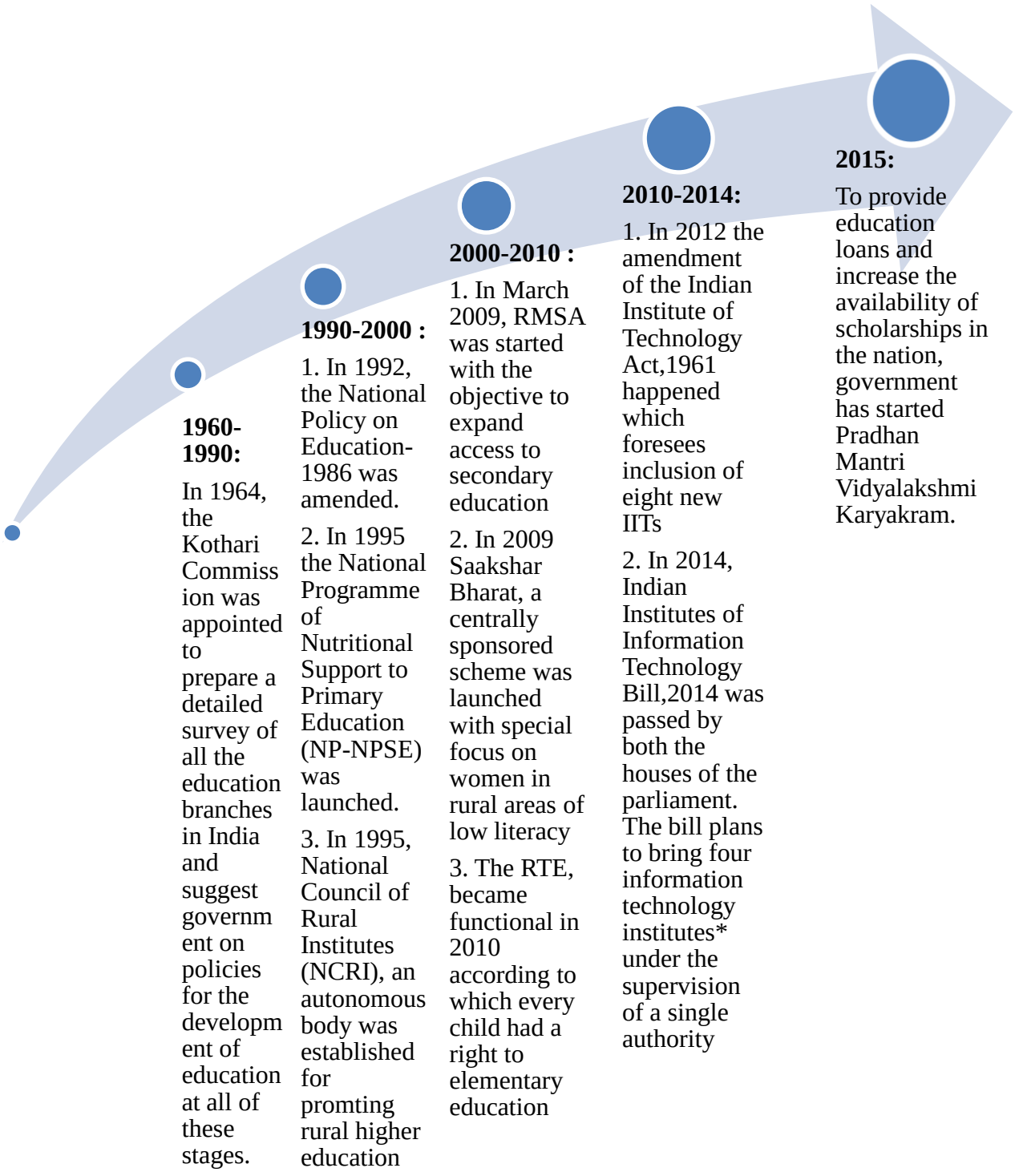


Figure 2.14: Growth of Education Sector

Source: Education sectoral report – October 2016, retrieved from http://www.ibef.org/industry/education-sector-india.aspx

Notes: RTE: Right of Children to Free and Compulsory Education, RMSA: Rashtriya Madhyamik Shiksha Abhiyan; *IIIT-Allahabad, IIIT-Gwalior, IIIT Design and Manufacturing Jabalpur, and IIIT Design and Manufacturing Kancheepuram

2.4.6 Healthcare Sector

India had the sixth largest healthcare market in terms of its size in 2014 and is estimated to stand among the top three healthcare markets in terms of incremental growth by 2020. India's healthcare sector is expected to grow at a CAGR of 22.87 per cent during 2015-2020 to reach 280 million USD by 2020. The healthcare expenditure is also estimated to increase at a CAGR of 17 per cent over the time period 2011-2020. The low cost of medical services has boosted country's medical tourism, thereby attractive patients from around the globe. Further, India has now raised itself as a primary hub of R&D (Research and Development) activities for international players due to its comparatively low expenses on clinical research. Hence, the healthcare sector becomes another major sub sector of Infrastructure which is critical to the Indian economy and has many advantages :

- **Strong Demand**: Higher income levels, ageing population, lifestyle diseases, increasing health awareness and finally changing attitude towards preventive healthcare are some of the key reasons for boosting healthcare services demand in India in near future.
- **Attractive Opportunities:** Investment in healthcare infrastructure is going to increase, hence becoming a boon for both 'hard' (hospitals) and 'soft' (R&D, education) infrastructure. Also, India is the largest exporter of formulations covering 14 per cent of the global market share and ranks 12^{th} in the world as far as export value is concerned. Hence, there is lot of attractive opportunities in the healthcare sector.
- **Quality and Affordability:** The healthcare sector also presents itself as the one which is of the highest quality and affordability. There is an accessibility of a large number of well trained medical professionals in our country. Also, India is well above its peers in the west and Asia in terms of its offerings of low cost and at the same time top quality medical services.

- **Policy Support**: The government's goal is to make India as a global healthcare hub and therefore, it is providing all kinds of policy support by ways of mitigated excise and customs duty, exemptions in service tax etc.. There is a special focus on creating new drug testing laboratories and at the same time strengthen the already existing 31 state laboratories.

The Healthcare market functions can be classified into five segments:

- **Hospitals**: This is further divided into Government hospitals and Private hospitals. Government hospitals include healthcare centres, district hospitals and general hospitals whereas Private hospitals include nursing homes, mid tier, top tier private hospitals.
- **Pharmaceutical**: It involves manufacturing, extraction, processing, purification and packaging of chemical materials for use as medications for humans or animals.
- **Diagnostics**: It comprises businesses and laboratories that provide analytical or diagnostic services, including body fluid analysis.
- **Medical equipment and supplies**: It includes manufacturing, extraction, processing, purification and packaging of chemical materials for use as medications for humans or animals.
- **Telemedicine**: Telemedicine has huge capabilities to meet the challenges of healthcare delivery to rural and remote areas in addition to several other applications in education, training and management in healthcare sector.
- **Medical insurance**: It refers to the health insurance and medical reimbursement facility, taking into account an individual's hospitalization expenses credited due to sickness.

2.4.6.1 Major Trends in Healthcare Sector

As discussed above, the growing urbanization and modern day lifestyle problems in urban areas have basically increased the demand for specialized healthcare. Tier 2 and Tier 3 cities

also present significant demand for high quality specialized healthcare services. Hence, the government aims to motivate private sector to construct hospitals in these cities by reducing the taxes on these hospitals for first five years. Many healthcare players like Fortis and Manipal Group are getting into management deals in order to offer extra revenue stream to hospitals.

Telemedicine is rapidly emerging as a major sector in India with several major hospitals like Apollo, All India Institute of Medical Science (AIIMS), and Narayana Hrudayalaya etc. making use of telemedicine services and entering into innumerable PPPs. According to latest data, the telemedicine market in India has been valued at 7.5 million USD and is expected to increase upto 18.7 million USD by 2017. Health insurance is also quickly picking up pace in India and this rising trend is expected to continue in the future.

Well-built mobile technology infrastructure and recent implementation of 4G is going to revolutionize mobile initiatives in the country. Also, there is another notable trend to improvise the quality of service delivery, control cost and develop patient engagement. For achieving this, most of healthcare providers are focused to improve the technological side/ of healthcare delivery. The healthcare sector's spending on IT products and services are estimated to have transcended to 1.2 billion USD in 2014 from 1.1 billion USD in 2013.

During 2008-20, the healthcare market is estimated to register a CAGR of 16.5 per cent. The total industry size is predicted to reach 160 billion USD by 2017 and 280 billion USD by 2020. According to Ministry of Health, there is a target to develop 50 technologies in FY16 for treating diseases like Cancer and TB.

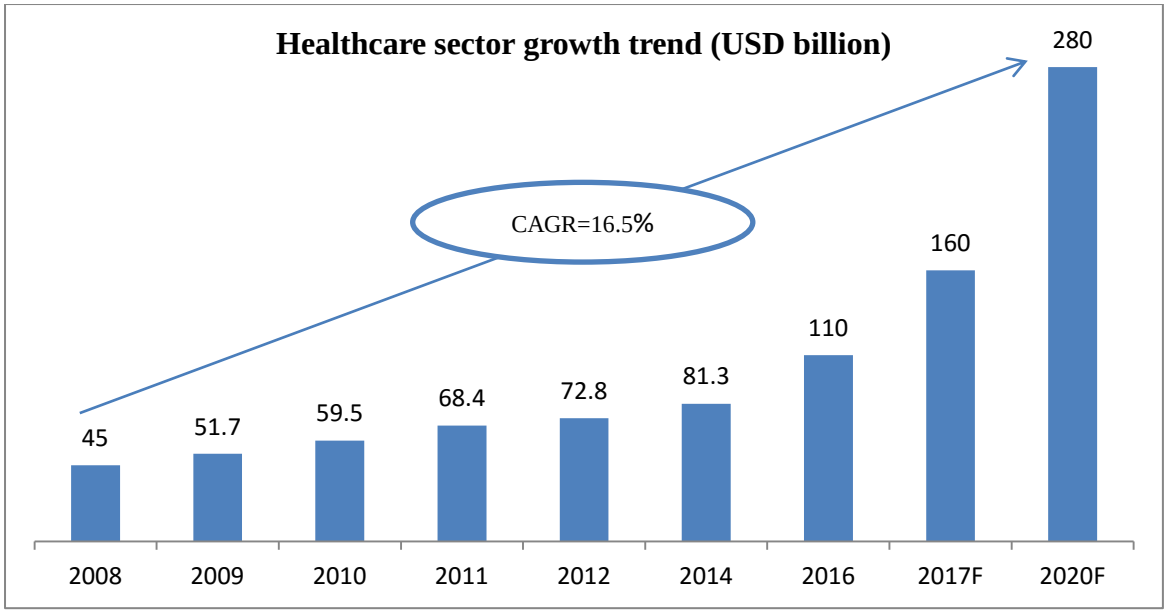


Figure 2.15: Growth trends in the Healthcare sector

Source: Healthcare sectoral presentation – August 2015, retrieved from http://www.ibef.org/industry/healthcare-presentation
Note: F –Forecast

2.5 GROWTH OF INDIA'S INFRASTRUCTURE SECTOR IN RECENT YEARS

Post liberalization era, the focus on infrastructure development has been increasing continuously. This is a total flipside to the pre liberalization times when not much emphasis was given on infrastructure asset creation and only government played the role of both facilitator and provider of infrastructure. The Gross Capital formation (GCF), as an indicator of investment in infrastructure rose from 5.6 per cent of GDP in FY07 to 6.5 per cent of GDP in FY12. The proportion of private sector participation in the 11th plan, which was initially set at 30 per cent when the plan was proposed, grew to reach at 37 per cent, by the time the duration of the plan got over.

From a growth enhancing point of view, Infrastructure sector has emerged as one of the most significant sectors in recent years. Indian government's focus on this sector has always been there. However, this focus seems to be expanding continuously if we are to observe the

current and futuristic trends. This view is substantiated by the fact that India has made considerable growth in terms of attracting private investments in infrastructure sector. During the time period 2002-2012, the private sector has invested nearly 250 billion USD in different infrastructure projects. What is more significant is the fact that investment in infrastructure as a percentage of GDP has increased from 4.9 per cent in 2002-03 to approximately 7.2 per cent in 2011-12 and is estimated to further increase up to 10 per cent by 2016-17. Moving forward during the 12th plan period, the government expects that for the total investment requirement of 970 billion USD in infrastructure sector, almost 50 per cent should come from private sources, including FDI. Figure 2.16 given below gives us an indication of what fraction of private investment is in the form of PPP investments. It is clearly obvious that there is a bigger focus to kick off PPP projects in the 12th five year Plan.

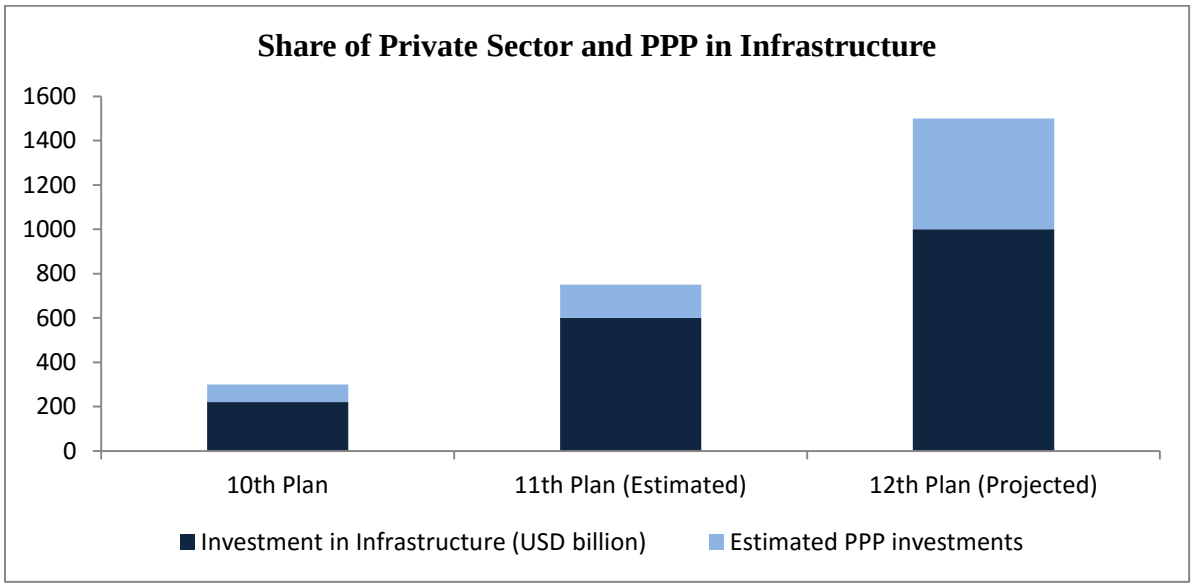


Fig 2.16: Share of Private sector and PPP in Infrastructure

Source: Public Private Partnership (PPP): Partnership for Growth Report, January 2013, retrieved from http://www.ibef.org/

The share of bank funding in financing the Infrastructure sector increased from 3.74 per cent in 2002 to around 10.40 per cent in 2015. It is also predicted that augmented spending on infrastructure would reach 19 billion USD during the 12th five year plan period.

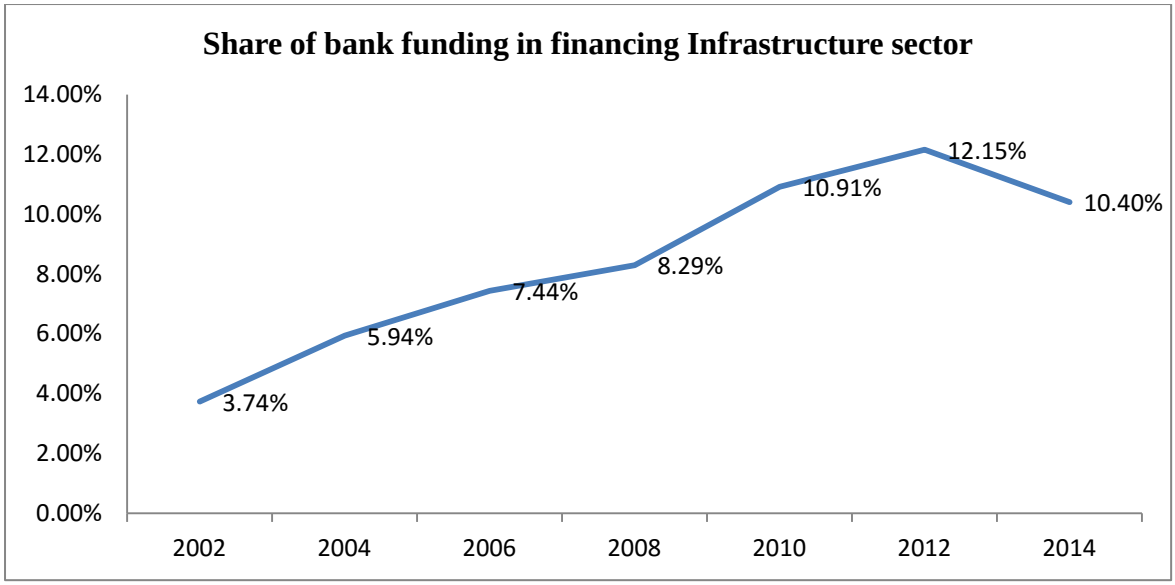


Figure 2.17: Share of bank funding in financing Infrastructure sector

Source**:** RBI

2.6 RISKS/ CHALLENGES FACED BY INDIA'S INFRASTRUCTURE SECTOR

While the growth in infrastructure sector is being discussed, there also exist various challenges which the infrastructure sector needs to conquer in order to ultimately convert this infrastructure dream into a reality. Some of these challenges have surfaced because of the fact that many announced projects are yet to be finished, with hefty time and cost overruns. Numbers from the government reports tell us that about 276 projects out of 566 projects followed by MOSPI have been delayed. The Ministry of Finance has approximated the value of these projects at about 1 lakh crore Indian Rupees (INR). Therefore, there are certain key factors or issues which are hampering the infrastructure sector and constraining its growth.

Some of these issues are discussed below:

1. Coordination problem between different government agencies.
2. Improper construction of the projects, predominantly in terms of segregation of risks and awards between Government and private sector.

3. There is no proper dispute resolution machinery which is in place between government agencies and private players.
4. Debt burden of infrastructure developers is also an issue of great concern. Execution delays and irrational bidding are the reasons which are usually cited for this issue of debt burden.
5. Challenges pertaining to Land acquisition and environmental clearance.

Several firms have had their debt restructured by corporate debt restructuring cell. Some of the firms have even taken the route of selling off their Build–operate–transfer (BOT) assets in order to reduce their debt burden, once the project has been awarded. This is one of the reasons why project implementation gets delayed. The inflow of orders for big infrastructure firms has also reduced over the past few years. The hunger of infrastructure developers for new projects too has considerably decreased. The resultant outcome is that government agencies like NHAI get a very unenthusiastic response to bids in the PPP route. Banks have also become extra cautions in terms of lending to those infrastructure sectors, where exposure limits have already been satisfied.

2.7 GROWTH PROSPECTS FOR INDIA'S INFRASTRUCTURE SECTOR

According to Ministry of Finance, the total investment in infrastructure sector in the near future may increase up to 1000 billion USD with more than 70 per cent of the investment estimated to come from private and foreign investors. India is particularly focusing on private sector investment through PPP model. The PPP aims to invest more than 400 billion USD in the infrastructure sector in next five years or so. Sectors like road, power are anticipated to draw a major proportion of these proposed investments. One example of a big planned infrastructure development project is the Delhi-Mumbai Industrial Corridor which has been touted to shelter large industrial zones, growth of smart cities and production of

logistics network. Recognizing the enormous investment requirements and need for superior and competitive services in the Infrastructure sector, government of India has started adopting a new approach in terms of their policy framework with PPP as the focal point. This current policy structure allows for 100 per cent FDI in various infrastructure sectors with no constraint on recovery of profit. Furthermore, the Government of India has also started a Viability Gap Funding Scheme in order to boost the financial feasibility of competitively bid infrastructure projects.

There is expectation that opportunities will come from the various areas of urban infrastructure development like huge urban transport and water supply projects in urban cities, on the back of fast paced urbanization. The Government of India also plans to form a devoted panel to improve the consent process of infrastructure projects. There are lots of investment opportunities for foreign investors who intend to invest in Indian Infrastructure sector. Some of these have been discussed below:

- All those Private Equity firms which are aiming for steady and secured returns on their investment can benefit from opportunities in the Indian Infrastructure sector. As per a recent analysis, India has been alluring vast amount of unlisted, close-ended funds, thus facilitating it to be a highly favored destination.
- The Indian infrastructure sector is expected to draw an investment of approximately more than 1.1 trillion USD in the upcoming five years or so. This also involves ambitious projects like NHDP and therefore, the infrastructure sector in India is estimated to supplement at a growth rate of 20 per cent every year.
- Over the next decade, more than 90 million jobs would be created across different sectors in India, which would generate a requirement of almost 8 million square feet of office space. This becomes one of the major magnets for foreign investors who aim to invest in industrial infrastructure sector of India.

2.7.1 Imperatives for Infrastructure Sector's Future and its Development

However, for the above mentioned predictions to occur, the infrastructure sector needs significant interference along with a revamp of existing manner of doing business across the different participants like developers, government etc. Even though government has been consistently increasing its focus on infrastructure sector, still it needs to discover ways of keeping the sector in motion. Government has moved ahead on many prime issues in terms of its positive approach, but still lot of work has to be done. The Land acquisition bill has been receiving mixed reactions, with some seeing it as a medium of possible cost appreciation, while the others are viewing it as an instrument for enhanced transparency on the subject. Moving ahead, another issue which requires urgent action from the government is the need for improvised access to key natural resources like coal and iron. The most important thing that will take the infrastructure sector forward is decisive action and the aid over four major areas given below:

- **Reduction of Regulatory Uncertainty and Delays** - The government should put in a framework for single window clearance of varied consents. Hence, an appropriate functioning body is required which can oversee and regulate the progress of approvals and coordinate with different government agencies. Attempts are also needed to guarantee implementation of contracts within a time boundation and in a clear way in order to engage FDI and private investment. Bodies like the 'Cabinet Committee for investment' should be more dedicated and clear backlog of detained projects.
- **Proper Structuring of Projects** – The existing mechanism of completion and structuring of a project as an EPC (Engineering, Procurement, Construction) or PPP or 100 per cent private ownership is required to be assessed so that it can take into account changing risk profiles of projects. The government should focus and give ample thought to the fact that what should be the suitable mode of project execution, especially when

private players have become cautions regarding risk-return of projects. Sufficient focus is required to be given in building contract terms so as to give adequate defense for private players from unwanted situations.

- **Development of Financing system to Cater to Sector's Needs** – Infrastructure companies are facing problems in terms of raising funds, as banks have limited subjection to the sector. Therefore, long term debt instruments like international pension funds will decrease the cost of debt, ultimately lowering the viability gap for infrastructure projects. The projected new investment vehicles like Infrastructure investment trusts (for securitization of assets) and Infrastructure Debt Funds (being surveyed by institutions like Infrastructure Leasing & Financial Services (IL&FS), India Infrastructure Finance Company Ltd. (IIFCL) etc.) need to be accelerated so that they can offer an impetus to the sector.
- **Efficient Project Management (from bid to execution)** – Private organizations are required to develop their mechanisms in order to implement best-in-class project management tools and techniques. The bidding and estimation process needs to be evaluated with more focus on proper revenue estimates and realization of project risks. Companies must tackle issues associated to dearth of skilled manpower and upgrade their existing sourcing & project management methods, to cut down the incidence of cost and time overruns during execution.

2.8 CONCLUSIONS

The preceding paragraphs aim to present an Overview of India's Infrastructure Sector. All the relevant issues pertinent to this sector like Classification of Infrastructure Sector, what are the Composition of overall Infrastructure Sector of India, Detailed Profiles of the important sub-sectors constituting Infrastructure sector, various risks and challenges faced

by this sector and finally the growth prospects of India's Infrastructure sector have been emphasized in the above discussed sections. We can neither underestimate the importance of India's Infrastructure Sector, nor can we undermine the relevance of Indian Infrastructure Sector on the world map. Hence the need for research related to India's Infrastructure Sector gets highlighted. With this premise, the next chapter, Chapter 3 reviews the literature on Infrastructure sector and related issues to study the work already done and ultimately find existing gaps in literature, especially in Indian context.

CHAPTER 3

REVIEW OF LITERATURE

3.1. INTRODUCTION

It is a widely acknowledged fact that Infrastructure has a significant positive effect on economic growth, trade and household welfare. While the importance of infrastructure is ascertained, it can be firmly said that investment in Infrastructure becomes a primary driving edge to accomplish fast and sustained economic growth. This critical relationship between Public Infrastructure Investment and economic growth has been of immense interest to the researchers around the world from the field of economics and related areas. For Investment in Public Infrastructure, money is required and that is when the issue of Infrastructure financing comes. Whether the financing will be done totally by the government (public sector) or whether the private sector (fully or partially) will handle the funding process of Infrastructure is an aspect that needs to be seen and comes under the Infrastructure financing part. However, if the required amounts of funds have not been generated via different modes of Infrastructure financing, then governments have to resort to taking debt and that is when the concerns of fiscal unsustainability start creeping in. If the amount of debt taken goes into alarming zones, then economic growth of an economy might be constrained. Therefore, three major issues arise – The relation between Public Infrastructure Investment and Economic growth, Issues pertaining to Infrastructure Financing and finally the fiscal sustainability and economic growth part. The following paragraphs list down some of the significant studies from literature which have addressed these issues.

This chapter has been organized in the following sequence. Section 3.1 reviews the different ways in which infrastructure has been defined in the literature. This section is followed by Section 3.2 which covers the various important definitions of infrastructure. Section 3.3 covers all the relevant literature on how to define Public Infrastructure Investment. Section 3.4 presents a comprehensive summary of research carried out on analyzing the relationship between Public Infrastructure Investment and economic growth. Section 3.5 enumerates the

issue of infrastructure financing and all pertinent literature to it. Section 3.6 provides an explicit and comprehensive literature review on the relation between debt sustainability and economic growth followed by the identification of Research gaps in Section 3.7 and eventually the brief conclusions of the chapter are presented in Section 3.8.

3.2. WHAT IS INFRASTRUCTURE?

Even though we are familiar with the term 'Infrastructure' and the related services, the word itself is quite new. The American Heritage Dictionary of the English Language states that "*the term infrastructure has been used since 1927 to depict collectively the roads, bridges, rail lines, and similar public works*". Even in the English dictionary the term did not find any place until 1950s. Moving forward, in the late 80s and 90s the word became very famous and a prominent topic of discussion in almost every forum. However, despite being widely discussed, there is no standard definition of infrastructure. Even though it is an accepted fact that infrastructure has a strong impact on the economic growth of a country, there is no exclusive concept prevalent in economic literature for defining infrastructure and describing its components.

In general terms, Infrastructure can be defined as a bunch of amenities through which goods and services are being bestowed on to the public. The installations to infrastructure do not manufacture goods and services directly but do give inputs for other socio-economic activities. Another popular definition of infrastructure defines it as the set of basic facilities and capital equipment required for the proper functioning of a nation or a particular area. Alternatively, this term refers collectively to the roads, bridges, railway lines, airports etc. and similar public works which are needed for an industrial economy to function properly.

The term was invented during the times of World War II as a military term meaning "underlying structures in the early days of Marshall Plan, as preferable to Social Overhead

Capital (SOC)" in order to avoid misunderstanding with schools, hospitals and similar welfare type facilities. Since then, the term infrastructure has been extensively used by economists around the world irrespective of the fact that there is no standard definition available in economic literature.

Different economists have made use of the term with different associations; keeping the core idea same that infrastructure is the base over which the whole economy's structure is built. Tinbergen (1962) made a distinction between 'infrastructure' (roads, railways, education etc.) and 'superstructure' (manufacturing, agriculture, mining, irrigation etc.) without giving a specific definition or any certain theoretical reference to these two terms.

Therefore, all economists basically felt the need to formulate a concept for dealing with three major objectives while addressing this term called 'Infrastructure'

- Designing a concept for the term infrastructure
- Incorporation of theoretical ways which give references to the term Infrastructure
- Description of how infrastructure provision is being done

Buhr (2003) in his study asserted that the broadest economic definition of the term 'Infrastructure' goes back to Jochimsen's (1966) book on the theory of infrastructure in which Jochimsen put forth his views for a modern theory of development of a market economy based on his study of infrastructure endowment. The author classified different time phases of economic development: a) quasi-stagnation b) economic dualism and c) self-intensifying growth. Quasi-stagnation refers to the time period which is illustrated through a constant level of economic activity. It is also recognized as the subsistence level due to dearth of any incentive to transformation. Dualism is the time period which sees the phenomenon of disintegration of the economy into varied fragments, each with their own activity levels which are consistently changing with respect to sectors, regions, firm sizes.

This change mainly takes place due to the amalgamations of external effects, institutional rigidities, technological discontinuities and any other hostilities of market economy. Self intensifying growth is the period which is encompassed by an immense number of economic activities which are continuously increasing. Consequently, Jochimsen (1966) defined infrastructure as one of the prime pre-condition of economic growth pertaining to these three time periods and the modification procedures resulting from one step to another.

Or, in a more realistic sense, infrastructure is pre-dominantly the sum total of:

- All earning assets, equipment and circulating capital in an economy that serve energy provision, transport service and telecommunications (telecom);
- The spots where we must build structures etc. for the preservation of natural resources and transport routes in a comprehensive aspect and
- Buildings and establishments of public administration, education, research, health care and social welfare (Jochimsen, 1966, p.103).

However this definition given by Jochimsen (1966), as noted by Buhr (2003), "has the disadvantage of not making factor price equalization concrete" (Buhr, 2003, p.1). Another aspect of this definition which might raise concerns is that it "understands infrastructure to be an enumeration of essentially public facilities characterized by specific attributes" (Buhr, 2003, p.1). This made evident that Buhr (2003) rejected the main stream approach followed by Jochimsen (1966) which was based on infrastructure attributes and deemed it to be incomplete. Instead, he was in support for an approach which was based on specific functions of infrastructure.

Therefore, a standard and a precise definition of infrastructure was still lacking which led different authors to model an assortment of varied indicators that indicate infrastructure. Moreover, in terms of policy making, the fact that we didn't have a common definition of

infrastructure made it very tough to develop any kind of uniform policies in this area (Infrastructure Canada, 2007).

The term "infrastructure" in its economic sense refers to two major characteristics:

i. Infrastructure is a *capital good* being bestowed in large units; Capital good in the sense that it is initiated by investment expenditure and is described by long duration, technical indivisibility and a high capital-output ratio;

ii. Infrastructure is also a *public good;* Public good not primarily in the notion that the public sector owns it, rather towards the more economic side that it completes the conditions of being *not excludable* and *not rival* in consumption.

An alternative approach was also developed named as "functional approach". It was based on *essential functions* of infrastructure. The term "essential" conveyed the idea that infrastructure initiates the transformation in the economic variables. Therefore, we can say that each kind of infrastructure could be defined depending upon its effect.

Following the track of this functional approach addressing the disparity in the definition of infrastructure, Buhr (2003) defined infrastructure as "the sum of all relevant and applicable economic data such as rules, stocks, and measures with the view of mobilizing the economic potentialities of economic agents" (Buhr, 2003, p.16).

The Organization for Economic Co-operation and Development (OECD) defined infrastructure as the equipment of industries and firms (stock of capital), public services (electric energy, water supply, and drainage), public endowment (roads and highways, airports), hotels and other services etc. Under this notion, the idea behind creating infrastructure is to set up optimized conditions for businesses that lead to economic growth, thereby increasing employment and productivity. Therefore, infrastructure has the potential

to promote social and economic opportunities of a nation with a view of augmenting the income of citizens and ultimately bringing about economic growth.

As discussed above, different researchers have given their own versions of the definition of Infrastructure. For formulation of policies, setting sectoral targets and examining projects, a clear understanding of what all is covered under the umbrella of 'infrastructure' is required so as to guarantee consistency in the data collection and reporting processes of different agencies.

3.3. LITERATURE ON DEFINING PUBLIC INFRASTRUCTURE INVESTMENT

Before defining Public Infrastructure investment, there is a need to first define Public Capital. Public capital is referred to as the tangible capital stock owned by the public sector, excluding military structures and equipment. This definition involves the 'core infrastructure' (i.e roads, railways, airports and utilities such as water and sewer systems, public educational buildings, public hospitals). Therefore, Public capital can be essentially said as the stock of Public Infrastructure only, and both represent the same thing.

In nations like United States (US) which have the presence of a fiscally decentralized government structure, the definition of public capital varies as the layer of government involved in its provisioning changes. Most of the studies utilize the public capital stock defined at the national level and this involves public capital provisioning at all government levels (Aschauer, 1989a). However, Ram and Ramsey (1989) argued that public infrastructure owned by local and regional governments can be more productive when compared to the public capital supplied by the federal or the central government. Motivated

by this argument, Evans and Karras (1994) abided by the public capital which is owned by regional governments only.

Looking at this issue in more detail, we can say that the main reason behind the existence of the various definitions of public capital is the explicit modeling of interregional spillover effects in studies which have a regional viewpoint. According to Munnell (1992), public infrastructure may have several beneficial effects that may accumulate to neighboring regions and hence it becomes difficult to capture interregional spillover effects. This spillover logic has been used to depict why higher output elasticities of public capital are usually estimated for the time series studies making use of more aggregate data. To counter spillover logic, one option can be to define public capital in the normal manner and have public infrastructure of neighbor as a separate variable. Using this method, Holtz- Eakin and Schwartz (1995) estimated tiny evidence of spillover effects. On the contrary, Boarnet (1998), using highly disaggregated data at the national level, achieved a significant negative spillover coefficient.

The basic question which arises here is about the types of expenditure that can be categorized as Public Investment. The answer to this question seems less obvious than what actually it appears to be at the first look. Broadly, the general distinction between capital and current outlays would hold, with capital outlays pertaining to any kind of expenditure whose productive life extends into the future. Therefore, it can be said that Public Infrastructure investment embodies the infrastructural outlays for different sub categories of infrastructure like road and rail networks, ports, bridges, energy, telecom, water and sanitation networks, government structures and buildings etc., all of which possess a productive life of many decades. Such kinds of outlays vary from small infrastructural projects which can be implemented within a year to large complex ones which span over decades, called as mega

projects. Few examples of mega projects are the Heathrow Terminal 5 in London, the Netherlands dike schemes etc.

To calculate the effects of public investment in infrastructure, a quantifiable indicator to fairly accurate development is required. This indicator can be used as an output measure or as a dependent variable depending upon the study. Various studies use real gross output of the private sector or real Gross Domestic Product (GDP) exclusive of public sector output, as indicators of development. When the data pertains to the regional level or state level (e.g., US, India), real Gross Regional Product or Gross State Product is used.

The last decade gone by has been a spectator of the revival of focus and attention that has gone into analyzing the role of Public investment. The governments all across the globe have identified this crucial need of boosting up the public investment levels. Several factors like the high economic growth in Asia fueled by high public investment , matching up with the ever increasing pace of urbanization and the related infrastructure demands, taking due advantage of various technological changes or cutting down on a country's carbon footprint, are behind this recent change. Even the recent financial crisis has further strengthened the concentration on public investment as a prospective countercyclical policy tool which can serve the dual purpose of creating jobs as well as laying the foundation for creating and sustaining economic growth. It also plays an important role in terms of achieving other major policy goals of government like poverty reduction, responding to demographic trends, increasing urbanization etc. Therefore, there is an utmost need to analyze this critical relation between Public Infrastructure Investment and Economic Growth. The following section presents all the significant literature available on this important relationship.

3.4. LITERATURE ON PUBLIC INFRASTRUCTURE INVESTMENT AND ECONOMIC GROWTH

It is a well known fact that spending on Infrastructure forms a major part in public capital investment. Therefore, public infrastructure investment was taken as a crucial component of economic development and growth. According to Estache (1994) "World Development Report - Infrastructure for Development", all the services related with infrastructure account for 7-9 per cent of the GDP in the low and middle-income countries. Infrastructure in these nations typically makes up about 20 per cent of total investment and 40 to 60 per cent of public investment. Further, the report postulated that 1 per cent increase in the stock of infrastructure is related with 1 per cent increase in GDP across all observed countries.

It is quite clear that focus needs to be given for a substantial increase in the infrastructure investment, particularly in low income countries where there is urgent need to deal with these issues and ultimately tackle multiple policy challenges. However, when it comes to analyzing the quantitative effect of public infrastructure investment on economic growth, the issue at hand is still ambiguous and needs to be analyzed further. Moving towards the literature side of this issue, it can be seen that the discussion and argument on assessing the impact of public infrastructure investment on economic development was revived by Aschauer (1989a) who observed that the productivity slowdown in US post 1973 was "*matched or slightly preceded by a precipitous decline in additions to the net stock of public non-military structures and equipment*". Aschauer estimated that core infrastructure is potentially more productive than other types of public capital. The analysis period was from 1949-1985 and his results proposed a positive relationship between public capital and private sector output. The elasticity was estimated to be 0.39 which meant that a 1 per cent increase in public capital stock was estimated to increase private sector output by 0.39 per cent. Accordingly, Aschauer put forth the view that the major reason behind the slowdown in U.S.

productivity growth in the 1970s and 1980s could possibly be examined by the decreasing rates of public investment spending. However, many authors did not conform to Aschauer's results mostly on econometric grounds. Issues like non-stationarity of the data, spurious correlation and potential endogeneity of public capital were cited with respect to Aschauer's study. All the critics said that these issues were the reasons behind the large public capital elasticity (0.39) estimated by Aschauer (1989). Gramlich (1994) in his review essay pointed out various plausible endogeneity issues and concluded that many researchers failed in their attempt to give conclusive results which could confirm Aschauer's findings. However, this chain of events did not suppress the interest of researchers, either in analyzing the role of public investment or evaluating its impact on economic growth empirically.

During the late 1990s, a strong upsurge in the prosperity of Asian economies was observed. During this time, huge public investment was done in these economies which actually led to a debate in Latin America where it was strongly assumed that low public investment was the major factor behind its poor growth performance. Calderon and Serven (2010), in a World Bank study discovered evidence of optimum positive contribution from public investment in four basic infrastructure sectors: telecom, land transportation, water and sanitation and electricity. The authors used regression framework and estimated marginal productivity of these assets to be considerably higher than that of non-infrastructure capital. Further, they estimated that curtailing the infrastructure spending decreased the long term growth by approximately 3 percentage points a year in Argentina and Brazil and by 1.5 to 2 percentage points per year in Mexico, Chile and Peru.

Sutherland, Araujo, Égert, & Kozluk (2009) in their study on network infrastructure investments in the OECD, aimed to investigate whether the infrastructural investment had an impact on output, over and above those from just adding to the productive capital stock.

They pointed out that "*infrastructure can produce additional effects through various channels, like by smoothening the progress of the division of labor, distribution of technology, offering access to a larger reach of markets, upcoming resources etc*." (Sutherland et al., 2009, p.13) Sutherland et al. (2009) predicted considerable non-linearities, with the relation between infrastructure and economic growth changing based on the level of infrastructure investment. Investments which are done initially demonstrate minor effects on economic growth. However, significant positive effects are perceived when an infrastructural network is established in a sector. Beyond this, subsequent investments which assist a network tend to have a small marginal pay off in terms of economic growth. For certain countries and their specific sectors, the infrastructure investment even had a negative impact. Australia, New Zealand and Ireland showed signs of negative spillovers from additional investment in electricity sector. Likewise for roads; France, Netherlands and Greece showed negative externalities. However these varying results (with both positive and negative effects) found in different nations, confirm the fact that the impact of infrastructure investment cannot be taken as universal. While infrastructural investment may have proved to be profitable for the OECD countries previously, new investments in the future may not prove to be that profitable. Equally valid is another argument which says that all those nations which have significant gaps in infrastructure, substantial returns can be expected from elaborating an infrastructural network.

Isaksson (2009) employed a panel data regression model in order to examine a group of 57 advanced and developing countries over the time period of 1970–2000. According to his analysis, public capital growth had the most significant impact on both on emerging economies as well as high-income economies.

Scandizzo and Sanguinetti (2009) underlined one important aspect of public infrastructure investment i.e. its effect on the quality of life and standard of living, especially in developing

economies like India. Adequate water and sanitation services have a positive impact on the health levels of households. Provision of electricity has numerous potential positive outcomes on people like access to information, increase in productivity etc. Good quality roads make it possible for the households to have better access to jobs, health and education services in an efficient manner. In another study done by Ter-Minassian, Hughes, & Hajdenberg (2008), the authors focused on the contextual factors that explain why the impact of public infrastructural investment is positive in certain countries and negative in others. According to these authors, the impact of public infrastructure investment on economic growth is dependent on the below mentioned factors:

a) The way in which an investment is financed. In other words, whether the government's mode of financing leads to accumulation of private investment or not. Governments round the globe may use investment as a budgetary measure to promote private investment or to diminish demand. According to the Keynesian economic exemplar, these effects of government expenditure are named as 'crowding in' and 'crowding out' of private investment.
b) Accessibility of complementary inputs, especially the quality of human capital (citing studies from Haque and Kim, 2003; Adam and Bevan, 2005; and Bose, Haque, & Osborn, 2007) which say that "*infrastructure investment has its largest effect when united with other forms of 'productive' public expenditure like effective education and health spending*" (Ter-Minassian et al., 2008, p.6)
c) Quality of project assessment, selection and management. Their exclusion can considerably reduce the cost bearings of infrastructure projects.
d) The operational and regulatory platform in which such kind of infrastructural services are offered.

Arslanalp, Bornhorst, Gupta, & Sze (2010) made use of a production function and estimated public capital for a total of 48 economies including both developed and developing, over the time period 1960–2001. They found out that increments in the public capital stock are linked with economic growth, with developed economies recording robust short-run effects and developing economies showing greater long-run effects.

During the same year, Zhai (2010) employed a global Computable general equilibrium (CGE) model, and found out that regional infrastructure investment in developing Asia would increase global income by 1.8 trillion United States Dollar (USD) by the year 2020, with majority of the profits (approximately 90 per cent) accumulating to the asian region itself. Similarly, the United Nations projected that in Asia alone; 500 million new entrants will be there in urban areas in the coming two decades. All these facts call for significant investment in public infrastructure, for providing basic universal services (roads, power, water, sanitation) and the infrastructure required to promote private sector investments which will help in the creation of jobs (Heller, 2009).

The requirements for public infrastructural investment are huge and it is pretty evident from the forecasts of the OECD, Asian Development Bank etc. The OECD (2007) estimates the investments to be in the range of approximately 3 trillion USD per year, if the focus is only on emerging market economies and industrial nations. The Asian Development Bank estimates that Asia alone will require almost 1 trillion USD of investment over the new few years. However, many studies still say that present investment spending is just about half of the actual amount which is required, and neither the governments not the private sector players can finance this huge requirement of infrastructure investment on their own (Kuroda, Nag, & Nangia, 2008).

Therefore, as the existing infrastructural gaps and future policy challenges confronted the governments around the globe, the call for high quality public infrastructure investment became overpowering. The following section presents all the empirical evidences from literature on the above discussed relationship.

3.4.1. Empirical Evidences from Literature

This section of literature review aims to provide a broad overview of all the methodological developments which have taken place while evaluating this critical relationship between public infrastructure investment and economic growth. All the developments starting from estimations via the production functions to more recently, the vector autoregressive model have been covered under the review of literature discussed below.

3.4.1.1. Production Function Approach – Evidences from US

The evidences from the US are categorized and presented in detail below. Out of various approaches available in the literature, two major methods standout - Production function approach and the Vector Autoregression (VAR) approach.

As discussed in above sections, the topic of analyzing the impact of public infrastructure investment on economic growth and performance was initiated by the seminal works of Aschauer (1989a, 1989b). He used the production function approach to establish a relationship between output employment and private capital as well as public capital. Aschauer's work created an explosion in the relevant literature and many researchers subsequently started applying the same methodology to sector-specific, regional or international data.

Aaron (1990) made use of Cobb-Douglas (C-D) model specification on US public capital stock time series data from 1951-1985 and explained that public capital has a positive effect

on output with elasticities ranging from 0.09 to 0.27. Hulten and Schwab (1991) carried out another analysis on US public capital stock taking data from 1949-1985 and estimated that there are insignificant impacts of public capital on output. However, they got elasticity as 0.03 and hence their results were not taken as robust. Tatom (1991) used same specifications as Hulten and Schwab (1991) with time period between 1949 -1989 and found out the same result i.e insignificant effects of public capital on output with 0.04 as the elasticity. Munnell (1992) used a similar methodology as Aschauer (1989a, 1989b) but she found slightly lower output elasticity of public infrastructure. Moomaw, Mullen, and Williams (1995) in their analysis produced elasticities' for all 50 states of US and the results maintained a positive correlation between public infrastructure and economic output in mostly all cases.

Nourzad and Vriese (1995) used public capital stock and core infrastructures as their public capital measures and carried out an analysis on US from 1949-1987. These authors estimated elasticities between 0.31 and 0.39 confirming the fact that there happens to be significant positive effects of public capital on output. Sturm and De Haan (1995) used public capital stock of US from 1949-1985 and concluded that there are positive but insignificant effects of public capital on output using time differences. Harmatuck (1996) used US Highways data from 1949-1985 as his public capital measure and employed Transfer function as the model specification. He estimated insignificant effects of public capital on output with a reported value of 0.03. Vijverberg, Vijverberg, and Gamble (1997) analyzed the US time series data on Net stock of non-military equipments from 1958-1989. The model specifications used were C-D and semi-Translog. However, the results from this study did not seem to be conclusive due to multicollinearity problems.

Batina (1999) used the US state public capital data ranging from 1948-1993 and estimated that the productivity of public capital is influenced by the proxies used for private and public capital. Fernald (1999) employed stock of roads and highways as the public capital measure

from 1953-1989 and Total Factor Productivity (TFP) growth as the model specification. The effect of public capital measure on output came out to be significant explaining half of the observed contraction in the productivity growth. Further, Fernald (1999) stated that roads contributed about 1.4 per cent per year to growth before 1973 and about 0.4 per cent after 1973. Seung and Kraybill (2001) performed a research at the U.S. regional level for the Ohio state with data calibrated on the year 1990 and total public capital as public stock measure. General equilibrium model was employed as model specification and it was concluded that welfare effects of infrastructure are nonlinear.

Shioji (2001) did a panel data analysis on the US States with data ranging from 1963-1993 and on certain Japan regions with data spanning across 1963-1993 with a 5 year gap. Public capital stock was used with CGE as model specification. The elasticity estimated from the study was between 0.10 and 0.15.

Moving ahead, Cohen and Paul (2004) employed Highways data for 48 US states from the year 1982-1996 in their panel study and the results confirmed the fact that Infrastructure investment mitigates its own costs and augments cost reduction effects of adjacent states. Abdih and Joutz (2008) used US public capital stock from 1984-2004 and predicted an aggregate production function in a cointegrating framework. The authors concluded that there is a positive and remarkable long run effect of public capital, skill-adjusted labor, and technology/ knowledge on private sector output, with estimated long run elasticities of 0.39, 0.61, and 0.13 respectively.

3.4.1.2. VAR Approach – Evidences from US

Coming to studies carried out on this issue with VAR approach, Lau and Sin (1997) performed out their analysis using US public capital stock data from 1925-1989 and estimated the elasticity value at 0.11, which was smaller than the usual values attained in

single-equation studies. The authors further concluded that if the share of capital income is taken to be one-third, the spillover effect due to private capital is positive but may be as low as 0.10. Pereira and Flores (1999) went in the same direction and used US public capital stock data from 1956-1989 and estimated that Public capital is productive but less than that suggested by Aschauer (1989a).

Following this, Pereira (2000) analyzed different types of Public investment data of US from 1956-1997 using the VAR approach and said that all types of public investment used by him impact private output in a positive manner. In other words, there is an accumulation of positive impact on private investment. Pereira (2001a) in his next study studied US core infrastructure data using 34 observations and finally estimated that there exists a positive effect of public capital on output with an elasticity of 0.257. Voss (2002) was the next researcher who jumped into this field with one of his studies where he took up U.S. and Canada data with different time period for each country (1951-1997 for US and 1951-1996 for Canada) and Public investment as his public stock measure. Applying the VAR approach, he concluded that that for both countries there is no evidence of 'crowding in' due to complementarities between public and private investment. In other words, Public investment crowds out private investment.

Pereira and Andraz (2003) took up their research on 48 states of US across the time span 1977-1999 with highways as the public stock measure. The authors made use of the VAR approach and concluded that 80 per cent of the aggregate effects of public investment in US highways are basically the spillover effects from other states. Following this, Pereira and Andraz (2004) carried out another study where they just changed their analysis period to 1956-1997 and predicted that only 20 percent of aggregate effects of public investment in US highways contribute to the direct effects on each state's output (in terms of public investment in the state itself). In other words, the authors got the same conclusion which

they had inferred in their 2003 study. Pina and St. Aubyn (2006) studied the US public capital stock data from 1956-2001 and concluded that when we take into account the crowding out effect on private investment, this effectively lowers the rate of return of public investment.

More recently, Pereira and Andraz (2012) have done a time series study on US highways data from 1977-1999. Through this study, they concluded that outcome that investment in highways has a direct positive impact on private sector variables. Of lately, Calderon, Moral-Benito and Servén (2011) have estimated a positive relation between infrastructure and output using a panel time-series approach. Also, Leduc and Wilson (2013) have studied the short and long term effects of infrastructure investment in the US, and have estimated a positive short run relationship between infrastructure investment and economic growth.

3.4.1.3. Production Function Approach – Evidences from Rest of the World

The evidences from the Rest of the World are classified and presented in detail in the section given below. Out of different approaches available in the literature, again two significant methods are noticeable - Production function approach and the VAR approach.

Munnell (1990) analyzed the issue for seven OECD nations using up public investment data from 1963-1988 and concluded that public capital has a positive impact on output. The elasticity of output with respect to total public capital was estimated at 0.31 with the elasticity of output with respect to core infrastructures even higher at 0.49. Bajo and Sosvilla (1993) carried out a time series analysis from 1964-1988 on Spain to conclude that public capital is exogenous and has a positive effect on output with elasticity estimated to be 0.18. However, in the same year Evans and Karras (1994) got different results to what Munnell (1990) had estimated. Though, Evans and Karras (1994) had also analyzed seven OECD countries taking the same data period from 1963-1988, however, they took public capital

stock instead of public investment data in their panel data analysis and estimated insignificant effects of public capital on output.

Otto and Voss (1994) performed their research on Australia's Construction and equipment sectors from 1966-1990 and found out elasticities ranging from 0.38 to 0.45. However, these results were still considered to be demeaning at sectoral level. Sturm and de Haan (1995) studied public capital stock, buildings and core infrastructure data of Netherlands from 1960-1990 and found out their elasticities as 1.15, 0.98 and 0.80 respectively. Also, there was no evidence of cointegration among the analyzed time series. Wylie (1996) took up Infrastructure capital stock of Canada from 1946-1991 and estimated positive impacts of public capital on output. The estimated elasticities were in the range of 0.11-0.52 Kavanagh (1997) performed an analysis on Ireland's public capital stock from 1958-1990 but ended up finding insignificant effects of public capital on output.

Canning (1999) took 57 countries across the globe and did a panel data study taking data of Telephones, electricity, roads and railways sectors from 1960-1990. Final results showed that Electricity and transportation routes possess normal capital rate of return with telephone giving above normal returns. Demetriades and Mamuneas (2000) studied public capital stock of twelve OECD nations from 1972-1991 and concluded that increases in public capital help in the reduction of costs. The value of elasticity varied from as low as 0.36 in the United Kingdom (UK) to as high as 2.06 in Norway. Same year, Stephan (2000) inspected the Infrastructure capital stock of West German and French regions taking C-D and Translog as model specifications and found out that elasticity of output with respect to public capital comes out as 0.11. However, it was also estimated that Translog specification has multicollinearity issues.

Kemmerling and Stephan (2002) did their cross- sectional research on 87 cities of Germany at specific time periods of 1980, 1986, 1988. Infrastructure public capital was used as public stock measure and making use of Simultaneous-equation approach, Public capital was predicted to be a prime input in private production. Simultaneity between output and public capital was found out to be weak and hence it was concluded that feedback impacts from output to infrastructure are negligible. During the same year, Ligthart (2000) evaluated the Portugal scenario using time series data of public capital stock from 1965-1995. The results suggested that there exist positive effects of public capital on output and sectors like roads, railways and airports are more productive. Moreno, Lopez-Bazo, and ArtÍs (2003) carried out research on the Transportation and Communication sectors of different regions of Spain from 1980-1991. The results of this analysis stated that Public and private investments increase efficiency and effectiveness. Also, it was estimated that Public capital and labor are complements and Private and public capitals are substitutes.

Following this, Stephan (2003) examined eleven regions of West Germany from 1970-1996 using Infrastructure capital stock (transportation and communications sectors) and found elasticities varying between 0.38 (first differences) and 0.65 (log levels). The research did not seem to stop during 2003 when Calderón and Servén (2003) carried out their panel data research on an enormous data set of 101 countries with Infrastructure capital stock as public stock measure and data period from 1960-1997. The findings suggested positive effects of public capital on output with an elasticity of 0.16. Albala-Bertrand and Mamatzakis (2004) did their research on Infrastructure capital data of Chile from 1960-1998. Using the translog model specification, it was concluded that till 1971, Infrastructure capital growth appeared to reduce productivity. From 1972 onwards, the reverse started happening.

Wang (2005) researched on time series data of Human capital, debt charges, social services, protection infrastructure from Canada over the time period of 1961 – 2000 and ultimately

concluded that expenditure on education has a positive effect on private investment. Everaert and Heylen (2004) chose to do their analysis on 43 regions of Belgium with Public investment as public stock measure and time period from 1965-1996. The estimated value of elasticity was 0.31 meaning that robust positive effects of public capital on private output and capital formation exist. Also, it was found that Public capital and private employment are substitutes with public capital having a negative impact on employment. Kamps (2005) carried out a panel as well as time series analysis on twenty two OECD countries using public capital stock data from 1960-2001 and found out positive effects of public capital on output. The Elasticity value came out to be 0.22 in panel data model and even higher in time series model.

Further, Arslanalp et al. (2010) have evaluated the public capital stock data spanning across 1960-2001 from 48 OECD and non-OECD countries. The conclusions suggested that increases in public capital stock are positively correlated with growth, after managing the initial level of public capital. The effect is stronger in the short term for OECD countries, while it is stronger in the long term for non-OECD countries. In other words, the impact level of public capital on growth is prolonging as far as longer time intervals are concerned for non-OECD countries. More recently, Gupta, Kangur, Papageorgiou, and Wane (2014) have used a production function approach with Generalized Method of Moments (GMM) estimation. The authors have used efficiency-adjusted public capital stock data for 52 developing nations, and concluded that this type of public capital has a strong effect on output.

3.4.1.4. VAR Approach – Evidences from the Rest of the World

Mittnik and Newman (2001) examined public investment data of six (Canada, France, Great Britain, Japan, The Netherlands, Germany) industrialized countries and estimated the presence of weak positive effects of infrastructure, with public investment inducing private investment and existence of no reverse causation whatsoever. Pereira (2001b) investigated the Core infrastructure data of eleven countries from 1960-1990 and estimated elasticities varying from 0.021 to 0.257. The author also found positive and statistically significant short-run effects of core infrastructure from his analysis. The same year, Pereira collaborated with Roca- Sagales to explore the Infrastructure capital data (transport and communications sectors) of Spain from 1970-1993. Through this study, Pereira and Roca-Sagales (2001) estimated positive and important long-run effects of infrastructure capital on output, employment and private capital. However, Pereira and Roca-Sagales did not stop here. Again, Pereira and Roca-Sagales (2003) took up the challenge of once again analyzing the Infrastructure capital (transport and communications sectors) of Spain. This time they considered the time period of 1970-1995 and concluded with the same result i.e. positive and significant long-run impacts on output, employment and private capital.

Everaert (2003) analyzed the Public capital stock of certain regions of Belgium from 1953-1996. Using Vector Error Correction Model (VECM), the elasticity of output with respect to public capital was estimated at 0.14, which was lower than elasticity with respect to private capital. Agénor, Nabli, and Yousef (2005) investigated the public capital stock data of Egypt, Jordan, Tunisia using the time period from 1965-2002 and found out a weak, tiny effect, short-lived and usually insignificant effect of public capital on private capital. Kamps (2005) analyzed the public capital stock of twenty two OECD nations from 1960-2001. The results of the analysis confirmed positive effects on growth and development in most of the nations.

Pina and St. Aubyn (2005) explored the public capital stock of Portugal from 1960-2001 and found non- existence of feedback effects. Also, the rates of return on public investment were found to be larger than on private investment. During the same year, Pereira and Andraz (2005) evaluated Portugal's transportation sector data from 1976-1998 and concluded that private investment, employment and output are positively affected by public investment. Belloc and Vertova (2006) examined Public investment data for seven nations (Cameroon, Democratic Republic of Congo, Ghana, Kenya, Malawi, Myanmar, Nicaragua) with the analysis period ranging from 1970-1999. Using VECM it was concluded that in six of the seven cases, there exists a positive effect of public investment on output.

Pereira and Andraz (2006) examined the Transportation sector of five regions of Portugal from 1980-1998 and suggested that the investment effects are unevenly distributed. Pereira and Roca (2007) studied the Transport and Communication sector of 17 regions of Spain from 1970-1995 and concluded that spillovers account for 50 per cent of the total effects of investments in these two sectors.

More recently, Pereira and Andraz (2010a) have analyzed the Road infrastructure of five regions of Portugal from 1980-1998. The results of the analysis suggested that investments in seven shadow-tolled freeways (called SCUT) have positive economic effects in all regions of the country. To add to this, regional spillovers constitute around 75 per cent of the total effects of these investments. The same year, Pereira and Andraz (2011) carried out another study on the Road infrastructure of 5 regions of Portugal from 1977- 1988 and concluded that Road infrastructure investments support long-term growth in all regions of the country. Further, the authors concluded that in the long term, there is no trade-off between the potentially positive economic effects and the potentially negative budgetary effects of such investments.

3.4.2. Evidences from the Literature in the Indian Context

Coming to the Indian context, there have been very few studies which have examined this important relationship between Public infrastructure investment and economic growth. Though there have been studies which have analyzed the various aspects of the role of infrastructure in terms of achieving economic growth. However, there is still insufficiency of research works when it comes to particularly analyze the Public infrastructure investment and economic growth relationship.

Barnes and Binswanger (1986) focused on the energy infrastructure and suggested that electricity and other rural infrastructure have a relatively direct influence on agricultural productivity through private investment on electric pumps. Binswanger, Khandker, and Rosenzweig (1993) stressed on the importance of road infrastructure and concluded that the major impact of road infrastructure is in terms of achieving mitigation in transportation costs and an increase in productivity.

Elhance and Lakshamanan (1988) highlighted the importance of infrastructure investment from an Indian prospective. They made use of both physical and social infrastructures to show that the mitigations in production costs in manufacturing occur because of investing in infrastructure. In a more exhaustive study, Datt and Ravallion (1988) concluded that Indian states which are possessed with better infrastructure and human resources, when compared with other facilities, usually have observed higher growth rates and faster poverty reduction. Das and Barua (1996) estimated that inter-state inequality is increasing day by day among infrastructure sectors like construction, electricity, gas and water supply and transport, storage and communication. Employing Indian data, Serven (1996) found out that, while public infrastructure investment crowds in private capital in the long run, other kinds of

government investment that compete in a direct sense with the private sector crowd out long run private investment.

Devarajan, Swaroop, and Zou (1996) put forth their view that public expenditure such as capital investment which was basically perceived as productive, could turn out be unproductive. Differentiating between productive and unproductive expenditures, they illustrated that the impact on growth is dependent not only on the productivity of the two expenditures but also on their initial shares. Hence, an increase in productive public expenditure might prove to be unproductive if its initial share is already extreme. This inference was substantiated by fetching data from 43 developing countries over a time span of 20 years. Further, through their analysis Devarajan et al. (1996) concluded that the relationship between capital expenditure and growth per capita was negative, while that between current expenditure and growth was positive. On the basis of these results, they suggested that governments of developing countries had the tendency to 'over-invest' in public capital. On similar lines, Pritchett (1996) asserted that public investment in developing nations is quite often contributed for unproductive projects. As a result, the proportion of public investment in GDP can sometimes be demonstrated not to be a good measure of the actual increase in economically productive public capital. Therefore, the effect of infrastructure on economic growth can differ from being negligible to even becoming negative (Eberts, 1986; Devarajan et al., 1996; Pritchett, 1996).

Sahoo and Saxena (1999) used the production function approach and estimated that infrastructure sub sectors like transport, electricity, gas, water supply and communication facilities have a considerable positive effect on economic growth with increasing returns to scale. Ahluwalia (2000) employed plan expenditure as a pivot for public investment and analyzed the factors of economic growth for Indian states. She pointed out that though plan expenditure is not exactly same as public investment due to scarcity of data, the only option

which remains is the size of State plan expenditure, as it has a relationship with the State plan only. Ghosh and De (2000) paid attention to the physical infrastructure facilities across the South Asian nations over the last two decades and suggested that the differential endowments in physical infrastructure majorly accounted for increasing regional disparities in South Asia.

Jena (2004) carried out a state level study and examined the effect of public expenditure on economic growth for the period 1980–2000 using the simple pooled panel regression model. He concluded that Indian states have diverse and varied cultures, infrastructure, natural endowments etc., all of which have the ability to affect their local economic growth either directly or indirectly. Sahoo (2006) in his research showed that infrastructure development has the ability to attract Foreign Direct Investment (FDI) into South Asian nations. During 2006 only, Trivedi (2006) investigated the impact of human capital along with state's developmental expenditure on inter-State economic growth of India.

Sahoo and Dash (2012) worked on a panel causality analysis involving four South Asian countries including India and found out a long run equilibrium relationship between output and infrastructure. They also concluded that infrastructure development contributes in a significant manner to attain output growth in South Asia. Further, the examination showed that there is a mutual feedback between total output and infrastructure development with one way causality running from infrastructure to per capita income. Next year, Sahoo and Dash (2009) carried out another research where they estimated three production functions. Each production function had infrastructure stocks index as an input factor alongside varying private inputs. The authors estimated that the long-run output elasticity of infrastructure is positive and statistically significant in each of the three cases, with values ranging from 0.24 to 0.35. These results further revealed that the output elasticity of the infrastructure index is greater than that of private capital and total real investment, meaning that infrastructure has a

considerable impact on economic growth in India when compared with either of these two variables.

In general, it becomes quite evident from the previous research works that the impact of public capital or public infrastructure investment is growth enhancing. However, the impact is still lower than what was estimated by Aschauer (1989a) and Munnell (1990), which is supposed to be the initiating point in this field of research. Further, as per the studies cited above it can be seen that the effect of public infrastructure investment differs across nations, regions and sectors depending upon the quality and quantity of capital stock and level of infrastructure development. Besides this, there is proof for reverse causality also. Therefore, not only does public infrastructure investment fuel economic growth, but higher growth also results in a higher demand for public infrastructure investment.

Hence, it can be said that Public Infrastructure Investment is a critical input for economic growth. The requirement for a substantial increase in the Infrastructure Investment, particularly in low income countries gets more and more important and there is an urgent need to deal with these issues and ultimately tackle multiple policy challenges. However, as nations around the globe continue to grow and develop, there is increasing interest in elucidating this dynamic relationship more comprehensively. Though there have been studies which have analyzed the different aspects of the role of infrastructure in terms of achieving economic growth, however, there is still insufficiency of research works when it comes to particularly analyze the relationship between Public Infrastructure Investment and economic growth for India, particularly from a state level point of view. Hence, it becomes all the more important that a state level study is carried out to analyze this vital relationship between Public infrastructure investment and economic growth for the Indian states. This forms the basis for the first research gap of our study i.e to examine the critical relationship between public infrastructure investment and economic growth for the Indian states.

3.5. ISSUE OF INFRASTRUCTURE FINANCING

Public infrastructure investments are illustrated by large capital intensive natural monopolies like railways, highways, water and sanitation systems (Gramlich, 1994). It is a well established fact that public infrastructure availability has a crucial role to play in bringing down the poverty levels and supporting economic growth. That is why governments of developing nations, including India, prioritize infrastructure development in their policy making agenda. From an Indian context, the inadequate and below par state of Infrastructure is well understood and documented. That is where the issue of getting money and investing in infrastructure comes into the picture. In other words, the topic of Infrastructure financing attains importance.

When the issue of infrastructure financing is being discussed, it refers to the financing of an infrastructure project. The seminal issue relates to the fact that how global savings can be channelized on the lines of long term financing for investment and in particular public infrastructure investment. Over the past few years, this issue has attained paramount importance with discussions happening on it at various international forums, including the Group of Twenty (G20) and the Asia-Pacific Economic Cooperation forum (APEC), Even the G20 created a study group on Financing for Investment in February 2013 to explore ways through which the G20 can promote long-term investment and guarantee the availability of sufficient funding for infrastructure projects.

The ever increasing interest in this topic of Infrastructure Financing is based on appreciating the point that removal of infrastructure blockage is vital for achieving a strong, sustainable and balanced growth. Seeing the current scenario where interest rates are becoming static at historically low levels across many nations, there exists an opportunity to fund these long term productive investments, in particular public infrastructure investments. For many

economies, current as well as future infrastructure requirements are believed to be posing a problem for governments as they are unable to finance these needs given the fiscal constraints prevalent in those nations. This leads us to the question that whether the private sector financing can play a greater role or not. As per the 12th five year plan, the anticipation is that around 50 per cent of investment requirements in India would have to be met through private sector funding and hence the share of private sector funding is expected to rise considerably from approximately 37 per cent in 11th five year plan to around 48 per cent in 12th five year plan (Lakshmanan, 2008).

The different Infrastructure financing options have been discussed below:

3.5.1. Financing Options

It is a well known fact that financing the high primary cost of constructing infrastructure and the following payments for services bestowed by infrastructure can take numerous forms. At the opposite ends, there lies public procurement (in which the government finances and owns the asset) and private infrastructure investment (where the private sector finances and owns the asset). In between these two, there is something called a Public Private Partnership (PPP) arrangement in which the risk is shared between the public and private parties.

3.5.1.1 Public Financing

Public sector's role in infrastructure investment has been acknowledged for decades now. Public service provision is among the 'three duties' which Adam Smith attributed to a particular government (Smith, 1776). Public financing can take place in different forms like general budget appropriations for infrastructure projects which are financed through tax revenue or government debt, revenue bonds attached to specific infrastructure projects, or infrastructure investment by government trading enterprises (GTEs) including national development banks (NDBs). NDBs are a special kind of GTE which have been formed to

offer credit and other financial services to those sectors of the economy that are considered by private financial institutions as under-servicing. As such, they reside in economies with less developed financial sectors. While the NDBs server a broad range of sectors, a recent World Bank survey found that 65 per cent of NDBs possess infrastructure as one of the 'target sectors' to which they can lend (Luna-Martinez & Vicente, 2012). Developing countries can also have the privilege of getting access to concessional and/or non-concessional financing from multilateral development banks (MDBs), such as the World Bank. In many nations, public financing of infrastructure through budget appropriation is prevalent. Budget appropriation has high level of transparency and public scrutiny in comparison to other government financing methods. Given the lower cost of government debt in relation with private sector debt, it can also prove to be a cost effective way of financing infrastructure.

On the other side, there are possibilities of certain constraints from budgetary processes like fiscal rules (debt or deficit limits) which can impact public infrastructure investment. Also sometimes there can be political pressure to take on particular investments without doing any sort of cost benefit analysis. Hence, in this direction the option of privatization of existing assets has also been exploited to delve into new avenues of public financing for upcoming new infrastructure projects.

3.5.1.2 Private Financing

As the name suggests, the financing is primarily done by the private sector. Under this, infrastructure projects financed come under two groups: those which are fully owned and operated by private sector, for example private telecom networks etc. and those which are commissioned by the government but partially financed by private sector. Those projects which fall under the second group are named as PPPs. Under this section, we will focus on the Private financing mode. Private financing is done through two ways – debt and equity.

Debt forms a prime part of infrastructure financing, with its dependency on the stability and certainty of income flows. As a matter of fact, debt funding has been considered to be around 90 per cent of total funding for PPP social infrastructure projects wherein the payments made by the government for the infrastructure services are stable and expected (Ke, Wang, Chan, & Lam, 2010). Debt financing is generally constituted by loans from banks, although some private projects have also been funded by issuing bonds in the capital markets, particularly in Europe. Coming to equity financing, investors under this category can be categorized as primary or secondary investors. Primary investors directly indulge in decisions concerning the construction of the infrastructure asset, such as construction companies. Certain projects also have the option of raising equity on financial markets via an initial public offering (IPO). A recent progress in the field of equity financing has been the superposition of large pension or superannuation funds, some of which have been invested directly in an equity stake at the start-up (Greenfield) phase of the project. Once the projects start operating with established revenues, many times it is observed that equity is sold in the secondary market to investors with a lower desire for risk. The infrastructure funds and pension funds usually prefer to invest at this stage of the project. By selling off these proven assets, primary equity investors get the opportunity to free up capital so that they can invest in new infrastructure projects.

3.5.2. Promotion of Private Investment in India's Infrastructure

Post 1991, India has followed the policy of drawing private investment into the infrastructure sector. In 1997, the Infrastructure Development Finance Corporation Ltd. (IDFC) was included as a dedicated financial intermediary for infrastructure. The IDFC's range of infrastructure services covers energy, telecom and information technology, urban infrastructure, health, education, and tourism infrastructure etc. The IDFC handles all those initiatives which will effectively rationalize the policy and regulatory frameworks and

ultimately remove any kind of barriers which are obstructing the movement of capital towards the infrastructure sector.

Historically, the public sector used to claim that they only have the responsibility of providing access of basic infrastructure services to the poor. However, these claims have been mainly rejected by continuous letdown of public sector in terms of fulfilling this ensured access. At the same time, all those projects which had the involvement of private sector have displayed considerable superior quantity, efficiency gains and giving benefits for the poor (Mukhopadhyay, 2004). Friedman (2009) in his book 'Capitalism and Freedom' points out to the issue of minimal state and maximum private sector participation. Going by his theory, the public institutions are not capable enough to deliver public services in an efficient way and hence, private sector's involvement is required to produce more efficient and qualitative goods and services (Friedman, 2009).

3.5.3. Importance of Private Financing

The above discussion shows that it is time to promote private sector investment. This section gives an overview of the literature which highlights the importance of private financing. Perotti (1995) through his study gave a framework which stated that partial privatization is a way for a government to signal in a convincing manner that it will not act opportunistically upon privatization (like decreasing or eliminating tolls, once the toll-highways are privatized). The profits were understood to be exogenous in this model. Clarke and Wallsten (2002) focused on the insufficiency of public provision of infrastructure services in fulfilling the increasing demand for many nations around the world.

Many studies have been done which have studied the impact of privatization and depicted that well designed schemes can help in raising the welfare levels. Shirley (2002) carried out his study and concluded that private participation in water and sanitation leads to overall

domestic welfare benefits of 1.4 billion USD in Buenos Aires and 23 million USD in Guinea. Also, cases of private involvement in sectors like power, telecom and port were analyzed for a group of nations and it was concluded that private investment led to significant welfare gains to the government, investors, consumers and most importantly the workers (Galal, 1994; Newbery & Pollitt, 1997). Private participation has got the ability to improve efficiency by introducing various incentives in order to ultimately cut down on the wasteful costs and collect greater revenues. Some of these benefits were observed in the telecom sector, where the major driver for improved efficiency had been competition (Ros, 1999; Bortolotti, D'Souza, Fantini, & Megginson, 2002). Kikeri and Nellis (2002) through their study on various economies pointed out yet another improvement brought by privatization to the government. This benefit was in terms of fiscal gain. There was an increase in amount of tax revenues collected when compared with a situation before privatization where losses came to as much as 5-6 per cent of GDP.

Many European nations and other governments around the world have gradually turned towards private sector involvement (either fully or via PPPs) in the development, financing and provisioning of public infrastructure and related services (Maynard, 1986; Zheng, Roehrich, & Lewis, 2008; Mahoney, McGahan, & Pitelis, 2009; Anderson, 2012). Their supporters put forth the argument that by preaching increased diversity of provision and contestability, these 'partnerships' are able to provide better quality infrastructure and services at 'optimal' cost and risk allocation (Kwak, Chih, & Ibbs, 2009). Over the past decade, the use of PPPs has grown almost five times (PWC, 2010), with almost 4 billion USD worth of health PPP contracts signed universally in 2010 alone (Carty, 2012). The rising popularity of PPPs can also be seen in many other developed, developing and emerging nations (English, 2005; Guasch et al., 2008; Yang et al., 2013).

Coming to the Indian context, two studies carried out on PPPs need a special mention here. Lakshmanan (2008) made his contributions by giving an abstract of sector wise infrastructure progress in India and the development of PPPs in building such infrastructure. Through this study, certain concerns and issues were highlighted that needed awareness in terms of attracting private investors to get involved in infrastructure building. The other study was done by Kaur, Lakshmanan, Rajesh, and Kumar (2010) where the authors studied the means of infrastructure financing in India and focused on the crucial and pristine role played by the Reserve Bank of India (RBI) with respect to this field. Now, it can be certainly said that PPP option of infrastructure financing is increasingly becoming the better way to provide public services in various nations across the world.

Therefore, the above discussion says that there have been studies which have focused either on the inefficiency of public financing or stressed on the importance of private financing including the PPPs. However, little research has been done on analyzing the different modes (Public, Private and PPP) of investing/financing major sectors of Infrastructure, and then suggesting the best mode of financing for the purpose of designing developmental policy. Hence, it becomes all the more important that a study to examine which mode of infrastructure financing is preferred for India's major Infrastructure sectors as well as overall scenario is carried out. This forms the basis for the first issue pertaining to the second research objective of this study.

3.5.4. Definition of PPP

While the above sections have discussed the importance of private financing including the PPPs and the viability of PPPs as an option of Infrastructure financing, one needs to be well acquainted with the term PPP. This section gives an outline of how PPP is defined in the literature.

There are numerous definitions existing in the literature for PPP. However, according to the most common definition of PPP, it refers to a contractual agreement between a public and a private party to produce and deliver public service under a particular time frame, agreed between both the parties. A PPP can also be defined as a long term contract between a private player and a government agency for giving a public asset or a service, for which the private party manages the responsibilities and bears a significant amount of risk (World Bank, 2012). A public private partnership is a legally binding contract between the Government and private operator for delivery of public services through provision of assets and division of risks. On a general basis, the private sector takes on the functions of project design, technology, construction, financing and operations. At the same time, it is the government's responsibility to make sure that there is proper legislation in place for letting the private players get involved and start working.

Historically it is observed that Indian government has acted like a monopoly in terms of provisioning the infrastructure. However, with the ever increasing gap between infrastructure requirements and the financing resources available at disposal of the government, PPP has appeared as a better option of financing infrastructure. Deloitte (2006) focused on this paradigm shift and discussed the pros and cons of this new financing mode. The World Bank also started tracking all the relevant details pertaining to PPPs around the world and ultimately started their own database i.e Private Participation in Infrastructure (PPI) Project database. This database consists of information on more than 4800 projects from different sectors and the provided data spans across 139 low and middle income nations.

There are certain advantages as well as disadvantages of PPPs which are presented and discussed in the following section.

3.5.4.1 Advantages of PPPs

The following section explains the benefits and opportunities which PPPs have to offer. Everyone is well aware of the huge capital required to finance infrastructure investments and the efforts which government put in to get this finance. However, they are able to finance only upto a certain limit. That is where the involvement of private sector comes in and it is able to tackle the capital constraint. This phenomenon is in particular a necessity in those nations which have lack of capital market and hence, private investment pushes the flow of capital higher, which otherwise would have been difficult to obtain. Due to its experience in several nations, the private sector is able to bring in advanced technology and as a result public services are delivered in a more cost- efficient way rather than the traditional approaches. Ultimately, this efficiency delivery of services by PPPs boosts the savings which can be used to fund other needed operations. Example of developed nations like US and UK can be cited where the PPPs projects in infrastructure have made the savings amount to 15-30 per cent on the back of efficient project management by the private investors, less construction time, and lower administrative expenses (Moszoro and Gasiorowski, 2007). For a given infrastructure project, the private sector has the ability to get financing and management competency. With the major focus on profits, the private sector makes sure that efficiency and self sustainability of infrastructure facilities are not compromised with the ultimate objective of providing best quality of services. In exchange to this, the public sector can provide encouraging business environment, better access to credit along with investor protection (De Bettignies and Ross 2004; Kirkpatrick, Parker, & Zhang, 2006; Linder 1999). Harris, Hodges, Schur, and Shukla (2003) have concluded that PPPs enhance access to services, raise the efficiency, provide better quality services and have positive fiscal impacts. Andres, Foster, and Guasch (2006) did their research in electricity sector and finally concluded that PPPs can produce considerable improvements in labor productivity, efficiency and product/service quality of the electricity firms.

Nickson and Franceys (2003) found evidence which suggested that general public perception regarding the affordability of privately managed utilities is not correct as there are clear facts which confirm that these utilities can extensively improve access to basic services for the poor at reasonable price. Joha and Janssen (2010) evaluated the strategic intents and motives for PPP in three projects by making use of the case study method. They founded out that PPPs were focused on developing new and innovative services along with the fact that projects managed to achieve majority of their intents at the cost of higher risks.

3.5.4.2 Criticisms of PPPs

In spite of the advantages of PPPs, they also pose certain risk for both government as well as the private sector. Due to higher level of autonomy given to the private sector, the government may lose its control from the service delivery which formerly was under the monopoly of the government. Also, the costs of PPPs can rise to a higher level during the implementation phase because of autonomy which the private sector possesses. If the private sector fails in its attempt to offer high quality services with low cost, it leads to a scenario where there are high chances of the government of losing its reputation and credibility. Also, it is observed many a times that the consultation process for investing through PPPs is pretty poor and it is carried out just for the sake of formality, that too at late stages with no real intention of taking public opinions into consideration. This also becomes a limitation for the public as they are the final beneficiaries of services delivered.

The difficulty in terms of balancing out the interest of the poor against the interest of the private sector is a usual phenomenon observed in terms of PPPs as private sector always aims for profit maximization (Nkohma-Mbawa, 2006). Edwards and Shaoul (2003) analyzed the effectiveness of PPPs and suggested that several times contractors fail in their attempt to transfer risk and ultimately the public sector has to bear the majority of the cost of projects,

which leads to the failure of PPP projects. In a series of case studies of PPPs across eight nations, Sanghi, Sundakov, and Hankinson (2007) found that at the initial level the major motivation for governments to enter into a PPP contractual framework was to basically draw private players so that they can fund the infrastructure investment requirement. However, as nations gained experience with PPPs, governments started taking into account the optimal risk allocation and net present value of money under a PPP contract as compared to a scenario where the governments fund infrastructure fully on its own.

After discussing what PPPs are and what are their pros and cons, we move forward to examine the issue which still continues to attract attention from most of the researchers i.e what are the determinants of PPPs in developing nations. The following section gives an overview of the studies which have examined and estimated the determinants of PPPs.

3.5.5. Determinants of PPPs in Developing Countries

There have been numerous studies which have examined the impact of PPPs on economic development and stressed on the need which the developing nations possess for PPPs. According to (Dailami & Leipziger, 1998; Fay & Yepes, 2003; Yang & Kohler, 2008) the rapid and fast paced industrialization and urbanization is piling on the pressure on existing infrastructure in developing nations. The latest trend points to the fact that governments in developing nations are heavily dependent on PPP model to plan, finance, build and operate infrastructure projects (PPI database, 2013). Hence, this leads us to the major question which is being posed by researchers of this field that what are the major factors which determine the PPPs involvement in developing countries. For this study, the focus is on estimating the determinants of PPPs in India. Certain empirical studies exist in the literature that have tried to explain and examine the major determinants of PPPs. One recent study was done by Sharma (2012), which he took variables related to macroeconomic conditions, market size,

government effectiveness, politic environment etc. and estimated that macroeconomic stability, quality of regulation and governance are important factors in terms of attracting more PPP projects. The author carried out this analysis for twenty two developing nations. These nations are Argentina, Bangladesh, Brazil, Chile, China, Colombia, Egypt, India, Indonesia, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Russian Federation, South Africa, Srilanka, Thailand, Turkey, Venezuela, Vietnam. Based on the literature available, three pertinent areas have been classified so as to analyze the determinants of PPPs:

- The motivation available to governments to involve the private sector in infrastructure financing
- The motivation available to the private sector to enter into a PPP with the government
- The fundamental context in terms of institutional and macroeconomic environment, which motivates both the public and private sectors to get engaged in PPP framework

In the table given below, certain important factors (majorly used in the literature as the determinants of PPPs) falling under each of the above mentioned three categories have been discussed.

Table 3.1: Factors potentially impacting the level of PPP received

Category	Factors identified in the literature
Government Motivations	Ability of government to finance infrastructure; Improved efficiency and tariff discipline in infrastructure sectors
Private firm motivations	Adequate regulatory framework and proper enforcement of laws; Independent regulatory institutions and processes; Access to credit; Consumers' ability to pay for services; Political stability and public opinion on private provision of infrastructure services
Enabling environment	Macroeconomic environment; Institutional capacity to regulate PPPs; Structural characteristics of a nation

- The first factor is Government's resource constraint. Governments with large deficits and huge debt burden are expected to have PPPs. The constraints of the governments in terms

of having a limited budget motivate them to engage with private firms through PPP projects.

- The second factor is stable macroeconomic situation. PPP projects and related investments in private sector are usually observed in nations with reliable and stable macroeconomic conditions. Previous studies of Ghura and Hadjimichael (1996), De Soto (2000), Allayannis and Weston (2001), Estache (2006) and Banerjee, Oetzel, & Ranganathan (2006) have concluded and confirmed the important fact that macroeconomic stability is a vital and imperative issue in private sector involvement. Banerjee et al. (2006) substantiated the importance of macroeconomic environment by concluding that Inflation and variations in exchange rate are supposed to have a detrimental effect on PPP. Moreover, while analyzing PPP trends over the past few decades, we can clearly observe stark drops in PPPs during the times of macroeconomic crises, like the financial crises in Asia in 1997 and in Argentina in 1999 (Harris, 2003).
- The third factor is market size. According to Sharma (2012), a large market is expected to attract more private firms to get involved in PPP projects majorly because of the possible future growth prospects.
- The fourth factor is political environment. It is widely accepted fact that foreign investors take into account the political environment of a nation before investing in that particular country. This factor is measured by rating agencies such as Moody's, Standard and Poor, International Country Risk Guide. Sharma (2012) in his study took this factor and put forth the hypothesis that better political environment lead us to a large number of PPPs.
- The fifth and final factor is regulatory environment. Previous studies by Pistor, Raiser, & Gelfer (2000) and Hammami, Ruhashyankiko, & Yehoue (2006), suggest that weak and incoherent institutions and political risk lead to uncertainties about the regulations, which

further boost the country risk and have a detrimental effect on the nation's image. In this view, Sharma (2012) in his study raised another hypothesis that better regulation attracts more number of private firms for PPP projects. Lamech and Saeed (2003) carried out a survey of firms from power sector that are investing in PPPs for developing nations. The authors found out that firms prioritize the presence of a regulatory framework while taking their decision on whether or not to invest in a developing nation. The firms feel that the presence of a regulatory framework effectively defines investors' rights and responsibilities along with the ability to enforce them. Pargal (2003) focused on the significance of the regulatory framework as a determinant of PPP for Latin America and the Caribbean (LAC) nations and concluded that the most important determinant of PPP is the passage of legislation liberalizing the investment establishment. In another study of this kind, Kirkpatrick et al. (2006) found out that institutional framework and regulation hold the key.

- A list of other factors associated with the structural characteristics of the PPP receiving nation may also impact. For example, the legal tradition in the country can impact the regulatory environment in which PPPs operate (Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1997; de Silanes, La Porta, Shleifer, & Vishny, 1998). Furthermore, the trade openness holds a positive link with increased FDI (Asiedu 2002; Morrisset, 2000).

Therefore, the above discussion indicates that it becomes very crucial to examine what are the major factors that determine PPPs involvement in India. This helps to identify one more research issue i.e. investigating and estimating the important determinants of attracting any PPP in India, which will be addressed under the second research objective of this study.

3.6. DEBT AND ECONOMIC GROWTH

It is a well known fact that majority of the developing nations face the issue of high debt burdens and the related hazardous effects on their economic growth and development aspects. This is of deep worry to the researchers and policymakers around the world (Pattillo et al., 2002; Scharlarek & Ramon-Ballester, 2005; Rogoff & Reinhart, 2010; Kumar & Woo, 2010; Cecherita & Rother, 2010). If the economy is described by a high debt stock, then a major proportion of the tax revenue must be used for repaying the interest payments incurred on public debt, leading to fewer resources being left for public investment. Also the uncertainty quotient accompanying high levels of debt creates less efficient investment in the sense of fewer returns and hence leads to slower productivity growth.

Therefore, the impact of public debt on economic growth still remains a contentious issue both from a policy making as well as an academic point of view. This issue is of particular severity when it comes to Indian context, where the nation along with its states is confronted by heavy debt burdens and low economic growth. The following section gives a summary of the literature available on this issue.

3.6.1 Literature Review

Theoretically, there is availability of substantial amount of literature that links debt levels with the growth scenario of an economy. The usual argument is that debt can help underfunded economies to achieve higher economic growth, only if proper allocation is done. However, at the same time if this debt exceeds a particular threshold value it may prove out to be harmful. In this regard, the economic literature cites many instances and channels where debt gets transformed into a major factor hampering economic growth. Excessive debt may obstruct future economic growth through the debt overhand effect (Sachs, 1986; Krugman, 1988; Borenstein, 1990; Checherita-Westphal & Rother, 2012 etc.).

Going back into the history, it all started when Krugman (1988) coined the term "debt overhang". The debt overhang theory proposes that in the initial developing stage, a nation needs to enhance its capital stock and in turn, economic growth and development, by borrowing. However, when the debt starts accumulating, all the resources are used up to service this debt, diverting the first and foremost focus of using these resources to finance the development needs of the nation.

Krugman (1988) defined debt overhang as "*the presence of an existing inherited debt sufficiently large that creditors do not expect with confidence to be fully repaid*" (Krugman, 1988, p.254). Another argument came from Claessens and Diwan (1990) who said that "*debt overhang is a situation in which the illiquidity effect, the disincentive effect, or both effects are strong enough to discourage growth in the absence of concessions by creditors*" (Claessens & Diwan, 1990, p. 31). Cohen (1993) proposed a theoretical model which postulated a non-linear effect of foreign borrowing on investment. Nguyen, Clements, & Bhattacharya (2003) suggested that up to a threshold, foreign debt accumulation can encourage investment, but beyond such a point the debt overhang will start mounting negative pressure on investors' desire to provide capital.

Going on same line of action, the growth model proposed by Aschauer (2000), which estimates a non-linear effect of public capital on economic growth, can be further extended to cover the impact of public debt. Based on the assumption that government debt is used at least partially to finance productive public capital, an increase in debt would impart positive effects till a particular threshold and negative impacts beyond it. Serieux and Samy (2001) put forth their argument that debt overhang induces a hindrance environment for private investment which eventually leads to a slowdown in economic growth rate on the back of lower investment spending. As economic growth dips, debt to income ratio increases thereby

leading to the escalation of risk premium for future borrowing, and ultimately strengthening the disincentive effect.

Till now in the literature, there have been many research studies which have analyzed the debt growth nexus. Mostly of these have examined that the relationship between debt and economic growth is non-linear and is distinguished by the fact that there is a particular threshold value above which the debt starts putting a negative impact on economic growth. Pattillo et al. (2002) took a large panel dataset of ninety three (93) developing countries over the time period of 1969-1998 and estimated that the effect of external debt on per-capita GDP growth is negative for net present value of debt levels above 35-40 per cent of GDP. Nguyen et al. (2003) analyzed the same relationship for a bunch of 55 low-income nations spanning across the time period 1970-1999 and concluded that the turning point in the net present value of external debt is approximately around 20-25 per cent of GDP. Earlier researches which had found out a non-linear impact of external debt on economic growth included Smyth and Hsing (1995) & Cohen (1997).

However, contrary to all this, Schclarek (2004) found a linear negative impact of external debt on per-capita growth (with no proof of an inverted U-shape relation) for a bunch of 59 developing nations over the time period 1970-2002. Schclarek (2004) also examined the association between gross government debt and per capita GDP growth in developed nations. The analysis was done for a sample of 24 industrial nations with data averaged over seven 5 year periods between 1970 and 200. However, no statistically significant relationship was found for this sample between the analyzed variables.

More recently, Rogoff and Reinhart (2010) carried out their study and found out that alarming debt alarms are negative correlated with economic growth. However, they also suggested that there is no connection between debt and economic growth when the public

debt is below 90 per cent of GDP. The authors depicted this threshold effect by accumulating annual data on debt and output growth for twenty advanced economies spanning across the time period of 1946 to 2009 and dividing the overall sample into four groups: (i) country-years for which public debt is below 30 per cent of GDP (443 observations); (ii) country-years for which public debt is between 30 and 60 per cent of GDP (442 observations); (iii) country-years for which public debt is between 60 and 90 per cent of GDP (199 observations); and (iv) country-years for which public debt is above 90 per cent of GDP (96 observations). Post this classification, they calculated median and average GDP growth for each group and demonstrated that there are no major differences among the first three groups. However, for the fourth group i.e country-years for which public debt is above 90 per cent of GDP, the average and median GDP growth are significantly lower. Specifically, the authors estimated that in the high debt group, median growth is approximately 1 percentage point lower and average growth is roughly 4 percentage points lower than in other groups.

Rogoff and Reinhart (2010) prominent paper commenced a novel wave and literature aimed at analyzing whether their findings were strong enough to allow for non-arbitrary debt brackets, to control for other variables in a suitable regression set-up, and to instrument public debt in order to assess its causal impact on economic growth. However, Rogoff and Reinhart (2010) study was criticized by the economics fraternity when a new study by Herndon, Ash, and Pollin (2014) discovered mathematical errors in Rogoff and Reinhart (2010) dataset. Herndon et al. (2014) reported that in the same postwar sample which Rogoff and Reinhart (2010) had taken, the average annual growth rate only reduces from 3 per cent to 2.2 per cent when the debt to GDP ratio is greater than the 90 per cent threshold. Even though neither of these studies was able to answer the causality question, the empirical conclusions of both the studies referred to a negative relationship between debt and

economic growth when debt is greater than a particular threshold. Even if we exclude the causality issue, all the worry about high indebtedness for achieving economic growth and socioeconomic development are rightly arranged in a broader sense. Of late, Checherita-Westphal, Hughes Hallett, and Rother (2012) have framed a theoretical model which says that, over the business cycle, debt can only be issued to finance public investment and the optimal level of public debt can be calculated by the public to private capital ratio that maximizes economic growth. Checherita-Westphal et al. (2012) employed this model and estimated optimal debt ratios for various subsamples of OECD nations. The authors found out values in the range of 43 to 63 per cent of GDP.

However, Greiner (2012) argued that the results given by Checherita-Westphal et al. (2012) were based on the assumption that deficit is equal to public investment at each point of time. As per the argument given by Greiner (2012), in such a case, debt becomes totally irrelevant and the non-linear relationship between debt and economic growth is explained by growth-maximizing tax rate. He further analyzed that if a comparatively general policy on debt is allowed, then it leads to a monotone and a negative relationship between public debt and steady-state growth. Greiner (2011, 2013) also said that the impact of debt on economic growth is dependent on the rigidity in the economy. More specifically, Greiner (2011) showed that, in a model with no rigidities and elastic labor supply, public debt imparts a negative effect on investment, labour supply, and finally economic growth. When there is an existence of any wage rigidities and unemployment, public debt can even exert a positive impact if it is used to finance productive investment.

Greiner (2012) also concluded that there is no well known precise model which can produce an inverted U-shaped relationship between debt and growth. Non linearities may arise if there is a particular threshold point above which public debt will become unsustainable (Ghosh, Kim, Mendoza, Ostry, & Qureshi, 2013).

Minea and Parent (2012) studied the relationship between debt and economic growth by making use of the Panel Smooth Threshold Regressions model originally proposed by Gonzalez, Terasvirta, and Dijk (2005). Using this model, that allows for a measured change in the regression coefficient when moving from one regime to the other, these authors concluded that public debt is negatively related with economic growth when the debt-to-GDP ratio is above 90 per cent and below 115 per cent. They further added that the correlation between debt and growth becomes positive when debt exceeds the level of 115 per cent of GDP. Minea and Parent's (2012) results suggested that there is a presence of complex non-linearities, which might not be included by models that use a set of exogenous thresholds.

Going by Rogoff and Reinhart (2010) results which said that differences in median growth are much lower than differences in average growth, Minea and Parent (2012) suggested that researchers should take into account the role of outliers and focus on checking their results by using different sources of data. They demonstrated how crucial the tests are by showing that varied data sources produce results that are different from those given by Rogoff and Reinhart (2010). For example, Minea and Parent (2012) used the data from Maddison (2007) and International Monetary Fund (IMF) Public Debt Database (Abbas, Belhocine, El-Ganainy, and Horton, 2011) and estimated that decrease in average (and median) growth rate between nations with a debt-to-GDP ratio below and above 90 per cent is small and not statistically significant.

In the same way, Afonso and Jalles (2013) showed that in a sample of OECD nations, the average growth rates over the time period of 1970-2008 for nations with low debt (i.e debt-to-GDP ratio < 30 per cent) is same that of high debt (i.e. debt-to-GDP ratio > 90 per cent) nations. Going by this trend, Egert (2015) extended the Rogoff and Reinhart (2010) sample back to 1790. Egert (2015) kept the twenty economies sample same as in Rogoff and

Reinhart (2010). However, the only change was the addition of Switzerland and the subtraction of Ireland. The results confirmed the presence of a tiny negative correlation between debt and growth and, using an endogenous threshold model, some sort of evidence of a non linear relationship between debt and economic growth. However, the predicted endogenous debt-to-GDP threshold value was much lower than 90 per cent.

Caner, Grennes, and Koehler-Geib (2010) in their research made use of a threshold regression model in order to assess the impact of debt on economic growth. The authors took a sample of 101 countries (75 developing and 26 developed) for the time period 1980–2008 and estimated that there are well defined levels of public debt, beyond which debt commences to have venomous effects on economic growth. This threshold or well defined level of debt was 77 per cent of GDP for the full sample and 64 per cent of GDP for the developing nations' sample. Therefore through this analysis, it was observed that the threshold value of public debt was lower in developing and emerging economies when compared with the developed ones.

Cecchetti, Mohanty, and Zampolli (2011) performed an analysis on this topic for a sample of eighteen OECD countries over the period 1980-2006 and concluded that a 10 percentage point increase in the debt-to-GDP ratio is correlated with an 18 basis points decrease in subsequent GDP growth. The authors further added by saying that the public debt variable is not statistically notable in all those regressions that do not involve time or country fixed effects.

While all these evidences of public debt being negatively correlated with economic growth are observed, such type of negative correlation does not essentially point to the fact that debt reduces economic growth. The relationship between public debt and economic growth could be based on the phenomena that it is the low economic growth that forces high levels of debt

(Reinhart et al., 2012). In alternate terms, the observed correlation between debt and growth could possibly be due to a third factor that imparts combined effect on these two variables. In other words, there can be an endogeneity problem.

Panizza and Presbitero (2014) explained the endogeneity problem and analyzed the probable direction of the bias by using a simple bivariate model in which economic growth was a function of debt and vice versa, debt was a function of growth. Kumar and Woo (2010) studied the relationship between debt and growth for a sample of 30 developed as well as emerging market economies for the time period 1970-2007. These authors tried to experiment with different estimation techniques and put forth their view that the system GMM estimator allows them to cater to the issue of endogeneity. The empirical results of Kumar and Woo (2010) aligned with those of Cecchetti et al. (2011), who had estimated that a 10 percentage point increase in the initial debt-to-GDP ratio is coupled with a slowdown in annual real per capita GDP growth of about 20 basis points.

However, the above discussed results must be deciphered with some caution. Attention needs to be given on the fact that system GMM estimators were created for their application on micro data and that they are poorly matched with macroeconomic datasets with a relatively small number of cross-sectional units (Bond, 2002). These system GMM estimators can experience weak instrument problems (Bun and Windmeijer, 2010). Also, the system GMM estimations of the relationship between debt and growth are pretty same to those obtained via usual Ordinary Least Squares (OLS) regressions. In actual sense, the system GMM coefficients are larger (in absolute value) than the OLS coefficients. Therefore, there can only be two likely interpretations for this result: either public debt is not endogenous, or the system GMM estimator does not solve the endogeneity problem.

From the above discussion, it can be inferred that the nature of the relationship between public debt and economic growth of a country has always been a much debated topic. Till today, there has been no clear consensus being developed among economists on this relationship. Further, it is quite visible that relationship between public debt and economic growth has been well researched at the international forum with numerous studies carried out in this respect. However, from an Indian context, there is a lack of focus in terms of examining this relationship between debt and economic growth barring a couple of studies (Singh, 1999; Bal & Rath, 2014). Therefore, it becomes very important to analyze how does public debt affects the growth of India and whether there exists a direct or an inverse relationship between the two variables. Overall the complete understanding about this relationship is very much necessary for our monetary and fiscal policy makers while formulating and implementing various policy decisions. The above discussion helps to identify the first issue under the third research objective of this study.

3.6.2 Relation between Debt and Fiscal Sustainability

While the critical relationship between debt and economic growth is being discussed, the issue of debt sustainability and eventually fiscal sustainability has to be considered. If the amount of debt taken by a nation goes into alarming zones, then it may have a detrimental effect on the economic growth of the economy and that is when this issue of fiscal sustainability gains importance. As per the discussion above, there are evidences of existence of an optimal value of debt above which public debt becomes negatively correlated with economic growth. The logic behind achieving an optimal value of debt is to ensure that fiscal sustainability of an economy is maintained. This viewpoint is discussed in the next section.

Conventional indicators of fiscal activity like public debt or annual public deficit were not successful enough to gauge the sustainability of government's policies. These traditional indicators only captured the short-term effects of current political decisions and because of which the issue of fiscal sustainability, which takes into account the long-term effects of the fiscal policy, became an important field in the economic literature. Sustainability is a term which is used quite often in the economics literature. But each time its usage is with different connotations under different circumstances (Balassone and Franco, 2000). If we relate the concept of sustainability concept with debt, then we can broadly say that a sustainable level of debt refers to the level which can be serviced through potential revenue expected in the future without impeding the productivity and solvency of the government. Here, clear distinction needs to be made between 'Sustainability' with 'Solvency'. Sustainability means having the ability to maintain or support government programmes in the future whereas Solvency refers to ability of a borrower to make required payments on debt.

Also, fiscal deficit of a government is defined as the surplus of government expenditure over government revenue. The accrued value of this deficit at any point in time is referred as the public debt. Therefore, deficit is a flow and debt is a stock. Soaring fiscal deficits impede the economy in various ways. From the context of developing and emerging economies, fiscal deficit is mostly high as public expenditure in these nations is often wasteful being poorly targeted along with the fact that good amount of subsidies are given on food, fertilizers, petroleum etc. A high fiscal deficit may result in an increase in interest rates, thereby enhancing the debt service payments and hence worsening the economic condition. Higher debt service charges constrain the amount of investment for the public sector, thus ultimately lowering the potential economic growth. Hence, it can be posited that if an economy is fiscally sustainable, then automatically its debt is also under control. Hence, by achieving debt sustainability, the aim is to achieve fiscal sustainability. The appropriate level of debt

that should be maintained leads us to a stable fiscal position. In other words, reviewing the previous research works on debt sustainability effectively gives us a comprehensive idea regarding fiscal sustainability and that both debt and fiscal sustainability can be used interchangeably.

From an Indian context point of view, the debt sustainability analysis gained significance during the late 1980s when stark fiscal deterioration was observed both at national as well as sub-national levels. However, majority of the research works done from an Indian prospective on debt sustainability have been restricted to Central government finances or to the state finances only at a consolidated level viz. Seshan (1987), Buiter and Patel (1992), Pattnaik, Prakash, and Misra (2003). Prasad, Goyal, and Prakash (2004) were some of the initial authors who laid emphasis on debt sustainability of Indian states. They focused on the warning effects of increasing debt and put forth their view that policy responses would decrease debt by a meager 1-2 per cent only. Dholakia, Mohan, and Karan (2004) submitted a report to the Twelfth Finance Commission in which they tackled two major issues: firstly, defining the sub-national debt to draw comparisons across the Sub national governments (SNGs) and secondly a state-wise assessment of debt sustainability. Taking debt/GSDP (Gross State Domestic Product) ratio and debt/states own revenue ratio, they observed huge decline in SNGs debt position. By disintegrating fiscal deficit into growth and fiscal behavior components, they estimated that fiscal stance taken up by the SNGs was highly unsustainable. Rajaraman, Bhide, and Pattnaik (2005) found out similar results when they detected a sharp rise in debt/GSDP ratio of SNGs during 1992-2002. In terms of Indian states, Rath (2005) investigated the fiscal development in Orissa and found out low level of development as the main reason behind poor tax base and tax revenues. As a result, Orissa totally relied on RBI to help the state in terms of fulfilling their daily expenditures. Hence, the debt position of the state was below sustainable levels. Sawhney (2005) analyzed the

fiscal position of Punjab and concluded that it faced fiscal difficulties during 1990s. Tamilnadu also saw unsustainable level of debts during 1990s and in the early 2000s (Ianchovichina, Liu, & Nagarajan, 2007).

Different types of approaches have been employed in the literature in order to analyze the debt sustainability issue. Some of the major ones include Domar debt sustainability condition, sustainability indicators analysis and present value budget constraint approach (Buiter & Patel 1992; Khundrakpam, 1998; Pattnaik et al., 2003). Some other approaches like the tax gap approach developed by Blanchard (1990) and Chouraqui, Hagemann, & Sartor (1990) were employed by Pattnaik et al. (2003) respectively.

However, there is no simple method or rule which tells us how to measure and assess fiscal sustainability. Chalk and Hemming (2000) provided an overview of various approaches which have used in the literature to assess fiscal sustainability. Vito and Wickens (2005) employed a simple VAR forecasting model to construct a fiscal sustainability index for US, UK and Germany by using the inter-temporal budget constraint. The index was based on a comparison of existing level of government debt with a forecast of the present value of current and future deficits and surpluses derived from the VAR model. The index was calculated as the ratio of this present value to the existing level of debt. If the index exceeds unity then the current fiscal standpoint of the considered nations is sustainable and if the index value is less than unity then the nations face concerns of fiscal unsustainability.

As discussed in the review of literature on the debt- growth relationship, the generally used approach to assess the sustainability of the fiscal policy for a nation is to observe if it has a stable public debt to GDP ratio (Blanchard, 1990). Various research works have been carried out estimating what should be the optimal value of debt to GDP ratio till which fiscal sustainability is intact. In an optimization setup, an optimal debt/GDP ratio can be defined as

one that maximizes social welfare and economic growth without cutting down on the private investments or increasing sovereign credit risks or raising overall development costs (Blanchard, 1983; Stein, 2004; Alfaro & Kanczuk, 2006; Rochet, 2006). Other way round, an optimal debt/GDP can be seen as one that is in sync with fiscal sustainability. For a bunch of 19 OECD nations, Perotti (1999) found out strong proof that fiscal stress, which he found out as a function of public debt and government's future expenditure needs, is a primary determinant of the impact of fiscal policy. Smyth and Hsing (1995) concluded that the optimal debt ratio that maximizes US growth is about 40 per cent of GDP.

Makin (2005) carried out an analysis for Indonesia and predicted that debt levels of above 38 per cent of GDP will be damaging to Indonesia's economic growth. Thus, the empirical literature is able to provide a variety of probable threshold levels of public debt dependent on countries' situations and the importance of policy objectives. These estimates vary from as low as 15 per cent of debt to GDP ratios for nations having a history of default (Reinhart, Rogoff, & Savastano, 2003) to as high as 60-70 per cent.

Therefore, the above discussion suggests that under the debt growth dynamics for India, there have been very few studies which have measured the fiscal sustainability of the Indian states. Also, till today there is hardly any study in the literature which estimates a threshold value of debt/GDP ratio (for each of the Indian states) above which it can be assumed that the fiscal stance becomes unsustainable for a state economy and ultimately India. This forms the base for the second issue that has been addressed under the third research objective of this study.

3.7. RESEARCH GAPS

Based on the review of literature, the following research gaps were identified:

- Firstly, to-date, very few studies have been conducted in India in terms of analyzing the relationship between Public Infrastructure Investment and economic growth for India, particularly from a state level point of view.

- Secondly, there is insufficiency of research works which have explored and suggested the best mode of infrastructure financing for India's major Infrastructure sectors. Also, the aspect of determining the major determinants of attracting any PPP in India is largely untouched and needs attention.

- Thirdly, the vital relationship between debt and economic growth needs to be evaluated, particularly from an Indian context. Also, measurement of fiscal sustainability and estimation of a threshold value of debt/GDP ratio for Indian states still remains relatively unexplored and requires its due attention.

3.8. CONCLUSIONS

On the basis of literature reviewed in the previous sections of this chapter, following conclusions were drawn. The relationship between Public Infrastructure Investment and Economic growth has been well researched elsewhere but it is slowly gaining pace in Indian context. On a general basis, it can be concluded from the previous research works that the effect of public infrastructure investment is growth enhancing. Further, the existing literature indicates that the impact of public infrastructure investment is different across nations, regions and sectors and depending upon the quality and quantity of capital stock and infrastructure development. Very few preceding studies done in Indian context have explored the relationship between Public Infrastructure Investment and economic growth

from a state level point of view and hence it becomes all the more important to undertake this study. Moving on to the issue of Infrastructure financing, the theoretical literature existing on this topic has analyzed only specific issues like either focusing on means of Infrastructure financing or just examining the private financing part. There are not many studies done in Indian context that have compared the different modes of Infrastructure financing for Infrastructure sectors and then evaluating which one should be preferred. Also, analysis and estimation of determinants of PPPs still remains an issue which is relatively unexplored, particularly from an Indian prospective. Proceeding to the contentious issue of analyzing the impact of public debt on economic growth, there is good amount of empirical literature which has investigated this issue. Most of these studies have negatively correlated public debt with economic growth and provided a variety of probable threshold levels of public debt above which concerns of fiscal sustainability arise. These threshold estimates vary from as low as 15 per cent of debt to GDP ratios to as high as 60-70 per cent. However, India's debt levels and economic growth need attention. Under the debt growth dynamics for India, the fact that what should be the optimal value of debt to GDP ratio for each of the Indian state so that their debt and effectively fiscal sustainability is intact requires investigation. Based on these premises and identified research gaps, the next chapter, Chapter 4 describes the research process and methodology for carrying out the work.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

During the recent times, there has been an increase in the focus on Public Infrastructure and more so on the fact that how to invest in this Public Infrastructure. While it is quite certain that not only does Public Infrastructure Investment fuel economic growth, but at the same time higher economic growth also creates more demand for Public Infrastructure Investment. From an Indian context, it becomes quite important to carry out a state level study and examine this crucial relationship between Public Infrastructure Investment and economic growth. This is the first research objective of this study. For investing in Public Infrastructure, funds are required and hence it leads to the issue of Infrastructure financing. Infrastructure can be financed through multiple modes i.e. Public financing, Private financing, Public Private Partnerships (PPPs) etc. and therefore it needs to be seen which mode should be preferred from an individual infrastructure sector's point of view as well as the overall scenario. The gaining importance and usage of PPPs tell us to examine and estimate the important determinants of attracting any PPP in India. These two research problems together compose the second research objective. The ever increasing gap between Infrastructure demands and Infrastructure funds creates debt and that is why the relationship between India's debt levels and economic growth needs particular attention. If the debt levels enter into an alarming zone, then it might pose danger to the fiscal sustainability of the nation. Therefore, while examining the debt growth dynamics for India, focus needs to be put on the Indian states and estimate an optimal value of debt to Gross Domestic Product (GDP) ratio such that a particular state's fiscal sustainability is intact. These two research issues constitute our third and final research objective. The contents of this chapter have been presented in the following manner. Section 4.2 discusses the Research process followed by Section 4.3 that presents the research framework developed under each of the research objectives. Section 4.4 gives a brief overview of the research techniques chosen for carrying

out the empirical work on the framed research objectives and finally Section 4.5 gives the chapter conclusions.

4.2 RESEARCH PROCESS

The current research work follows an empirical approach and was designed along the different steps which form the base of the research process. The research process adopted in this thesis is presented in Figure 4.1 given below:

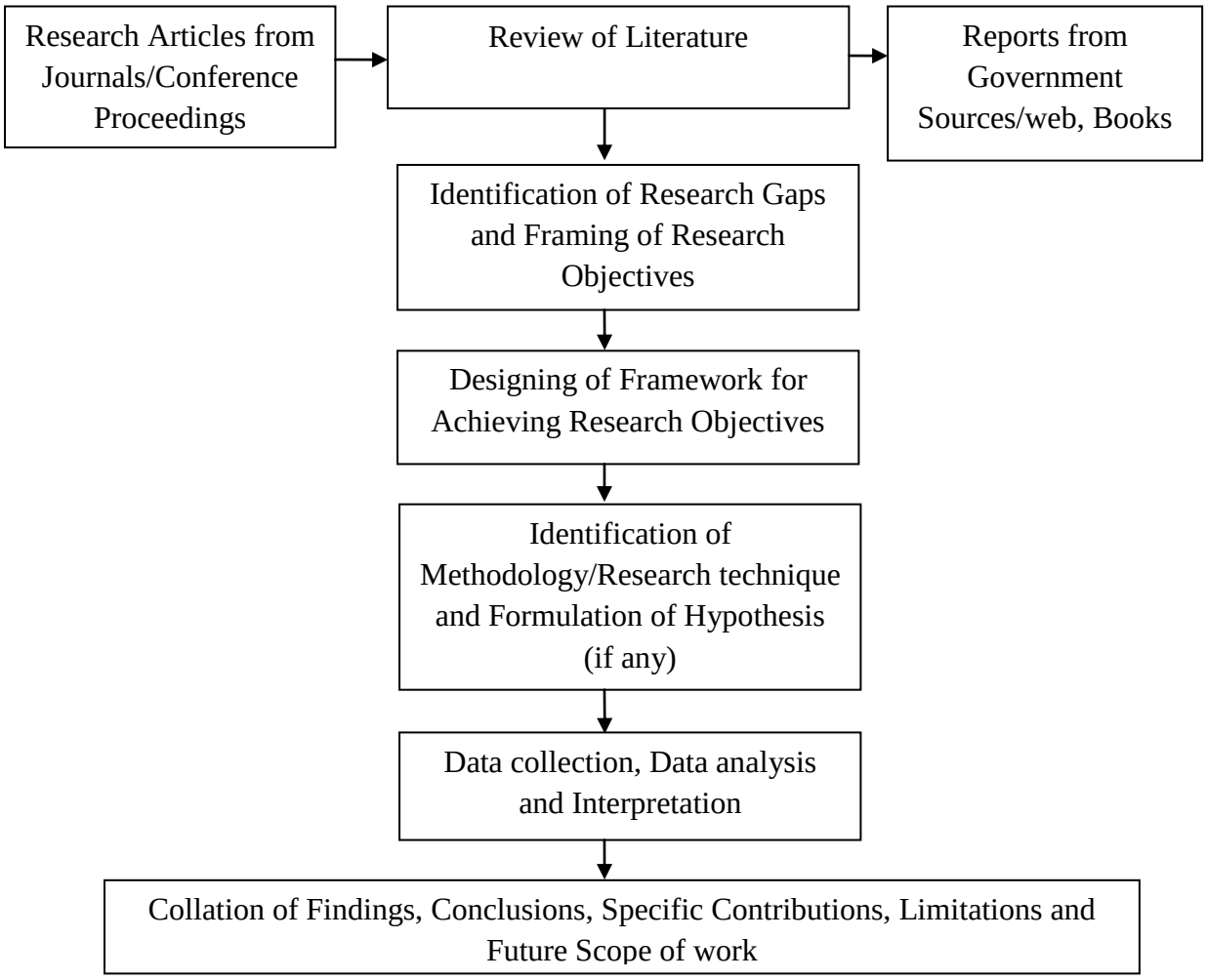


Figure 4.1 Research Process

4.3 DEVELOPMENT OF RESEARCH FRAMEWORK

After the literature was reviewed, research gaps were identified and three major research objectives were formulated, as discussed in 'Chapter 3'. For each of these research objectives, a research framework was designed based on which the empirical analysis was carried out. The research framework pertaining to each of the research objectives is mentioned below:

Research Objective 1: Under this research objective, the aim was to examine the critical relationship between Public infrastructure investment and economic growth for Indian states. To capture the essence of this vital relationship for India, a sectoral analysis was performed for the twenty eight Indian states, excluding Telangana. For all the states, Public Investment data was taken for six major sub sectors falling under overall Infrastructure sector: Public Investment in Transport (PTRANS); Public Investment in Education, Sports, Art and Culture (PEDU); Public Investment in Medical and Public Health (PMED); Public Investment in Water supply and sanitation (PDW); Public Investment in Irrigation (PIRRI); Public Investment in Energy/Power (PENG). The relationship between Public infrastructure investment and economic growth was examined by using time series econometric techniques such as Im, Pesaran and Shin (IPS) (2003) panel unit root test and Westerlund (2007) panel cointegration in order to analyze a panel data set for twenty eight Indian states. The ultimate objective of designing this framework was to investigate the long run and short run dynamics between overall public infrastructure investment and economic growth.

Research Objective 2: Under this research objective, there are two research problems which have been addressed. Firstly, among public financing, private financing and the PPP approach, which mode of infrastructure financing is preferred for major infrastructure sectors of India was examined. Based on the data availability, the historical trends were examined

for each mode of infrastructure financing over the last two decades for the major sectors falling under the Infrastructure sector i.e Transport, Telecommunication (Telecom), Energy, Water and Sewerage. Further for these sectors individually as well as the aggregate scenario, the preferred mode of financing was estimated by analyzing the impact of Public, Private and PPP mode of investment on India's economic growth using the Structural Vector Autoregression model (SVAR) model.

For the second issue, the focus was put on the PPP mode of infrastructure financing. Under this mode, the important determinants of attracting any PPP in India were estimated. To test and estimate the possible determinants of PPPs in India, eight research hypotheses were framed and tested which will be discussed in detail in the proceeding section.

Research Objective 3: For the third and final research objective, again two major research issues were addressed. Firstly, the dynamic relationship between debt and economic growth for India was examined. Secondly, a fiscal sustainability index was calculated for the twenty eight Indian states, excluding Telangana, signifying each state's fiscal stance. Following this, techniques like Pareto principle and decision tree algorithm were used to calculate an optimal value of debt/GDP ratio above which it can be said that an Indian state's economy becomes fiscally unsustainable.

4.4 OVERVIEW OF RESEARCH TECHNIQUES

This section presents an overview of research techniques which were used for the three research objectives framed under this thesis.

Research Objective 1: Under the first research objective, the relationship between Public infrastructure investment and economic growth was examined by using time series econometric techniques such as IPS (2003) panel unit root test and Westerlund (2007) panel

cointegration, to analyze a panel data set for twenty eight Indian states. Firstly, the stationarity properties of these time series needed to be addressed and hence the IPS (2003) panel data unit root test was employed to check for the same.

4.4.1 Panel Unit Root testing – The Im-Pesaran-Shin test

We made use of the IPS (2003) test, which was usually considered appropriate for balanced panels (as in this case with states acting as the panels). Basically the aim was to verify whether or not the state specific time series exhibit stochastic trends or not.

The model for IPS (2003) test is:

$$y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \epsilon_{i,t} \quad ; t = 1,2,\ldots T$$

The null and alternative hypotheses are defined as:

$$H_0 : \rho_i = 1,\ i = 1, 2, \ldots..N$$

against the alternatives

$$H_A : \rho_i < 1,\ i = 1, 2, \ldots..N_1;\ \rho_i = 1,\ i = N_1 + 1, N_1 + 2, \ldots..N$$

Separate unit root tests for the N cross-section units are used.

The Dickey Fuller (DF) regression:

$$y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \epsilon_{i,t} \quad ; t = 1,2,\ldots T$$

Or Augmented Dickey Fuller (ADF) regression:

$$y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \sum_{j=1}^{pi} \theta_{ij}\, \Delta y_{i,t-j} + \epsilon_{i,t} \quad ; t = 1,2,\ldots T$$

is estimated and the t-statistic for testing $\rho_i = 1$ is computed. Let $t_{i,T}$ (i = 1, 2, . . . , N) denote the t-statistic for testing unit roots in individual series i, and let $E(t_{i,T}) = \mu$ and $V(t_{i,T}) = \sigma^2$. Then

$$t\ bar_{N,T} = \frac{1}{N}\sum_{i=1}^{N} t_{i,T}$$

And $\sqrt{N}\frac{(t\ bar_{N,T} - \mu)}{\sigma} =>^{N} N(0,1)$

The IPS (2003) test is a way of combining the evidence on the unit root hypothesis from N unit root tests performed on N cross-section units. The test assumption is that T remains the same for all cross-section units and hence E ($t_{i,T}$) and V ($t_{i,T}$) are same for all i, and hence IPS (2003) test is applied only for balanced panel data. Technically, we can make use of the IPS (2003) test in association with any parametric unit-root test, provided the fact that the panel is balanced and all the t-statistics for the unit-root in every cross-section are identically distributed so that they will have the same variance and mean. In such a scenario, we can even apply the Central Limit Theorem, if the research problem demands. Although the IPS (2003) test requires a balanced panel, it is the test most often used in practice because it is simple and easy to use.

4.4.2 Westerlund Panel Cointegration approach

Post the unit root test, the panel cointegration tests developed by Westerlund (2007) and Persyn and Westerlund (2008) were applied. The logic behind these tests was to check for the absence of cointegration by determining whether Error Correction exists for individual panel members or for the panel as a whole.

For these tests, the null and alternate hypotheses are:

H_0: No cointegration

H_a: Presence of cointegration

The panel cointegration techniques were used to test for the presence of long-run relationships among the integrated variables with both a time-series dimension (T) and a cross-sectional dimension (N). There has been a recent focus of the researchers on the usage of these techniques. One of the major reasons behind this recent focus is the increased power that may be gained and achieved by using these techniques as they account for both the time-series dimension and the cross-sectional dimension. Inspite of all this, a majority of the

studies still fail to reject the null hypothesis of no cointegration even in those cases where cointegration is strongly supported and suggested by theory. One possible reason for this failure to reject the null hypothesis is based on the ground that most residual based cointegration tests, both in pure time series and in panel studies, require that the long run parameters for the variables in their level forms are equal to the short run parameters for the variables in their differences. Research works by Banerjee, Dolado, and Mestre (1998) and Kremers, Ericsson, and Dolado (1992) pointed towards this reason as a common factor restriction and suggested that this failure is basically leading to a significant loss of power for the residual based cointegration tests.

In response to this, Westerlund (2007) developed four new panel cointegration tests which were based on structural rather than residual dynamics and hence did not impose any kind of common-factor restriction. The logic was to test the null hypothesis of no cointegration by checking whether the error-correction term in a conditional panel error-correction model is equal to zero or not. These four tests are all normally distributed and are general enough to accommodate unit-specific short-run dynamics, unit-specific trend and slope parameters, and cross-sectional dependence. Out of these four tests, two tests are designed to test the alternative hypothesis that the panel is cointegrated as a whole, while the other two tests are designed to test the alternative that at least one unit is cointegrated.

Research Objective 2: Under the second research objective, two research issues were addressed. For the first issue, the historical trends of each mode of infrastructure financing (Public, Private, PPP) over the last two decades for the major sectors falling under the Infrastructure sector - Transport, Telecom, Energy, Water and Sewerage, were examined. Further for these considered sectors, the preferred mode of financing was estimated by analyzing the impact of Public, Private and PPP mode of investment on economic growth for

each of the individual sectors as well as the aggregate scenario. SVAR methodology was used to achieve the same.

4.4.3 SVAR approach

The SVAR is represented by the following equation:

$$AX_t = \sum_{i=1}^{p} B_i X_{t-i} + e_t$$

Where vector X_t is the vector of endogenous variables and vector e_t is the vector of orthogonal independent shocks to the variables. Let Σ_e denote the covariance matrix of e_t.

The model is rewritten in the standard Vector Autoregression (VAR) Notation which is as follows

$$X_t = \sum_{i=1}^{p} B_i^* X_{t-i} + u_t$$

Where $u_t = A^{-1}e_t$ are called the reduced form disturbances and $B_i^* = A^{-1}B_i$. Unlike e_t , the individual components in the reduced form disturbances u_t are not orthogonal to each other. The standard form of VAR is a set of reduced form equations which can be estimated using Ordinary Least Squares (OLS). This gives estimates for B_i^* and Σ_u which are used to deduce the values of A and B_i. Before deducing these values, firstly the identifying restrictions need to be placed.

4.4.3.1 Orthogonality and Normalization Restrictions

The first restriction is placed on the covariance matrix Σ_e. The restrictions on this matrix come from the basic assumption underlying SVAR which states that the individual components of the vector e_t must be orthogonal. This leads us to the Orthogonality restrictions on the covariance matrix. These restrictions imply that the covariance matrix must be a diagonal matrix. Firstly, it is assumed that the diagonal elements in the matrix A

are 1. This provides us with n new restrictions. Also without any loss of generality it is assumed that the covariance matrix Σ_e is an identity matrix. In formal mathematical terms, $\Sigma_e = I$. The above restrictions on the diagonal elements of the coefficient matrix and the covariance matrix are together termed as the Normalization Restrictions.

4.4.3.2 Restrictions on the Coefficient Matrix A

The reduced form covariance matrix can be expressed as follows

$$\Sigma_u = A^{-1} \Sigma_e (A^{-1})'$$

Due to the normalization restrictions this can now be written in the form:

$$\Sigma_u = A^{-1} (A^{-1})'$$

The model can be simplified further and written in its Moving Average form as follows

$X_t = C(L)u_t = \sum_{i=1}^{p} C_i u_{t-i}$

Where C (L) is not a single term but it is a summation of terms as it is using the lag notation.

The moving average representation is required for generating and understanding the Impulse Response Functions (IRFs). Thus the moving average form of VAR expresses the variables as a sum of the current and past values of the reduced form disturbances at different lags. A moving average form must express output as a function of the current and past values of the true orthogonal disturbances e_t and can be obtained using the Moving Average form with reduced form disturbances as follows:

$$X_t = C(L)A^{-1}Au_t$$

$$X_t = C(L)A^{-1}(Au_t)$$

Now, $u_t = A^{-1}e_t$ hence:

$$X_t = C^*(L)e_t$$

Where $C^*(L) = C(L)A^{-1}$

The above equation will give the IRFs that can be interpreted. The Moving Average representation leads us to the conclusion that in order to identify the model, only the orthogonal shocks e_t need to be recognized, given the reduced form shocks u_t.

In other words the following equation needs to be identified:

$$e_t = Au_t$$

The Choleski decomposition provides a way to achieve this identification using the above equation and the relationship between the two covariance matrices Σ_u and Σ_e.

The Choleski Decompostion imposes a lower triangular structure on the coefficient matrix A. Combining this with the normalization restriction, the following matrix form for A is obtained. Here the assumption is that a five variable structural vector autoregression model is being estimated. The matrix will accordingly vary based on the number of variables which are being estimated.

$$A = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix}$$

The Choleski decomposition leads us to a recursive structure of the model. It leads to an ordering of the variables in descending order of exogeneity. This order of exogeneity means that the orthogonal instantaneous (or contemporaneous) shocks to a variable only affect those variables which are less exogenous than the shock variable. On the other hand a variable only responds to the instantaneous orthogonal shocks to variables which are more exogenous than itself.

For the second issue under this research objective, the important determinants of attracting any PPP in India have been estimated. To test and estimate the possible determinants of

PPPs in infrastructure in India, eight research hypotheses were framed and tested. To test these hypotheses, the below mentioned techniques were chosen.

4.4.4 Poisson Regression

Poisson regression is widely used in the form of count data regression analysis. It is very similar to the OLS except two exceptions

i. Errors follow a Poisson distribution, rather than the normal distribution
ii. Modelling ln(Y) i.e natural log of response variable Y as a linear function of the coefficients, instead of modeling y as a linear function of the explanatory variables. It is assumed that mean and variance of the errors are equal. However, in practice it is a very rare phenomenon.

Poisson regression is used to predict a dependent variable which consists of count data given one or more independent variables. In order to apply Poisson regression to a given dataset, it should pass certain assumptions to give valid results. The said assumptions are:

- The dependent variable should consist of count data. Count data is different to the other regression models in terms of the data requirements. Linear and multiple regression models require data to be measured on a continuous scale; logistic regression requires a dependent variable to be measured on a "dichotomous" scale and multinomial regression on an ordinal scale. However, Count variable requires data to be a whole number i.e zero or greater than zero. Negative values are not considered as count data. Also Poisson regression works in the cases where mean value of the data is smaller (e.g less than 10).
- Two or more independent variable measured on a continuous, ordinal or nominal scale should be present.
- Observations should be independent of each other i.e. one observation should not provide any information about the other observation.

- The distribution of counts (conditional on the model) should follow a Poisson distribution i.e. the observed and the predicted counts should be equal or closely similar.
- The mean and variance of the model should be identical. This is a direct consequence of the above assumption which says that the data follows a Poisson distribution and the data is equi-dispersed.

  E $[y_i \,|x_i]$ = λ_i= $e^{x_i}\beta$= Var $[y_i \,|x_i\,]$ with over-dispersion (if Var[y]>E[y]) or under-dispersion (if Var[y] < E[y])

A Poisson distribution is given by

Pr [Y = y] =$\frac{e^{\lambda}\lambda^{y}}{y\,!}$, y = 0, 1, 2…; Where, λ is the average number of occurrences in a specified interval.

Primary equation of the model is

Pr [Y_i = y_i] =$\frac{e^{\lambda i}\lambda^{yi}}{y_i\,!}$, y_i = 0, 1, 2…

The most common formulation of this model is the log-linear specification:

ln λ_i=$x_i'\beta$

The expected number of events per period is given by

E $[y_i \,|x_i]$ = λ_i= $e^{x_i}\beta$

The model is estimated using MLE. The Likelihood function is non linear:

$$\ln L = \sum_{i=1}^{n}[-\lambda_i + y_i x_i^{'}\beta - \ln\, y_i!] = \sum_{i=1}^{n}[-e^{\mathbf{x}_i^{'}\beta} + y_i x_i^{'}\beta - \ln\, y_i!]$$

The parameters of this equation can be estimated using maximum likelihood method

$$\frac{\partial L}{\partial \beta} = -\sum_{i=1}^{n}[\mathbf{x}_i[e^{\mathbf{x}_i^{'}\beta} - y_i]] = 0$$

Note: The log-likelihood function is concave and has unique maxima (Gourieroux, Monfort, & Renault, 1991).

4.4.5 Negative Binomial Regression

The negative binomial distribution is a form of the Poisson distribution in which the distribution's parameter is itself considered a random variable. The variation of this parameter can account for a variance of the data that is higher than the mean. Negative Binomial regression can be thought of as a generalization of Poisson regression since it has an identical mean structure as Poisson regression along with the fact that it has an additional parameter to model the over-dispersion. If the conditional distribution of the resulting variable is over-dispersed, the confidence intervals for Negative binomial regression are expected to be narrower as compared to those from a Poisson regression.

As mentioned, Negative binomial regression is used for modeling count variables, usually the over-dispersed count outcome variables.

Negative binomial regression is a type of generalized linear model in which the dependent variable Y is a count of the number of times an event occurs. A convenient parameterization of the negative binomial distribution is given by Hilbe (2011).

$$p(y) = p(Y= y) = \frac{\Gamma\left(y+\frac{1}{\alpha}\right)}{\Gamma(y+1)\Gamma\left(\frac{1}{\alpha}\right)}\left(\frac{1}{1+\alpha\mu}\right)^{1/\alpha}\left(\frac{\alpha\mu}{1+\alpha\mu}\right)^{y}$$

Where $\mu > 0$ is the mean of Y and $\alpha > 0$ is the heterogeneity parameter.

Hilbe (2011) derived this parameterization as a Poisson-gamma mixture, or in other words as the number of failures before the $(1/\alpha)^{th}$ success.

4.4.6 Tobit Regression

The Tobit model is a statistical model proposed by James Tobin (1958) to describe the relationship between a non-negative dependent variable y_i and an independent variable (or a

vector) x_i. The Tobit model can be described in terms of a latent variable y^*. Suppose, however that y_i^* is observed if $y_i^* > 0$ and is not observed if $y_i^* \leq 0$.

Then the observed *yi* will be defined as

$$y_i = \begin{cases} y_i^* = \beta x_i + u_i & if\ y_i^* > 0 \\ 0 & if\ y_i^* \leq 0 \end{cases}$$

$$u_i \sim IIDN(0,\ \sigma^2)$$

This is known as the Tobit model. Tobit model is also called a censored regression model because certain observations on y_i (those for which $y_i \leq 0$) are censored. The ultimate objective is to estimate the parameters β and σ . Putting it the other way round, the latent variable y* is observed only if Y* >0. More specifically, the actual dependent variable is y = max (0, y*). It is called as a censored regression model and is designed to estimate linear relationships between variables when there is either left- or right-censoring in the dependent variable (also called as censoring from below and above, respectively). Censoring from the above takes place when cases with value at or above certain threshold, all take on the value of that particular threshold, so that the true value might be equal to the threshold or it may even be higher. For cases when censoring from below takes place, values which fall at or below certain threshold are censored. A limitation of this approach is that once the variable is censored, OLS provides inconsistent estimates of the parameters, which means that the coefficients from the analysis won't essentially approach the "true" population parameters because the sample size will increase.

Research Objective 3: For the third and final research objective, again the concentration was on two major issues. Firstly, the dynamic relationship between debt and economic growth was investigated for India by doing a multiple regression analysis. Further for the

second issue, a fiscal sustainability index was calculated for each of the Indian states. The following methodology was used in order to arrive at the fiscal sustainability index:

4.4.7 Fiscal Sustainability Index

Based on the studies done by Benz & Fetzer (2006) and Polito & Wickens (2005), the following methodology described below was finalized in order to obtain an indicator of fiscal sustainability.

The total receipts is the sum of Revenue Receipts and Capital Receipts for a particular year 'i'. Similarly, total expenditure is equal to the sum of Revenue Expenditure and Capital Expenditure.

$$R_i = RR_i + CR_i$$

$$E_i = RE_i + CE_i$$

Where all the symbols mean the following:

R_i: Total Receipts at year i

E_i: Total Expenditure at year i

CR_i: Capital Receipts for year i

RR_i: Revenue Receipts for year i

CE_i: Captial Expenditure for year i

RE_i: Revenue expenditure for year i

Now below mentioned are some definitions which will help us develop a better understanding of the process:

Revenue Receipts: Receipts which neither (i) create liabilities nor (ii) reduce assets are called revenue receipts. These can be proceeds on taxes, interest and dividend on investment,

cess and other receipts for services rendered by the government. These are current income receipts of the government from all sources. Government revenue is the source of government expenditure.

Capital Receipts: Government Receipts which either (i) create liabilities or (ii) reduce assets are called capital receipts. Thus, when government raises funds by incurring a liability or disposing off an asset, it is called a capital receipt.

The main difference between the two is that in the case of revenue receipts, government is under no obligation to return the amount collected through Revenue Receipts. However, for the capital receipts which are basically the borrowings, government is under obligation to return the amount along with Interest.

Revenue Expenditure: An expenditure which neither creates assets nor reduces liability is called Revenue expenditure. Salaries of employees, interest on previous debts, subsidies, pension etc. are all examples of Revenue expenditure. All these are financed out of Revenue receipts. It is a short period expenditure which is recurring in nature and is incurred every year with the main purpose of not to build any capital asset, but to ensure normal functioning of the government machinery.

Capital Expenditure: An expenditure which either creates an asset or reduces liability is called capital expenditure. Capital Expenditure that leads to creation of asset are expenditure on purchase of land, machinery etc. whereas Capital Expenditure that leads to reduction of liabilities is repayment of loans.

Plan vs Non-Plan Expenditure: In the light of Five year plans, Government Expenditure is classified into plan expenditure and non- plan expenditure.

(a) Plan Expenditure: Any expenditure that is incurred on programmes which are detailed under the current (Five Year) Plan of the centre or centre's advances to states for their plans is called plan expenditure. Provision of such expenditure in the budget is called Plan Expenditure. Examples of Plan Expenditure include expenditure on electricity generation, irrigation and rural developments, construction of roads, bridges, canals etc. It includes both revenue expenditure and capital expenditure.

(b) Non-Plan Expenditure: This refers to the estimated expenditure provided in the budget for spending during the year on routine functioning of the government. Non- Plan expenditure is all expenditure other than plan expenditure of the government.

For the current research problem, a premise was made that excessive non-plan expenditure is not ideal. Further, it was assumed that it is non-plan expenditure that leads to debt in a state. Using this as base, an index was proposed which measures fiscal condition of a state and ultimately evaluates the fiscal sustainability in the long run.

Another premise was set that the debt incurred for a particular year 'i' is equal to the difference in Expenditures and Revenues in year 'i' along with the debt incurred during year 'i-1'. This accounts for the planned part of the debt. The rest of the debt incurred is non-planned and is non productive.

$D_{ei} = D_{a(i-1)} * (1 + r) + (E_i - R_i)$

Where the following symbols mean the following:

D_{ei}: Expected debt at year i

$D_{a(i-1)}$: Actual debt at year i-1

r: The risk free rate of return

R_i , E_i : As discussed above

Considering a happy path scenario, the expected debt should be equal to the actual debt. But in cases where the actual debt is much more than expected debt, it can be said that the state is not in a fiscally sustainable state.

Therefore, **'Sustainability Gap'** can be defined as the difference between the Expected debt and Actual debt. In other words, higher the Sustainability gap, lower the fiscal sustainability. To scale the gap according to the size of the states, it can be further divided by the GDP of the state for that particular year.

Hence, the Sustainability Gap is given by the formula:

$$SG_i = (D_{ei} - D_{ai})/GDP_i$$

Where all the symbols mean the following:

SG_i : Sustainability Gap at year i

D_{ei}: Expected debt at year i

D_{ai}: Actual debt at year i

GDP_i: GDP for the year i

Once the fiscal sustainability index is calculated for the Indian states, the focus shifts to calculate the optimal value of debt till which an Indian state can go and at the same time its fiscal sustainability is maintained. For achieving this research objective, techniques such as Pareto principle and decision tree algorithm were used.

4.4.8 Pareto Principle

The Pareto principle (also known as the 80–20 rule, the law of the vital few, and the principle of factor sparsity) is named after economist Vilfredo Pareto. The principle specifies an unequal relationship between input and output and states that, for many phenomena, 20% of invested input is responsible for 80% of the results obtained. In other words, for many

events, roughly eighty (80) per cent of the effects come from twenty (20) per cent of the causes". It is observed in many natural as well as economic and business phenomenon. Few examples are:

- Pareto showed that 80% of the land in Italy was owned by 20% of the people.
- A common rule of thumb in business is that 80% of the sales are generated by 20% of the clients.
- Mathematically, the 80–20 rule is roughly followed by a power law distribution (also known as a Pareto distribution) for a particular set of parameters.

For this research problem, after applying the Pareto principle the 80-20 rule can be defined as:

20 per cent of the states with highest negative sustainability give rise to 80 per cent of the whole fiscal unsustainability in all the states.

4.4.9 Decision Tree Algorithm

Decision tree is defined as a decision support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. Decision trees are widely used in operations research, more specifically in decision analysis, to help identify a strategy most likely to reach a goal. It is also a popular tool in Data Mining and Machine Learning.

A decision tree is a flowchart- like structure which contains internal nodes. Each internal node indicates a "test" on an attribute (for example when a coin is flipped, it will result in either head or tail). Further, there are branches with each branch representing the outcome of the test and each leaf node indicating a class label (decision taken after computing all attributes). The paths from root to leaf represent classification rules. A decision is used as a

visual and analytical decision support tool, where the expected values (or expected utility) of competing alternatives are calculated.

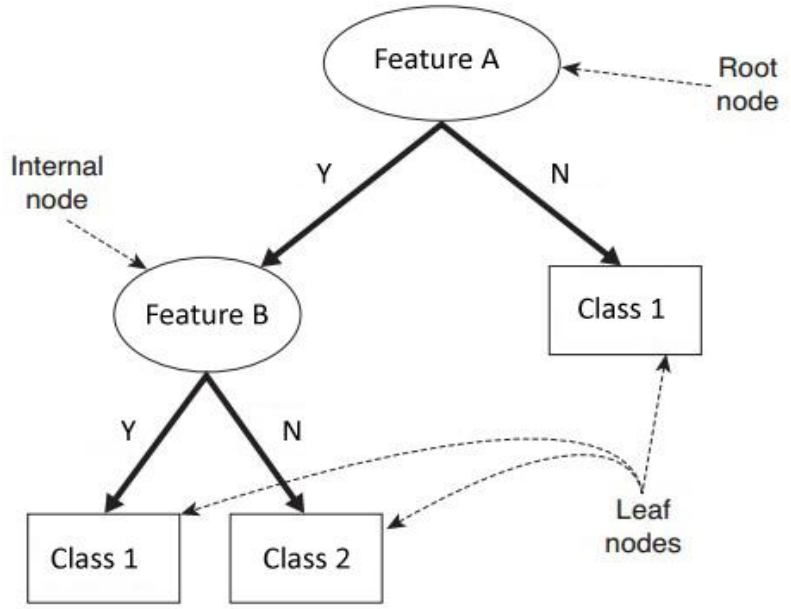


Figure 4.2: Sample Decision tree model

Decision trees are commonly employed in the field of operations research and operations management. They are also used as a descriptive means for calculating conditional probabilities.

For the current research problem, using the calculated fiscal sustainability indicator for the Indian states, the optimal value of debt will be computed till which an Indian state can go and at the same time ensuring that India's fiscal sustainability is maintained. To represent debt, debt/GDP ratio was used throughout the analysis. Further, in order to apply the decision tree algorithm to this case, certain macroeconomic variables were used assuming the fact that the fiscal sustainability is dependent on these variables. The chosen variables were debt/GDP ratio, fiscal deficit as a ratio of GDP and growth rate (GDP %) at 2004-05 constant prices.

As a result of this application of decision tree algorithm, post the analysis certain interesting rules will be extracted like:

"If Debt-GDP ratio is < A, and Fiscal Deficit is < B and Growth Rate is >C, then the state is likely to be Fiscally Sustainable."

A, B, and C are the constants that will be calculated by the decision tree algorithm.

Using decision tree algorithm, the major objective in this case is to predict the fiscal sustainability of a state economy depending on three levels each corresponding to above discussed macroeconomic variables in the descending order of their importance. At each level, the relevant indicator has to be identified marking its importance and accordingly rules have to be derived for predicting fiscal sustainability using the decision tree algorithm. The first level being the most important has fiscal deficit as its indicator with the corresponding rule. The second level being the next important has debt - GDP ratio as its indicator and the rule pertaining to this level will have conditions for the first level indicator as well as the second level indicator. This level will suggest an optimal value of debt which the states should not breach. The third and the least important level has growth rate as the indicator with its rule based on conditions for the first level, second level and third level indicators. One important thing to note here is that for the second and third level which includes two and three indicators respectively, the suggested rules will be mutually inclusive. Failure in accomplishing any one condition will result in not meeting the conclusion.

For this study, the decision tree will look like this:

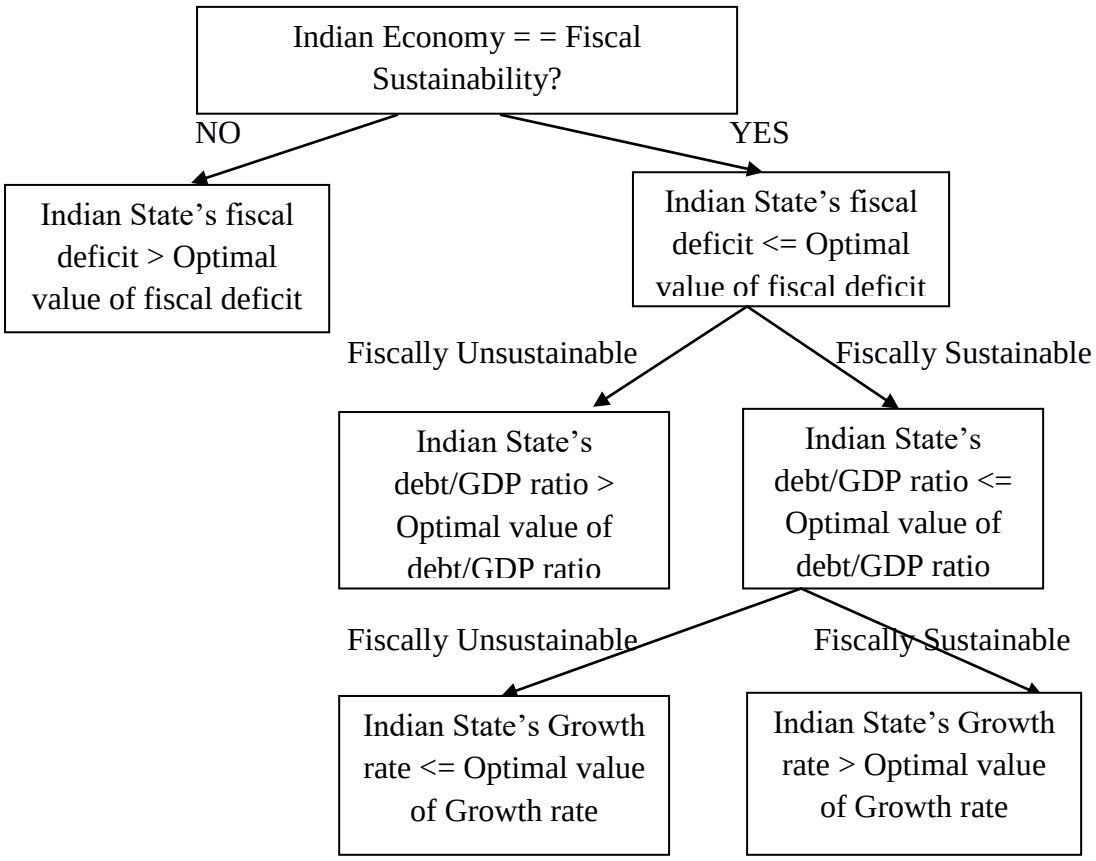


Figure 4.3: Decision Tree model for maintaining Indian Economy's Fiscal Sustainability

4.4.9.1 Working of Decision Trees

Decision tree builds models in the form of a tree structure. It breaks the dataset into smaller and even smaller subsets. This is an example of a 'greedy algorithm' where an algorithm makes a locally optimum choice without taking the global optima into consideration. The final result is a tree with decision nodes and leaf nodes.

A decision node (for our research problem, Fiscal Sustainability) has three predictors (Fiscal deficit, Debt/GDP and Economic growth). Decision trees can handle both categorical and numerical data.

Table 4.1: Decision tree table in terms of Predictors and Target

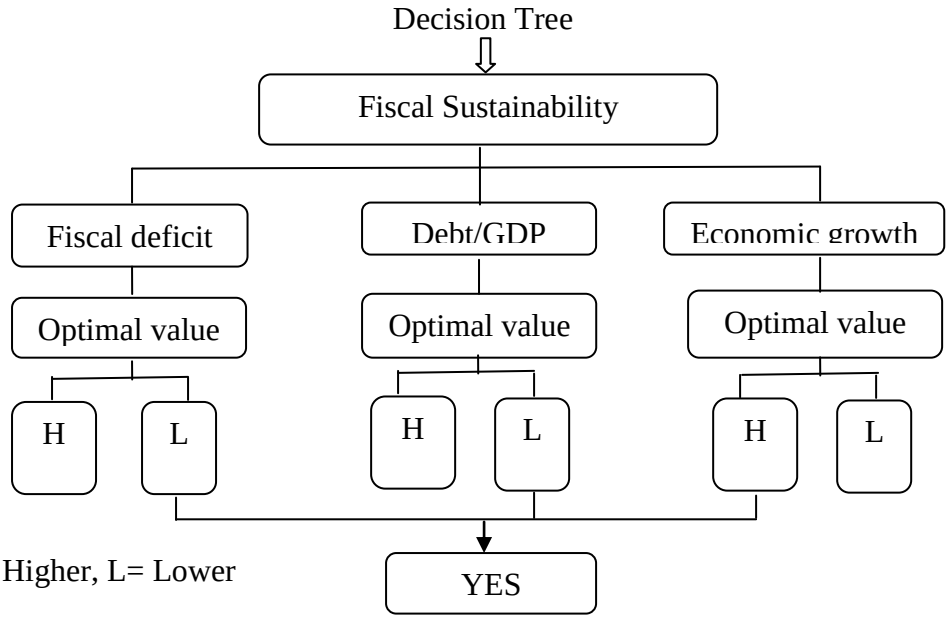
	PREDICTORS			TARGET
	Fiscal Deficit	**Debt/GDP**	**Economic growth**	**Fiscally Sustainability**
Optimal value	Lower	Higher	Higher	No
	Higher	Lower	Higher	No
	Higher	Higher	Lower	No
	Higher	Lower	Lower	No
	Lower	Lower	Higher	Yes
	Lower	Higher	Lower	No
	Lower	Lower	Lower	No
	Higher	Higher	Higher	No

4.4.9.2 Algorithm

The core algorithm for building decision trees is called Iterative Dichotomiser 3 (ID3) which was given by J. R. Quinlan in 1986. Quinlan (1986) employs a top-down, greedy search through the space of possible branches with no backtracking. ID3 uses Entropy and Information Gain to construct a decision tree.

4.4.9.3 Decision Tree to Decision Rules

A decision tree can easily be transformed to a set of rules by mapping from the root node to the leaf nodes one by one, as described by the Figure 4.3 given below.



Note: H= Higher, L= Lower

Figure 4.4: Decision rules for maintaining Indian Economy's Fiscal Sustainability

Rule 1 (R_1): IF (Fiscal deficit optimal value=Lower) THEN Fiscal Sustainability=Yes

This means that if a particular state's fiscal deficit value is lower than the calculated optimal value of fiscal deficit, then the state is fiscally sustainable.

Rule 2 (R_2): IF (Fiscal deficit optimal value=Lower) AND (Debt/GDP optimal value=Lower) THEN Fiscal Sustainability=Yes

This rule says that if a particular state's fiscal deficit value along with its debt/GDP ratio value, both are lower than their respective calculated optimal values, then the state is fiscally sustainable.

Rule 3 (R_3): IF (Fiscal deficit optimal value=Lower) AND (Debt/GDP optimal value=Lower) AND (Economic growth optimal value=Higher) THEN Fiscal Sustainability=Yes. This Rule is shown in the figure 4.3, given above.

This rule says that a particular state's fiscal deficit value along with its debt/GDP ratio value, both are lower than their respective calculated optimal values. However the economic growth value of the state is higher than the calculated optimal value, then the state is fiscally sustainable (provided all three conditions are met together at the same time).

4.4.9.4 Precision, Recall and Accuracy

Before the application of decision tree algorithm, there are certain terms and steps which one need to be aware. These are discussed below:

4.4.9.4.1 Measuring Prediction Quality using Precision and Recall

In the field of machine learning, precision is a measure of the relevance of the results, while recall is a measure of how many relevant results are truly getting returned.

Precision is defined as the number of true positives over the number of true positives plus the number of false positives.

$$P = \frac{T_P}{T_P + F_P}$$

Where T_P = number of true positives; F_P = number of false positives.

Recall is defined as the number of true positives over the number of true positives plus the number of false negatives.

$$R = \frac{T_P}{T_P + F_n}$$

Where T_P = number of true positives; F_n = number of false negatives.

A system with high recall and low precision returns many results, but most of its predicted labels are incorrect when compared to the training labels. A system with high precision but low recall is the opposite, returning very few results, but most of its predicted labels are correct when compared to the training labels. An ideal system with high precision and high recall will return many results, with all results labelled correctly.

4.4.9.4.2 Measuring Prediction Quality using Accuracy

Using the data available, a prediction of the decision tree model is run, after removing the "flag" variable, which tells whether a state economy is fiscally sustainable or not.

When the prediction is run, a column vector of predicted values is obtained with these values as either 0 or 1. If the value is 1, it means that the model has predicted the state economy as fiscally unsustainable. If the value is 0, then this predictor has predicted that the state economy is fiscally sustainable. After the values are predicted, the total number of predictions which were correct can be calculated, and then it can be divided by the total number of observations. This gives the accuracy of training of the model.

4.4.9.4.3 Adding Confusion Matrix to Decision Tree

In the field of machine learning and specifically the problem of classification, a confusion matrix, also known as an error matrix, is a specific table layout that allows visualization of the performance of an algorithm, typically a supervised learning one. Each column of the matrix represents the instances in a predicted class while each row represents the instances in an actual class (or vice-versa). It is called as 'Confusion matrix' because the matrix makes it easy to see if the system is confusing two classes (i.e. commonly mislabelling one as another) or not. It is a special kind of contingency table, with two dimensions ("actual" and "predicted"), and identical sets of "classes" in both dimensions (each combination of dimension and class is a variable in the contingency table).

(a) Why there is a need of a confusion matrix in this analysis?

Case 1: A state is fiscally sustainable but it is wrongly predicted to be fiscally unsustainable.

This condition is not necessarily bad for the economy of the state. Excluding political pressures that would arise by such a prediction, a state can be on their toes while managing its finances in the coming years. Sustainability gap index, which we have calculated, can then be used as a measure to access the situation. If the sustainability gap index is higher than the contemporaries, then the state can take relevant measures to make better plans on expenditure and reach a better position in future. Also, since the aim of our study is to find an optimum debt value, the focus should be on predicting all the states which are fiscally unsustainable correctly. There should be a willingness to accept some level of error in wrongly predicting the fiscally sustainable states as fiscally unsustainable.

Case 2: A state is fiscally unsustainable but it is wrongly predicted to be fiscally sustainable

This situation should be avoided. The focus is on making this study comprehensive and encompassing all states. As it has been observed earlier with the euro-zone crisis, it's not

always a single government that has to pay the price of a bad economy. The neighbors and the trade partners suffer too. Therefore, the focus should be on predicting all the states which are fiscally unsustainable correctly, as discussed in Case 1. The optimal debt-value which arises from this analysis should be an indicator of the danger ahead and the states should be cautioned after crossing this limit of debt.

(b) Cost Matrix in our analysis

The aim will be to use this algorithm using 2 different cost matrices and accordingly analyze how decision trees work with cost-matrices. The assumption here is that the decision tree with better results (precision and recall) will give us a better value of optimum debt that should not be crossed.

Table 4.2: Cost Matrix -I

The Cost Matrix	Predicted Class		
Actual Class		Fiscally Unsustainable	Fiscally Sustainable
	Fiscally Unsustainable	0	1
	Fiscally Sustainable	3	0

By using the cost matrix I given above, a cost can be introduced for incorrectly classifying a fiscally unsustainable economy as 3 and vice-versa as 1. This makes the training algorithm more careful while making decisions as it will be known that which outcomes are more important and which are not.

Table 4.3: Cost Matrix -II

The Cost Matrix	Predicted Class		
Actual Class		Fiscally Unsustainable	Fiscally Sustainable
	Fiscally Unsustainable	0	1
	Fiscally Sustainable	2	0

By using the cost matrix I given above, a cost will be introduced for incorrectly classifying a fiscally unsustainable economy as 2 and vice-versa.

4.5 CONCLUSIONS

The research methodology adopted in the current study has been presented in this chapter. Firstly, the research process is presented followed by a discussion on the research framework formulated under each of the research objectives. Further, an overview of the research techniques chosen for carrying out the empirical work is given in this chapter. With this foundation, the next chapter presents and discusses the analysis of the empirical results.

CHAPTER 5

ANALYSIS OF EMPIRICAL RESULTS

5.1 INTRODUCTION

This chapter presents a detailed discussion on the empirical findings of the thesis work. As mentioned in the previous chapters, three major research objectives were framed for this thesis. For each of the research objectives, appropriate research techniques were employed and accordingly the empirical analysis was carried out. The analysis was started off with examining the critical relationship between Public infrastructure investment and economic growth for India. For this, a sectoral analysis was performed for the twenty eight Indian states, excluding Telangana, in order to get a real picture of how this important linkage between Public infrastructure investment and economic growth fares in the Indian context. Relevant time series econometric techniques like Im, Pesaran and Shin (IPS) (2003) unit root test and panel cointegration tests developed by Westerlund (2007) and Persyn and Westerlund (2008), were employed to carry out this empirical analysis on this panel dataset of twenty eight Indian states. Moving ahead, the historical trends of each mode of infrastructure financing i.e Public, Private, Public Private Partnership (PPP) over the last two decades for the major sectors falling under Infrastructure were examined. Structural Vector Autoregression (SVAR) methodology was used to analyze the impact of Public, Private and PPP mode of infrastructure financing on economic growth of India for each of the individual sectors as well as the aggregate scenario via combining all the sectors. For infrastructure financing, particular focus was given to PPP mode by investigating and estimating the significant determinants of attracting any PPP in India. For this, eight relevant research hypotheses were framed and tested using techniques like Poisson regression, Negative binomial regression and Tobit regression. Finally, the vital relationship between debt and economic growth was examined for India under the third and final research objective of this study. Moving ahead, the issue of fiscal sustainability state was examined by carrying out a state wise analysis for the twenty eight Indian states, excluding Telangana. Firstly, a fiscal

sustainability indicator was calculated for each of the Indian states which could give an indication of how the states fare on the grounds of fiscal sustainability. Following this, an optimal value of debt was estimated till which India's fiscal sustainability is maintained. With this optimal value, it is assumed that if India crosses this value, its fiscal position will be unstable. Techniques like Pareto principle and decision tree algorithm were employed to achieve this task.

Taking into consideration the objectives of the research, this chapter has been broadly segregated into three parts as follows:

Part I gives the results of the empirical analysis carried out for the first research objective where the relationship between Public Infrastructure Investment and economic growth is examined for a panel data set for twenty eight Indian states. All the results and findings of IPS (2003) test for checking unit root and Westerlund-based panel cointegration tests for checking the presence of panel cointegration are presented in this part. The results of short run causality tests are also given in Part I.

Part II gives the results of the empirical analysis carried out for the second research objective where two issues have been addressed. Firstly, the historical trends of each mode of infrastructure financing (Public, Private and PPP) over the last two decades for the major sectors falling under the Infrastructure sector i.e Roads, Seaports, Telecommunication (Telecom) and Energy are examined and presented in this part. Further for these selected sectors individually as well as for the aggregate scenario, the impact of Public, Private and PPP mode on economic growth has been analyzed using the SVAR methodology. The results of SVAR method are also given in Part II. For the second issue, the focus is put specifically on the PPP mode of infrastructure financing by investigating and estimating the significant determinants of attracting any PPP in India. Eight relevant research hypotheses are framed and tested for this purpose using techniques like Poisson regression, Tobit

regression, and Negative binomial regression. The results of hypothesis testing along with these regressions are presented in Part II.

Part III gives the results of the empirical analysis carried out for the third research objective where once again two research issues have been taken care of. Firstly, the relationship between debt and economic growth for India has been examined using multiple regression analysis. The results of this analysis are presented in Part III. Secondly, the fiscal sustainability issue has been addressed in this part. The fiscal stance of Indian states is evaluated by carrying out a state wise analysis for the twenty eight Indian states. For this purpose, a fiscal sustainability indicator is calculated for each of the Indian states. The results of this indicator calculation are presented in this part. Further, the focus is on calculating an optimal value of debt till which India's fiscal sustainability is maintained. The Pareto principle and decision tree algorithm are applied to achieve this task. The corresponding results of this application are given in Part III.

PART I

5.2 PUBLIC INFRASTRUCTURE INVESTMENT AND ECONOMIC GROWTH

Part I pertains to the first research objective. This analysis has been presented in Chotia and Rao (2016) where the relationship between Public Infrastructure Investment and Economic Growth is empirically analyzed for India using yearly data over the time period of 1999-00 to 2014-15 for its twenty-eight states, excluding Telangana as it was formed recently and there was no data available for it. For all the states, Public Investment data in crores is taken for six major sub sectors falling under overall Infrastructure sector: Public Investment in Transport (PTRANS); Public Investment in Education, Sports, Art and Culture (PEDU); Public Investment in Medical and Public Health (PMED); Public Investment in Water supply and sanitation (PDW); Public Investment in Irrigation (PIRRI); Public Investment in Energy/Power (PENG). To evaluate the effects of Public Investment in infrastructure on economic growth at a state level, Per Capita Gross State Domestic Product (PCGSDP) is used as a measurable indicator variable to represent the respective state's economic growth. The PCGSDP data is taken in Crores for all the twenty eight states. The analyzed data set consists of a data panel covering twenty eight Indian states for the period 1999–2000 to 2014-15. For historical period i.e 1999-00 to 2012-13, actual expenditure values are available. For 2013-14, revised estimates and for 2014-15 budget estimate values are taken to indicate Public Infrastructure Investment.

The basis of this empirical analysis is the technique proposed by Westerlund (2007), in which a panel Error correction – Cointegration approach is employed to test whether the variables under study are cointegrated i.e whether there is any sort of stationary linear combination of the random variables among PCGSDP and

PTRANS,PEDU,PMED,PDW,PIRRI,PENG. The heterogeneous panel unit root test developed by IPS (2003) is applied to check for stationarity. Since every state is different in terms of their population and area, therefore to set a leveling field certain computations were performed in order to remove the disparities in terms of population and area and accordingly comparisons can be made among states. With this view, Public Investment data for sectors - PEDU, PMED, PDW, and PENG was divided with respective state's population (in lakhs) so as to make the resulting values in terms of Crores per one lakh of population. Similarly, PTRANS and PIRRI was divided with respective state's area (in Square Km) so as to make the resulting values in terms of Crores per Square Km. The state-level data, i.e. PCGSDP was obtained from Reserve Bank of India (RBI) and Planning commission. Public Investment data for different sub sectors of Infrastructure was obtained from the RBI database, annual financial statements (present in Appendix IV: Capital expenditure of Individual states) for the time period 1999-00 to 2014-15.

5.2.1 Empirical Analysis and Discussion

This section presents all the empirical results pertaining to the first research objective discussed above.

5.2.1.1 Panel Unit Root Test

As indicated above, the relationship among PCGSDP and PTRANS, PEDU, PMED, PDW, PIRRI, PENG is being examined. To address the stationarity properties of these time series, IPS (2003) panel unit root test, which is appropriate for balanced panels (as in our case) is applied, so as to verify whether or not these state specific time series exhibit stochastic trends or not.

The test results for PCGSDP and PTRANS, PEDU, PMED, PDW, PIRRI, PENG are summarized in Table 5.1 given below. $W_{[t-bar]}$ Statistic is used to take the decision of whether or not to reject the null hypothesis of unit root for the panel as whole. When expressed in level form (for constant and trend), we fail to reject the null hypothesis of unit root for all the series i.e PCGSDP and PTRANS, PEDU, PMED, PDW, PIRRI, PENG. When we go for first differences, it is observed that we are able to strongly reject the null hypothesis of unit root at 5 per cent significance level for all these series. This implies that all the series are I (1).

Table 5.1: IPS Test for Unit Root in Panels for the full sample

	LEVELS	**FIRST DIFFERENCES**
Variable	**Constant and Trend**	**Constant and Trend**
	$W_{[t-bar]}$ Statistic	
PCGSDP	5.081	-10.118*
PTRANS	9.764	-11.302*
PEDU	1.849	-2.013*
PMED	6.545	-8.295*
PDW	3.991	-7.239*
PIRRI	6.582	-8.972*
PENG	3.623	-5.011*
* indicates significance at p<0.05 level		

5.2.1.2 Error Correction based Panel Cointegration Test

As a following step, the panel cointegration tests developed by Westerlund (2007) and Persyn and Westerlund (2008) are applied. The logic behind these tests is to check for the absence of cointegration by determining whether Error Correction exists for individual panel members or for the panel as a whole.

Consider the Error Correction Models (ECM) described by below mentioned equations (1), (2), (3), (4), (5) ,(6) and (7) in which all variables in levels are assumed to be I(1):

$$\Delta PCSGDP_{i,t} = \alpha_i^{PCSGDP} + \lambda_i^{PCSGDDP}(PCSGDP_{i,t-1} - \beta_i^{PCSGDP} PTRANS_{i,t-1} - \gamma_i^{PCSGDP} PEDU_{i,t-1} - \pi_i^{PCSGDP} PMED_{i,t-1} - \tau_i^{PCSGDP} PDW_{i,t-1} - \omega_i^{PCSGDP} PIRRI_{i,t-1} - \psi_i^{PCSGDP} PENG_{i,t-1}) + \sum_{j=1}^{n} \theta_{i,j}^{PCSGDP} \Delta PCSGDP_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PCSGDP} \Delta PTRANS_{i,t-j} + \sum_{j=1}^{n} \delta_{i,j}^{PCSGDP} \Delta PEDU_{i,t-j} + \sum_{j=1}^{n} £_{i,j}^{PCSGDP} \Delta PMED_{i,t-j} + \sum_{j=1}^{n} \chi_{i,j}^{PCSGDP} \Delta PDW_{i,t-j} + \sum_{j=1}^{n} ¥_{i,j}^{PCSGDP} \Delta PIRRI_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PCSGDP} \Delta PENG_{i,t-j} + A_{i,t}$$

(1)

$$\Delta PTRANS_{i,t} = \alpha_i^{PTRANS} + \lambda_i^{PTRANS}(PTRANS_{i,t-1} - \beta_i^{PTRANS} PCSGDP_{i,t-1} - \gamma_i^{PTRANS} PEDU_{i,t-1} - \pi_i^{PTRANS} PMED_{i,t-1} - \tau_i^{PTRANS} PDW_{i,t-1} - \omega_i^{PTRANS} PIRRI_{i,t-1} - \psi_i^{PTRANS} PENG_{i,t-1}) + \sum_{j=1}^{n} \phi_{i,j}^{PTRANS} \Delta PTRANS_{i,t-j} + \sum_{j=1}^{n} \theta_{i,j}^{PTRANS} \Delta PCSGDP_{i,t-j} + \sum_{j=1}^{n} \delta_{i,j}^{PTRANS} \Delta PEDU_{i,t-j} + \sum_{j=1}^{n} £_{i,j}^{PTRANS} \Delta PMED_{i,t-j} + \sum_{j=1}^{n} \chi_{i,j}^{PTRANS} \Delta PDW_{i,t-j} + \sum_{j=1}^{n} ¥_{i,j}^{PTRANS} \Delta PIRRI_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PTRANS} \Delta PENG_{i,t-j} + B_{i,t}$$

(2)

$$\Delta PEDU_{i,t} = \alpha_i^{PEDU} + \lambda_i^{PEDU}(PEDU_{i,t-1} - \beta_i^{PEDU} PCSGDP_{i,t-1} - \gamma_i^{PTEDU} PTRANS_{i,t-1} - \pi_i^{PEDU} PMED_{i,t-1} - \tau_i^{PTEDU} PDW_{i,t-1} - \omega_i^{PEDU} PIRRI_{i,t-1} - \psi_i^{PEDU} PENG_{i,t-1}) + \sum_{j=1}^{n} \delta_{i,j}^{PEDU} \Delta PEDU_{i,t-j} + \sum_{j=1}^{n} \theta_{i,j}^{PEDU} \Delta PCGSDP_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PEDU} \Delta PTRANS_{i,t-j} + \sum_{j=1}^{n} £_{i,j}^{PEDU} \Delta PMED_{i,t-j} + \sum_{j=1}^{n} \chi_{i,j}^{PEDU} \Delta PDW_{i,t-j} + \sum_{j=1}^{n} ¥_{i,j}^{PEDU} \Delta PIRRI_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PEDU} \Delta PENG_{i,t-j} + C_{i,t}$$

(3)

$$\Delta PMED_{i,t} = \alpha_i^{PMED} + \lambda_i^{PMED}(PMED_{i,t-1} - \beta_i^{PMED} PCSGDP_{i,t-1} - \gamma_i^{PMED} PTRANS_{i,t-1} - \pi_i^{PMED} PEDU_{i,t-1} - \tau_i^{PMED} PDW_{i,t-1} - \omega_i^{PMED} PIRRI_{i,t-1} - \psi_i^{PMED} PENG_{i,t-1}) + \sum_{j=1}^{n} £_{i,j}^{PMED} \Delta PMED_{i,t-j} + \sum_{j=1}^{n} \theta_{i,j}^{PMED} \Delta PCGSDP_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PMED} \Delta PTRANS_{i,t-j} + \sum_{j=1}^{n} \delta_{i,j}^{PMED} \Delta PEDU_{i,t-j} + \sum_{j=1}^{n} \chi_{i,j}^{PMED} \Delta PDW_{i,t-j} + \sum_{j=1}^{n} ¥_{i,j}^{PMED} \Delta PIRRI_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PMED} \Delta PENG_{i,t-j} + D_{i,t}$$

(4)

$$\Delta PDW_{i,t} = \alpha_i^{PDW} + \lambda_i^{PDW}(PDW_{i,t-1} - \beta_i^{PDW} PCSGDP_{i,t-1} - \gamma_i^{PDW} PTRANS_{i,t-1} - \pi_i^{PDW} PEDU_{i,t-1} - \tau_i^{PDW} PMED_{i,t-1} - \omega_i^{PDW} PIRRI_{i,t-1} - \psi_i^{PDW} PENG_{i,t-1}) + \sum_{j=1}^{n} \chi_{i,j}^{PDW} \Delta PDW_{i,t-j} + \sum_{j=1}^{n} \theta_{i,j}^{PDW} \Delta PCGSDP_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PDW} \Delta PTRANS_{i,t-j} + \sum_{j=1}^{n} \delta_{i,j}^{PDW} \Delta PEDU_{i,t-j} + \sum_{j=1}^{n} £_{i,j}^{PDW} \Delta PMED_{i,t-j} + \sum_{j=1}^{n} ¥_{i,j}^{PDW} \Delta PIRRI_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PDW} \Delta PENG_{i,t-j} + E_{i,t}$$

(5)

$$\Delta PIRRI_{i,t} = \alpha_i^{PIRRI} + \lambda_i^{PIRRI}(PIRRI_{i,t-1} - \beta_i^{PIRRI} PCSGDP_{i,t-1} - \gamma_i^{PIRRI} PTRANS_{i,t-1} - \pi_i^{PIRRI} PEDU_{i,t-1} - \tau_i^{PIRRI} PMED_{i,t-1} - \omega_i^{PIRRI} PDW_{i,t-1} - \psi_i^{PIRRI} PENG_{i,t-1}) + \sum_{j=1}^{n} ¥_{i,j}^{PIRRI} \Delta PIRRI_{i,t-j} + \sum_{j=1}^{n} \theta_{i,j}^{PIRRI} \Delta PCGSDP_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PIRRI} \Delta PTRANS_{i,t-j} + \sum_{j=1}^{n} \delta_{i,j}^{PIRRI} \Delta PEDU_{i,t-j} + \sum_{j=1}^{n} £_{i,j}^{PIRRI} \Delta PMED_{i,t-j} + \sum_{j=1}^{n} \chi_{i,j}^{PIRRI} \Delta PDW_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PIRRI} \Delta PENG_{i,t-j} + F_{i,t}$$ **(6)**

$$\Delta PENG_{i,t} = \alpha_i^{PENG} + \lambda_i^{PENG}(PENG_{i,t-1} - \beta_i^{PENG} PCSGDP_{i,t-1} - \gamma_i^{PENG} PTRANS_{i,t-1} - \pi_i^{PENG} PEDU_{i,t-1} - \tau_i^{PENG} PMED_{i,t-1} - \omega_i^{PENG} PDW_{i,t-1} - \psi_i^{PENG} PIRRI_{i,t-1}) + \sum_{j=1}^{n} \ell_{i,j}^{PENG} \Delta PENG_{i,t-j} + \sum_{j=1}^{n} \theta_{i,j}^{PENG} \Delta PCGSDP_{i,t-j} + \sum_{j=1}^{n} \phi_{i,j}^{PENG} \Delta PTRANS_{i,t-j} + \sum_{j=1}^{n} \delta_{i,j}^{PENG} \Delta PEDU_{i,t-j} + \sum_{j=1}^{n} \xi_{i,j}^{PENG} \Delta PMED_{i,t-j} + \sum_{j=1}^{n} \chi_{i,j}^{PENG} \Delta PDW_{i,t-j} + \sum_{j=1}^{n} ¥_{i,j}^{PENG} \Delta PIRRI_{i,t-j} + G_{i,t} \quad \textbf{(7)}$$

Here, the parameters λ_i^k, k ϵ (PCGSDP, PTRANS, PEDU, PMED, PDW, PIRRI, PENG) are the parameters of the Error Correction term and give us the estimates of the speed of error correction towards the long run equilibrium for state i, while $A_{i,t}, B_{i,t}, C_{i,t}, D_{i,t}, E_{i,t}, F_{i,t}, G_{i,t}$ are white noise random disturbances. The main focus is on Equation (1) i.e analyzing the relationship between Public Infrastructure Investment in six major sectors of infrastructure and economic growth. In other words, the focus is on PCGSDP and its relation with PTRANS, PEDU, PMED, PDW, PIRRI and PENG.

The null hypothesis of no cointegration and alternative hypothesis of cointegration can be tested by two different types of tests i.e group mean tests and panel tests. Westerlund (2007) developed four panel cointegration test statistics ($G_a, G_t P_a, P_t$) based on the ECM. The group-mean tests are based on weighted sums of the λ_i^k estimated for individual states of India, whereas the panel tests are based on an estimate of λ^k for the panel as a whole. All these four test statistics are normally distributed.

The two tests (G_t, P_t) are calculated with the standard errors of λ_i^k estimated in a customary way, while the other statistics (G_a, P_a) are based on Newey and West (1994) standard errors, which are adjusted for heteroskedasticity and autocorrelation. When an ECM is applied to a particular case where all analyzed variables are assumed to be I(1), the tests proposed by Westerlund (2007) investigate whether cointegration is present or not by determining whether error-correction is present for individual panel members and for the panel as a whole.

If $\lambda_i^k < 0$, then it confirms the presence of error correction, and hence it can be inferred that $PCGSDP_{i,t}$ and $PTRANS_{i,t}, PEDU_{i,t}, PMED_{i,t}, PDW_{i,t}, PIRRI_{i,t}, PENG_{i,t}$ are cointegrated.

However when $\lambda_i^k = 0$ is there, then there is no error correction and hence no cointegration. Therefore, the null hypothesis of no cointegration for the group-mean tests (G_a, G_tstatistics) is: $H_0^G: \lambda_i^k = 0$ for all i, which is tested against $H_1^G: \lambda_i^k < 0 \ : 0$ for at least one i. Putting this in other words, for the two group mean based tests, the alternative hypothesis says that there is cointegration in at least one of the cross-section unit. So, the adjustment coefficient λ_i^k may be heterogeneous across the cross-section units. This means that if H_0 is rejected, then it can be taken as evidence of cointegration in at least one of the cross-sectional units. The panel tests (P_a, P_tstatistics) as an alternative assume that $\lambda_i^k = \lambda^k$for all i, so the alternative hypothesis says that adjustment to equilibrium is homogenous across cross-section units. In that case, we proceed to test $H_0^P: \lambda^k = 0$ against$H_1^P: \lambda^k < 0$. If H_0 is rejected, then it can be taken as evidence of cointegration for the panel as a whole. Basically the focus is on the long run behavior of the specified model so the next thing is to calculate the coefficients of the conditional long-run relationships between PCGSDP, PTRANS, PEDU, PMED, PDW, PIRRI and PENG when the short-run terms are set to zero. The long-run coefficients can be estimated from the following long-run equation, which has been obtained from the reduced form of equation (1) when the terms representing short-run changes are ΔPCGSDP= ΔPTRANS= ΔPEDU= ΔPMED= ΔPDW=ΔPIRRI=ΔPENG=0, as:

$$PCGSDP_{i,t} = -\frac{\alpha_i^{PCGSDP}}{\lambda_i^{PCGSDP}} + \beta_i^{PCGSDP} PTRANS_{i,t} + \gamma_i^{PCGSDP} PEDU_{i,t} + \pi_i^{PCGSDP} PMED_{i,t} + \tau_i^{PCGSDP} PDW_{i,t} + \omega_i^{PCGSDP} PIRRI_{i,t} + \psi_i^{PCGSDP} PENG_{i,t} \quad \textbf{(8)}$$

For these Westerlund-based panel cointegration tests, a single lag and lead, $h_i = q_i = 1$ are used. These lead and lag orders are chosen based on the minimum Akaike's Information Criterion (AIC). The cointegration tests are then carried out. We have also considered the robust P-values attained after bootstrapping using 800 replicates following the examination of cross-sectional dependence among residuals. The results are obtained as shown in Table 5.2, given below.

Table 5.2: Results of the Westerlund-based Panel Cointegration tests (with Constant and Trend)

Model	Test	value of test	Z-value	p-value	Robust p-value
PCGSDP (For eq.1)	G_t	-3.101*	-0.622	0.000	0.002
	G_a	-7.682*	-6.491	0.000	0.001
	P_t	-22.476*	3.909	0.000	0.000
	P_a	-8.391*	4.435	0.000	0.000
* indicates significance at p<0.05 level.					

As it can be observed, these results for the whole sample, i.e. from the panel co-integration tests signify that there is a long-run cointegrating relationship for PCGSDP among the series under consideration, based on equation (1). As the P- values indicate, for the major equation of analysis (PCGSDP, Equation 1) the null hypothesis of no cointegration is rejected. The G_t, G_a, P_t and P_a values specify that the null hypothesis of no cointegration, and therefore no stationary equilibrium relationship among the variables should be rejected at 5 per cent significance level for the individual panel members as well as full panel of twenty eight Indian states. Further, the robust P-values also indicate the same thing that the null hypothesis of no cointegration should be rejected. On the whole, the primary model focused in this study indicates that there are long-run relationships among PCGSDP and PTRANS, PEDU, PMED, PDW, PIRRI, PENG for the whole sample of twenty eight Indian states as a panel and as individual panel members.

5.2.1.3 ECM Estimates

Once the presence of panel cointegration is confirmed, the long-run relationships among PCGSDP and PTRANS, PEDU, PMED, PDW, PIRRI, PENG are estimated by applying the estimator of Westerlund (2007). Consequently, equation (1) of the ECM is estimated, reparameterized based on panel data. Table 5.3 given below presents the results for this equation.

Table 5.3: Results of the ECM Estimates

Regressors	ΔPCGSDP	t – values
Constant	0.308	12.81
$PCGSDP_{t-1}$	-0.035*	12.26
$PTRANS_{t-1}$	0.025	5.72
$PEDU_{t-1}$	0.125**	10.52
$PMED_{t-1}$	0.024***	2.45
PDW_{t-1}	-0.088*	-7.33
$PIRRI_{t-1}$	0.004	0.91
$PENG_{t-1}$	0.015***	3.11
$\Delta PCGSDP_{t-1}$	-0.067	13.64
$\Delta PTRANS_{t-1}$	0.029**	5.73
$\Delta PEDU_{t-1}$	0.132*	10.29
$\Delta PMED_{t-1}$	0.031**	2.39
ΔPDW_{t-1}	-0.092*	-6.93
$\Delta PIRRI_{t-1}$	0.007	0.92
$\Delta PENG_{t-1}$	0.021***	13.77
ΔPCGSDP	-	-
ΔPTRANS	0.041*	6.27
ΔPEDU	0.254*	12.51
ΔPMED	0.075**	3.15
ΔPDW	-1.012*	-7.08
ΔPIRRI	0.023***	1.12
ΔPENG	0.063**	14.42

Significance levels: *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$. Lag and lead lengths both 1.

The output given in Table 5.3 can be interpreted from the viewpoint of short-run fluctuations around a long-run equilibrium relationship. As we can observe in Table 5.3, for equation 1 the estimated adjustment parameter (the coefficient of the Error Correction term) is statistically significant and has the expected negative sign. The negative sign of EC term

means that it will induce a negative change in PCGSDP back towards the long run equilibrium. In absolute sense, if the value of adjustment parameter is high then it implies that a much longer time will be required for equilibrium to be restored following any fluctuations from the long-run equilibrium of dependent variable with independent ones.

The estimated long-run ECM coefficients are presented in Table 5.4 given below.

Table 5.4: Estimated long-run ECM coefficients

Variable	α_i^k	β_i^k	γ_i^k	π_i^k	τ_i^k	ω_i^k	ψ_i^k
PCGSDP	2.75	0.44	0.66	1.05	1.55	1.12	0.08
PTRANS	2.3	0.10	0.15	2.91	1.87	2.05	1.35
PEDU	2.68	2.56	1.39	1.15	2.67	1.42	2.21
PMED	1.15	2.34	1.86	2.54	1.39	2.51	1.19
PDW	2.41	1.98	1.45	0.82	0.47	1.65	2.42
PIRRI	1.71	2.22	1.99	1.25	0.79	1.82	2.11
PENG	1.44	1.30	2.73	0.57	1.55	0.49	2.21

According to these results which were received for the full sample of twenty eight Indian states, a 1 per cent increase in PTRANS will increase PCGSDP by 0.44 Crores of Indian Rupee (INR), which signifies the long-term effect of PTRANS on PCGSDP over future periods. The increase of PTRANS will cause fluctuations from its equilibrium, causing PCGSDP to be even higher. PCGSDP will then accordingly decrease to correct this disequilibrium, with the deviation decreasing by 3.5 per cent (λ_i^{PCGSDP}) in each consequent time period. In other way, PCGSDP will decrease by on average 0.44 Crores INR in response, with the decrease taking place over consecutive future measurement intervals at a rate of 3.5 per cent per interval. A one-unit increase in PEDU will increase PCGSDP by 0.66 Crores INR. Accordingly to re-establish equilibrium, PCGSDP will then decrease by 0.66 Crores over consecutive future measurement intervals at a rate of 3.5 per cent per interval. Likewise, a one-unit increase in PMED will increase PCGSDP by 1.05 Crores INR. Accordingly to re-establish equilibrium, PCGSDP will then decrease by 1.05

Crores over consecutive future measurement intervals at a rate of 3.5 per cent per interval. On similar lines we can interpret the results for other variables.

5.2.1.4 Short Run Causality

Further, the short run causality is also checked. In other words, the significance of the coefficients of the lagged difference of the variables is tested by employing the Wald restriction test for the equations (1), (2), (3) , (4) , (5) , (6) and (7). The assumed causality of individual associations and relationships is checked by analyzing the significance of the t-statistic for the coefficient of the lagged variable, whereas the joint causality is checked as: let's say to examine whether there is presence of causality from PTRANS and PENG to PCGSDP in equation 1, then the null hypothesis, $H_0: \phi_i^{PCGSDP} = ¢_i^{PCGSDP} = 0$ for all i, will be tested. If this null hypothesis is rejected, it can be concluded that PTRANS and PENG are causally related to PCGSDP.

The short run causality results are given in Table 5.5, where the direction of causal relationships is indicated by (→) for unidirectional causal relationships.

Table 5.5: Results of the short-run causality tests

Causality test	Null Hypothesis	Test statistic value
ΔPTRANS → ΔPCGSDP	$\phi_i^{PCGSDP} = 0$	7.95*
ΔPTRANS+ΔPENG→ ΔPCGSDP	$\phi_i^{PCGSDP} = ¢_i^{PCGSDP} = 0$	14.49*
ΔPEDU+ΔPMED→ ΔPCGSDP	$\delta_i^{PCGSDP} = £_i^{PCGSDP} = 0$	28.25**
ΔPENG→ ΔPCGSDP	$¢_i^{PCGSDP} = 0$	0.156***
ΔPIRRI → ΔPCGSDP	$¥_i^{PCGSDP} = 0$	0.455***
ΔPTRANS+ΔPIRRI→ ΔPCGSDP	$\phi_i^{PCGSDP} = ¥_i^{PCGSDP} = 0$	0.678***
ΔPCGSDP+ΔPENG→ ΔPTRANS	$\theta_i^{PTRANS} = ¢_i^{PTRANS} = 0$	11.22
ΔPCGSDP+ΔPTRANS→ ΔPENG	$\theta_i^{PENG} = \phi_i^{PENG} = 0$	9.56
ΔPCGSDP → ΔPTRANS	$\theta_i^{PTRANS} = 0$	8.19*
ΔPCGSDP → ΔPENG	$\theta_i^{PENG} = 0$	0.034***
ΔPCGSDP+ΔPIRRI→ ΔPTRANS	$\theta_i^{PTRANS} = ¥_i^{PTRANS} = 0$	1.712
ΔPTRANS+ΔPCGSDP→ ΔPIRRI	$\phi_i^{PIRRI} = \theta_i^{PIRRI} = 0$	1.194
ΔPDW → ΔPEDU	$\chi_i^{PEDU} = 0$	0.098***
ΔPDW → ΔPMED	$\chi_i^{PMED} = 0$	1.45*

ΔPMED → ΔPDW	$£_i^{PDW} = 0$	1.04
ΔPEDU → ΔPDW	$\delta_i^{PDW} = 0$	0.058
ΔPCGSDP→ ΔPIRRI	$\theta_i^{PIRRI} = 0$	1.569
ΔPCGSDP+ΔPEDU→ ΔPMED	$\theta_i^{PMED} = \delta_i^{PMED} = 0$	17.34
ΔPCGSDP+ΔPMED→ ΔPEDU	$\theta_i^{PEDU} = £_i^{PEDU} = 0$	12.79

Significance levels: *, p<0.05; **, p<0.01; ***, p<0.001. For the co-joint test, we have used the Wald-test (χ^2).

As per the values which were obtained, the relationship between PTRANS and PCGSDP demonstrates bidirectional causality for full sample of twenty eight Indian states, i.e. a change in PTRANS will impact PCGSDP and a change in PCGSDP will similarly have an effect on PTRANS. There is also a bi-directional relationship between PENG and PCGSDP. Also, PEDU and PMED are causally related to PCGSDP and there are unidirectional causal relationships from PDW to PEDU and from PDW to PMED. These results also confirm that PTRANS and PIRRI are causally related to PCGSDP and there is unidirectional causal relationship from PIRRI to PCGSDP. Finally, PTRANS and PENG are causally related to PCGSDP.

Therefore as per the empirical analysis discussed above, the cointegration and short-run causal relationships were examined between PCGSDP and PTRANS, PEDU, PMED, PDW, PIRRI, PENG based on a panel data set of twenty eight states of India, excluding Telangana during the time period 1999–2000 to 2014-15. The empirical analysis suggests that all the seven variables under study i.e PCGSDP and PTRANS, PEDU, PMED, PDW, PIRRI, PENG are cointegrated and hence there are long-run equilibrium relationships among these seven variables. Further, the causality results indicated that there is short-run bi-directional causality relationship between PTRANS and PCGSDP. We also found bi-directional causality relationship between PENG and PCGSDP, unidirectional causality running from PDW to PEDU, from PDW to PMED, from PEDU to PCGSDP and finally from PMED to PCGSDP.

PART II

5.3 ISSUE OF INFRASTRUCTURE FINANCING

Part II pertains to the second research objective where two issues pertaining to Infrastructure Financing have been addressed. Therefore, this part is divided into two sections: Section A and Section B. The first issue under this research objective is presented in Section A where the historical trends of each mode of infrastructure financing (Public, Private and PPP) over the last two decades for the major sectors falling under the Infrastructure sector i.e Roads, Seaports, Telecom and Energy have been examined and presented. Further for these selected sectors individually as well as for the aggregate scenario, the impact of Public, Private and PPP mode of infrastructure financing on economic growth has also been examined using the SVAR methodology. The results of SVAR method are also given in Section A.

In Section B, the second issue is presented where the focus is put exclusively on the PPP mode of infrastructure financing by investigating and estimating the significant determinants of attracting any PPP in India. Eight relevant research hypotheses are framed. These hypotheses are tested using the techniques like Poisson regression, Tobit regression, and Negative Binomial regression. The results of hypothesis testing along with these regressions are put together and presented in Section B.

Section A

5.3.1 HISTORICAL TRENDS IN DIFFERENT MODES OF INFRASTRUCTURE FINANCING

This section focuses on examining the historical trends in different modes of infrastructure financing for major infrastructure sectors i.e Roads, Seaports, Telecom and Energy. By examining the historical data available for each mode of financing for these major sectors, we have arrived at the most preferred mode of financing for each sector.

5.3.1.1 Data Sources and Time Period

The historical data pertaining to each mode of financing is in crores of INR. The considered time period of analysis is 1995 to 2014. The data for public mode of financing in all the sectors has been collected from the budget data files of Government of India (Government of India database). The data for PPP and private investment has been obtained from World Bank database.

5.3.1.2 Historical Trends in Energy Sector

India is a fast growing economy and Energy sector is the focal point to achieve and meet India's development ambitions, to sustain an expanding economy, to bring electricity to those who are still living their lives without it, to fuel the demand for greater mobility and to develop and strengthen the existing level of infrastructure. India's energy consumption has almost doubled since 2000 and the potential for even further growth is massive. The Energy sector is constituted by several components such as Electricity (Power), Coal, oil, and natural gas. However, the most prominent one among these is Power. Access to affordable and reliable electricity is critical to a country's growth and prosperity and that is why, Power Infrastructure holds a vital place while we are seeing the historical trends of financing in the Energy sector. The power sector in India has an installed capacity of 288 Gigawatt (GW) (as

of 31 January 2016). With the increasing capacity of power infrastructure the demand of investment is also growing at a large pace. If the general patterns of investment in the Indian power sector are looked at, private mode of investment emerges as the major source of financing of the power sector. Power is one of the key sectors attracting Foreign Direct Investment (FDI) inflows into India. FDI inflows into the sector increased from a mere 87 million United States Dollar (USD) in FY 06 (Financial Year 2006) to 1,066 million USD in FY 14 and 486 million USD during April 2014 to October 2014 itself. The sector accounted for 4.1 per cent of the total inflows in FY 14.

The increasing demand of funds for power sector can be attributed not only to the increasing quantity of conventional electricity generation like thermal power plants but also to the unconventional renewable sources like wind and solar energy. India has an expansive coastline belt from Gujarat to Kerala and from Kerala to West Bengal that provides ample scope for wind power generation. India's wind power potential has been assessed at 45,000 Megawatt (MW). During the last five years, wind power generation projects received increased investments from the government as well as from private players, which resulted in significant capacity additions. India's solar power capacity is around 2 MW. A large number of small and large-size solar projects are coming up in the near future. On a state level, the Rajasthan government is set to approve solar thermal projects of 250 MW. Many other states like Haryana and West Bengal are also in the process of implementing solar power projects.

Moving further, the following figures given below depict the historical trends of power sector for all the three modes of infrastructure financing: Public, Private and PPP.

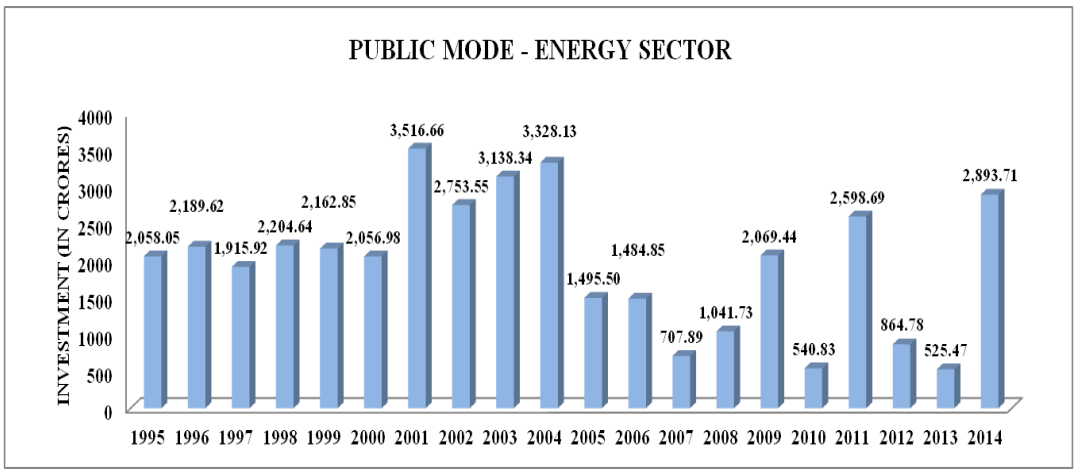


Figure 5.1: Public Investment in Energy Sector

Public mode of financing has had an important role in the financing of energy infrastructure. Fig 5.1 shows the trends in public statement over a period of twenty years from 1995-2014. The share of public investment has witnessed an overall decline, particularly after 2004. One of the major reasons for this could be enactment of Electricity Act 2003 and National Tariff Policy 2006 leading to a more liberal framework for power sector across the value chain and increasing investment through competitive bidding.

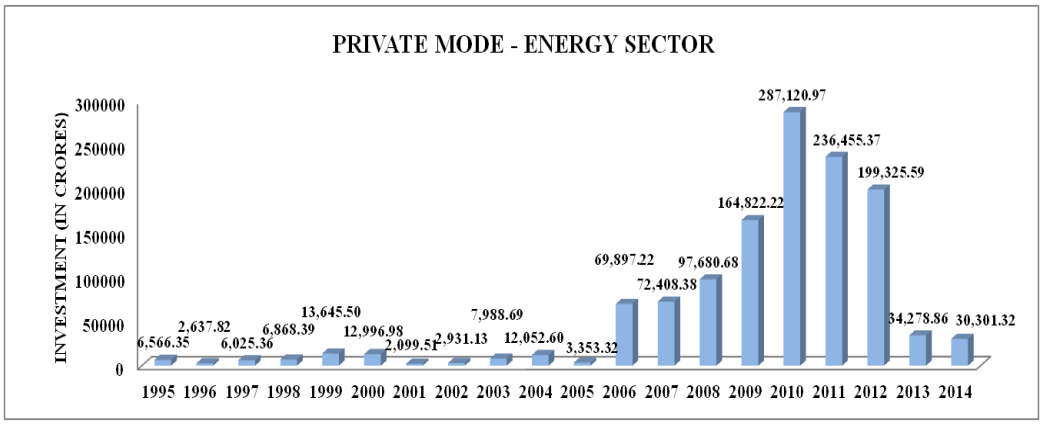


Figure 5.2: Private Investment in Energy Sector

Private mode of investment has witnessed an overall increasing trend since liberalization of Indian Economy with its growth further triggered by Electricity Act 2003 and National Tariff Policy 2006 which created a liberal framework for private investments to pour in. The

investments in the private sector showed an increasing trend from 2006-2010 with a dipping trend post 2011. National Tariff Policy 2006 along with New Hydro Policy of 2008 could be the major reasons of increase in private investment from 2006 onwards.

The New Hydro Policy gave private players flexibility to tie up with states for setting up projects. However, the New Hydro Policy gave the provision to award projects to developers through tariff base bidding only up to 2011 and hence the private investment observed a decline from 2011 onwards.

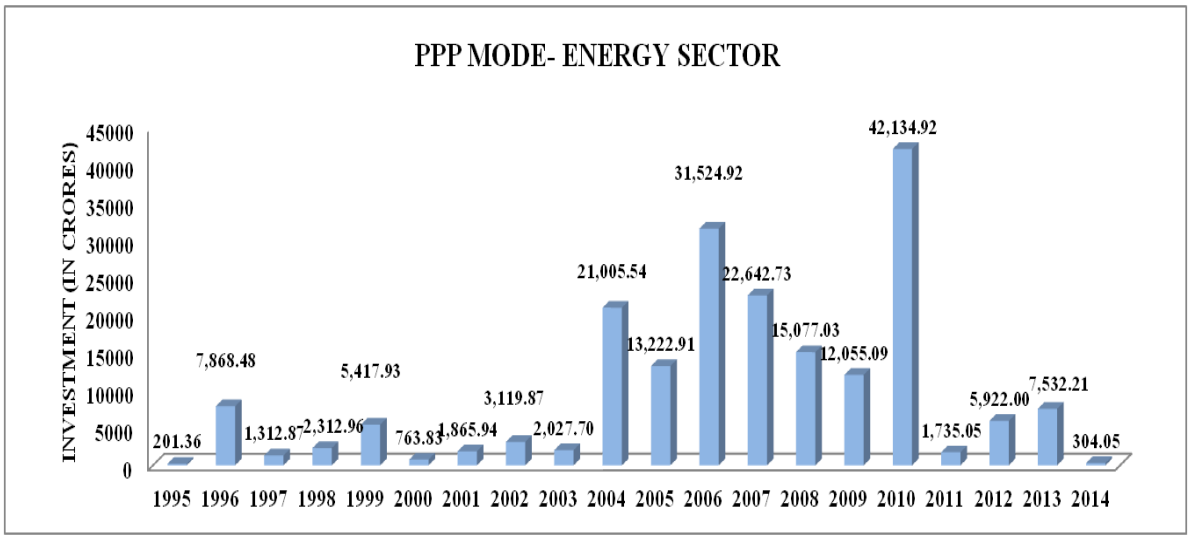


Fig 5.3: PPP Investment in Energy Sector

Public Private Mode of financing constitutes only a small proportion of total investment in the power sector. The general trend of PPP has been quite fluctuating with no predictable pattern coming up. The major increase or decrease in this mode could be largely explained by the fact that certain major PPP projects came up in those respective years. A large increase in PPP investment was witnessed in the year 2004 on the back of large energy projects such as Enercon Wind farms (Jaisalmer) Private Limited and two National Thermal Power Corporation (NTPC) projects.

Fig 5.4 illustrates the PPP, Private and Public investments as a percentage of total investment in the Energy sector over the considered period of twenty years. Private source of financing constitutes the major segment of financing as far as energy sector is concerned. The major reason behind this could be the strong focus on undertaking large energy projects after liberalization along with several policies that have set up an environment of competitive bidding for projects in power sector. Future trends also point towards higher private participation with the High Level Committee on Infrastructure Financing projecting an investment of 9.1 lakh crore INR in Electricity and 1.7 lakh crore INR in Renewable Energy sector during the 12th Five year Plan (2012-2017) of which, approximately 50 per cent is to be met through the private sector participation.

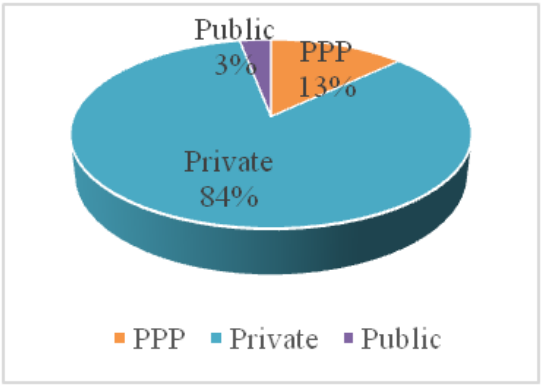


Fig 5.4: Public, Private and PPP investments as a percentage of total investment - Energy sector

5.3.1.3 Historical Trends in Transport Sector

India's transport is quite large in proportion and caters to the needs of 1.25 billion people. Since the early 1990s, India's growing economy coupled with its increasing population has pushed an increase in demand for transport infrastructure and services. Also, we are aware that good physical connectivity in the urban and rural areas is essential for achieving economic growth. All these reasons make Transport as one of the crucial sub sectors of Infrastructure.

Based on data availability, the focus is put on two major sub sectors of Transport i.e Roads and Seaports. The following figures given below depict the historical trends of these two sectors for all the three modes of infrastructure financing: Public-Private Partnership, Private and Public.

5.3.1.3.1 Historical trends in Roads Sector

India has the second largest road network across the world at 4.7 million km. This road network transports more than 60 per cent of all goods in the country and 85 per cent of India's total passenger traffic. Road transportation has gradually increased over the years due to the improvement in connectivity between cities, towns and villages across the nation. However, being cognizant of the need to create an adequate and ample road network to cater to the increased traffic and movement of goods, this sector has witnessed a large increase in investment inflow from various modes. The historical data trends reveal that private sector has been the major source of financing for the roads sector.

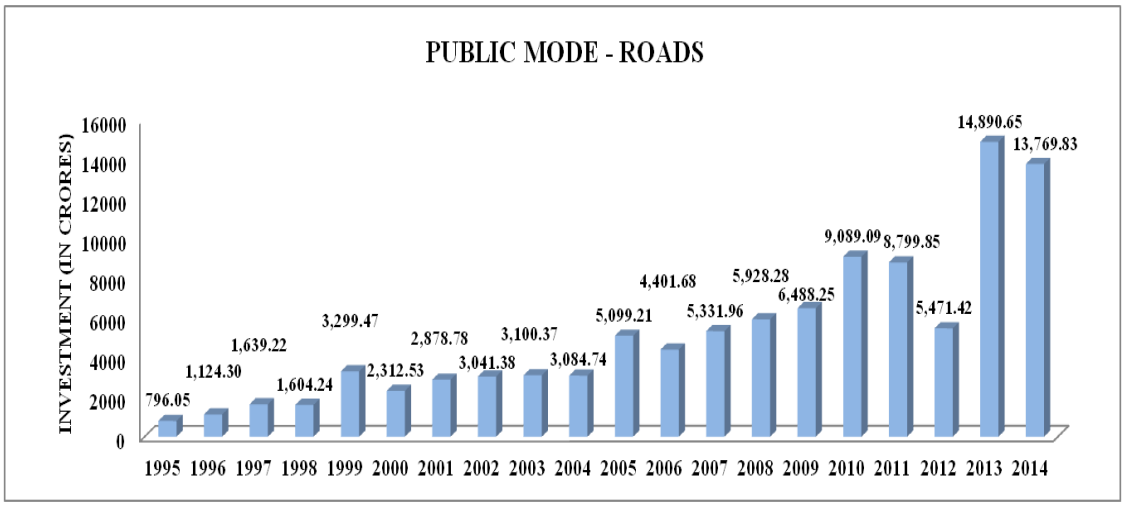


Figure 5.5: Public Investment in Roads Sector

Historically, budgetary resources from the governments have been the major source of financing for infrastructure such as road projects in India. With increasing private

participation in roads infrastructure, the contribution of public source as a percentage of total investment has declined despite the increase in the amount of money invested through public mode over the past two decades.

As can be seen in Fig 5.5, the public investment in roads sector doubled from 1604.24 crores INR to 3299.47 crores INR from year 1998 to 1999 due to the start of Pradhan Mantri Gram Sadak Yojna which was launched as fully funded centrally sponsored scheme. The public investment has seen an overall increasing trend from 2001 onwards, barring a few dips for certain years due to the launch of NHDP which took place in seven phases. There was a dip in the public financing of roads during 2013 which could be explained by the fact that the first stage of NHDP for all the seven phases was completed by 2012. All of the stages were funded largely by the government's special petroleum product tax revenues and government borrowing.

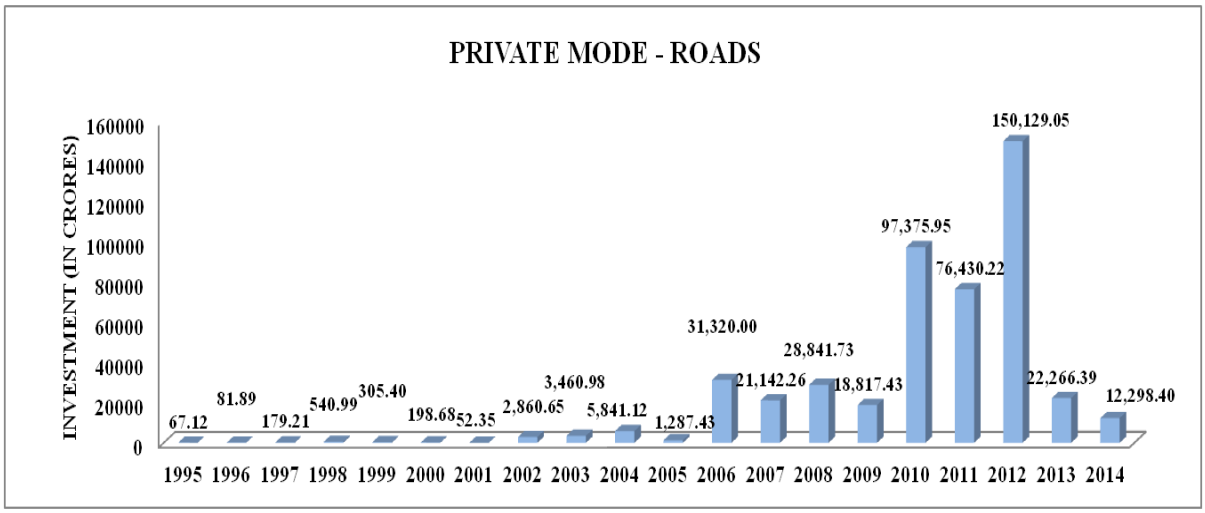


Figure 5.6: Private Investment in Roads Sector

Private mode of investment has been the major financing source in the roads sector. National Highways Act 1956 was amended in June 1995 to facilitate private participation in road infrastructure projects. With this major amendment, the roads sector has received an

increasing financial stream from the private sector. Until 2004-05, the road construction and maintenance market in India was dominated by the Public Sector. However, in the present times, the private sector has emerged as a major player in the development of the road infrastructure. The road construction projects awarded to private companies recorded a Compounded Annual Growth Rate (CAGR) of 17.1 per cent over the period FY 06-13. This is substantiated by the fact that during the eleventh five year plan, total private sector investment on NHDP was recorded at 62,629 crore INR against a target of 86,792 crore INR, which is a significant jump from the Tenth five year plan amount of 11,032 crore INR. The private sector investment in roads sector is expected to grow at a CAGR of about 10 per cent during the period 2013-17.

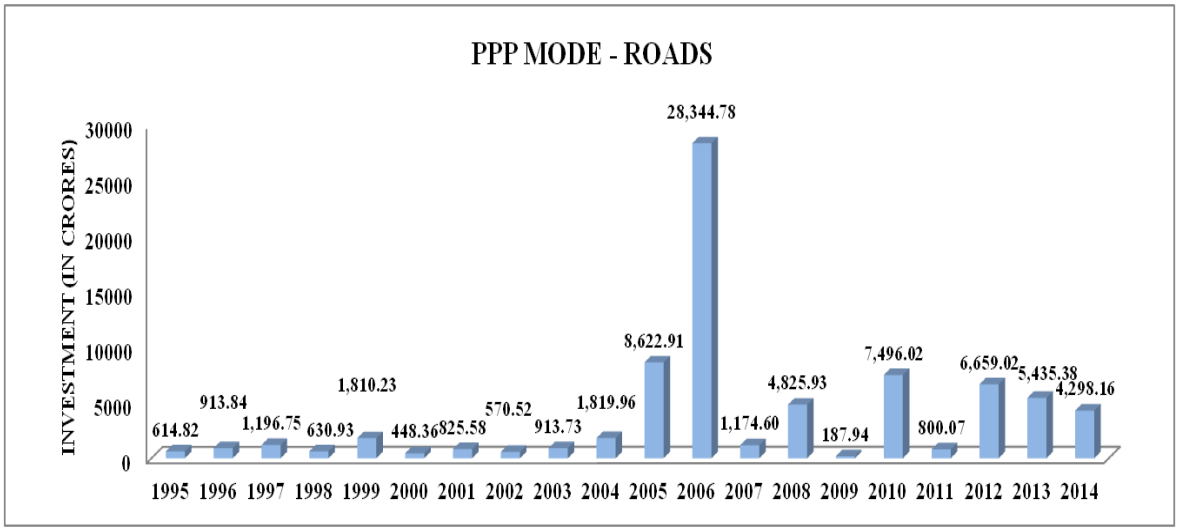


Figure 5.7: PPP Investment in Roads Sector

The PPP model may be considered as a successful one in India, particularly in the development of road sector as majority of the on-going highways development projects have been taken up under this model. While there are a number of forms of PPP, the common forms that have been used in road projects are Build Operate Transfer (BOT) Toll and BOT Annuity. India has completed 100 PPP projects and 165 are still ongoing as of March, 2014.

As of March 2015, projects worth 1, 97,045 crores INR have been awarded through this PPP mode of infrastructure financing. During the next five years, investment through PPPs is expected to be around 31 billion USD for National Highways which confirms the fact that in the coming years, PPP mode of investment is going to be more prevalent in the financing of road sector.

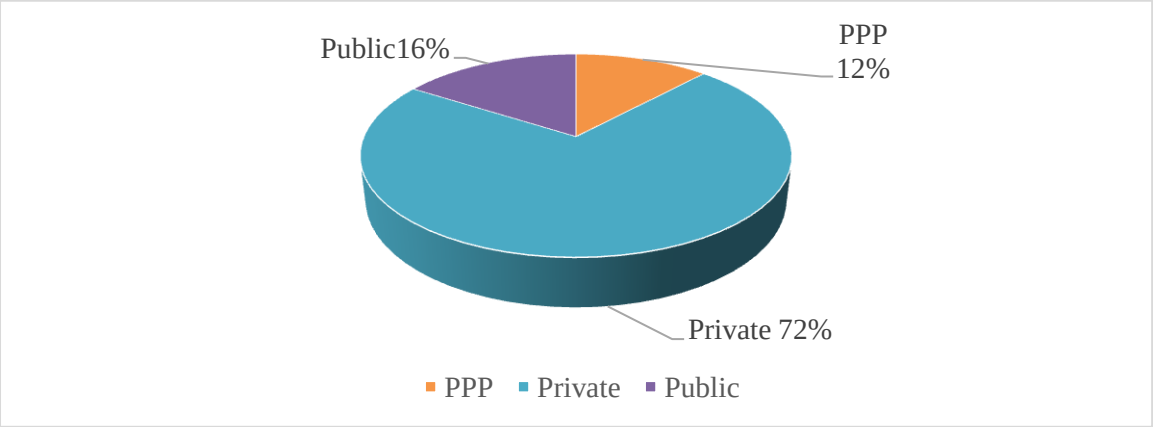


Fig 5.8: Public, Private and PPP investments as a percentage of total investment - Roads sector

Analysis of the total investment in the roads sector over the period from 1995-2014 (Refer Fig 5.8) indicates that the private mode of financing has emerged as the major financing mode for roads sector with total contribution of 72 per cent, while public mode is the second most preferred mode of financing roads with a share of 16 per cent. PPP partnership, despite its increasing share in recent times remains the third most preferred mode. One reason behind this could be that although PPPs can present a number of advantages, it must be remembered that these schemes are also complex to design, implement and manage.

5.3.1.3.2 Historical Trends in Seaports Sector

The Seaports sector is also known as the ports and shipping sector. There are 12 major ports and about 60 non-major and private ports in India. With the awarding of infrastructure status for inland waterways and inland ports, the construction of ports under private sector has picked up. The historical data indicates that PPP mode of financing is the most preferred investment mode as far as Ports and shipping sector is concerned.

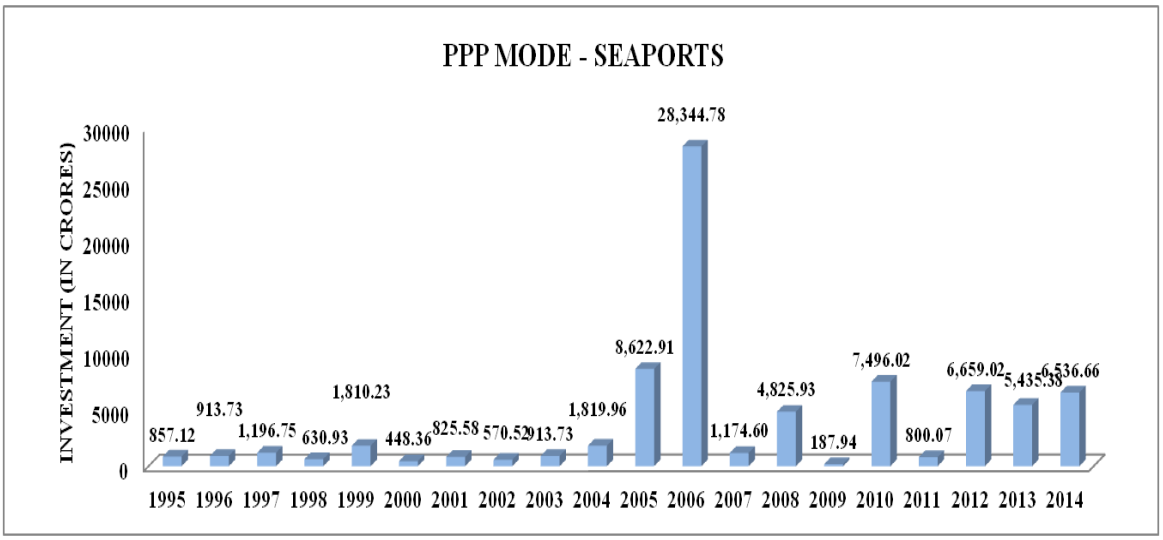


Figure 5.9: PPP Investment in Seaports Sector

PPP Mode is the most preferred mode of financing for ports and shipping sector. The sector has witnessed significant private participation particularly after 1996. This could be attributed to the fact that in 1996, the port sector was opened for private sector participation, following which the government decided to move towards the Landlord Port concept where new ports were expected to be established as companies under the Companies Act 1956 and existing port trusts were expected to be corporatized. Also, Ministry of Shipping has notified standardized bidding and contractual documents to encourage PPPs in the sector. Private ports enjoy price flexibility, as the government allows non-major ports to determine their own tariffs in consultation with the State Maritime Boards.

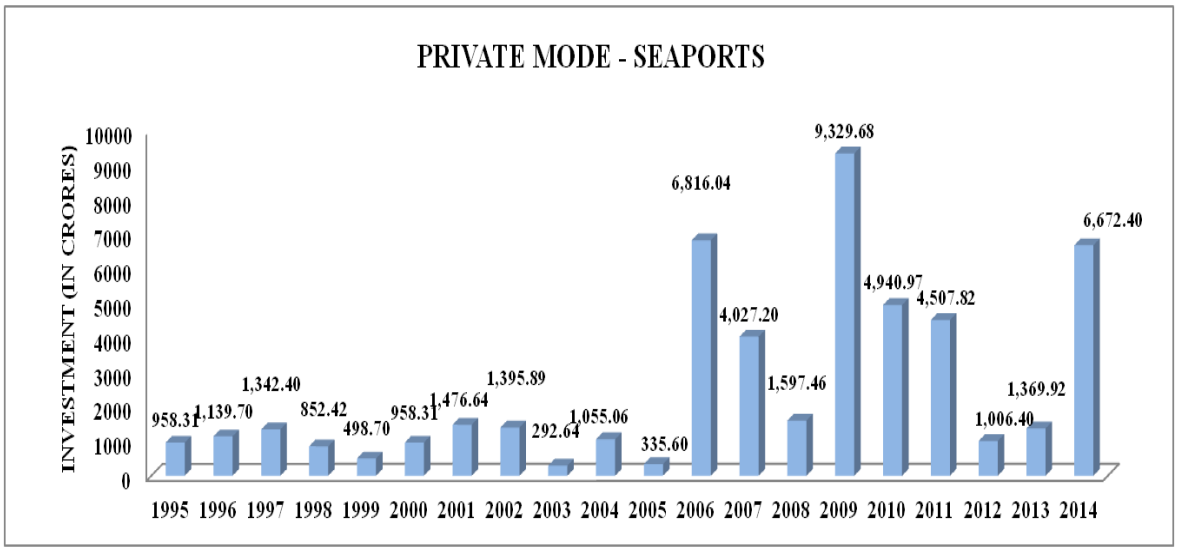


Figure 5.10: Private Investment in Seaports Sector

The private mode of financing is also quite prevalent in the Ports and Shipping sector on the back of active government policies like National Maritime Development Program (NMDP). NMDP is an initiative to develop the maritime sector with the planned outlay of 11.8 billion USD. The focus of the program is to provide guidelines for capacity augmentation and hinterland connectivity improvements at major ports. The NMDP program mandates that over 60 per cent of the required funds should be raised from private sector.

As a way of incentive, 100 per cent income tax exemption is extended to companies investing in port infrastructure. Further, a 10-year tax holiday has been given to enterprises engaged in the business of developing, maintaining and operating ports, inland waterways and inland ports. The High Level Committee on Infrastructure Financing projects an investment of 95,424 crore INR during the 12th five year plan, of which, approximately 80 per cent of the investment is expected to be raised through private sector participation.

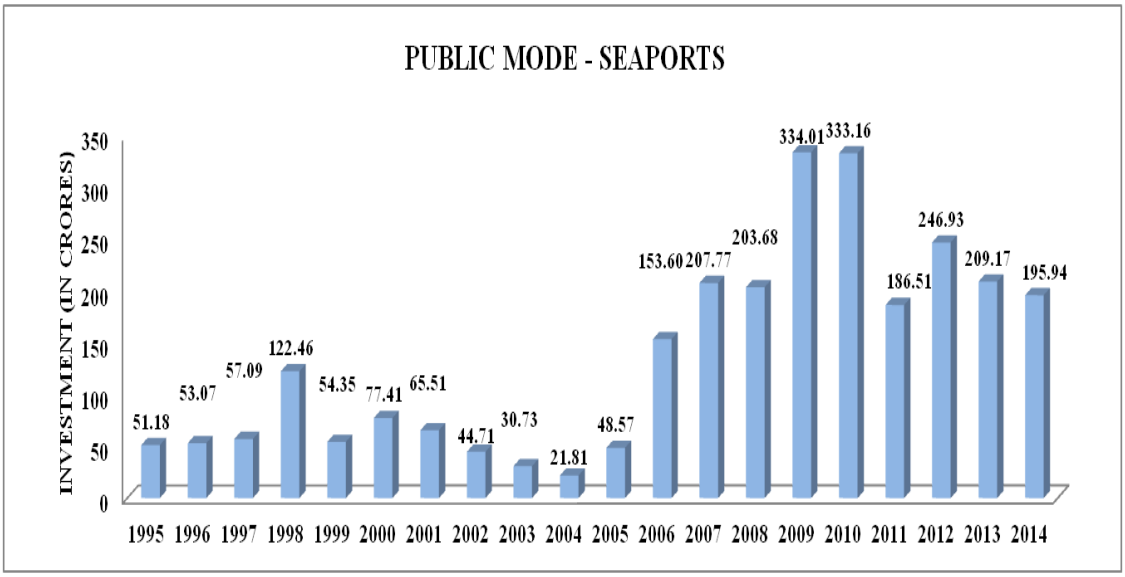


Figure 5.11: Public Investment in Seaports Sector

Public mode of investment is the least preferred mode of investment in the seaports sector of India which is largely dominated by the PPP and private mode of investment. Inspite of being the least preferred mode of financing, the public investment in seaports sector has seen an increasing trend, especially over the last decade or so. This is due to the fact that governments are well aware that Maritime transport is a critical infrastructure for achieving social and economic development of a country.

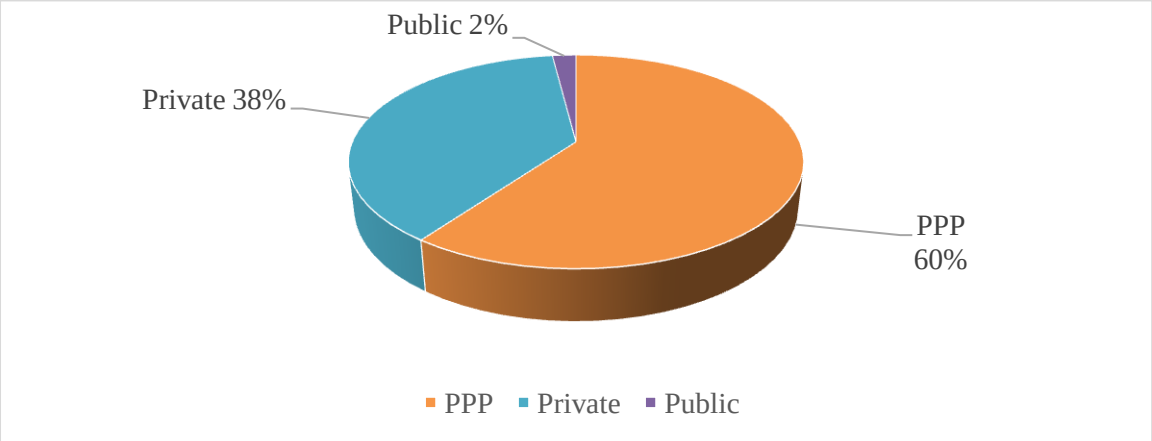


Fig 5.12: Public, Private and PPP investments as a percentage of total investment - Seaports sector

5.3.1.4 Historical Trends in Telecom Sector

The Telecom sector of India is 165 years old and is currently the world's second-largest telecom market while recording strong growth in the past decade and half. The Telecom sector in India experienced a rapid growth over the past decade on account of regulatory liberalization, structural reforms and competition, making telecom one of the major catalysts in India's growth story. The historical data indicates that Private mode of financing is the most preferred investment mode as far as telecom sector is concerned.

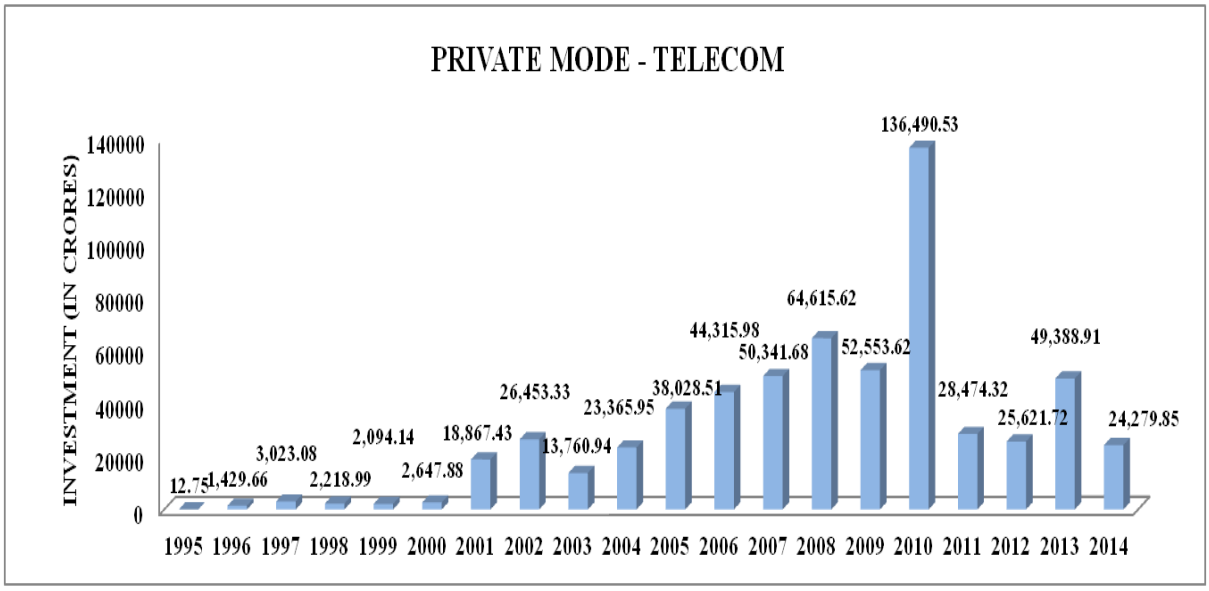


Figure 5.13: Private Investment in Telecom Sector

Private mode of investment is the most preferred mode of investment for Telecom sector. Until few decades ago when infrastructure investment was largely dominated by public investment, Telecom sector was the first sector to draw in private investment due to high investment in cellular technology. The Indian Telecom sector was completely under government ownership until 1984, when the private sector was allowed in Telecom equipment manufacturing only. Further, the Telecom sector was liberalized in early 1990s which gave an impetus for a higher private participation in the sector. However, the private

sector investment started dominating the Telecom sector post 2000 when the New Telecom Policy (NTP) was announced in 1999. NTP main objective was to ensure India's emergence as major manufacturing / export base of Telecom equipment and universal availability of basic Telecom services for Pan-India. Post the introduction of NTP, all the segments of Telecom sector were opened for private sector participation. As of now, the Telecom industry has attracted FDI worth 17.7 billion USD during the time period April 2000 to September 2015.

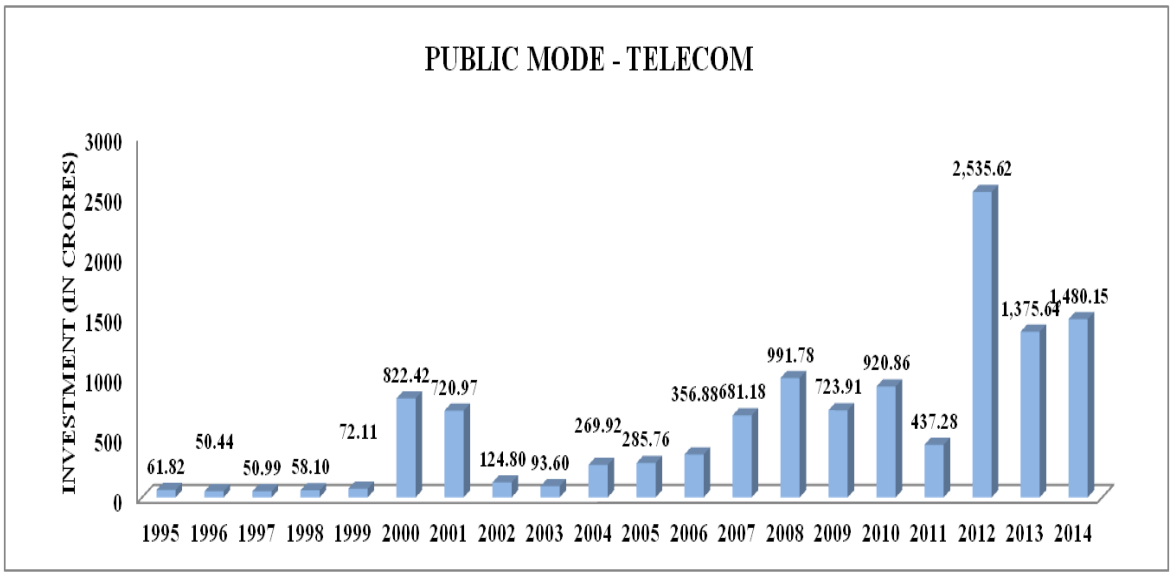


Figure 5.14: Public Investment in Telecom Sector

Public mode of investment comes after the private mode in the Telecom sector. Inspite of not being the preferred mode of financing, the public investment in Telecom sector has seen an increasing trend, especially over the last decade or so. This is due to the fact that government has fast-tracked reforms in the Telecom sector and still continues to be proactive in providing room for growth for Telecom companies.

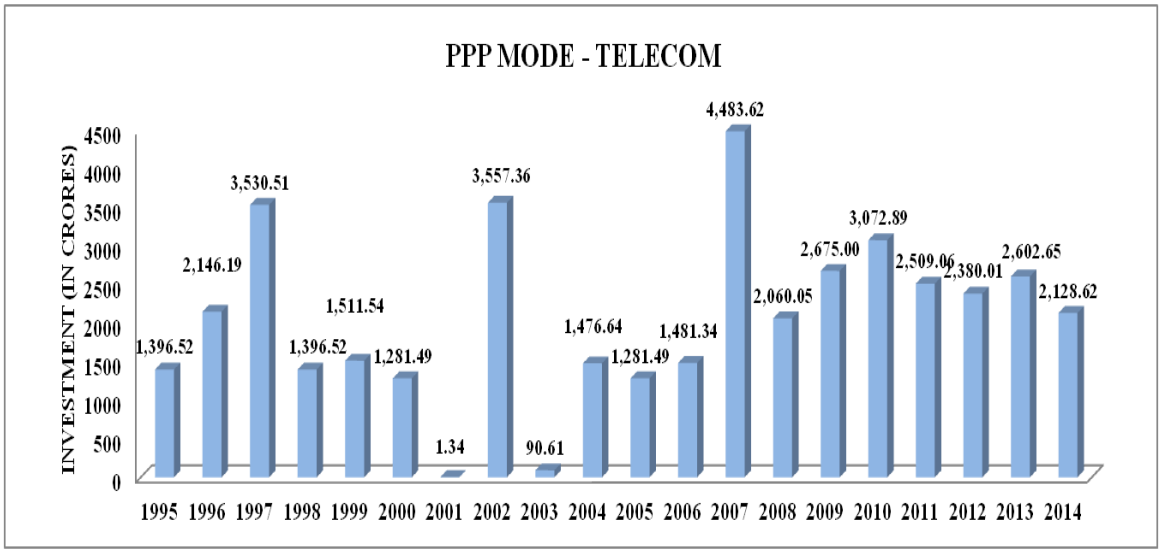


Figure 5.15: PPP Investment in Telecom Sector

Like the public mode, PPP mode of investment holds a minimal role in terms of financing of telecom sector. The historical trend suggests that for certain years, the PPP mode of investment rose sharply while for remaining years it was negligible.

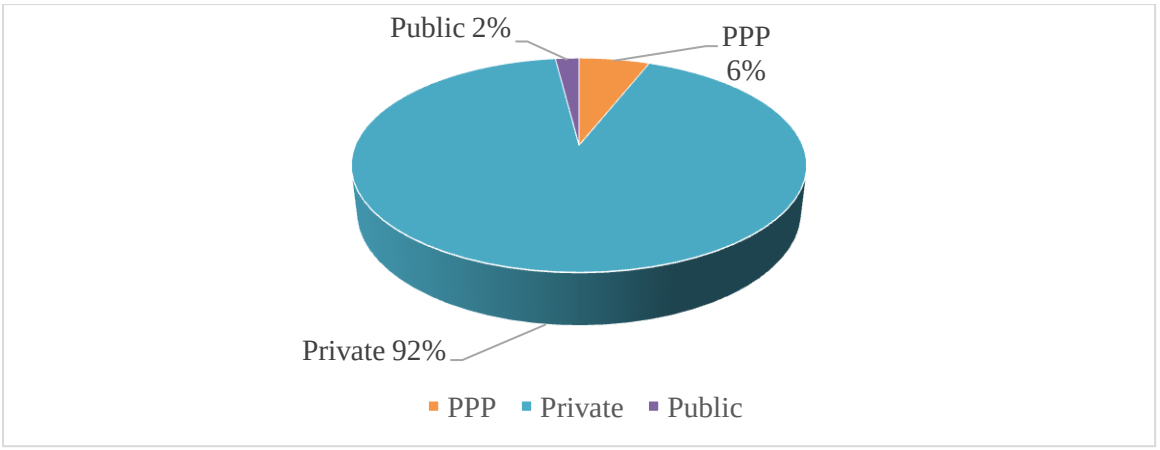


Fig 5.16: Public, Private and PPP investments as a percentage of total investment - Telecom sector

Hence from the above discussion and historical trend analysis of each of these four major infrastructure sectors, we get to know which mode of infrastructure financing is the most preferred one for the last twenty years (1995 to 2014).

Table 5.6 presents the summary of the results inferred from the above analysis of historical trends.

Table 5.6: Most Preferred mode of infrastructure financing (in terms of having the maximum investment in a particular infrastructure sector)

Models	Most significant mode of investment
Roads sector	PRIVATE MODE
Seaports sector	PPP MODE
Energy sector	PRIVATE MODE
Telecom sector	PRIVATE MODE

5.3.2 IMPACT OF DIFFERENT MODES OF INFRASTRUCTURE FINANCING ON ECONOMIC GROWTH

Further for these selected sectors individually as well as for the aggregate scenario, the SVAR methodology is used in order to empirically assess the impact of Public, Private and PPP mode of infrastructure financing on economic growth. Motivated by the works of Pereira (2000), Pereira & Andraz (2005) and Afonso & St. Aubyn (2008), this analysis is carried out and the results for the same are presented and discussed below.

5.3.2.1 Empirical Models for Individual Sectors as well as Aggregate Scenario

Since there are four individual sectors along with one aggregate scenario (combining all four), SVAR method is applied to these five cases. In that case, five different models will be there pertaining to each of the cases. All the models are discussed below:

Roads Sector: $\mathbf{Y_t = f\ (I_{PUBR},\ I_{PVTR},\ I_{PPPR})}$

Y_t refers to the Per capita Gross Domestic Product (GDP) at factor cost of Indian economy. This variable remains common for all the models. $I_{PUBR,}\ I_{PVTR,}\ I_{PPPR}$ represent the Investment in roads sector by public mode of financing, private mode of financing and PPP mode of financing respectively. The three investment variables pertaining to public mode, private mode and PPP mode change for each of the five cases (four individual sectors and one overall scenario).

Seaports Sector: $\mathbf{Y_t = f\ (I_{PUBSP},\ I_{PVTSP},\ I_{PPPSP})}$

$I_{PUBSP,}\ I_{PVTSP,}\ I_{PPPSP}$ represent the Investment in Seaports sector by public mode of financing, private mode of financing and PPP mode of financing respectively.

Energy Sector: $\mathbf{Y_t = f\ (I_{PUBEG},\ I_{PVTEG},\ I_{PPPEG})}$

I_{PUBSEG}, I_{PVTSEG}, I_{PPPSEG} represent the Investment in Energy sector by public mode of financing, private mode of financing and PPP mode of financing respectively.

Telecom Sector: $\mathbf{Y_t = f\ (I_{PUBTC},\ I_{PVTTC},\ I_{PPPTC})}$

I_{PUBTC}, I_{PVTTC}, I_{PPPTC} represent the Investment in Telecom sector by public mode of financing, private mode of financing and PPP mode of financing respectively.

Aggregate Scenario: $\mathbf{Y_t = f\ (I_{PUBT},\ I_{PVTT},\ I_{PPPT})}$

I_{PUBT}, I_{PVTT}, I_{PPPT} represent the Investment in overall/aggregate scenario (combining all the four individual sectors i.e Roads, Seaports, Energy, Telecom) by public mode of financing, private mode of financing and PPP mode of financing respectively.

In this case, all the variables of Public investment, Private investment, PPP investment along with GDP are taken as endogenous variables. The data sources and other steps in the empirical analysis are discussed in the proceeding section.

5.3.2.1.1 Data Sources

All the three investment variables corresponding to each mode for these four major sectors have data in crores INR for the considered time period of 1995 to 2014. The GDP data is also taken in crores INR. The data for public investment in all the sectors along with GDP has been obtained from the budget data files of Government of India (Government of India database). The data for PPP and private investment has been obtained from World Bank database. The database has been compiled after careful examination of all the aforementioned sources. However, data has been found to be unavailable for PPP and private investment in many of the sub sectors of Infrastructure which limits this analysis to these four major sectors only.

5.3.2.2 Empirical Analysis and Results of different steps under SVAR model

Since all the steps in the SVAR analysis remain same for each of the five models, so under each step the results are explained for all the five models together.

5.3.2.2.1 Stationarity Tests

Before proceeding for this analysis, the log of all the investment variables along with GDP was taken. Therefore, all the investment variables along with GDP are prefixed with L so as to represent that they are used in their logarithmic forms. For example, public investment in Roads sector (I_{PUBR}) becomes LI_{PUBR} and so on.

The analysis started off by testing the time series for stationarity. Phillips–Perron unit-root was used to test for the presence of unit roots and ultimately check for stationarity. The stationarity test revealed that the time series of public investment, private investment and PPP investment for each of the five models along with GDP come out to be stationary at their levels. In other words, the null hypothesis stating presence of unit root at 5 per cent level of significance was rejected for all the variables and hence it can be said that investment variables of all the five models along with GDP come out as I (0). Table 5.7 given below presents the results for the PPP test for all the five models.

Table 5.7: Phillips Perron test for all the five models– Stationarity results

Models	Variables	LEVELS	CONCLUSION
Roads sector	LI_{PUBR}	4.47*	I(0)
	LI_{PVTR}	-5.99*	I(0)
	LI_{PPPR}	3.50*	I(0)
	LGDP	5.02*	I(0)
Seaports sector	LI_{PUBSP}	5.05*	I(0)
	LI_{PVTSP}	-6.12*	I(0)
	$L\ I_{PPPSP}$	4.04*	I(0)
	LGDP	4.86*	I(0)
Telecom sector	LI_{PUBTC}	-7.05*	I(0)
	LI_{PVTTC}	5.76*	I(0)
	LI_{PPPTC}	3.98*	I(0)
	LGDP	4.92*	I(0)
Energy sector	LI_{PUBEG}	-5.82*	I(0)
	LI_{PVTEG}	4.61*	I(0)
	LI_{PPPEG}	3.75*	I(0)
	LGDP	5.33*	I(0)
Aggregate scenario	LI_{PUBT}	-8.10*	I(0)
	LI_{PVTT}	5.17*	I(0)
	LI_{PPPT}	4.49*	I(0)
	LGDP	5.97*	I(0)

Note: * indicates significance at $p<0.05$ level.

5.3.2.2.2 Determination of Lag Length

The next step of the analysis involves determining the lag length or in other words the order of the Vector Autoregression (VAR). The optimal lag length obtained from tests for all the five models comes out to be 1. Thus, only one lag is included in the model. The AIC, Schwarz's Bayesian information criterion (SBIC) and the Hannan and Quinn information criterion (HQIC) all lead to the same conclusion. In practical sense also, optimal lag of one time period is advantageous because higher the number of lags, the lesser are the degrees of freedom available.

5.3.2.2.3 SVAR Model Estimation

Since the optimal lag length is determined, the model specification is now complete. Now, a SVAR can be estimated with the identification restrictions corresponding to the Choleski

decomposition. The covariance matrix is also restricted to be an identity matrix. Since only one time period of lag can be included, the summation of lag terms in the Autoregressive form of the VAR model reduces to just one term. SVAR allows us to examine the scenarios where the shock is given to every variable in the model and the analysis allows us to see the impact on the other remaining variables in the model. In this case there are five models and hence if we want to examine the impact of a shock to a particular variable on the other variables, then there will be multiple cases. However, the major interest is in examining the impact of each mode of infrastructure financing (Public, Private and PPP) on economic growth for the four major sectors and the overall scenario. We will get to know this from the Impulse Response functions (IRFs) which have been discussed later in Section 5.3.2.2.5.

5.3.2.2.4 Testing for Stability and Serial Correlation

The validity of the VAR is established by testing for the dynamic stability of the SVAR. The requirement for this stability is that the resulting table from this step should have all the eigenvalues less than one. For this case, in all of the five models the eigenvalues come out to be less than one and hence it can be concluded with certainty that the VAR is stable. This stability has important implications for the IRFs. This suggests that the impulse response must converge to zero. It can be interpreted in this way that one-off shocks to the variables do not have a permanent effect. Table 5.8 given below presents the output of eigenvalue stability condition.

Table 5.8: Eigenvalue Table

Models	Eigenvalue	Modulus
Road Sector	0.8942601	0.8943
	-0.4244399	0.4244
	0.2871355	0.2871
	-0.02133782	0.0213
Seaports Sector	0.7791501	0.7791
	-0.3109506 + 0.1451746i	0.3431
	-0.3109506 - 0.1451746i	0.3431
	0.2590488	0.2590
Telecom Sector	0.8404037	0.8404
	-0.7167946 +0.6419914i	0.7167
	-0.7167946 -0.6419914i	0.6419
	-0.09456415	0.0945
Energy Sector	0.608818	0.6088
	-0.41583	0.4158
	0.34174	0.3417
	-0.08559	0.0855
Aggregate Sector	0.9111037	0.9111
	0.63877	0.6387
	-0.2828288	0.2828
	0.2045253	0.2045
Note: All Eigen values lie inside the unit circle.VAR satisfies stability condition.		

5.3.2.2.5 Interpretation of IRFs

As discussed above, the major focus is towards the research problem i.e seeing the impact of each mode of infrastructure financing (Public, Private and PPP) on economic growth for the four major sectors and the overall scenario. Essentially we want to know that when a shock is being given to the investment variable corresponding to each of the three modes of financing, which mode of financing is able to have the maximum positive impact on India's GDP. In other words, we want to know the marginal returns in terms of the impact on GDP when shocks are given to each of the investment variables. This is achieved by interpreting the impulse response functions for these five cases where a shock to each investment variable (public, private and PPP modes) will give us the resulting impact on the dependent

variable (economic growth represented by GDP). The IRF graphs for each of these five models are discussed below.

i. Roads Sector Model:

For the Roads sector model, while giving shocks to each of the investment variables (public, private and PPP) the maximum positive resulting impact on GDP comes through Private mode of investment. Given below are the IRFs for the same:

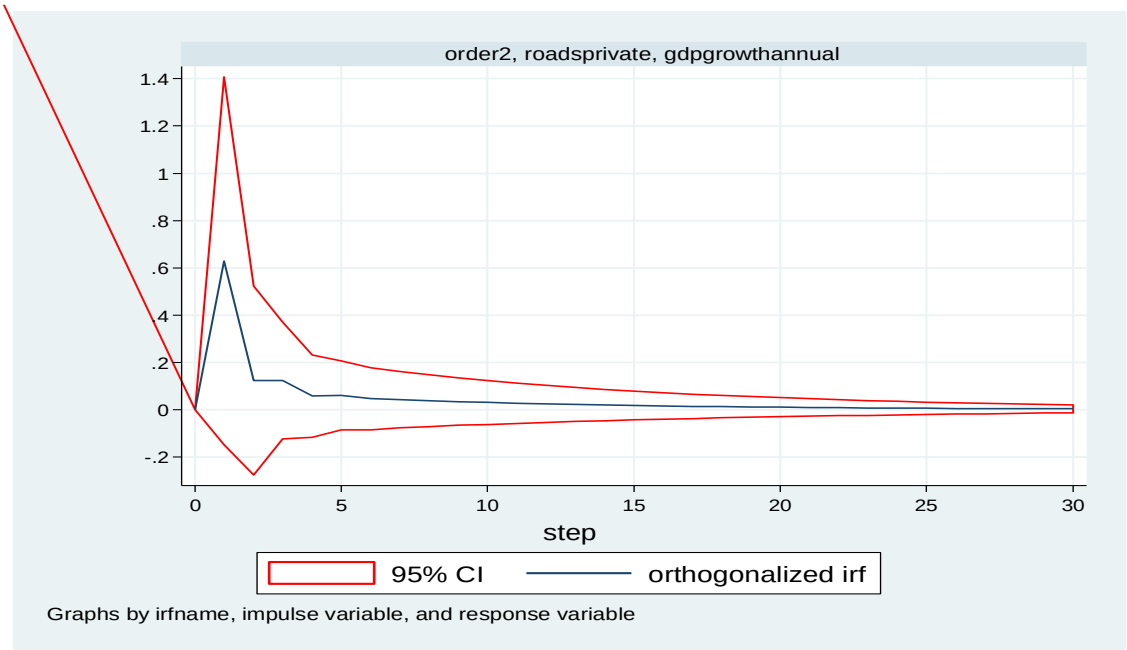


Figure 5.17: Response of GDP to a shock in Private Investment in Roads

As mentioned above that out of the three modes of financing, private mode of investment in the roads sector has the maximum positive effect on the GDP. The analysis of IRF (fig 5.17, given above) shows that a 1 per cent change in Private investment in this sector would lead to an increase of 0.63 per cent in GDP in the same time period. After a lag of one year the value of impulse response show a dip but the interesting point is even after lag of k years the response of GDP to Private investment in roads is positive (above zero). Thus Private investment in roads will always have a positive impact on GDP, even in long term. Just for

confirmation, in order to understand the long run response, the cumulative orthographic response function of the GDP to a shock in Private investment in roads sector is observed.

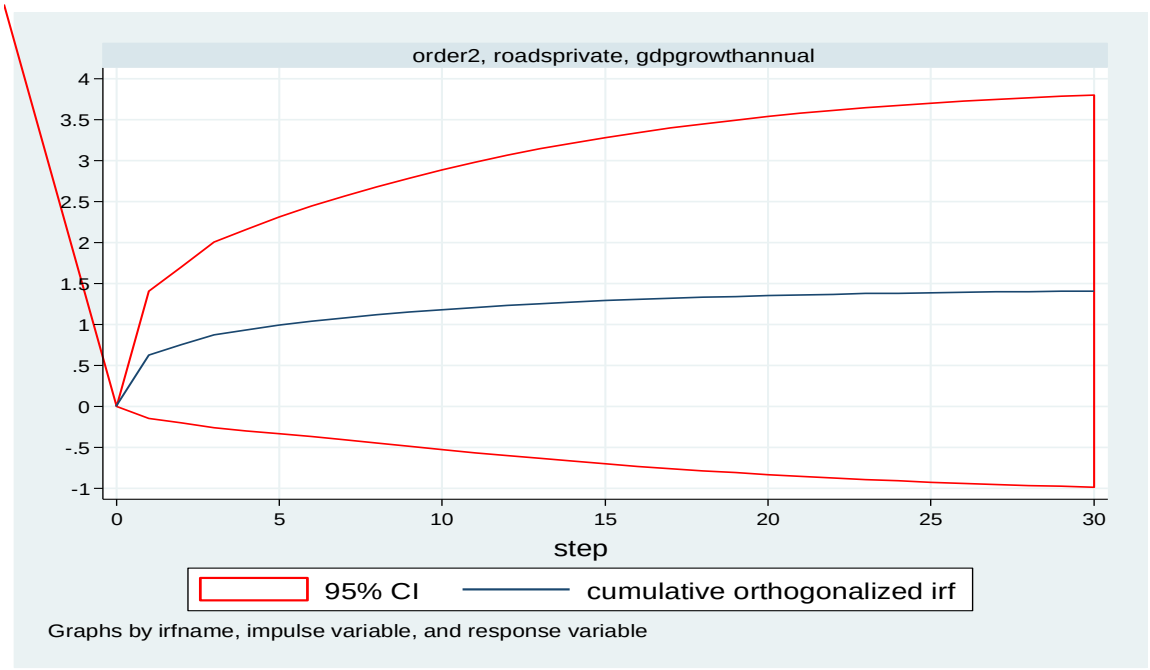


Figure 5.18: Cumulative IRF: Response of GDP to a shock in Private Investment in Roads

Cumulative Response at a lag k means the sum of the individual impulse responses from lag 0 to lag k. The cumulative response of GDP continuously increases over time. The increase is expected as the orthogonalized Inverse response function is positive. This implies that Private investment in roads sector will have a positive impact on GDP in long run.

ii. Seaports Sector Model:

For the Seaports sector model, while giving shocks to each of the investment variables (Public, Private and PPP) the maximum positive resulting impact on GDP comes through PPP mode of investment. Given below are the IRFs for the same:

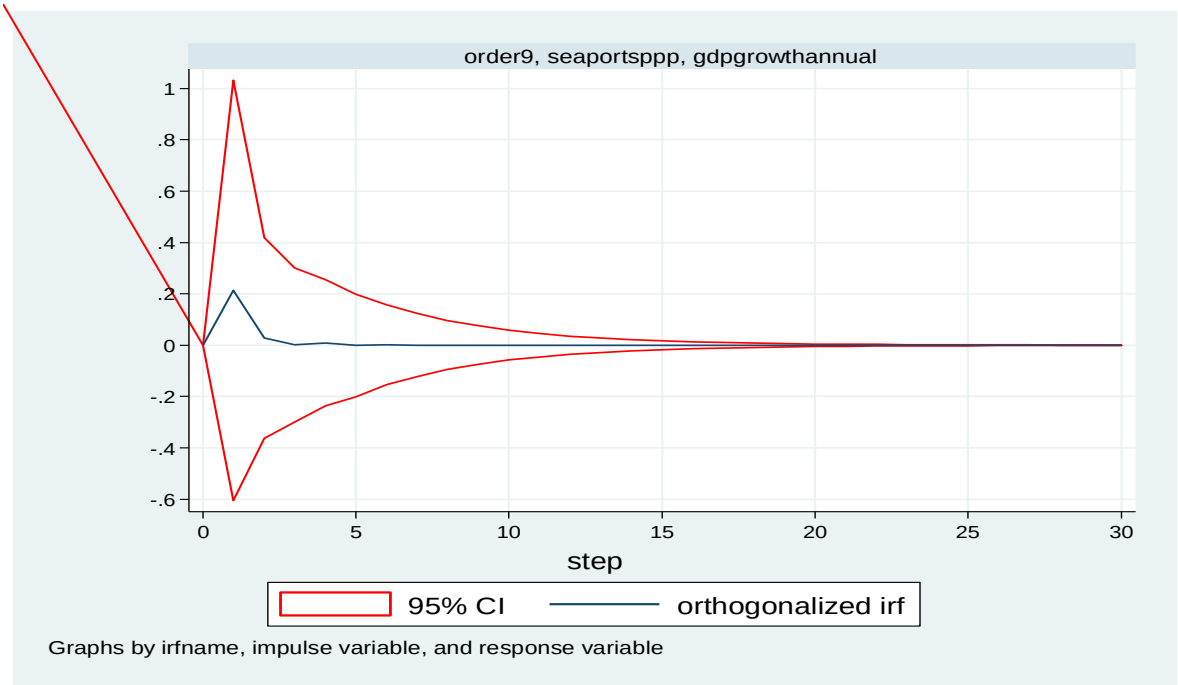


Figure 5.19: Response of GDP to a shock in PPP Investment in Seaports

As mentioned above that out of the three modes of financing, PPP mode of investment in the seaports sector has the maximum effect on the GDP. The response of economic growth i.e GDP to PPP investment in seaports sector is positive and the graph shows that a 1 per cent change in PPP investment in seaports sector leads to a 0.21 per cent increment in the GDP in the same time period. This response stays above zero till lag of four years. At the fifth lag, the response reverses and gets negative though the magnitude of reversal is very low. However straight after the fifth lag i.e at the sixth lag, the response becomes again positive. After a lag of six years, the IRF stabilizes and remains constant thereafter.

In order to understand the long run response, the cumulative orthographic response function of the GDP to a shock in PPP investment in seaports sector is observed by the following graph.

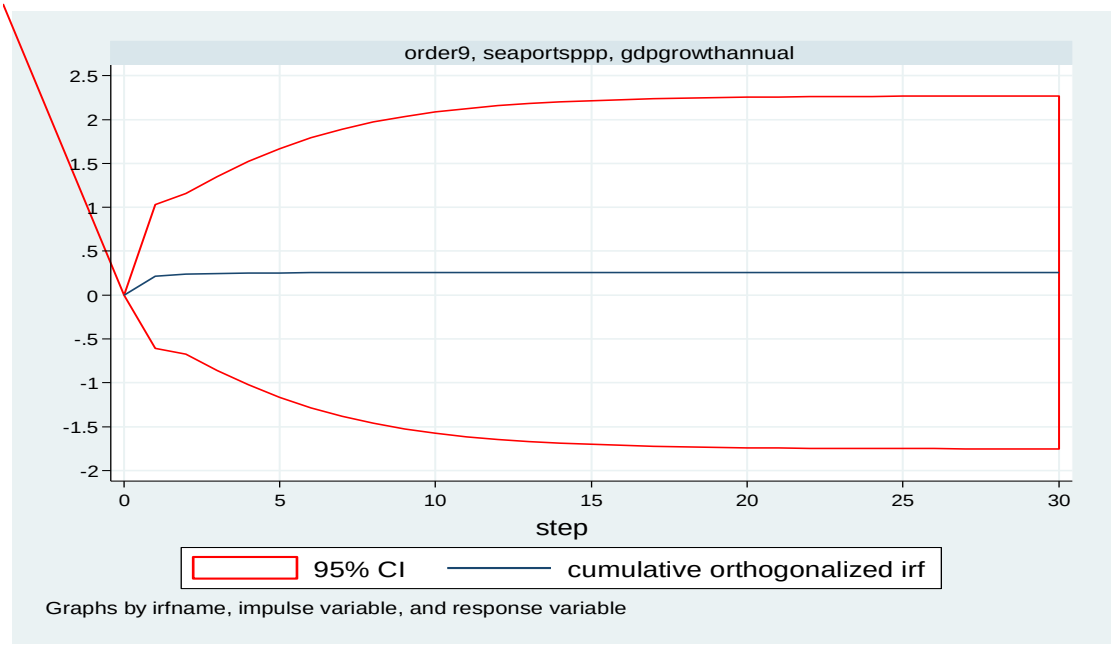


Figure 5.20: Cumulative IRF: Response of GDP to a shock in PPP Investment in Seaports

The cumulative response of GDP is stabilized and constant over time with values remaining positive. This is expected as seeing the trend of the orthogonalized Inverse response function discussed above. This implies that PPP investment in seaports sector will have a positive impact on GDP in long run.

iii. Telecom Sector Model

For the Telecom sector model, while giving shocks to each of the investment variables (Public, Private and PPP) the maximum positive resulting impact on GDP comes through Private mode of investment. Given below are the IRFs for the same:

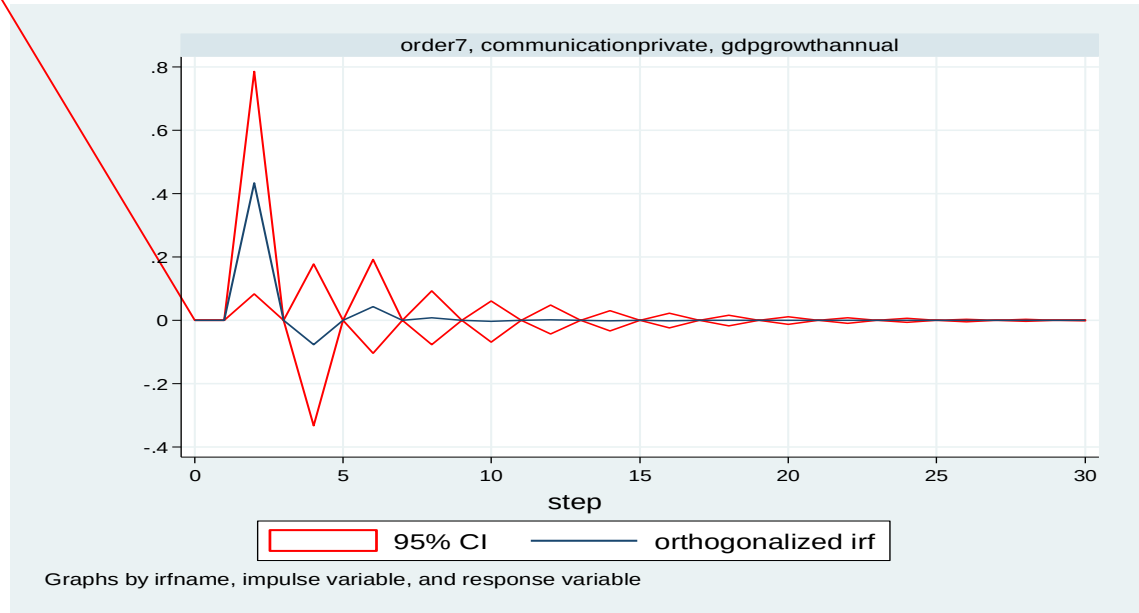


Figure 5.21: Response of GDP to a shock in Private Investment in Telecom sector

As mentioned above that out of the three modes of financing, Private mode of investment in the Telecom sector has the maximum effect on the GDP. The analysis of IRF (fig 5.21, given above) shows that at first lag the impulse response value is zero signifying no impact on GDP. After a lag of two, the impulse response becomes positive and leads to an increase of 0.43 per cent in GDP. After a lag of two years i.e at the third year, the response again decreases and becomes zero. At the fourth lag, the response is negative but then it again becomes zero at fifth lag and then positive at lag six.

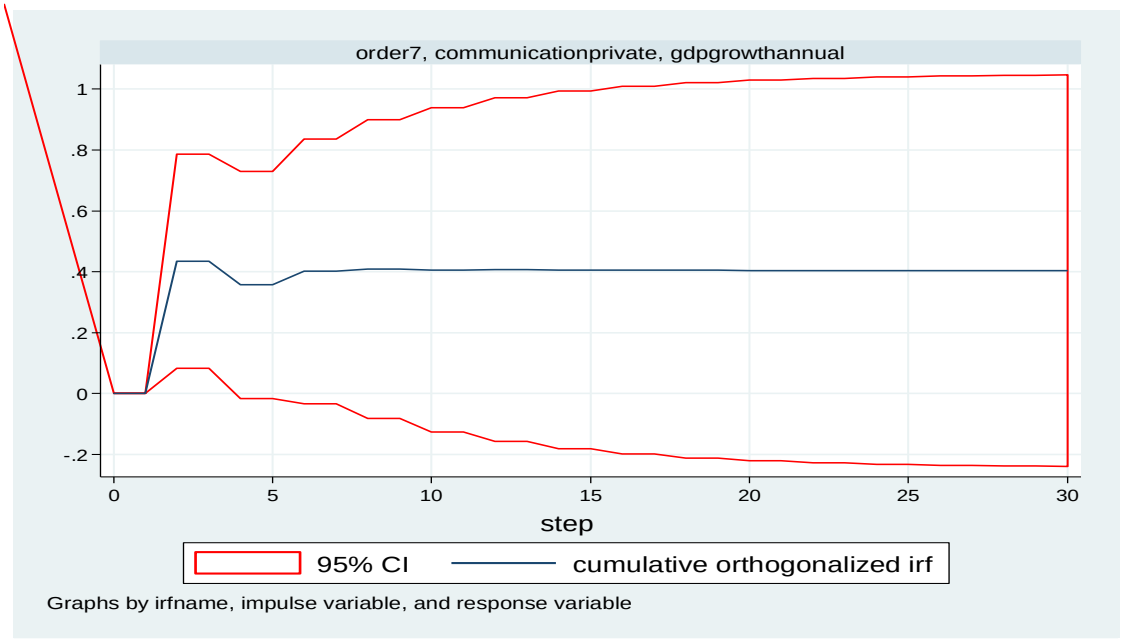


Figure 5.22: Cumulative IRF: Response of GDP to a shock in Private Investment in Telecom sector

Note that the cumulative response starts with the same value as the one lag response i.e. zero. However, it increases for lag two, stays the same for lag three, decreases for lag four, stays the same for lag five, increases for lag six and then stabilizes (remaining positive) as the lag increases. This cyclical trend is expected as was the case in the previous graph.

The cumulative response after three years however is not statistically significant. This can be inferred directly from the cumulative Impulse response graph. The zero line lies inside the 95 per cent confidence interval for all lags from four to thirty. The cumulative response indicates that there is no significant long term response of GDP to Private investment in the telecom in the long run after three years. The cumulative response shows that GDP increases in the immediate short term till three years. However, in the long run, the response of GDP stabilizes. It is more difficult to interpret the cumulative response of GDP as although the long run responses are not statistically significant the cumulative response stabilizes after increasing from the initial response.

Also, it must be noted that although the results are not significant, the cumulative response lies above the zero line. This seems to show that the Private investment in telecom sector does lead to a small increase in GDP in the long run. However, it is difficult to determine if the Private investment in the past had any role in this increase. The fact that the Private investment in the current period boosts GDP is unquestionable given that the immediate impulse response is statistically significant till three years.

iv. Energy Sector Model

For the Energy sector model, while giving shocks to each of the investment variables (Public, Private and PPP) the maximum positive resulting impact on GDP comes through Private mode of investment. Given below are the IRFs for the same:

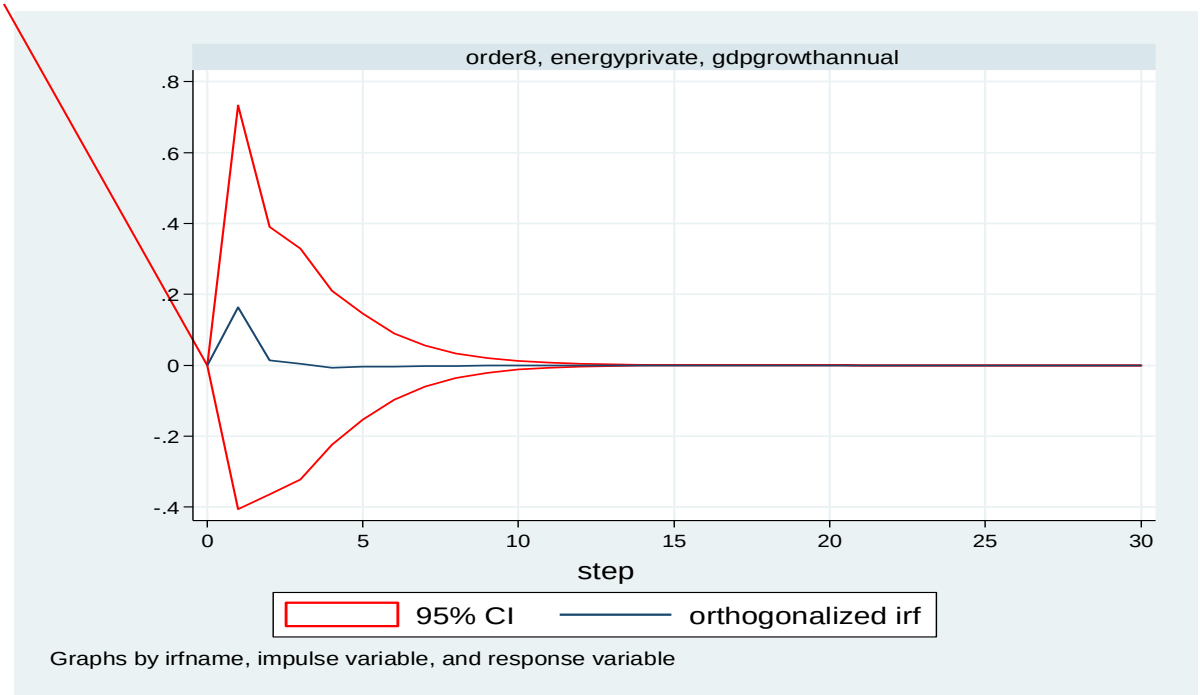


Figure 5.23: Response of GDP to a shock in Private Investment in Energy

As mentioned above that out of the three modes of financing, Private mode of investment in the seaports sector has the maximum effect on the GDP. The analysis of IRF function (fig 5.23, given above) shows that a shock of 1 per cent in Private investment in the energy leads

to a 0.16 per cent increment in the GDP in the same time period. This response stays positive till lag of three years. However from the fourth lag onwards, the response becomes negative and stays like that thereafter. This means that a 1 per cent increase in Private investment in energy sector leads to a decline in GDP after three years or more. This response can be interpreted as follows: an increase in Private investment in energy sector leads to an increase in GDP in the short term. However, in the long run the increase is mitigated.

In order to understand the long run response, the cumulative orthographic response function of the GDP to a shock in Private investment in energy sector is observed from the below mentioned graph.

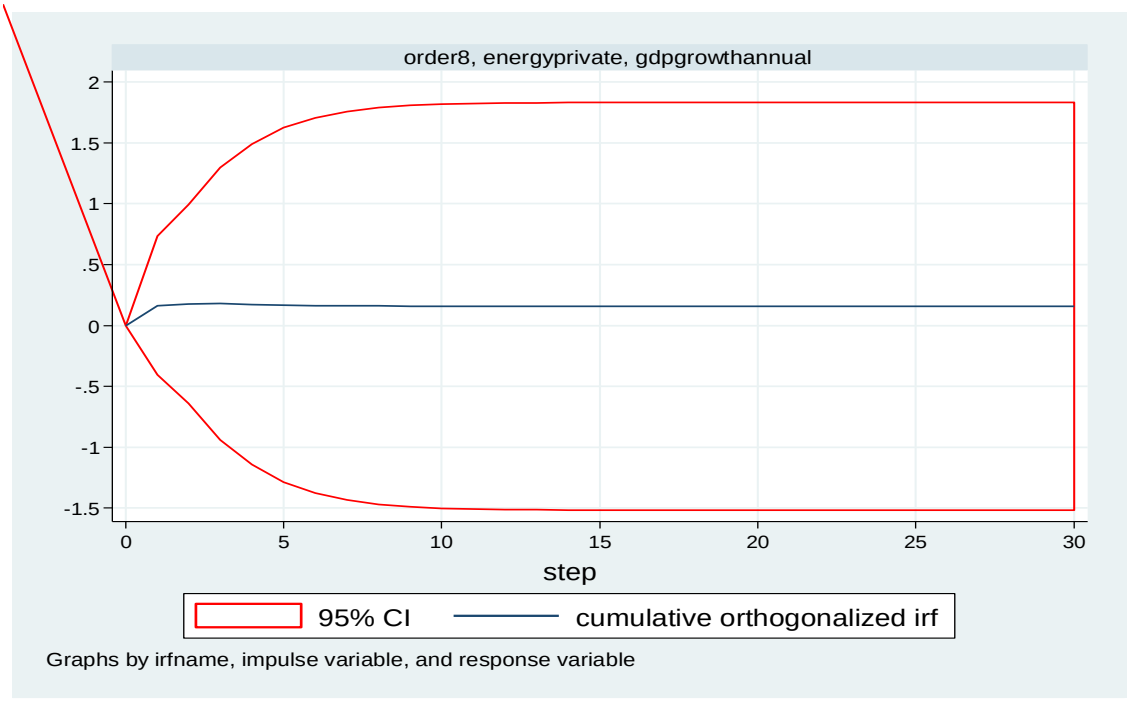


Figure 5.24: Cumulative IRF: Response of GDP to a shock in Private Investment in Energy

Note that the cumulative response starts with the same value as the one lag response i.e. 0.16 per cent. However, it stabilizes as the lag increases. Even in the cumulative response, only the immediate response is significant. All the lagged cumulative responses are not

significant. This can be seen from the fact that the zero line lies inside the 95 per cent confidence interval for all values of lag from two to thirty. This confirms our earlier hypothesis that for the energy sector, the long run response is mitigated as compared to the earlier surge in GDP. The cumulative response clearly indicates that there is no significant long term response of GDP to Public investment in energy sector.

v. Aggregate Scenario Model

For the Aggregate Scenario model, while giving shocks to each of the investment variables (Public, Private and PPP) the maximum positive resulting impact on GDP comes through PPP mode of investment. Given below are the IRFs for the same:

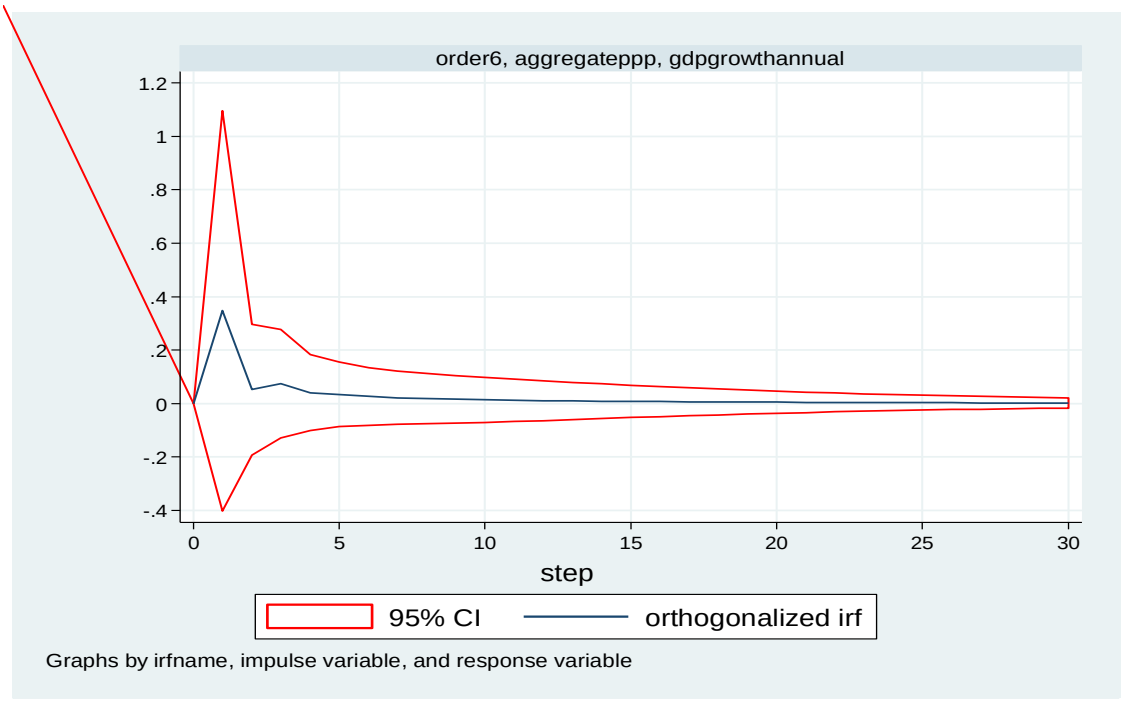


Figure 5.25: Response of GDP to a shock in PPP Investment in Aggregate scenario (overall sector)

As mentioned above that out of the three modes of financing, PPP mode of investment in the aggregate scenario has the maximum positive effect on the GDP. The analysis of IRF (fig 5.25, given above) shows that a 1 per cent change in PPP investment in aggregate sector would lead to an increase of 0.347 per cent in GDP in the same time period. After a lag of one year the value of impulse response show a dip but the interesting point is even after lag of k years the response of GDP to PPP investment in overall Infrastructure sector is positive (above zero). Thus PPP investment in Infrastructure will always have a positive impact on GDP, even in long term. Just for confirmation, in order to understand the long run response, the cumulative orthographic response function of the GDP to a shock in PPP investment in aggregate sector model of infrastructure is observed.

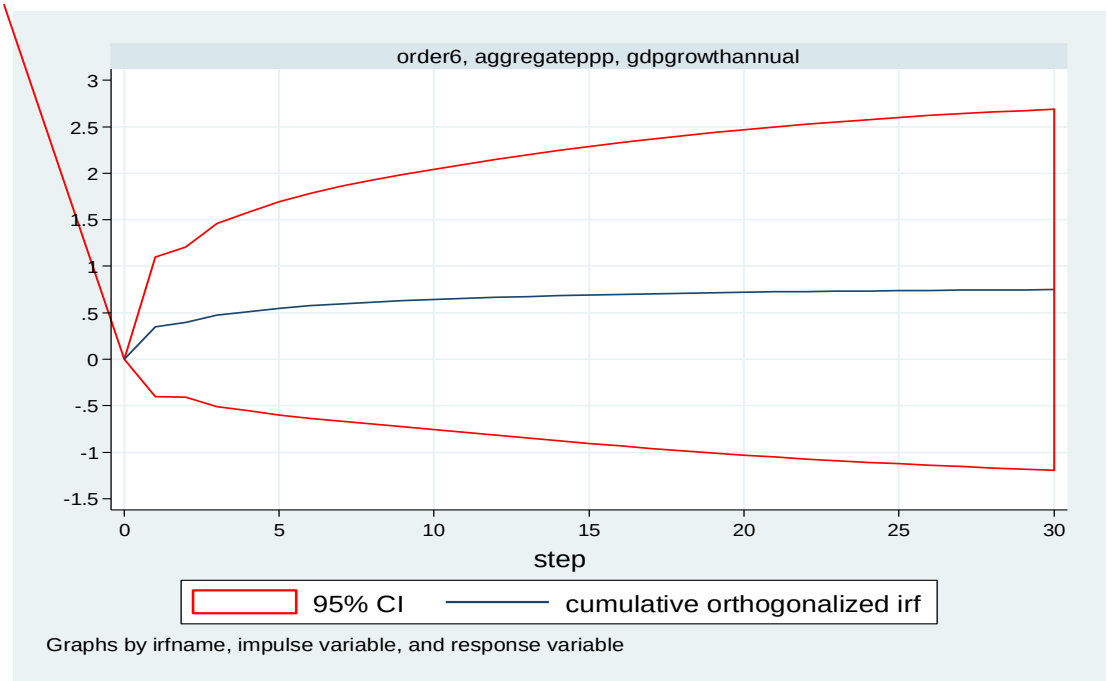


Figure 5.26: Cumulative IRF: Response of GDP to a shock in PPP Investment in Aggregate scenario (overall sector)

It is to be noted that the cumulative response starts with the same value as the one lag response which is equal to 0.347 per cent. The cumulative response of GDP increases continuously over time. The increase is expected as the orthogonalized Inverse response function is positive. This implies that PPP investment in overall Infrastructure sector will have a positive impact on GDP in long run.

Hence from the above discussion and empirical analysis of each of these five models, we get to know which mode of infrastructure financing is having a maximum positive impact on GDP. Table 5.9 presents the summary of the results inferred from the above analysis of IRFs.

Table 5.9: Most significant mode of infrastructure financing (in terms of having the maximum positive impact on GDP)

Models	Most significant mode of investment	Corresponding Variable
Roads sector	PRIVATE MODE	$\mathbf{LI_{PVTR}}$
Seaports sector	PPP MODE	$\mathbf{LI_{PPPSP}}$
Energy sector	PRIVATE MODE	$\mathbf{LI_{PVTEG}}$
Telecom sector	PRIVATE MODE	$\mathbf{LI_{PVTTC}}$
Aggregate scenario	PPP MODE	$\mathbf{LI_{PPPT}}$

Looking at the tables 5.6 and 5.9, it can be observed that for each of the four major infrastructure sectors (Roads, Seaports, Energy and Telecom), the most preferred mode of infrastructure financing suggested by the historical trend analysis is the one that exerts the maximum positive impact on India's GDP.

Section B

5.3.3 DETERMINANTS OF PPPs IN INDIA

As per the empirical analysis for overall Infrastructure scenario constituting of Roads, Seaports, Telecom and Energy sectors, PPP mode of infrastructure financing comes out to be the most significant one in terms of having the maximum positive impact on India's GDP. Everyone is well aware that PPP mode of financing is quickly becoming the favored way to invest and fund infrastructure in India. Hence, in this section the focus is put exclusively on the PPP mode of infrastructure financing. Based on the work of Hammami et al. (2006), the significant determinants of attracting any PPP in India have been estimated. Eight relevant research hypotheses are framed and tested for this purpose using techniques like Poisson regression, Tobit regression, and Negative binomial regression. Based on the literature review, four major types of factors – Government, Political, Market and Macroeconomic, were identified as the ones which can possibly determine a PPP.

5.3.3.1 Determinants of PPPs

This section discusses all the possible determinants/factors for a PPP in detail.

5.3.3.1.1 Government Factors

Lack of governmental capacity and experience is a major challenge to a successful PPP. In many scenarios the needs of the people exceed the budget of government and in such cases where there is a evident infrastructural gap between the two parties, PPP arrangements help to fill this gap. In this way PPPs help the government to consider costly and unaffordable projects. Theoretically countries with a stable fiscal position i.e having a fairly positive cash surplus and manageable debt tend to be less dependent on PPP. Also it has been observed that countries which receive a regular and substantial foreign aid tend to be less open towards foreign private investments. Therefore, countries having external sources of

financial aid have faced smaller economic crisis and have a significant cushion over fiscal shocks and are thus not open to the idea of PPP.

5.3.3.1.2 Macroeconomic Factors

The most basic requirement for a successful and effective PPP is the stable macroeconomic condition of the country. PPP projects are more common in countries which have credible and stable macroeconomic conditions. A country whose GDP is growing at an acceptable rate and all its key sectors are also growing at satisfactory rates will infuse high business confidence in private investors. Also price stability and reasonable interest rates are important for a sound macroeconomic condition. Since most of the projects are financed through foreign capital, investors are more worried about exchange rate risk than country risks. While the income and profits accrue in domestic currency, debt repayments have to happen in the foreign currency which is very much susceptible to exchange rate risks.

Previous studies of Ghura and Hadjimichael (1995), De Soto (2000), Allayannis and Weston (2000), Estache (2006) & Banerjee et al. (2006) have concluded and confirmed the important fact that macroeconomic stability is a vital and imperative issue in private sector involvement. Banerjee et al. (2006) substantiated the importance of macroeconomic environment by concluding that Inflation and variations in exchange rate are supposed to have a detrimental effect on PPP. Moreover, while analyzing PPP trends over the past few decades, we can clearly observe stark drops in PPPs during the times of macroeconomic crises, like the financial crises in Asian in 1997 and in Argentina in 1999 (Harris 2003).

5.3.3.1.3 Market Factors

The third factor is market size. The willingness of private parties to invest in PPP arrangements depends greatly on the market which they target. In a PPP arrangement public sector is motivated by providing quality services to its people while private firms are

motivated by the profits they could get out of the arrangement. Hence, the profitability of PPP projects is crucial for attracting private sector partners. Commercial risks of PPP projects are quite high because of the initial upfront capital investment and various risks associated with it. Therefore private firms would invest in those projects which would ultimately provide services which have a greater demand in the market. Both the size of the market and purchasing power of the people (their income level) are important determinants for a successful PPP as it would ensure large number of high paying customers for the service and thus recovering the fixed cost quickly. According to Sharma (2012), either a large market is expected to attract more private firms to involve in PPP projects majorly because of the possible future growth prospects.

5.3.3.1.4 Political Factors

The fourth factor is political environment. This factor is measured by rating agencies such as Moody's, Standard and Poor, International Country Risk Guide and investors get sufficient information to invest. Sharma (2012) in his study took this factor and put forth the hypothesis that better political environment leads us to a large number of PPPs. Country with a large ethnic diversity would require far more number of infrastructure projects to satisfy the needs and requirements of different ethnic groups. Different groups will have different demands and government needs to listen and respect its people's freedom of speech and expression and also work in harmony with them to satisfy their demands. Such large number of infrastructure projects would create a huge financial pressure on the government. To attract private parties, government need to show them that they are running a fairly stable government which is able to formulate and implement sound policies and regulations, which permits and promotes private sector development and at the same time fights strongly against any form of politically motivated violence including terrorism. Government effectiveness in terms of providing quality public and civil services to its people, not

succumbing to political pressures and its commitment towards formulating and implementing quality policies is also a crucial factor in attracting private financial aid.

5.3.3.1.5 Institutional Quality Factors

The fifth and final factor is regulatory environment. Sustainability of the contractual agreement between the public and private sector in a PPP arrangement depends on the regulatory environment which in turn depends on the quality of the institutions in the country. Private investors will be hesitant to invest in an environment where local authorities are viewed as having poor credit and trust ratings. A corruption free regulatory environment needs to be established to enable the formulation of effective contractual agreements which are in line with the country's legal system. Tenders should be awarded in a transparent fair fashion to avoid any kind of political favoritism. Corruption may be spawned by the lack of transparency, which greatly impacts public interest (Zhang, 2005)

Previous studies by Pistor et al. (2000) and Hammami et al. (2006), have suggested that weak incoherent institutions and political risk lead to uncertainties about the regulations, which further boost the country risk and have a detrimental effect on the nation's image. In this view, Sharma (2012) in his study raised another hypothesis that better regulation attracts more number of private firms for PPP projects. Lamech and Saeed (2003) did a survey of firms investing in PPPs in power sector for developing nations and concluded that firms prioritize the presence of a regulatory framework while taking their decision on whether or not to invest in a developing nation. Pargal (2003) concluded that the most important determinant of PPP is the passage of legislation liberalizing the investment establishment, while Kirkpatrick et al. (2006) found out that institutional framework and regulation hold the key.

5.3.3.2 Data Sources and Choice of Variables

This section describes the choice of variables selected under each type of factors discussed above. The relevant data sources used for data collection purpose have also been discussed in this section.

5.3.3.2.1 Choice of Variables

To examine and estimate the significant determinants of attracting any PPP in India, we needed to do an empirical analysis between the independent variables (determinants of PPP projects) and dependent variables capturing the extent of PPP projects in India. For classifying the dependent variables which capture the essence of PPP projects in India, we have used two different variables. First is the number of PPP projects in each financial year which are under construction, completed, terminated or operational. The second dependent variable selected for this study is the value of the PPP projects in terms of their total cost. The government of India captures information on PPP projects which cost more than 5 crores INR. Hence, the same convention has been followed for this analysis. For this analysis the INR values have been converted to USD (in millions).

The different independent variables which have been used under each of the five types of factors are described below. The same explanatory variables have been used for both the cases (Number of projects and Total project cost) to test the extent of PPPs in India.

- For **government factors**, Cash Surplus/Deficit and Central Government's Total Debt have been used. Both are expressed as a percentage of GDP. Cash surplus or deficit is revenue (including grants) minus expense, minus net acquisition of nonfinancial assets (World Bank Database). This cash surplus or deficit is closest to the overall budget balance. For India, all values for considered time period are in negative implying that we have Cash Deficit. Central Government's Total Debt includes domestic and foreign

liabilities such as currency and money deposits, securities other than shares, and loans. It is the gross amount of government liabilities reduced by the amount of equity and financial derivatives held by the government (World Bank Database). Both these variables capture the fiscal position of the country. We have also used three different variables to capture the extent of external non-oil income which the country receives in form of financial aid and credit. These variable are Net Official Development Assistance (ODA) received (% of Gross National Income - GNI), Portfolio equity-net inflows (Balance of Payments- BOP, current USD in millions), Use of International Monetary Fund (IMF) credit (Disbursed and outstanding debt- DOD, current USD in millions). The more a country receives foreign aid the less likely it will engage in PPP. Data for all these five variables has been gathered from the World Bank Database.

- For **political factors**, various indexes from Worldwide Governance Indicators (WGI) such as Voice and Accountability index, Political Stability and Absence of Violence/Terrorism index, Government Effectiveness index and Regulatory Quality index have been used. Voice and Accountability index reflects citizen's freedom of speech, expression, association and free media whereas Political stability and Absence of Violence/Terrorism index measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism. Government effectiveness index and Regulatory quality index both reflect the perceptions of the ability of the government to formulate and implement sound policies for providing quality civil and public services to its people and also reflect its degree of independence from political pressures.

- To capture the essence of **market factors**, GDP per capita, gross savings and population size have been used. The population of the country captures the total market size i.e. the

number of consumers of the service provided by the PPP project. To solve the scaling issue, the logarithm of the population is taken. GDP per capita in current USD and Gross Saving as a percentage of GDP capture the purchasing power of the population. Increase in saving will in turn allow the people to readily purchase the different services and contribute to the GDP of the country. Data for all three variables has been collected from the World Bank Database.

- For **macroeconomic factors** - A credible government is the one which is able to keep its macroeconomic condition stable. For a common man, macroeconomic stability is price stability. If a government is able to keep the prices of basic commodities and interest rates stable, people continue to have faith in the government which in turn increases its credit rating and therefore attract more private investments into the country. To measure the macroeconomic condition of the country, consumer price index (CPI) and interest rates are used. CPI is the annual percentage change in the cost of acquiring a basket of goods and services to the average consumer. The interest rates are measured by the GDP deflator. So if interest rates are lowered, people will borrow more money, spend more on goods and commodities causing economy to grow and inflation to increase. Growing economy in turn will attract greater private investments and there will be an increase in the number of PPP projects. Therefore to maintain a stable macroeconomic condition, government needs to implement suitable monetary policies to strike a right balance between the two variables. Data for both the variables is again gathered from the World Bank Database.

- For **Institutional quality factors**, 'Freedom from Corruption Index' (FCI) derived from 'Corruption Perception Index' of Transparency International e.v (an international non-governmental organization) and 'Control of Corruption Index' of WGI have been used.

Control of Corruption index reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Together, better institution and lower corruption will help to promote PPPs.

5.3.3.2.2 Data Sources

For collection of data on PPP projects, the Government Infrastructure Projects (PPP) database from www.infrastructureindia.gov.in web source has been referred. It is maintained by the Department of Economic Affairs (DEA), Ministry of Finance- Government of India. The PPP database classifies infrastructure projects based on status (under construction, completed, terminated or operational), sectors (Communication, Energy, Social and Commercial Infrastructure, Transport and Water Sanitation), project cost and location. The data was taken for the Government Infrastructure Projects (PPP) that were either 'Under Construction' or 'Operational' as on April 1, 2011 or 'Awarded' thereafter. The timeframe of this analysis is from 1990 to 2015.

5.3.3.3 Research Hypotheses

This section presents the eight hypotheses framed under the different factors and variables discussed above. Eight hypotheses were framed to test the possible determinants of PPPs in infrastructure in India. Table 5.10 given below presents all the research hypotheses (null and alternate) which have been framed corresponding to the different variables chosen under each of the major factors i.e Government, Political, Market, Institutional quality, Macroeconomic.

Table 5.10: Research Hypotheses corresponding to PPP determinants

Category of PPP determinant	Variables chosen	Research Hypothesis
Government Factors	Surplus/Deficit, Central ; Government's Total Debt	**H_0: Countries with large cash deficits and heavy governmental debt burden will not engage in PPP.** **H_a: Countries with large cash deficits and heavy governmental debt burden tend to engage in PPP.**
Political Factors	Net ODA received (% of GNI), Portfolio equity-net inflows (BOP, current USD in millions), Use of IMF credit	**H_0: Countries having external sources of income and receiving substantial foreign aid are less motivated to participate in a PPP.** **H_a: Countries having external sources of income and receiving substantial foreign aid are more motivated to participate in a PPP.**
	Voice and Accountability index	**H_0: Government which listens to its widely ethnic population and responds to their needs is less likely to engage in PPP.** **H_a: Government which listens to its widely ethnic population and responds to their needs is likely to engage in PPP.**
	Political Stability and Absence of Violence/Terrorism index	**H_0: Countries having politically stable government do not tend to attract more private funds.** **H_a: Countries having politically stable government tend to attract more private funds.**
	Government Effectiveness index; Regulatory Quality index	**H_0: Effective governments with quality regulatory policies in terms of formulating and implementing policies are less likely to attract private investments and engage in PPP.** **H_a: Effective governments with quality regulatory policies in terms of formulating and implementing policies are more likely to attract private investments and engage in PPP.**
Market Factors	GDP per capita, gross savings, population size	**H_0: PPP are rarely seen in countries where market size is large and people have higher income levels.** **H_a: PPP tend to be common in countries where market size is large and people have higher income levels.**

Macroeconomic Factors	CPI, interest rates	**H_0: PPPs are less likely in a country with stable and credible macroeconomic condition where there is minimal exchange rate risk and maximum price stability** **H_a: PPPs are more likely in a country with stable and credible macroeconomic condition where there is minimal exchange rate risk and maximum price stability**
Institutional Quality Factors	'FCI', 'Control of Corruption Index'	**H_0: Countries with strong institutions and low corruption rate are less likely to attract private investors and therefore less PPP projects.** **H_a: Countries with strong institutions and low corruption rate are more likely to attract private investors and therefore more PPP projects.**

After framing the above mentioned research hypotheses, these were tested using the selected techniques.

5.3.3.4 Results and Observations

This section discusses all the empirical results and observations pertaining to the above discussed research problem.

5.3.3.4.1 Case I – Dependent Variable is Number of PPP projects

In the first regression where the dependent variable is number of PPP projects in a financial year, Poisson regression and negative Binomial regression model were used to test the hypotheses. When the response variable is a count data, ordinary least squares (OLS) does not provide correct results because it assumes residual errors to follow a normal distribution which might not always be the case with discrete data. Also if the data is skewed then applying simple transformations to it might not produce normally distributed errors. Since our dependent variable is a non-negative count data, applying OLS to it could predict negative values which are theoretically impossible. As discussed in the methodology, we first perform the Poisson regression taking number of projects as the dependent variable and

other possible determinants of PPP as explanatory variables. Table 5.10 given below shows the results of Poisson Regression.

Table 5.11 : Poisson Regression results

Log Likelihood = - 65.407			Number of obs = 20 LR Chi^2 =374.26 Prob > Chi^2=0.000 Pseudo R^2=0.7410	
Dependent variable :**Number of PPP projects**	Coef.	Std. Err.	z	P>|z|
Explanatory variables				
Cash surplus/deficit (% of GDP)	0.467	0.139	3.36	0.001**
Central government debt, total (% of GDP)	0.290	0.136	2.12	0.034**
Net ODA received (% of GNI)	3.895	2.750	1.42	0.157
Portfolio equity, net inflows	2.453	2.050	1.19	0.142
Use of IMF credit	1.932	2.030	0.95	0.105
GDP per capita	0.014	0.006	2.2	0.028**
Gross savings (% of GDP)	0.414	0.106	3.89	0.001*
Population (log)	-11.722	7.466	-1.57	0.116
Inflation, consumer prices (annual %)	0.151	0.107	1.40	0.161
Real interest rate (%)	0.021	0.057	0.35	0.723
Voice and Accountability	16.225	6.410	2.53	0.011**
Political Stability and Absence of Violence/Terrorism	5.135	1.841	2.79	0.005**
Government Effectiveness	-5.015	4.755	-1.05	0.292
Regulatory Quality	7.644	3.040	2.51	0.012***
FCI	0.187	0.069	2.69	0.007**
Control of Corruption	-3.631	2.565	-1.41	0.157
Constant	10.284	6.596	1.56	0.119
Note : Significant at 10% level (*), 5% level (**) and 1 % level (***)				

From the table 5.11 given above, the estimation results indicate that Cash surplus/deficit and Central government debt significantly affect the number of PPP projects. It can be seen that number of PPP projects is positively related to both Cash surplus/deficit and Central government debt. It is also found that Market conditions significantly affect the number of PPP projects with GDP per capita and Gross savings coming out to be statistically significant. The estimation results also found evidence regarding positive relationship between the number of PPP projects and political factors. The empirical findings indicate that a 1 point increase in the Voice and Accountability index number is associated with an increase in the number of PPP project by 16.22 units. Similarly, a 1 point increase in the Political Stability and Absence of Violence/Terrorism number is associated with an increase

of 5.13 units in the number of PPP project while a 1 point increase in the Regulatory Quality index number is associated with an increase in the number of PPP project by 7.66 units. Therefore, Voice and Accountability, Political Stability and Regulatory Quality are indeed responsible and play a crucial role for the private sector in terms of making decisions regarding involvement of the PPP mode for financing Infrastructure.

The estimation results also indicate a positive relationship between the number of PPP projects and institutional factors. A 10-point increase in the FCI number indicator is associated with an increase in the number of PPP project by around 1.87 units. This clearly shows that a corruption free India is more likely to attract private investment through a higher number of PPP projects.

To summarize, the above analysis finds that hard government constraints indicated by high cash deficits and huge government debt, favorable market conditions reflected in higher GDP and more savings, stable political environment and institutional quality shown by FCI are important determinants of the number of PPP projects. Actually, there is evidence in favour of all the channels except the macroeconomic factors.

Based on the results of the Poisson regression, Table 5.12 given below presents the results of the hypothesis testing.

Table 5.12: Hypothesis testing results based on Poisson Regression

Variables	Significance	Category of PPP determinant	Conclusion
Cash surplus/deficit (% of GDP), Central government debt- total (% of GDP)	YES	Government factors	**REJECT H_0** = Countries with large cash deficits and heavy governmental debt burden tend to engage in PPP.
Net ODA received (% of GNI), Portfolio equity-net inflows (BOP, current USD in millions), Use of IMF credit	NO	Government factors	**ACCEPT H_0** = Countries having external sources of income and receiving substantial foreign aid are less motivated to participate in a PPP**.**
Voice and Accountability index	YES	Political factors	**REJECT H_0** = Government which listens to its widely ethnic population and responds to their needs is likely to engage in PPP.
Political Stability and Absence of Violence/ Terrorism	YES	Political factors	**REJECT H_0** = Countries having politically stable government tend to attract more private funds.
Regulatory Quality	YES	Political factors	**REJECT H_0** = Effective governments with quality regulatory policies in terms of formulating and implementing policies are more likely to attract private investments and engage in PPP.
GDP per capita, Gross savings (% of GDP)	YES	Market factors	**REJECT H_0** = PPPs tend to be common in countries where market size is large and people have higher income levels.
CPI, interest rates	NO	Macroeconomic factors	**ACCEPT H_0** = PPPs are less likely in a country with stable and credible macroeconomic condition where there is minimal exchange rate risk and maximum price stability
FCI	YES	Institutional Quality Factors	**REJECT H_0** = Countries with strong institutions and low corruption rate are more likely to attract private investors and therefore more PPP projects.

Further, the negative binomial regression was performed taking number of PPP projects as the dependent variable. Table 5.13 shows the result of the negative binomial regression.

Table 5.13: Negative Binomial Regression Results

Log Likelihood = - 60.944			Number of obs = 20 LR Chi^2 =50.24 Prob > Chi^2=0.000 Pseudo R^2=0.356	
Dependent variable : **Number of PPP projects**	Coef.	Std. Err.	z	P>|z|
Explanatory variables				
Cash surplus/deficit (% of GDP)	0.493	0.175	-2.81	0.005**
Central government debt, total (% of GDP)	0.316	0.172	1.83	0.067*
Net ODA received (% of GNI)	3.486	3.465	1.01	0.314
Portfolio equity, net inflows	-2.102	1.655	-1.27	0.202
Use of IMF credit	-1.767	1.577	-1.12	0.263
GDP per capita	0.014	0.007	1.86	0.062*
Gross savings (% of GDP)	0.432	0.133	3.23	0.001**
Population (log)	-12.955	9.667	-1.34	0.18
Inflation, consumer prices (annual %)	0.173	0.136	1.27	0.204
Real interest rate (%)	0.032	0.073	0.44	0.663
Voice and Accountability	17.372	8.083	-2.15	0.032**
Political Stability and Absence of Violence/Terrorism	5.304	2.248	-2.36	0.018**
Government Effectiveness	-5.214	6.145	-0.85	0.396
Regulatory Quality	8.146	3.846	2.12	0.034**
FCI	0.198	0.088	-2.24	0.025**
Control of Corruption	-3.875	3.331	-1.16	0.245
Constant	11.376	8.544	1.33	0.183
/lnalpha	-0.626	0.998		
Alpha	0.534	0.533		
Note : Significant at 10% level (*), 5% level (**) and 1 % level (***)				

From the above table it can be observed that Cash surplus/deficit (% of GDP), Central government debt-total (% of GDP), GDP per capita, Gross savings (% of GDP), Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Regulatory Quality, FCI come out to be statistically significant. Interestingly these were the exact same variables which came out to be statistically significant when we performed the Poisson regression on

the data. Hence, the hypothesis testing results are the same for Negative binomial regression.

After carrying out both kinds of regression for the dependent variable – Number of PPP projects, a likelihood ratio test was carried out in order to compare both the models. Table 5.14 gives us the results of a likelihood ratio test. For this test, the associated chi-squared value comes out to be 1.67 with p value as 0.098. This suggests that we fail to reject the null hypothesis of the test (Likelihood-ratio test of alpha=0) and hence it can be concluded that the negative binomial model is not appropriate in this case when compared with the Poisson model. In other words, Poisson model is more appropriate than the negative binomial model.

Table 5.14: Likelihood Ratio Test

Likelihood-ratio test of delta	= 0
chibar^2 (01)	1.67
Prob>=chibar^2	0.098

OLS regression was also performed as a benchmark for Poisson and negative binomial regression on the data. Table 5.15 presents the results of OLS. It was observed that none of the variables come out to be significant when we have applied OLS to our data.

Table 5.15: OLS results – Number of PPP projects

Dependent variable : **Number of PPP projects**	Coef.	Std. Err.	z	P>|z|
Explanatory Variables				
Cash surplus/deficit (% of GDP)	13.517	10.591	-1.28	0.292
Central government debt, total (% of GDP)	9.976	8.474	1.18	0.324
Net ODA received (% of GNI)	11.767	15.951	0.74	0.514
Portfolio equity, net inflows	-0.901	1.110	-0.81	0.478
Use of IMF credit	-0.520	1.080	-0.48	0.663
GDP per capita	0.550	0.402	1.37	0.265
Gross savings (% of GDP)	15.182	7.314	2.08	0.13
Population (log)	-57.779	45.410	-1.27	0.293
Inflation, consumer prices (annual %)	5.824	6.204	0.94	0.417
Real interest rate (%)	0.110	4.265	0.03	0.981
Voice and Accountability	33.318	31.453	-1.06	0.367
Political Stability and Absence of Violence/Terrorism	18.497	12.979	-1.43	0.249
Government Effectiveness	-31.449	31.073	-1.01	0.386
Regulatory Quality	31.516	21.090	1.49	0.232
FCI	5.0821	3.567	-1.42	0.249
Control of Corruption	-14.820	13.640	-1.09	0.357
Constant	50.876	40.110	1.27	0.294

5.3.3.4.2 Case II – Dependent Variable is Total Cost of PPP Projects

In the second regression where the dependent variable is the total cost of the projects in a financial year, the methodology used is the Tobit regression model. A limitation of this approach is that once the variable is censored, OLS provides inconsistent estimates of the parameters, which means that the coefficients from the analysis won't essentially approach the "true" population parameters because the sample size will increase.

Tobit regression is a censored regression model designed to estimate linear relationships between variables when there is either left- or right-censoring in the dependent variable (also known as censoring from below and above, respectively). This analysis uses censoring from above since all the values are non-negative total project costs of PPP and the lower threshold can be fixed at 0. As discussed above, Tobit regression was performed taking total cost of

the projects as the dependent variable and other PPP determinants as explanatory variables. Table 5.16 given below present the results for this case.

Table 5.16: Tobit Regression Results

Dependent variable : Total cost of projects	Coef.	Std. Err.	t	P>|t|
Explanatory variables				
Cash surplus/deficit (% of GDP)	398.583	732.953	0.54	0.615
Central government debt, total (% of GDP)	-104.856	58.710	-1.79	0.149
Net ODA received (% of GNI)	124.209	108.401	1.15	0.316
Portfolio equity, net inflows	-0.193	0.077	-2.50	0.067*
Use of IMF credit	-0.943	0.741	-1.27	0.272
GDP per capita	-48.459	27.832	-1.74	0.157
Gross savings (% of GDP)	-468.378	508.696	-0.92	0.409
Population (log)	676.561	313.978	2.15	0.097*
Inflation, consumer prices (annual %)	-420.948	428.028	-0.98	0.381
Real interest rate (%)	-65.6229	293.2634	-0.22	0.834
Voice and Accountability	-165.763	218.398	-0.76	0.49
Political Stability and Absence of Violence/Terrorism	149.836	886.525	1.69	0.166
Government Effectiveness	812.933	211.305	3.85	0.018**
Regulatory Quality	-284.195	144.833	-1.96	0.121
FCI	206.016	249.424	0.83	0.455
Control of Corruption	-149.216	93.491	-1.60	0.186
Constant	-599.922	277.338	-2.16	0.097
/sigma	974.476	160.032		
Note : Significant at 10% level (*), 5% level (**)				

As it is evident from the above table, Portfolio equity, net inflows from the government factors significantly affect the total cost of PPP projects. It can be seen that cost of PPP projects is negatively related to Portfolio equity, net inflows. This clearly indicates that if there is an increase in the amount of net inflows coming into the Indian economy, naturally the investment is coming in and the tendency to engage in PPPs will not be that much.

It is also found that Market conditions significantly impact the cost of PPP projects with Population size coming out to be statistically significant. A 1 per cent increase in the

population number is positively explaining the increase in the PPP investments (total cost of PPP projects) by around 676.56 million USD. These results are quite intuitive, considering the fact that India has a high population growth rate as compared to the world's average and this result is a clear signal for all the private sectors wishing to participate in the PPP arrangements in our nation.

From the Political factors, Government Effectiveness has a positive and significant impact on the cost of PPP projects. In other words, it means that if government's functioning and working style is effective, it will surely lead to an increase in the PPP investment (cost of PPP projects) in India.

So finally it can be said that the results from Tobit regression indicate that soft governmental constraints, market conditions and effectiveness of government impact the total investment in PPP projects.

Based on the results of the Tobit regression, Table 5.17 gives the results of the hypothesis testing.

Table 5.17: Hypothesis Testing Results based on Tobit Regression

Variables	Significance	Category of PPP determinant	Conclusion
Cash surplus/deficit (% of GDP), Central government debt- total (% of GDP)	NO	Government factors	**ACCEPT H_0** = Countries with large cash deficits and heavy governmental debt burden will not engage in PPP.
Portfolio equity-net inflows (BOP, current USD in millions)	YES	Government factors	**REJECT H_0** = Countries having external sources of income and receiving substantial foreign aid are more motivated to participate in a PPP.
Voice and Accountability index	NO	Political factors	**ACCEPT H_0** = Government which listens to its widely ethnic population and responds to their needs is less likely to engage in PPP.
Political Stability and Absence of Violence/ Terrorism	NO	Political factors	**ACCEPT H_0** = Countries having politically stable government do not tend to attract more private funds.
Government effectiveness	YES	Political factors	**REJECT H_0** = Effective governments with quality regulatory policies in terms of formulating and implementing policies are more likely to attract private investments and engage in PPP.
Population size	YES	Market factors	**REJECT H_0** = PPPs tend to be common in countries where market size is large and people have higher income levels.
CPI, interest rates	NO	Macroeconomic factors	**ACCEPT H_0** = PPPs are less likely in a country with stable and credible macroeconomic condition where there is minimal exchange rate risk and maximum price stability
FCI , Control of Corruption Index	NO	Institutional Quality Factors	**ACCEPT H_0** = Countries with strong institutions and low corruption rate are less likely to attract private investors and therefore less PPP projects.

Further, OLS was applied as the benchmark for the Tobit model. Table 5.18 shows the result of OLS on the same set of variables. From this table, it is clearly evident that none of the explanatory variables come to be significant.

Table 5.18: OLS Results – Total Cost of Projects

Dependent variable : Total cost of projects	Coef.	Std. Err.	t	P>|t|
Explanatory variables				
Cash surplus/deficit (% of GDP)	-117.721	142.254	-0.83	0.469
Central government debt, total (% of GDP)	131.984	267.755	0.49	0.656
Net ODA received (% of GNI)	0.208	0.188	1.10	0.350
Portfolio equity, net inflows	-0.922	1.835	-0.50	0.650
Use of IMF credit	-54.335	67.5437	-0.80	0.480
GDP per capita	-589.185	1227.837	-0.48	0.664
Gross savings (% of GDP)	742.248	762.244	0.97	0.402
Population (log)	505.101	1041.541	-0.48	0.661
Inflation, consumer prices (annual %)	-117.607	715.946	-0.16	0.880
Real interest rate (%)	-11.546	52.796	-0.22	0.841
Voice and Accountability	161.282	217.861	0.74	0.513
Political Stability and Absence of Violence/Terrorism	830.173	521.583	1.59	0.210
Government Effectiveness	308.712	354.023	-0.87	0.447
Regulatory Quality	271.108	598.778	0.45	0.681
FCI	-134.595	228.957	-0.59	0.598
Control of Corruption	-657.988	673.274	-0.98	0.400
Constant	555.053	1777.926	0.31	0.775

PART III

5.4 DEBT, ECONOMIC GROWTH AND FISCAL SUSTAINABILITY

This part relates to the third research objective where again two issues pertaining to interlinkages between Debt, economic growth and Fiscal sustainability have been addressed. Since, there are two research issues; hence this part is divided into two sections: Section A and Section B. In Section A, the dynamic relationship between debt and economic growth is explored for India. A multiple regression analysis is carried out so as to see what kind of relationship does debt and economic growth hold for India. This section discusses all the analysis and results corresponding to this investigation of the relationship between debt and economic growth.

In Section B, the second issue under this research objective i.e Fiscal sustainability is addressed. Here, the focus is shifted to Indian states and specifically to examine their fiscal sustainability. For this, a fiscal sustainability indicator is calculated for the twenty eight Indian states, excluding Telangana as it was formed recently and there was no data available for it. This calculated fiscal sustainability indicator for each of the Indian states gives a fair indication of how the states stand on grounds of fiscal sustainability. Post the calculation of fiscal sustainability indicator; an optimal value of debt is calculated. With this optimal value, we are suggesting that if a particular Indian state crosses this value, its fiscal position will be unstable and ultimately India's fiscal sustainability will be in jeopardy. Vice versa, if the debt levels are under this calculated threshold value, then in that case India's fiscal sustainability is maintained. The Pareto principle and decision tree algorithm are employed in order to achieve this task. The related results of this analysis are presented in this section.

Section A

5.4.1 DEBT AND ECONOMIC GROWTH

It has now been universally accepted that country's ability to grow also depends critically on its level of indebtedness. However from an Indian context, the concern about the increasing government indebtedness to facilitate the economic growth has always been the main debating point over these decades. Hence, it becomes important to analyze how does public debt affects the growth of a nation and whether there exists a direct or an inverse relationship between the two variables. If public debt directly or indirectly influences the economic growth in a negative manner, then the policy makers need to be aware of this fact while formulating and implementing the nationwide policies. On the other hand, if the accumulation of public debt enhances the growth process or at least not put a road block in the path of capital formation for the country, then also the policy makers need to be fully aware about the dynamics of this vital relationship. Overall the complete understanding about this relationship is very much necessary for our monetary and fiscal policy makers while formulating and implementing various policy decisions. Motivated by all this, an analysis is carried out in this section which examines the relationship between debt and economic growth for India.

5.4.1.1 Model Specification

To establish and explore this relationship between debt and economic growth, the following model is constructed:

$$Y_{rt} = \alpha + \beta_1 D_t + \beta_2 ITR_t + \beta_3 T_t + \beta_4 M_t + \beta_5 GFS_t + \varepsilon \quad (1)$$

Where Economic growth is measured by Y_{rt} (real GDP growth rate year on year); Debt is measured by D (public debt to GDP ratio). Other macroeconomic variables considered as control regressors in the model are: T (the international trade in real terms as a percentage of

GDP); Interest rate (ITR), Money supply (M) and GFS (Gross Domestic Savings) both as a percentage of GDP.

The theoretical model suggests that there exists a direct relationship between public debt and economic growth. However, the major question which still remains is whether the relationship can be empirically substantiated in a fully specified model that controls, among other things, for the indirect effect of public debt on economic growth via investment aspect. Therefore, in order to perform an in-depth analysis of the debt - economic growth relationship, it is better to disentangle the debt-growth nexus by looking this relationship from the view of investment also. In other words, we should find answer to the question that does debt induces investment over time. To find answer to this question, the following model given below is constructed:

$$I_t = \alpha + \beta_1 Y_{rt} + \beta_2 D_t + \beta_3 ITR_t + \beta_4 T_t + \beta_5 M_t + \beta_6 GFS_t + \varepsilon \quad (2)$$

Where the dependent variable is (I_t) representing investment ratio (total investment, as a % of GDP in Indian economy). The dependent variable from equation (1) i.e Y_{rt} becomes an explanatory variable here with the remaining variables remaining the same.

The rationale of this specification lies in the expected positive effect that trade, level of debt, money supply, savings and the level of GDP have on investment decisions. The interest rate is expected to have a negative impact (Barro & Sala-i-Martin, 2004; Cohen, 1993).

We will first run the equation (2) model to see the influence of debt on investment, following which we will return to the usual growth equation (1) where the effect of debt on economic growth will be investigated.

5.4.1.2 Data Sources and Variables

The dependent variable, Y_{rt} (real GDP growth rate year on year) is measured by using the GDP values at constant market prices (constant at 2005 USD). The combined outstanding liabilities of the central and State governments of India have been used as a measure of the public debt. The investment ratio is computed from the data available in Indian Public Finance Statistics 2014-15 report, Ministry of Finance. M comprises the sum of currency outside banks, demand deposits other than those of the central government, and the time, savings, and foreign currency deposits of resident sectors other than the central government. T is captured as the combined sum of import and export of the country. Finally once all the data is collected, it is converted into percentage terms of GDP (% of GDP). Except Investment ratio, all the data has been obtained from the RBI- Handbook of Statistics on the Indian Economy and World Bank data source.

The following figure depicts the trend of debt, investment and growth for India for the considered time period of analysis for this study i.e 1991-92 to 2014-15.

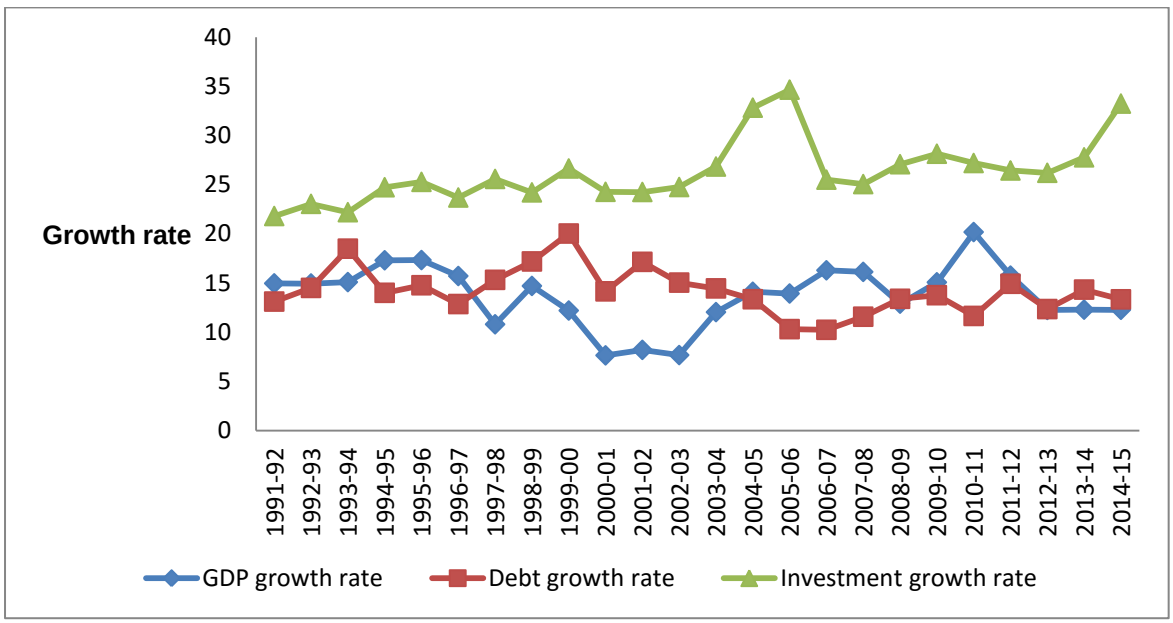


Figure 5.27: **Debt, Growth and Investment Trends**

Source: RBI- Handbook of Statistics on the Indian Economy, Indian Public Finance Statistics 2014-15 report, Ministry of Finance

5.4.1.3 Empirical Results

For model pertaining to equation (2), the following output is obtained:

$\widehat{I_t}$=16.18 + 17.75 $\widehat{Y_{rt}}$ + 8.42 $\widehat{D_t}$ - 2.43 $\widehat{ITR_t}$ + 14.97 $\widehat{T_t}$ + 11.21 $\widehat{M_t}$ + 9.13 $\widehat{GFS_t}$; R^2 = 0.76

Table 5.19: Estimation results – Impact of Debt on Investment

Dependent variable : I (Investment)	Coef.	Std. Err.	T	P>|t|
Explanatory variables				
Y_{rt}	17.75	6.18	2.87	0.002**
D_t	8.42	2.86	2.94	0.001**
ITR_t	-2.43	0.88	-2.76	0.003**
T_t	14.97	4.66	3.21	0.000**
M_t	11.21	5.66	1.98	0.131
GFS_t	9.13	5.53	1.65	0.122
Constant	16.18	9.98	1.62	0.110
Note : **, 5 % level of Significance, p <0.05				

Table 5.18 given above shows the estimates when public debt is analyzed with investment. From the empirical estimates presented above, the most important result which we can conclude is the positive and statistically significant relationship between public debt and the investment ratio, at 5 per cent level of significance. Therefore, it can be said that public debt does not have a detrimental impact on investment. As expected, GDP is expected to have a positive and significant relationship with the investment. Also in line with the apriori expectations, interest rate and investment have a negative relationship. However, coefficients of other explanatory variables such as trade and money supply come out to be insignificant and hence no concrete conclusion can be taken in terms of their relation with investment. With a R^2 value of 0.76, this specification explains almost 76 per cent of variations in the investment ratio during the time frame of analysis.

We then proceeded to run the model for equation (1) and examined the relationship between public debt and economic growth. For model pertaining to equation (1), the following output is obtained:

$\widehat{Y_{rt}}$=3898.56 - 24224.33$\widehat{D_t}$ +110.09 $\widehat{I_t}$ +108.26$\widehat{ITR_t}$ -179.74 $\widehat{T_t}$ + 183.781$\widehat{M_t}$ + 209.84 $\widehat{GFS_t}$

; R^2 = 0.92

Table 5.20: Estimation Results – Impact of Debt on Economic Growth

Dependent variable : Y_{rt} (Real GDP)	Coef.	Std. Err.	T	P>|t|
Explanatory variables				
D_t	1.022	0.385	2.65	0.038**
I_t	1.100	.417	2.64	0.041**
ITR_t	1.082	.263	4.11	0.001**
T_t	-1.797	.646	-2.78	0.004**
M_t	1.837	.620	2.96	0.031**
GFS_t	2.098	.780	2.69	0.039**
Constant	1.398	.684	2.04	0.053
Note : **, 5 % level of significance, p <0.05				

All the values were significant at 5 per cent significance level. Positive coefficient of public Debt/GDP implies that GDP growth rate and public debt follow a direct relationship and an increase in the public debt/GDP is going to raise the GDP growth rate. The sign of the investment ratio's coefficient confirms the fact that investment and economic growth are positively related. Also, the signs of the coefficients of GFS and M confirm the general macroeconomic theory of a direct relationship between public saving and money supply with the economic growth of the country.

From the previous result while examining debt and investment, it was concluded that public debt appears to enhance the level of investment. For this case of debt and economic growth, it can be concluded that an increase in level of public debt, all else being equal, would appear to induce the rate of investment over the course of time and, in turn, indirectly boost

the economic growth. This evidence on the indirect impact of public debt on economic growth via investment is quite fascinating as it supports the argument that public debt has an indirect effect on economic growth through its beneficial impact on investment.

This model has no multicollinearity and was also checked for autocorrelation using the Durbin-Watson test. The test statistic value of Durbin Watson comes out to be 1.92 which almost confirms that there is no autocorrelation. Heteroskedasticity was also checked for by using Breusch-Pagan/Cook-Weisberg test. The Breusch-Pagan test for heteroskedasticity with a null hypothesis of constant variance has test statistic value of 0.83. Through this test we fail to reject the null hypothesis which ultimately confirms constant variance or homoskedasticity.

However, just because a positive relationship was found between debt and economic growth does not necessarily mean that a particular economy keeps on taking debt in order to enhance its economic growth. Crossing certain levels can be alarming for the fiscal stance of the nation. There has to be some threshold value of debt till which the nation's fiscal sustainability is intact and preserved. This issue of calculating an optimal value of debt till which the fiscal sustainability is maintained leads us to the next research problem under this third research objective. The empirical analysis on the same is discussed in the proceeding section.

Section B

5.4.2 FISCAL SUSTAINABILITY AND ECONOMIC GROWTH

Post examining the relation between debt and economic growth, we move on to another important issue i.e Fiscal Sustainability. To determine whether a nation or a state is fiscally sustainable or not has always proved difficult as well as controversial. The stability and growth pact attempts to resolve this problem by setting limits on indicators like government deficit to GDP and government debt to GDP. Such types of rules are restrictive. Moreover, they can be shown to be neither necessary nor sufficient to achieve fiscal sustainability i.e. a state or a country could breach these limits and still have a sustainable fiscal policy, or it could satisfy the limits but still not have a sustainable fiscal policy.

Therefore, in this section the focus is put exclusively on the fiscal sustainability issue. Since there are not many studies which have dealt with the investigation of fiscal sustainability of Indian states and constructing a measure to examine the same, hence the focus is given to this eye catching issue. In this section, the fiscal stance of Indian states is examined by carrying out a state wise analysis for the twenty eight Indian states, excluding Telangana, as it has been formed recently and there was no data available for it. For this purpose, we have calculated a fiscal sustainability indicator for each of the Indian states. This calculation of fiscal indicator and the corresponding empirical results are explained and discussed in this section. Further, the focus is on calculating an optimal value of debt till which India's fiscal sustainability is maintained. The Pareto principle and decision tree algorithm have been employed to accomplish this objective. The related results are also explained and discussed in this section.

5.4.2.1 Calculation of Fiscal Sustainability Indicator

As discussed above, a state wise analysis has been carried out for India in order to assess the situation of fiscal sustainability. Motivated by the works of Benz & Fetzer (2006) and Polito & Wickens (2005), a fiscal sustainability indicator is calculated for each of the twenty eight Indian states, excluding Telangana. For this analysis, an assumption is made that the debt incurred for a particular year 'i' is equal to the difference in Expenditures and Revenues in year 'i' along with the debt incurred on debt of year 'i-1'. This basically accounts for the planned part of the debt, with the rest of the debt incurred is taken as non-planned and non productive. The formula for this is given by:

$$D_{ei} = D_{a(i-1)} * (1 + r) + (E_i - R_i)$$

Where D_{ei}: Expected debt at year i; D_{ai}: Actual debt at year i; R_i: Total Receipts at year i

E_i: Total Expenditure at year i; r: Interest rate on debt (risk free rate of return, taken as the yearly average of India Treasury bill 91 day yield) .

$R_i = RR_i + CR_i$; RR_i: Revenue Receipts for year i and CR_i: Capital Receipts for year i

$E_i = RE_i + CE_i$; RE_i: Revenue expenditure for year i and CE_i: Capital Expenditure for year i

If an ideal scenario is assumed, then the expected debt should be equal to the actual debt. However, in reality the actual debt is much more than the expected debt and that is when we it can be said that the state is not in a fiscally sustainable position. Vice- versa, when expected debt is much higher than the actual debt, we can again conclude that the state is not in a position of fiscal sustainability.

Therefore, in this case, a term named as **'Sustainability Gap'** (SG_i) is defined which can be understood as the difference between the Expected debt and Actual debt.

$$SG_i = D_{ei} - D_{ai}$$

Since different states have different sizes, therefore in order to scale the gap as per the size of the states, the Sustainability gap is further divided by the GDP of the state for that particular year.

Accordingly, the Sustainability Gap is given by the formula:

$$SG_i = (D_{ei} - D_{ai})/GDP_i$$

Where GDP_i: GDP for the year i.

This calculated Sustainability gap is our fiscal sustainability indicator for all the states. Based on this formula, it can be said that lower the Sustainability gap (highly negative), lower will be the fiscal sustainability. When the sustainability gap value is highly negative, we are saying that actual debt for that particular year is very high when compared with the expected debt. This is a clear sign of lower fiscal sustainability or in other words fiscal unsustainability. Another case may be encountered when the sustainability gap value is near to zero or marginally negative. For this case, it can be said that actual debt comes out to be either equal to expected debt or expected debt is slightly higher than the actual debt. Thus, an inference can be made that the situation is still under control but the state needs to have a look at its fiscal position so that it does not deteriorate in the future. Also, if the sustainability gap for a particular year comes out to be too high (highly positive), it can be concluded that expected debt was very high for that year, however the actual debt came out to be low due to a better fiscal performance in that observed year resulting in a high value of Sustainability gap. This means that positive or highly positive values can be taken as an indication of good fiscal performance for that particular year whenever they are observed as compared to the previous year.

The time period of analysis was 2002-03 to 2013-14. Yearly data for revenue receipts, revenue expenditure, capital receipts, and capital expenditure was collected RBI website – State finances: A Study of Budgets Source. Using the collected data for revenue receipts,

revenue expenditure, capital receipts, and capital expenditure, R_i and E_i were calculated for all the Indian states for the specified time period.

Further using the above formulae, first D_{ei} and ultimately the Sustainability Gap SG_i is calculated was for each of the states for the specified time period. Table 5.21 given below presents the results of the calculated fiscal sustainability indicator (Sustainability Gap) for all the twenty eight Indian states.

Table 5.21: Sustainability Gap Values for the Twenty Eight Indian States (2002-03 to 2013-2014)

State	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14
Andhra Pradesh	-0.28	-0.54	-0.81	-0.33	0.72	0.62	-0.10	-0.15	0.02	-0.19	-0.19	-0.27
Arunachal Pradesh	3.72	-6.95	9.25	1.46	-3.48	0.08	0.59	-0.03	6.12	1.64	1.64	-19.63
Assam	1.55	-0.94	-0.28	-0.35	-0.86	0.72	-0.18	0.06	0.01	-0.67	-0.67	-5.28
Bihar	-1.80	-0.82	0.08	0.13	-1.10	2.34	-0.18	0.13	0.17	0.15	-0.18	-3.68
Chhattisgarh	1.17	-0.09	-1.35	-0.13	-0.07	0.88	-0.20	-0.09	1.36	-1.33	-1.33	-0.38
Goa	0.21	-0.11	-0.72	0.11	-1.88	1.43	-0.05	-0.03	-0.64	-0.06	-0.06	-2.59
Gujarat	0.71	-0.12	-0.42	-0.43	-0.01	0.58	-0.28	-0.11	-0.33	-0.08	-0.52	-0.34
Haryana	0.56	0.10	-0.36	0.23	-0.50	0.25	-0.08	-0.25	0.51	0.05	0.05	-0.62
Himachal Pradesh	-0.11	0.43	-0.85	0.57	4.03	-0.12	-0.18	0.45	0.08	-0.98	-0.98	-1.51
Jammu & Kashmir	-2.71	-1.51	-0.72	-0.49	-0.03	2.56	-0.29	-1.47	-0.34	-50.86	-50.86	40.62
Jharkhand	-1.84	-1.00	-5.56	-0.25	-3.19	-2.59	0.14	-0.30	0.83	-0.08	-0.08	0.00
Karnataka	-0.58	-0.07	-0.23	-0.11	-0.37	0.17	-0.20	-0.20	0.12	-0.12	-0.22	-0.17
Kerala	-0.52	-0.08	-0.28	0.02	0.01	0.21	-0.17	-0.11	-0.30	0.06	-0.17	-0.57
Madhya Pradesh	-0.69	-0.59	15.74	-0.43	-0.71	0.35	0.02	-0.14	1.25	-0.31	-0.31	-0.25
Maharashtra	0.02	-0.25	-0.39	-0.36	-0.26	0.84	-0.09	-0.10	0.02	-0.04	-0.16	-0.18
Manipur	8.09	5.82	-0.05	-5.71	3.38	0.46	-0.03	0.17	-6.93	2.73	2.73	-1.74
Meghalaya	1.41	-1.56	2.31	-0.79	0.01	0.54	-0.17	-0.46	3.88	-0.94	-0.94	-0.37
Mizoram	2.01	-3.94	-0.19	2.82	-1.30	1.96	0.00	1.66	8.33	-0.88	-0.88	-14.31
Nagaland	6.40	0.42	-0.59	0.21	-2.31	0.84	-0.60	-0.20	3.17	-1.07	-1.07	-5.09
Odisha	1.15	0.12	-0.11	-0.36	-0.49	0.33	0.22	0.46	0.08	0.35	0.35	-0.09
Punjab	0.09	0.25	-0.31	-3.35	0.18	-0.13	-0.08	-0.08	-0.08	-0.15	-0.15	-0.05
Rajasthan	0.42	-0.27	-0.46	0.00	-0.56	0.72	-0.04	-0.01	0.01	0.00	0.00	-0.42
Sikkim	4.88	1.96	4.23	-5.63	0.78	0.88	-0.45	-0.40	-0.30	-0.65	-0.65	-0.53
Tamil Nadu	-0.80	-0.09	-0.32	-0.17	-0.32	0.53	-0.18	-0.19	0.04	-0.28	-0.28	-0.26
Tripura	-0.92	70.43	-1.17	0.32	-0.68	0.63	1.09	-0.26	0.89	-0.52	-0.08	0.76
Uttarakhand	0.09	-0.44	-0.28	-0.31	-0.13	-3.23	0.05	-0.07	-0.17	0.02	-0.16	-0.41
Uttar Pradesh	1.28	1.87	0.34	-1.24	0.41	0.52	-0.05	-0.17	-1.40	0.56	0.56	-1.61
West Bengal	0.83	-0.36	0.09	-0.47	-0.02	0.02	-0.05	-0.27	-0.34	0.12	-0.22	-0.59
Note : 02-03:2002-03;03-04:2003-04;04-05:2004-05; 05-06:2005-06;06-07:2006-07;07-08:2007-08;08 09:2008-09;09-10:2009-2010;10-11:2010-2011;11-12:2011-2012;12-13:2012-2013;2013-14												

So from the above discussion, it can be concluded that a state is fiscally unsustainable when Sustainability Gap values are highly negative. For cases when the Sustainability Gap is just below zero (marginally negative), the situation is still under control but the state needs to have a look at its fiscal position so that it does not deteriorate in the future. One more inference which can be drawn is that a state is showing signs of fiscal improvement if the Sustainability Gap value comes out be positive or highly positive.

Further, the states are categorized based on their calculated values of Sustainability gap into two major categories: Fiscally Improving (FI) and Fiscally Unsustainable (FUS). We have done the categorization based on the calculated values of Sustainability gap:

Fiscally Improving (FI): $-0.15 \leq$Sustainability gap > 0

Fiscally Unsustainable (FUS): Sustainability gap $<$ -0.15

As discussed above, if the sustainability gap value is positive, then the state is showing signs of fiscal improvement. For cases when the Sustainability Gap is just below zero or marginally negative, the situation is still under control. However, till what value of sustainability gap we can go below zero and say that the state's fiscal situation is not in an alarming zone and can be taken as a fiscally improving case. We have chosen the value of -0.15 as a benchmark through which it can be said that till the sustainability gap value of -0.15 for any particular Indian state, the fiscal scenario is under control and the state can be taken in the defined category of Fiscally Improving.

The value of -0.15 has been set as a benchmark based on the hockey sticky graph given by Mann et al. (1999). Through these hockey sticky graphs, we get to see the sudden and dramatic shifts in the direction of data points. For all the twenty eight Indian states, the hockey sticky graphs were observed so as to arrive at the value of -0.15. Table 5.22 given below gives the categorization of the twenty eight Indian states based on their calculated sustainability gap values and the category (FI or FUS) in which they fall.

Table 5.22: Categorization of Twenty Eight Indian States based on the Fiscal Sustainability Indicator Values (2002-03 to 2013-2014)

State	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14
Andhra Pradesh	FUS	FUS	FUS	FUS	FI	FI	FI	FI	FI	FUS	FUS	FUS
Arunachal Pradesh	FI	FUS	FI	FI	FUS	FI	FI	FI	FI	FI	FI	FUS
Assam	FI	FUS	FUS	FUS	FUS	FI	FUS	FI	FI	FUS	FUS	FUS
Bihar	FUS	FUS	FI	FI	FUS	FI	FUS	FI	FI	FI	FUS	FUS
Chhattisgarh	FI	FI	FUS	FI	FI	FI	FUS	FI	FI	FUS	FUS	FUS
Goa	FI	FI	FUS	FI	FUS	FI	FI	FI	FUS	FI	FI	FUS
Gujarat	FI	FI	FUS	FUS	FI	FI	FUS	FI	FUS	FI	FUS	FUS
Haryana	FI	FI	FUS	FI	FUS	FI	FI	FUS	FI	FI	FI	FUS
Himachal Pradesh	FI	FI	FUS	FI	FI	FI	FUS	FI	FI	FUS	FUS	FUS
Jammu & Kashmir	FUS	FUS	FUS	FUS	FI	FI	FUS	FUS	FUS	FUS	FUS	FI
Jharkhand	FUS	FUS	FUS	FUS	FUS	FUS	FI	FUS	FI	FI	FI	FI
Karnataka	FUS	FI	FUS	FI	FUS	FI	FUS	FUS	FI	FI	FUS	FUS
Kerala	FUS	FI	FUS	FI	FI	FI	FUS	FI	FUS	FI	FUS	FUS
Madhya Pradesh	FUS	FUS	FI	FUS	FUS	FI	FI	FI	FI	FUS	FUS	FUS
Maharashtra	FI	FUS	FUS	FUS	FUS	FI	FI	FI	FI	FI	FUS	FUS
Manipur	FI	FI	FI	FUS	FI	FI	FI	FI	FUS	FI	FI	FUS
Meghalaya	FI	FUS	FI	FUS	FI	FI	FUS	FUS	FI	FUS	FUS	FUS
Mizoram	FI	FUS	FUS	FI	FUS	FI	FI	FI	FI	FUS	FUS	FUS
Nagaland	FI	FI	FUS	FI	FUS	FI	FUS	FUS	FI	FUS	FUS	FUS
Odisha	FI	FI	FI	FUS	FUS	FI	FI	FI	FI	FI	FI	FI
Punjab	FI	FI	FUS	FUS	FI	FI	FI	FI	FI	FI	FUS	FI
Rajasthan	FI	FUS	FUS	FI	FUS	FI	FI	FI	FI	FI	FI	FUS
Sikkim	FI	FI	FI	FUS	FI	FI	FUS	FUS	FUS	FUS	FUS	FUS
Tamil Nadu	FUS	FI	FUS	FUS	FUS	FI	FUS	FUS	FI	FUS	FUS	FUS
Tripura	FUS	FI	FUS	FI	FUS	FI	FI	FUS	FI	FUS	FI	FI
Uttarakhand	FI	FUS	FUS	FUS	FI	FUS	FI	FI	FUS	FI	FUS	FUS
Uttar Pradesh	FI	FI	FI	FUS	FI	FI	FI	FUS	FUS	FI	FI	FUS
West Bengal	FI	FUS	FI	FUS	FI	FI	FI	FUS	FUS	FI	FUS	FUS

Further, based on each state's performance (in terms of being FI and FUS) year on year over the considered time period, the states have been divided into three major performance categories: Top Performers, Moderate/Decent Performers and Bad Performers. This classification is done based on the fact that we give (+1) value to the FI category and (-1) to the FUS category. Accordingly, we get three cases:

- All those states which are having an overall value of atleast two (2) or more, over the considered time period of 2002-03 to 2013-14, fall in the category of Top Performers. In this case of top performers, FI's dominate FU's as they are higher by a number of two or more, when compared with FU's.
- All those states which are having an overall value of zero or (-1), over the considered time period of 2002-03 to 2013-14, fall in the category of Moderate/ Decent Performers. In this case of moderate performers, FI's are either equal to FU's, or they are lower by a value of just one when compared with FU's.
- All those states which are having an overall value of (-2) or lower, over the considered time period of 2002-03 to 2013-14, fall in the category of Poor Performers. In this case of poor performers, FU's dominate FI's and they are higher by a number of two or more, when compared with FI's.

Table 5.23: Categorization of Twenty Eight Indian States based on their Performance of Fiscal Sustainability Indicator Values (2002-03 to 2013-2014)

Top Performers	Arunachal Pradesh, Chhattisgarh, Goa, Haryana, Himachal Pradesh, Manipur, Odisha, Punjab, Rajasthan, Uttar Pradesh
Moderate/ Decent Performers	Bihar, Gujarat, Kerala, Maharashtra, Mizoram, Tripura, West Bengal
Bad Performers	Andhra Pradesh, Assam , Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand

Further, the different categories of performers are indicated on India's map using specific colors i.e Top performers are indicated by GREEN color, Moderate/ Decent performers are indicated by YELLLOW color and finally Bad performers are indicated by RED color. The following figure presents the same.

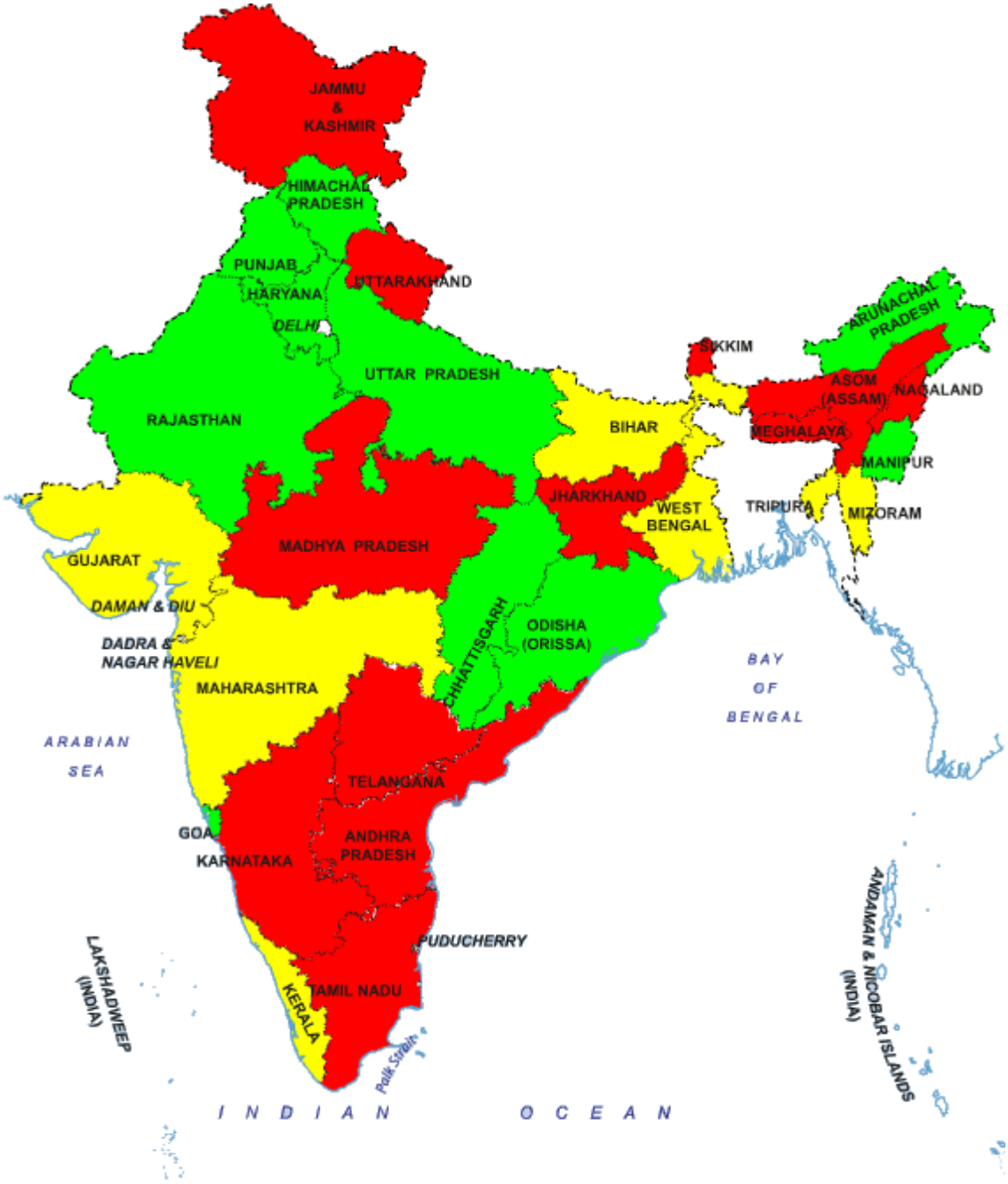


Fig 5.28: Performance of Indian states based on the fiscal sustainability indicator

5.4.2.2 Estimation of Threshold Value of Debt

After the calculation of fiscal sustainability indicator; we proceed to calculate an optimal value of debt. For representing debt, the debt/GDP ratio has been used throughout our analysis. With this optimal value of debt/GDP, it is suggested that if a particular Indian state is above this value, its fiscal position represents instability and ultimately India's fiscal sustainability will be at threat. Vice versa, if the debt/GDP values are below this calculated threshold value, then in that case India's fiscal sustainability is maintained. As discussed above, the Pareto principle and decision tree algorithm have been applied to our case for carrying out this portion of the analysis. The next section discusses the application of these techniques.

5.4.2.2.1 Application of Pareto Principle

Applying the Pareto principle to our case, the 80-20 rule can be defined as:

20 per cent of the states with highest negative sustainability give rise to 80 per cent of the whole fiscal unsustainability in all the states.

So, if 20 per cent of the data points are marked with maximum negative gap values, we can try to estimate the optimum debt value, which when practiced, can help eradicate 80 per cent of fiscal unsustainability.

5.4.2.2.2 Application of Decision Tree Algorithm

Further for applying decision tree algorithm to this case, certain macroeconomic variables are used and it is assumed that the fiscal sustainability indicator (sustainability gap) is dependent on these variables. The chosen variables are:

- Debt/GDP ratio
- Fiscal Deficit (as a % of GDP)
- GDP Growth rate (%, constant prices at the price level of the base year 2004-05)

As a result of the application of decision tree algorithm, post the analysis certain interesting rules can be extracted like

"If Debt-GDP ratio is < A, and Fiscal Deficit is < B and Growth Rate is > C, then the state is likely to be Fiscally Sustainable."

A, B, and C are constants that will be calculated by the decision tree algorithm.

5.4.2.2.3 Calculation of Optimal Value of Debt

Post the calculation of sustainability gap (which is being used as a proxy variable for indicating fiscal sustainability), the focus is shifted on deriving a threshold value of debt-GDP ratio. As planned, the analysis is performed for two different cost-matrices:

Cost Matrix –I

	Fiscally Unsustainable	Fiscally Sustainable
Fiscally Unsustainable	0	1
Fiscally Sustainable	3	0

Fig 5.29 given below presents the decision tree obtained for Cost Matrix I.

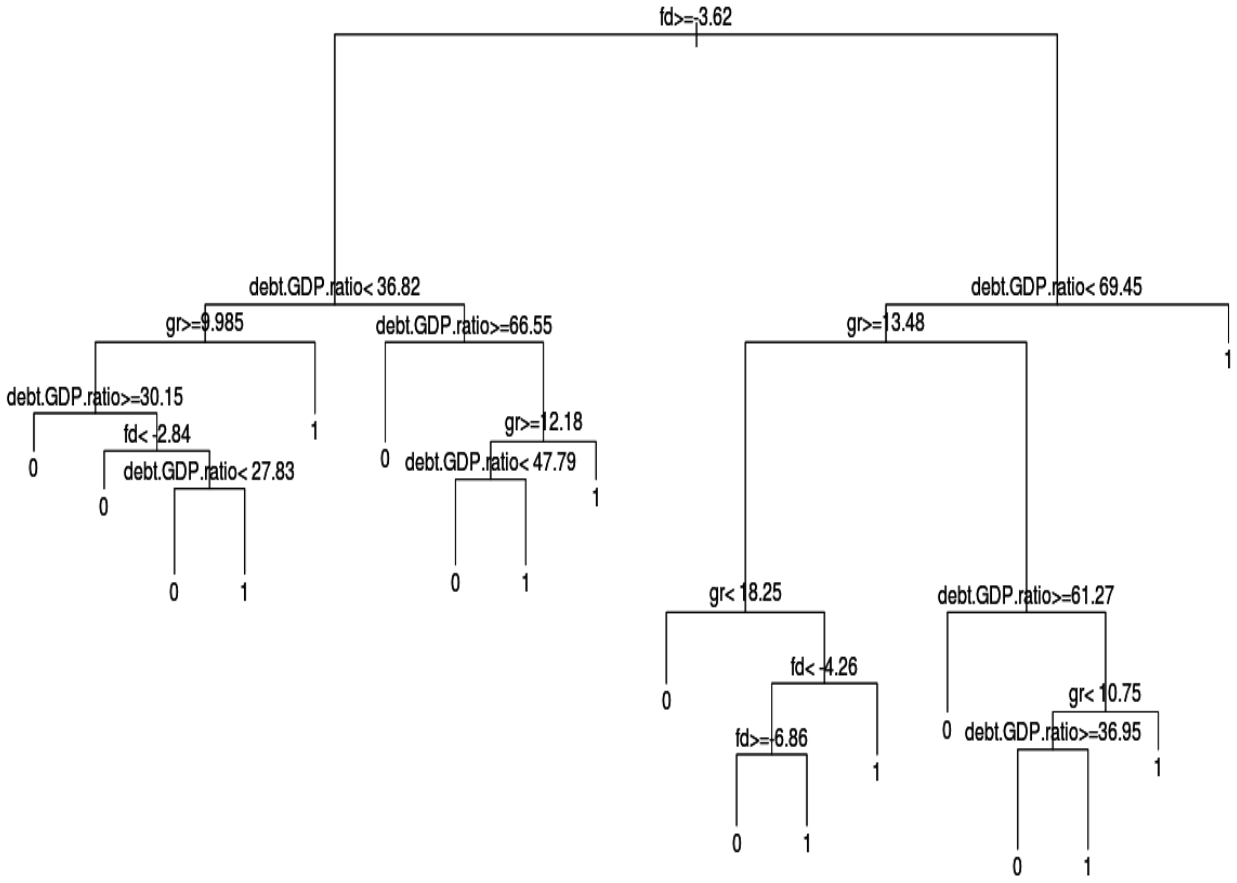


Fig 5.29: Decision Tree using Cost Matrix I

Accuracy = 77.45 per cent; Precision = 47.16 per cent; Recall = 79.36 per cent

Analysis of results obtained by using cost matrix -I:

Accuracy: The above trained model predicted 77.45 per cent of the records correctly. However, in research problems like these, accuracy is not the true indicator of performance. The data which we have is highly biased, meaning that 80 per cent of the records are flagged 0, and only 20 per cent of them are flagged 1. If this model simply marked every prediction as 0, it would still have an accuracy of 80 per cent, since it is known that 80 per cent of the records are flagged as 0 by us using the 80-20 Pareto rule. Precision and Recall, as explained in the previous sections will give better insights to the results.

Precision: In simple terms, it tells that, "*out of the predictions made as '1', how many of them were actually '1'?* We are getting a precision value of 47.16 per cent. This means that **out of every 100 records our model predicts as 1, 47.16 per cent of them are correctly predicted**. This is a relatively good result as we are able to predict that a state can be in a difficult fiscal condition correctly 47.16 per cent of the times. This result is acceptable, because as per the previous discussions, we would ideally prefer to have a higher recall than a high precision.

Recall: This, in our context means that out of the states which had been marked as fiscally unsustainable, how many of them were actually marked as fiscally unsustainable by our model. We are getting a recall value of 79.36 per cent, which means, **that we were able to cover 79.36 per cent of the states that were fiscally unsustainable.** This is an ideal result keeping into account the fact that we are willing to trade off on precision while having higher emphasis on recall.

Cost Matrix –II

	Fiscally Unsustainable	Fiscally Sustainable
Fiscally Unsustainable	0	1
Fiscally Sustainable	2	0

Fig 5.30 given below presents the decision tree obtained for Cost Matrix II.

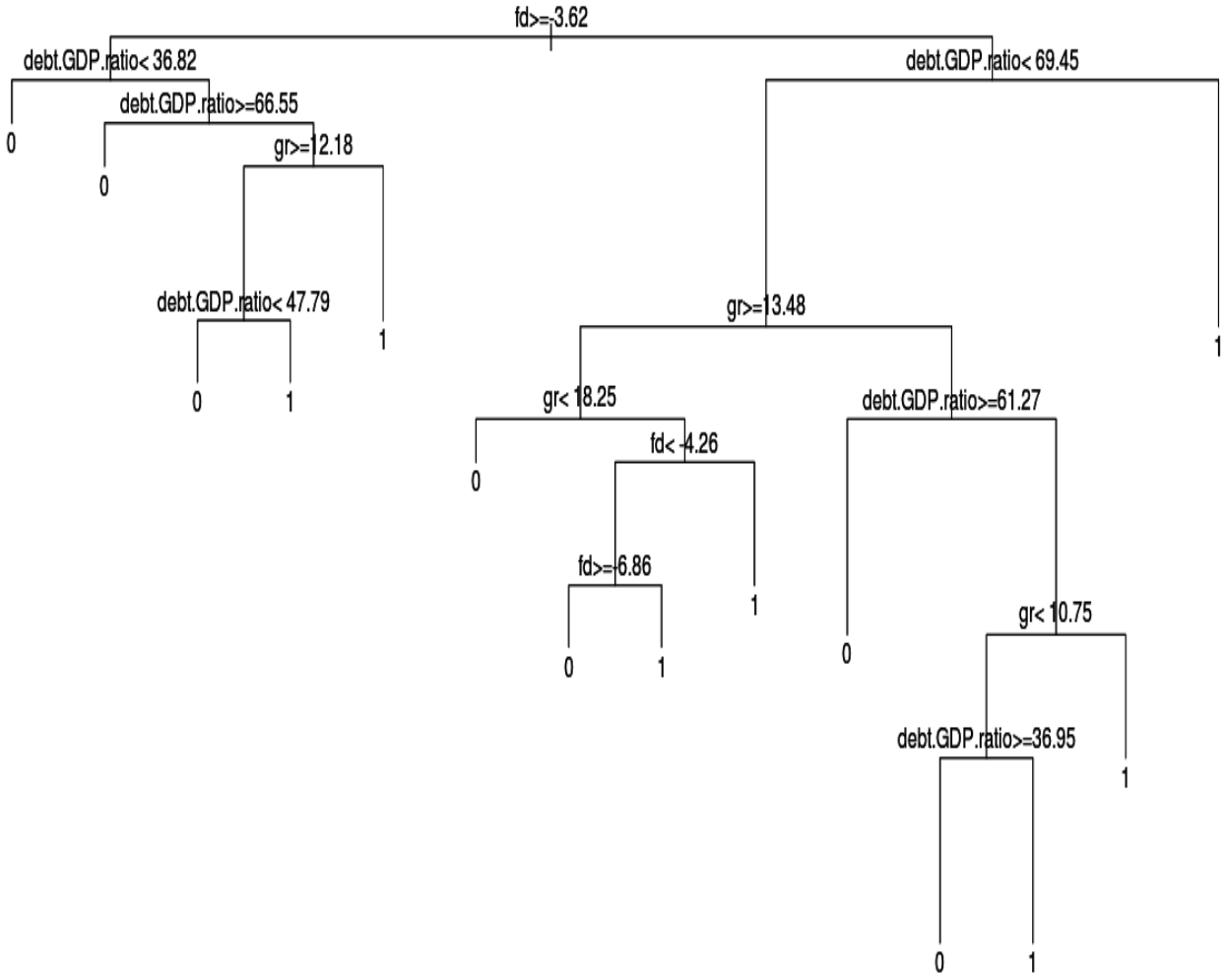


Fig 5.30: Decision Tree using Cost Matrix II

Accuracy = 79.08 per cent; Precision = 49.41 per cent; Recall = 66.67 per cent

Analysis of results obtained by using cost matrix -II:

Accuracy: The above trained model predicted 79.08 per cent of the records correctly.

Precision: This means that **out of every 100 records our model predicts as 1, 49.41 per cent of them are correctly predicted**. This is a good result, in fact better than the previous case in which we got 47.16 per cent of precision.

Recall: We are getting a recall value of 66.67 per cent, which means, **that we were able to cover 66.67 per cent of the states that were fiscally unsustainable.** This is a lesser value compared to the previous result, considering the fact that more emphasis is laid on the recall.

From the above discussion, it can be seen that the result of the decision tree created by cost-matrix I is better than the one created by cost-matrix II. So, further analysis can be continued on the 1st decision tree model.

The 1st decision tree is very extensive. In order to get a better and shorter explanation, the decision tree can be pruned upto a certain level itself, such that it will be able to give us relationships. Further, the pruning of this decision tree to extract simpler rules also helps us to determine threshold values of macroeconomic variables considered in this study including the optimal value of debt-GDP ratio, which the Indian states can follow.

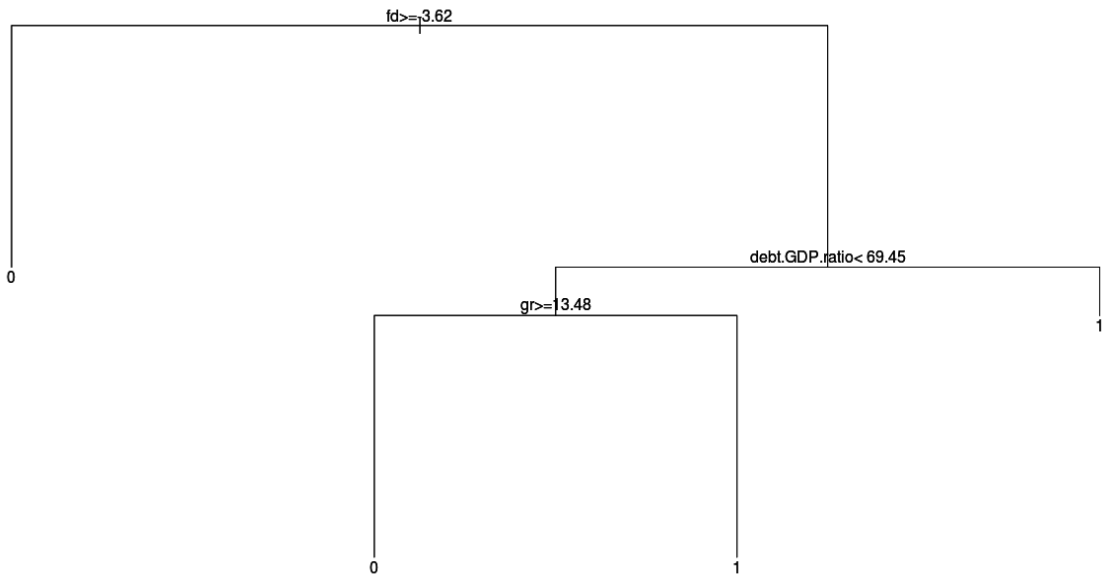


Fig 5.31: The Pruned Decision Tree

The decision tree obtained after pruning gives logical results, which confirms our approach in solving this research problem using the decision tree algorithm. The major rules (in terms

of optimal values for the considered macroeconomic variables) which have been obtained from this decision tree will be analyzed in order to extract meaning and conclusions out of it. All the conditions/rules have to be satisfied in order to meet the overall conclusion of fiscal sustainability. All the rules at each of these levels are discussed below.

- **FIRST LEVEL -> Fiscal deficit should not cross -3.62 per cent. Till -3.62 per cent of fiscal deficit, we are predicting that the economy is fiscally sustainable:** From this analysis, it can be concluded that fiscal deficit is the most important reason for fiscal unsustainability. The threshold value for fiscal deficit given by this analysis is -3.62. In other words, if a state's economy crosses this value, then it is predicted to be fiscally unsustainable. If fiscal deficit has values near zero or negative like -1, -2 per cent but below 3.62, then only we are saying that the state economy is fiscally sustainable.

- **SECOND LEVEL - > If fiscal deficit crosses -3.62 AND debt-GDP ratio is more than 69.45 per cent, then that the economy is predicted to be fiscally unsustainable. If fiscal deficit does not cross -3.62, AND debt-GDP ratio is also less than 69.45 per cent, then the economy is predicted as fiscally sustainable:** These two rules state that if the fiscal deficit crosses -3.62 per cent, then we further need to go one level down in terms of checking for one more indicator and ensure the fiscal unsustainability via debt-GDP ratio. If the debt-GDP ratio is greater than 69.45 per cent, then it is said that the economy is fiscally unsustainable. This rule arises out of the fact that fiscal deficit is the difference between receipts and expenditures for a particular fiscal year, while public debt is the effect of accumulation of continuous difference in receipts and expenditures year after year (obviously with expenditures dominating the receipts). In other words, public debt is the result of accrued fiscal deficit over the years. Hence, the optimal value of debt-GDP ratio till which a state's economy can go is 69.45 per cent.

- **THIRD LEVEL -> If fiscal deficit does not cross -3.62, AND debt-GDP ratio is also less than 69.45 per cent, AND growth rate is greater than 13.48 per cent, then it can be said that the economy is fiscally sustainable. If fiscal deficit does not cross -3.62, AND debt-GDP ratio is less than 69.45 per cent, AND growth rate is also less than 13.48 per cent, then the economy is predicted as fiscally unsustainable:** In this analysis using the decision tree algorithm, the growth rate at current prices is the least important feature when we are trying to predict for fiscal unsustainability in an economy. If the first two conditions are met (fiscal deficit does not cross -3.62 and debt-GDP < 69.45 per cent, then a good growth rate (>13.48) will not hamper the sustainability of an Indian state economy and it can be concluded that the state economy is fiscally sustainable. The role of economic growth cannot be overshadowed and this is confirmed by the fact that if an Indian state economy meets the initial two conditions of fiscal deficit and debt-GDP ratio, but the growth rate is less than 13.48 per cent then this analysis predicts that the state economy is fiscally unsustainable.

5.5 CONCLUSIONS

This chapter presented and discussed the empirical findings of this thesis. The analysis started off with the investigation of the relationship between Public Infrastructure Investment and economic growth in order to analyze a panel data set of twenty eight Indian states. All the empirical results and findings of IPS (2003) test for stationarity, Westerlund-based panel cointegration tests and finally the short run causality test results were discussed in Part I. Part II covered the results of the empirical analysis where firstly the historical trends of each mode of infrastructure financing (Public, Private and PPP) for the major sectors falling under the Infrastructure sector i.e Roads, Seaports, Telecom and Energy were analyzed. The results of the analysis pertaining to the impact of Public, Private and PPP mode of infrastructure

financing on economic growth were also discussed in Part II. Secondly, the results of eight research hypotheses framed for examining and estimating the significant determinants of attracting any PPP in India were presented in Part II. In Part III, the relationship between debt and economic growth for India was examined and the corresponding results were discussed. Also, the calculations of fiscal sustainability indicator for Indian states along with finding out an optimal value of debt till which India's fiscal sustainability is maintained were discussed and presented in Part III.

CHAPTER 6

SUMMARY OF FINDINGS AND CONCLUSIONS

6.1 INTRODUCTION

For the three research objectives framed under this thesis, the empirical analysis was carried out as discussed in Chapter 5. Based on the empirical results and findings of first research objective, the presence of cointegration was confirmed and hence long-run equilibrium relationship existed among Per Capita Gross State Domestic Product (PCGSDP) and Public Investment in Transport (PTRANS); Public Investment in Education, Sports, Art and Culture (PEDU); Public Investment in Medical and Public Health (PMED); Public Investment in Water supply and sanitation (PDW); Public Investment in Irrigation (PIRRI); Public Investment in Energy/Power (PENG). Further, the causality analysis was carried out which suggested that there is short-run bi-directional causality relationship between PTRANS and PCGSDP. Various causal relationships were also inferred among these seven variables of this study.

The empirical analysis performed under second research objective helped to achieve two goals. Firstly, the historical trend analysis suggested that Private mode of infrastructure financing was the most preferred one for sectors – Roads, Telecommunication (Telecom) and Energy while Public Private Partnership (PPP) mode was preferred for the Seaports sector. Further, Private mode of investment in Roads, Energy and Telecom sectors while PPP mode for Seaports sector was observed to have maximum positive impact on Gross Domestic Product (GDP). Looking at aggregate scenario, PPP mode of infrastructure financing was observed to produce the maximum positive impact on the overall GDP. Secondly, hard governmental constraints, market conditions, political environment and institutional quality came out as important determinants for the number of PPP projects in India while soft governmental constraints, market conditions and effectiveness of government had a significant impact in terms of the total investment in PPP projects.

For the third objective, empirical analysis was performed on two research issues. Firstly, it was concluded that for India an increase in level of public debt, all else being equal, would appear to induce the rate of investment over the course of time and, in turn, indirectly boost economic growth. Further, an indicator was constructed for the twenty eight Indian states, excluding Telangana to measure fiscal sustainability and was named as Sustainability Gap. Based on the calculations, Arunachal Pradesh, Chattisgarh, Goa, Haryana, Himachal Pradesh, Manipur, Odisha, Punjab, Rajasthan and Uttar Pradesh came out as top performers on grounds of fiscal sustainability. Moving ahead, three levels of conditions were predicted each indicating the fiscal sustainability for an Indian state economy. The first level gave the condition that fiscal deficit should not cross -3.62 %. The second level put forth the condition that if fiscal deficit does not cross -3.62 and debt-GDP ratio is below 69.45% then the state economy is fiscally sustainable. The third and final condition said that if fiscal deficit of a particular state does not cross -3.62 with its debt-GDP ratio being less than 69.45% and growth rate greater than 13.48%, then the state economy will remain fiscally sustainable.

This chapter has been organized in the following manner. A brief overview of work done vis-à-vis formulated research objectives is presented and discussed in this chapter in Section 6.2, followed by Conclusions and Recommendations in Section 6.3, Specific Contribution of the Thesis in Section 6.4, Limitations in Section 6.5 and Future Scope of Work in Section 6.6.

6.2 BRIEF OVERVIEW OF THE WORK DONE VIS-À-VIS FORMULATED RESEARCH OBJECTIVES

The review of literature in ‘Chapter 3’ formed the basis for the identification of research gaps among the interlinked issues of Public Infrastructure Investment, Economic growth and

Fiscal Sustainability in Indian context. For the identified research gaps, three major research objectives were formulated and empirical analysis was carried out for each of them as discussed in 'Chapter 5'. Based on the empirical analysis, following is the summary of the key findings.

In terms of first research objective, the cointegration and short-run causal relationships were examined between PCGSDP and PTRANS, PEDU, PMED, PDW, PIRRI, PENG, based on a panel data set of twenty eight (28) states of India, excluding Telangana, during the time period 1999–2000 to 2014-15. The empirical analysis suggests that all the seven variables under study i.e PCGSDP and PTRANS, PEDU, PMED, PDW, PIRRI, PENG are cointegrated and hence there are long-run equilibrium relationships among these seven variables. Further, the causality results indicated that there is short-run bi-directional causality relationship between PTRANS and PCGSDP. We also found bi-directional causality relationship between PENG and PCGSDP, unidirectional causality running from PDW to PEDU, from PDW to PMED, from PEDU to PCGSDP and finally from PMED to PCGSDP.

Under second research objective, empirical analysis was carried out on two issues. Firstly the most preferred mode of infrastructure financing is arrived at, for major sub sectors of Infrastructure i.e Roads, Seaports, Telecom and Energy by examining the historical data available for each mode of financing for these sectors. Based on the historical trend analysis, Private mode of infrastructure financing is seen to be the most preferred one for sectors – Roads, Telecom and Energy while PPP mode comes out to be the most preferred one for Seaports sector. Further, which mode of infrastructure financing has a maximum positive impact on the overall GDP of India is also examined for these four sectors. The same exercise is carried out for the overall Infrastructure sector (by clubbing all the sub sectors

data). Based on the empirical analysis, PPP mode of infrastructure financing is seen to produce the maximum positive impact on the overall GDP. For sector wise cases; Private mode of investment in Roads, Energy and Telecom while PPP mode for Seaports are observed to have maximum positive impact on GDP. This confirms the fact that for each of these sectors, the most preferred mode of infrastructure financing suggested by the historical trend analysis is the one that exerts the maximum positive impact on India's GDP.

Secondly, the significant determinants of attracting any PPP in India have been examined and estimated via framing and testing eight relevant research hypotheses. Based on the empirical analysis on this issue, hard governmental constraints, market conditions, political environment and institutional quality are important determinants of the number of PPP projects in India while soft governmental constraints, market conditions and effectiveness of government impact the total investment in a PPP project.

Again for the third research objective, the empirical analysis is performed on two issues. Firstly, the dynamic relationship between debt and economic growth for India is examined by looking at this relationship from the investment point of view. Based on the empirical findings it can be said that for India an increase in level of public debt, all else being equal, would appear to induce the rate of investment over the course of time and, in turn, indirectly boost economic growth, hence supporting the argument that public debt has an indirect effect on economic growth through its beneficial impact on investment.

For the second issue under this research objective, the subject of fiscal sustainability has been investigated. For the time period of 2002-03 to 2013-14, an indicator to measure fiscal sustainability for the twenty eight Indian states, excluding Telangana is constructed. This indicator is named as Sustainability Gap. Based on the calculations, Arunachal Pradesh, Chattisgarh, Goa, Haryana, Himachal Pradesh, Manipur, Odisha, Punjab, Rajasthan and

Uttar Pradesh are the states which are top performers on grounds of fiscal sustainability. Bihar, Gujarat, Kerala, Maharashtra, Mizoram, Tripura, West Bengal perform moderate/ decent while Andhra Pradesh, Assam , Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Meghalaya, Nagaland, Sikkim, Tamil Nadu and Uttarakhand perform poorly on the constructed fiscal sustainability parameter i.e Sustainability gap. Further, an optimal value of debt is calculated. With this threshold value it is suggested that if a particular Indian state is above this value, its fiscal position represents instability and ultimately India's fiscal sustainability will be at threat. Based on the empirical analysis and findings, three levels of conditions are predicted each indicating the fiscal sustainability for a state economy, thereby suggesting an optimal value of debt which the states should not breach. The first level gives the condition that fiscal deficit should not cross -3.62 %. Till -3.62 % of fiscal deficit, we are predicting that an Indian state economy is fiscally sustainable. The second level gives the condition that if fiscal deficit does not cross 3.62 and debt-GDP ratio is also less than 69.45%, then the Indian state economy is predicted as fiscally sustainable. Here, by including the debt-GDP ratio at the second level, the optimal level of debt for Indian states and effectively India is predicted as 69.45%. The third and final condition puts forth that if fiscal deficit of a particular Indian state does not cross -3.62 with its debt-GDP ratio being less than 69.45% and growth rate greater than 13.48%, then it can be concluded that the Indian state economy is fiscally sustainable.

6.3 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the thesis, following specific conclusions were drawn. In terms of first research objective, the findings from the panel data analysis of Indian states suggest that economic policies should address each of the cointegrated/interlinked sectors of Infrastructure (Transport; Education, Sports, Art and Culture; Medical and Public Health,

Water supply and sanitation; Irrigation; Energy/Power) simultaneously with investment being the top most priority in order to achieve higher economic development. From policy recommendation point of view, this empirical framework can help to estimate the short- and long-run elasticities of Public Investment in these major Infrastructure sectors, so as to calibrate the developed models and generate scenarios telling how openness policies might stimulate businesses to adopt different types of investment options (like PPPs etc.) so as to maximize growth prospects. Along with private investment options, the Indian states can also look towards increasing and sustaining the Foreign Direct Investment (FDI) which would ultimately help in improving the landscape of India's Infrastructure sector. Given the geographical diversity of population, industries and states in India, an appropriate modal mix of investment is quite necessary in order to promote and achieve economic growth. The empirical findings further suggest that all the state governments' top priority should be to vigilantly and proficiently handle their particular state's investment scenario in all Infrastructure sectors. For the above mentioned predictions to occur, the infrastructure sector needs a revamp of the existing ways of doing business across the different participants like developers, government etc. Even though the central and state governments across India have been consistently increasing their focus on infrastructure sector, still they need to discover ways of keeping the sector moving. Government has moved ahead on the key issue of Public Infrastructure Investment in terms of its positive approach; however lot of work is yet to be done.

For the second research objective, the historical trend analysis for the last twenty years concludes with Private mode of infrastructure financing coming as the most preferred one for sectors – Roads, Telecom and Energy while PPP mode is the most preferred one for Seaports sector. For each of these sectors, the following major points can be concluded:

i. For Energy sector, Private mode of investment has witnessed an overall increasing trend since liberalization of Indian Economy with its growth further triggered by Electricity Act 2003, National Tariff Policy 2006 and more recently by the New Hydro Policy of 2008 all of which have created a liberal framework for private investments to pour in the energy sector.

ii. For Roads sector, the National Highways Act 1956 was amended in June 1995 to facilitate private participation in road infrastructure projects. Until 2004-05, the road construction and maintenance market in India was dominated by the Public Sector. However, in the present times, the private sector has emerged as a major player in the development of the road infrastructure.

iii. The Seaports sector has witnessed significant private participation particularly after 1996 which could be attributed to the fact that in 1996, the port sector was opened for private sector participation, following which the government decided to move towards the Landlord Port concept where new ports were expected to be established as companies under the Companies Act 1956 and existing port trusts were expected to be corporatized.

iv. For Telecom sector, the New Telecom Policy (NTP) was announced in 1999 post which the private investment started pouring in. NTP main objective was to ensure India's emergence as major manufacturing / export base of Telecom equipment and universal availability of basic Telecom services for Pan-India. Post the introduction of NTP, all the segments of Telecom sector were opened for private sector participation.

Further, based on the findings of examining which mode of infrastructure financing has a maximum positive impact on the overall GDP of our nation, it is concluded that Private mode of investment in Roads, Energy, Telecom while PPP mode for Seaports are observed to have maximum positive impact on GDP. For each of these sectors, the following major points can be concluded:

i. For Energy sector, the Impulse Response functions suggested that an increase in Private investment leads to an increase in GDP in the short term. However, in the long run the increase is mitigated. This could be due to the ever increasing energy demands of our rising population which does not allow the investment in Energy sector to have a sustaining positive impact in the long run. Hence, the Indian government needs to focus on long-term measures which can focus on reducing dependence on any one source of imported energy, exploiting native fossil fuel or renewable energy resources, and reducing overall demand through energy conservation measures. The Government of India understands these issues and that is why it has identified energy sector as one of key sectors of focus with the focal point on bringing in private investment as much as possible. Looking at the recent trends, there have been various developments which have taken place in order to boost the private investment in the energy sector. The State Bank of India (SBI) has signed an agreement with the World Bank for Indian Rupee (INR) 4,200 crore credit facility aimed at financing Grid Connected Rooftop Solar Photovoltaic (GRPV) projects in India. Canada's second largest pension fund, Caisse de depot et placement du Quebec (CDPQ), has set up its office in India and committed to invest 150 million United States Dollar (USD) in the Indian renewable energy sector over the next three to four years. Surely, all these point towards the right direction for the Energy sector.

ii. For Roads sector, the Impulse Response functions obtained for the Indian economy clearly indicate that private investment has a maximum positive effect on GDP in short run as well as long run. Transport infrastructure is one of key ingredients to fuel economic growth and Roads are the lifeline of transportation in our country. When road transport steps up, both in quantity and quality, it adds to the government's revenue as well as to the economic growth via swift movement of goods and services. The future

outlook augurs well for the Roads sector as the Ministry of Road Transport and Highways (MoRTH), Government of India with the objective of increasing Private investment is now working on two particular models for attracting capital. One model proposes allowing bidding of a road project on the basis of the least present value, and the other envisages selling off road projects that have been built using government funds. The future outlook looks promising.

iii. For Seaports sector, the Impulse Response functions clearly indicate that PPP investment has a maximum positive effect on GDP in short run as well as in the long run. The Indian ports and shipping industry plays a crucial role in sustaining growth in the country's trade and commerce as around 95 percent of India's trading by volume and about 70 percent by value is done through maritime transport. Therefore, investment in the seaports sector is directly linked to boosting of our economy. The Government also understands the importance of seaports sector and the fact that PPP investment is the most influential one in terms of brining maximum economic growth. With this view, the Government plans to introduce a new framework on renegotiation of PPP contracts. The new framework will allow renegotiations based on sector-specific issues, particularly for national highways and ports, and provide greater flexibility to the parties involved as flexibility is one thing which is usually lacking in PPP contracts. Further, the Shipping Ministry's power to allot finances has been enhanced to accord investment approval for PPP projects. This surely points towards a healthy outlook for the Indian seaports sector.

iv. For the Telecom sector, the Impulse Response functions point towards the fact that an increase in Private investment leads to an increase in GDP in the short term. However, in the long run the increase is marginal and not a major one. This may be due to the fact that still there is a tremendous opportunity for future growth in the Telecom industry. Hence, the amount of investment going in presently might only be used up in trying to

sustain the existing demand and not ultimately getting transferred into exerting a positive impact on the economy. The rural areas are still underpenetrated and their demand is huge. The government is aware of the demand potential in Telecom sector and therefore it has fast-tracked reforms in this sector in order to be proactive and provide room for growth for Telecom companies in India enabling them to bring private investment as much as possible. Motivated by these kinds of efforts, the Lenovo Group of China has commenced manufacturing its smartphones in India, through its contract manufacturer Flex's facility near Chennai, thus becoming the largest Chinese company to follow 'Make in India' strategy. Swedish Telecom equipment maker Ericsson has announced the introduction of a new radio system in the Indian market, which will provide the necessary infrastructure required by mobile companies in order to provide fifth-generation (5G) services in future. On back of all this, the Indian Telecom sector is surely going to witness fast growth in the next few years.

Further as per the empirical analysis for overall Infrastructure scenario constituting of Roads, Seaports, Telecom and Energy sectors, PPP mode of infrastructure financing comes out to be the most significant one in terms of having the maximum positive impact on GDP of India. Hence, the focus is put exclusively on the PPP mode of infrastructure financing by examining and estimating the significant determinants of attracting any PPP in India. Eight relevant research hypotheses are framed and tested to do the same.

From the empirical evidences, it can be concluded that the major determinants of a successful PPP in India are hard government constraints, market conditions, political factors and institutional quality. Using the empirical findings, it can be said that for India a higher Cash deficit with huge government debt tends to attract more number of PPP projects. One possible explanation for this could be the fact that although huge cash deficit along with high

government debt represents government budget limitations, but at the same time it also serves as an indication for the need of financing which could be fulfilled by the private sector through the PPP arrangements. Further, the results imply that stable market conditions reflected in sufficient Gross savings and a rising GDP per capita ultimately lead to more number of PPP projects in India. Also in terms of political factors, Voice and Accountability, Political Stability and Regulatory Quality are indeed responsible and play a crucial role for the private sector in terms of making decisions regarding involvement of the PPP mode for financing Infrastructure. Finally, Institutional quality via freedom from corruption index (FCI) cannot be ignored and it also holds its significance in determining PPP projects in India. A corruption free India is more likely to attract more private investment through a higher number of PPP projects. Ultimately, there is evidence in favour of all the channels except the macroeconomic factors.

When the investment aspect for PPPs is examined, it is inferred that soft governmental constraints, market conditions and effectiveness of government prove to be decisive in terms of impacting the PPP investment (total cost of PPP projects). More specifically, a country with a large population and large demand, receiving net inflows from equity securities and having an effective and credible government attracts more investment in PPP.

From Policy recommendation point of view, everyone is aware of the importance of public infrastructure provisioning in terms of improving economic growth, distributing wealth and reducing poverty. Any kind of effort to increase the availability and reliability of Public Infrastructure is surely going to aid the economy. However, as Indian government faces issues of budget constraints, providing new infrastructure services can sometime become unattainable. In such cases, private financing and the involvement of private sector in the

form of PPP arrangements becomes the need of the hour which the Indian government needs to focus upon.

The conclusions of this study highlight that favorable market conditions come out as significant determinants of PPP arrangements in India. These results are very logical as rising GDP, high income translating into more savings and a large population size will definitely demand better quality public infrastructure. This demand for more and better provisioning of Public infrastructure can only be met through PPP arrangements.

Another major finding of this analysis indicates that building a strong and effective government is vital in attracting private financing for infrastructure development. In reality, PPP is an arrangement in which a government as the owner of a project makes an agreement to share the risks and returns with the private partner in developing public infrastructure; thereby the workability of the arrangement becomes all the more dependent on the credibility of the government. This credibility can be achieved by making sure that regulatory system is in place and enforceable. A proper functioning regulatory system safeguards the private sector rights in terms of securing their assets, claiming the share of returns, developing transparent and accountable procedures and ultimately avoiding corruption which is expected to one of the major concern for the Indian government. By tackling corruption the Indian government will be able to improve the institutional capacities of our nation rather than just focusing on the advancement of banking or financial structures.

For the third research objective, the dynamic relationship between debt and economic growth is empirically examined for India by looking at this relationship from the investment point of view. The results indicate that public debt makes a significant positive contribution to economic growth directly as well as indirectly via investment, because an increase in level of public debt, all else being equal, would appear to stimulate the rate of investment over the

course of time and, in turn, indirectly increase economic growth, hence supporting the argument that public debt has an indirect effect on economic growth through its beneficial impact on investment. If the results of empirical analysis are to be seen, then it can be concluded that public debt positively affects the economic growth while controlling for other determinants of growth. Numerically, on an average one percent point increase in debt is associated with an increase in Real GDP of around 1.02 percentage point per year. This suggests that all the resources created through public debt are being used up for productive purposes. However, the focus should not be only on raising public debts but also to ensure that these debts are placed in a stabilizing manner in the long term so that they do not have a detrimental effect on the economy. Just because a positive relationship is found out between debt and economic growth does not essentially mean that a particular economy keeps on taking debt in order to enhance its economic growth. Crossing certain levels can be alarming for the fiscal stance of the nation. There has to be some threshold value of debt till which the nation's fiscal sustainability is intact and preserved.

Therefore, it can be said that a comprehensive understanding of the debt and growth dynamics is very important for policy makers in order to make correct fiscal policy decisions. As our analysis indicates that raising debt might prove to be effective in stimulating the capital investment, however expansionary fiscal policy that increases the public debt may reduce the long term growth of the country. Therefore the policy makers need to continuously check the rising debt levels of the country and maintain a balance between debt and growth.

Moving ahead, the subject of fiscal sustainability is analyzed with an aim of calculating the threshold value of debt. The time period of 2002-03 to 2013-14 is considered and an indicator to measure fiscal sustainability is constructed for twenty eight Indian states,

excluding Telangana. This indicator is named as Sustainability Gap. Based on the calculations, Arunachal Pradesh, Chattisgarh, Goa, Haryana, Himachal Pradesh, Manipur, Odisha, Punjab, Rajasthan and Uttar Pradesh are the states which are top performers on grounds of fiscal sustainability.

Chhattisgarh, although an underdeveloped but a resource-rich state seems to be surprise entry in the list of top performers. This relatively new and small mineral-rich state is able to stand out because of a revenue surplus budget and low interest payment burden. In terms of interest payment as a proportion of the state gross domestic product, apart from Chhattisgarh, Goa and Odisha also have the least interest costs which benefits them a lot and that is why both of these states also find themselves in the list of Top performers. Small states like Arunachal Pradesh, Himachal Pradesh and Manipur also are performing well because of high revenue receipts and low expenditure. This puts them in revenue surplus which pushes them into the top performing category. States like Uttar Pradesh, Punjab and Rajasthan are less reliant on central government taxes as a source of revenue and are able to generate more income on their own. This puts their revenue account into a good stead and they also manage to land up in the top performers' bracket.

States like Gujarat and Maharashtra perform decent owing to higher capital expenditure spending and greater reliance on self-generating taxes. Kerala and Tripura have good revenue balance along with a low debt to GDP ratio which helps them to perform decently. Bihar, Mizoram and West Bengal have certain positive as well as negative issues. On the positive side, these states have a good revenue balance for the majority of years of considered time period of analysis. However, high debt ratios and rising expenditure on interest payments pushes them back. Overall they seem to perform moderately and lie in this middle bracket of performers.

States like Jharkhand, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, and Karnataka perform poorly because of a poor revenue balance. These states do not have sufficient revenue receipts to meet their expenditure. The extra burden of interest payments on past debt also makes them vulnerable and they lie in the poor performers' category. Further states like Assam, Jammu and Kashmir, Nagaland, Meghalaya, Sikkim and Uttarakhand face the problem of a growing debt- GDP ratio which implies that public expenditure is excessively devoted to unproductive spending majorly because of inefficient fiscal management of these state governments. This large debt ratio is a major cause of concern for these states particularly from the point of view of stability and sustainability of fiscal policy.

Moving ahead, a threshold value of debt is calculated. With this value we are suggesting that if a particular Indian state is above this value, its fiscal position represents instability and ultimately India's fiscal sustainability will be at threat. Based on the empirical findings, three levels of conditions are predicted each indicating the fiscal sustainability for a state economy, thereby suggesting an optimal value of debt which the states should not breach.

The first level gives the condition based on the fiscal deficit indicator. Fiscal deficit is one of the most important indicators whenever we discuss fiscal sustainability. While financing the revenue and expenditure mismatches along with future investments, the governments may go into deficits. There is nothing wrong in having fiscal deficits. However, the problematic part comes when fiscal deficit becomes too high and dangerous for the economy. The bad effects of high deficits are related to the way they are financed and the use they are put to. The fiscal deficits can be financed through domestic borrowing, foreign borrowing or by printing money. While excessive domestic borrowing can lead to a hardening of interest rates, an excess of foreign borrowings can result in an external debt crisis. Printing money may create inflationary pressures. Therefore, there should be a particular value of fiscal

deficit which the governments should take as a benchmark and should not cross it. The empirical findings suggest that the threshold value of fiscal deficit should not cross -3.62 (as a % of GDP), with the negative sign implying that it is a deficit. Till this fiscal deficit value of -3.62 %, the economy is predicted as fiscally sustainable. This result is almost equal to the fiscal deficit target of -3.9 (% of GDP) set by Government of India for the year 2015-16.

The second level gives the condition based on the combination of two indicators i.e fiscal deficit and debt-GDP ratio. The impact of public debt accumulation on economic growth always holds an essential place whenever any kind of policy debate takes place in terms of designing optimal fiscal policies that balance the short-run gains from fiscal expansion and possible adverse impact on growth in the long run. Increasing the amount of debt can prove to be useful in short run when our focus is on stimulating the capital investment. However, an expansionary fiscal policy which keeps on raising the public debt may reduce the long term growth of the country. With this point of view, the policy makers have always stressed on the need to continuously check the rising debt levels and maintain a balance between debt and growth. Therefore, there should be some threshold value of debt for India till which the fiscal sustainability is intact and preserved. The empirical findings give the condition that if fiscal deficit does not cross 3.62 and debt-GDP ratio is also less than 69.45%, then the economy is said to be fiscally sustainable. If fiscal deficit crosses -3.62 and debt-GDP ratio is more than 69.45% then the economy is predicted as fiscally unsustainable. Here, by including the debt-GDP ratio at the second level, the optimal level of debt for India is predicted as 69.45%.

The third and final condition is based on the combination of three macroeconomic indicators i.e fiscal deficit, debt-GDP ratio and growth rate. After reaching out at the above two conditions using fiscal deficit and then debt-GDP ratio, one more macroeconomic indicator

i.e growth rate is included just to expand the analysis and have a much more wider and realistic view in terms of examining this issue of fiscal sustainability. Growth rate of a state economy is vital when we are setting up benchmarks for fiscal deficit and debt-GDP ratio. Therefore, from the empirical findings it can be concluded that if fiscal deficit of a particular state does not cross -3.62 with its debt-GDP ratio being less than 69.45% and growth rate greater than 13.48%, then it can be inferred that the Indian state economy is fiscally sustainable.

6.4 SPECIFIC CONTRIBUTION OF THE THESIS WORK

The specific contribution from this thesis can be summarized as follows:

- Although the Indian Infrastructure sector is one of the most prominent ones in terms of its contribution to GDP, the research work with respect to this sector is still miniscule. Though there have been studies which have examined the different aspects of the role of infrastructure in terms of achieving economic growth, however, insufficiency of research work remains when it comes to specifically examine the Public Infrastructure Investment and economic growth relationship for India, particularly from a state level point of view.
- The studies focusing on Infrastructure sector in India have ignored the issue of Infrastructure Financing. This thesis takes up this issue and tries to explore and suggest the best mode of infrastructure financing for India's major Infrastructure sectors.
- The aspect of determining the major determinants of attracting any PPP project in India is also a unique contribution to the existing work.
- This thesis tries to examine the dynamic relationship between debt and economic growth for India by analyzing this linkage from the investment point of view.
- The thesis has contributed to the literature by analyzing the issue of fiscal sustainability for Indian states and constructing a measure to assess the same.

- Empirical work on estimating a threshold value of debt/GDP ratio for Indian states and ultimately India needs to be enriched. This work tries to provide empirical evidence on this front too.

6.5 LIMITATIONS OF THE WORK

i. While examining the relationship between Public Infrastructure Investment and Economic growth for the Indian states, we have taken six major sub sectors of Infrastructure based on limited data availability. Depending on the feasibility and importance in terms of the objective of the study, more number of Infrastructure sectors can be included so as to make the analysis more comprehensive and exhaustive.

ii. For the historical trend analysis suggesting the preferred mode of infrastructure financing, this study takes up four sectors (Roads, Seaports, Telecom and Energy) due to data unavailability for other sectors of Infrastructure. For the considered four sectors, the analysis carried out for estimating the impact of different modes of financing on economic growth was limited to annual time series data for twenty years from 1995 to 2014 due to lack of data for the years before 1995.

iii. In the specification of the Structural Vector Autoregression (SVAR) model, dummy variables were not used to account for major structural changes to the economy. Also, the analysis on examining and estimating the determinants of PPPs in India has limitations in terms of the considered time span and model specifications.

iv. For the empirical analysis on constructing the measure of fiscal sustainability and then estimating the threshold value of debt, validation measures to corroborate the calculation and estimation could not be carried out.

6.6 FUTURE SCOPE OF WORK

- Certain aspects which impact the quality of infrastructure sectors across Indian states, such as the identity of operators, the nature of the regulatory framework and the nature of the political economy and ultimately drive the Public Infrastructure Investment can be considered for future scope of work. In the Indian context, there is a huge research gap in this respect.
- One avenue for further research would be to impose sign restriction Vector Autoregression (VAR) and carry out the analysis on estimating the impact of different modes of infrastructure financing on economic growth.
- More number of variables and improving the model specifications by incorporating dummy variables for global crisis or decomposing the analysis for specific sectors of infrastructure (Transport, Energy, Telecom, etc), are some attempts that could be done to extend the analysis pertaining to estimation of determinants of PPPs in India.
- Further research can be focused in terms of establishing a causal link between public debt and economic growth, via the use of an instrumental variable which will have a direct impact on debt but no direct effect on economic growth.
- By estimating the threshold value of debt, we have tried to show that we can convert economic problems into machine learning problems and find out interesting relationships, which is relatively difficult to do while using statistics alone. Further research could be performed in terms of finding ways to bridge the gap between economics and machine learning.

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List of Publications and Papers Presented in Conferences

Papers Published

- Chotia, V. and Rao, N.V M. "Investigating the Interlinkages between Infrastructure Development, Poverty and Rural - Urban Income Inequality: Evidence from BRICS Nations" – **Accepted for publication in *Studies in Economics and Finance* for Vol. 34, Issue 4 (Ranked in "B" Category of ABDC Rankings, Emerald Publications).**

- Chotia, V. and Rao, N.V M. "An Empirical Investigation of the Link between Infrastructure Development and Poverty Reduction: The Case of India" – **Accepted for Publication in *International Journal of Social Economics* (Ranked in "B" Category of ABDC Rankings, Emerald Publications).**

- Chotia, V. and Rao, N.V M. "Examining the Impact of Public Investment and Private Investment on Economic Growth: Empirical Evidence from BRICS Nations" **– Accepted for Publication in *International Journal of Economics and Business Research* (Ranked in "C" Category of ABDC Rankings, Inderscience Publishers).**

- Chotia, V., Saxena, M. and Rao, N.V M. (2016) "Estimating the Efficiency of Public Infrastructure Investment: A State Wise Analysis" – **Accepted for publication in *Global Business Review* for Vol. 19, Issue 4 (Sage Publications).**

- Chotia, V., & Rao, N. V. M. (2016). Public Infrastructure Investment and Economic Growth: A Sector Wise Investigation for India Using Westerlund Panel Cointegration Approach. ***Romanian Economic Journal, 18*(59),** 217-240.

- Chotia, V. and Rao, N V M (2015) "Examining the Interlinkages between Regional Infrastructure Disparities, Economic Growth and Poverty: A Case of Indian States". ***Economic Annals, Volume LX, No. 205*** / April – June 2015.

- Chotia, V. and Rao, N V M (2015) "Investigating the Landscape of India's Balance of Payments: Cointegration and Causality Analysis**"**. ***International Journal of Statistics and Economics, 16*(3)** / July – Sep 2015 (**Ranked in "C" Category of ABDC Rankings, CESER Publications)**

- Gupta, M., Budhadev, R., Chotia, V., & Rao, N V M. (2016). "Integrating the issue of Infrastructure Investment with Economic Growth: The Case of India". ***Theoretical and Applied Economics, 23*(3)**, 141-162.

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- Mathur, S., Chotia, V and Rao, N V M. (2016) "Modelling the Impact of Global Financial Crisis on the Indian Stock Market through GARCH Models, ***Asia Pacific Journal of Management Research and Innovation, 12*****(1),** 11-22.

- Shah, S., Chotia, V. and Rao, N.V.M. (2017) "Generator Estimation for Transition Matrices with Applications To Credit Ratings – **Accepted for Publication in *IUP Journal of Applied Finance (IJAF).***

Papers presented in Conferences

- Chotia, V. and Rao, N.V M. (2016) "Determinants of Public Private Partnerships in Infrastructure: The Case of India". ***IMR Doctoral Students Conference (IMRDC) 2016-2017*** organized by ***Indian Institute of Management Bangalore (IIMB) Bengaluru, India***, Jan 11-12, 2017.

- Chotia, V. and Rao, N.V M. (2016) "Public Infrastructure Investment and Economic Growth: A Sectoral Analysis using Panel Cointegration Approach". ***Management Doctoral Colloquium and VGSOM Research Scholars Day 2016*** organized by ***Vinod Gupta School of Management Indian Institute of Technology Kharagpur, India***, Feb 10-11, 2016.

- Chotia, V. and Rao, N.V M. (2015) "Examining the State Level Disparities in Health, Education and Infrastructure: Is India on the path of Inclusive Growth". ***2015 IMRA-IIMB International Conference- "Inclusive Growth & Profits with Purpose: New Management Paradigm*** organized by ***International Management Research Academy (IMRA) London, United Kingdom and Indian Institute of Management Bangalore (IIMB) Bengaluru, India***, Dec 16-18, 2015.

- Chotia, V. and Rao, N.V M. (2015) "A GMM based approach to examine the relationship between expenditure in Social Infrastructure and Human Development**"**. ***Annual Conference, Papers in Public Economics and Policy*** organized by ***National Institute of Public Finance and Policy, New Delhi (NIPFP), India***, Mar 12-13, 2015.

- Chotia, V. and Rao, N.V M. (2015) "Examining the Relationship between Labour Laws and Economic Development of India**"**. ***International Conference on Law and Economics*** jointly organized by ***Gujarat Law University, Indian Institute of Management Ahmedabad (IIM Ahmedabad), Indian Institute of Technology Kanpur (IIT Kanpur) , India***, Mar 14-15, 2015.

- Chotia, V. and Rao, N.V M. (2014) "Analysing the Trends and Major Factors in India's Balance of Payments Function: Modelling using Cointegration Approach**"**. ***International Conference on Emerging Trends in Business and Economy: Mapping the way Ahead***, Organized by ***Department of Management Studies, Poornima University, Jaipur in collaboration with Hanyang University Business School, Seoul (South Korea), School of Management, Asian Institute of***

Technology, Bangkok, (Thailand) and JK Lakshmipat University, Jaipur, India, pp. 56- 68 : **Awarded with the prize of Best Paper of the Conference**

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Biography of the Supervisor

Dr. N.V.M Rao is Professor in the Department of Economics and Finance at Birla Institute of Technology & Science (BITS), Pilani (Rajasthan). He has been working here since 1994 with involvement in all the four fold activities of the Institute including teaching, research, consultancy and institutional development. He is currently Professor and Chief of Centralized Purchases at BITS, Pilani. He has also worked as Dean of Student Welfare Division and Dean of Educational Hardware Division, BITS Pilani during his tenure at BITS. He has taught seventeen courses and guided six Ph.D. students. At present one Ph.D. student is doing research under his supervision. His research interests are Econometric Methods, Health Economics and Policy, Microeconomic Analysis, Financial Economics, Financial Markets and Financial Engineering. He is a lifetime member of Indian Economic Association, The Indian Econometric Society, Indian Society of Labor Economics and Association of Management Scholars International. He has more than fifty five research papers published in national and international journals of repute and has attended more than twenty five national and international conferences. He has also served as Guest Editor for the renowned journal Elsevier and Elsevier- Procedia, for conference proceedings. He has also been appointed as "Country Expert" by World Intellectual Property Organization (WIPO), Japan and represented India on Multi-Country WIPO-UNU joint major research project on "Impact of Intellectual Property System on Economics Growth" and has addressed the UN University, Japan in May 15th 2007.

Biography of the Candidate

Varun Chotia is presently a Research Scholar, pursuing his PhD in the Department of Economics and Finance at Birla Institute of Technology and Science, BITS Pilani, Pilani Campus. His PhD thesis is entitled "Public Infrastructure Investment, Economic Growth and Fiscal Sustainability in India: An Empirical Analysis". He has received a First class Master's degree in Economics (Msc. Hons Economics) from BITS Pilani in 2011. Before coming into research and academics, he has almost two years of industry experience working as a business analyst in corporate firms like IMS Health and Accenture Management Consulting. His principal research interests lie in the field of Public infrastructure investment and its impact upon the economic growth of Indian economy taking into account the issue of fiscal sustainability. He is very much active in research and has authored a number of research papers in international and national journals. His other research interests include Public Finance, Applied Econometrics, Public Economics, Development Economics and Macroeconomics etc.