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INFRASTRUCTURE DEVELOPMENT AND SPILLOVERS IN THE INDIAN ECONOMY

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Abstract

Being one of the fastest growing economies, India has not only withstood the recent crisis and recovered fast, but also has emerged with brighter prospects amidst the global uncertainties. The growth in Indian economy has been fueled predominantly by the service sector. With recent initiatives by the Government, the manufacturing sector is expected to play a vital role in the growth story of India in coming years. One of the impediments for industrial growth in India has been considered to be lack of world-class infrastructure. To maintain high growth and take other diversified stakeholders of an emerging economy like India, it is indispensable to invest more for infrastructure development. In this paper, we have created a physical infrastructure index for the economy, to track the infrastructure status and pace of improvement in the infrastructure. We analyze whether infrastructure has a role in increasing GDP and manufacturing sector output, using data for the period 1981-2011. Using Vector Error Correction Model (VECM), we delineate that infrastructure has both long term and short term positive impacts on output of Indian economy. On the other hand, infrastructure has no short run impact on manufacturing output but has a significant long term positive impact on manufacturing output. This affirms that infrastructure plays significant role in stimulating growth in the economy.

Keywords: Infrastructure Index, Physical Infrastructure Backward and Forward Linkages, Growth.

1. Introduction

"We need to stop thinking about infrastructure as an economic stimulant and start thinking about it as a strategy. Economic stimulants produce bridges to nowhere and strategic investment in infrastructure produces a foundation for long-term growth."

- Roger McNamee

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Infrastructure development, both economic and social, is one of the crucial elements for economic growth. Infrastructure may affect aggregate output primarily in two ways, if analyzed from a production function angle: first, directly, as infrastructure services enter production as an additional input. Second, they raise total factor productivity of other factors of production.(See the production function below).

$$Y = A\,(K_{PUB})\ f\,(K; L; K_{PUB})$$

Where Y is output, K is private capital, L is labour, A is TFP and K_{PUB} is public capital.

The models which use infrastructure in the production function are primarily of two categories. Barro (1990) model considers infrastructure in the context of simple AK endogenous growth model. This model shows that the decision to invest in public infrastructure has two opposing effects: a positive one where an increase in productive government spending increases the marginal product of private capital and thus generates sustained per capita growth; and a negative one, where an increase in financing of public infrastructure by taxing income reduces per capita growth. Here, infrastructure is treated as a flow variable. Futagami et al. (1993) expound public infrastructure as accumulated capital, rather than as current flows, and thereby represents infrastructure as a stock variable in the aggregate production function.

Understanding of the role of productive public expenditure has to be broader than the traditional Keynesian view, where the expenditure adds to the aggregate demand thus increasing the output of the economy. Productive public spending including that on infrastructure directly adds to the demand and more importantly is a factor that improves productive performance and stimulates private sector investment. Public investment contributes to the growth by adding to the demand side, and furthermore by reinforcing the supply side of the economy. Dearth of adequate infrastructure acts as a constraint on the productive capacities of the economy.

Hirschman in his famous “Theory of Unbalanced growth” asserts that developing or underdeveloped economy has insufficient endowment of resources as to enable it to invest simultaneously in all sectors of the economy in order to achieve balanced growth. Hirschman maintains that investments in strategically selected industries or sectors of the economy will lead to new investment opportunities and so pave way for further economic development. Infrastructure is highly interconnected with other segments of the economy, through creation of production facilities and triggering economic activities or by reducing transaction costs and trade costs by improving competitiveness. This strongly asserts that investment in infrastructure leads to the improvement to the overall economy.

IMF in its World Economic Outlook (October 2014)[1], noted that increase in public infrastructure investment, if effectively implemented, affects the economy in both ways as mentioned above. Econometric exercises reported by the IMF confirm that increase in public investment can have positive effects on output. The medium term public investment multiplier for developing economies is estimated to be between 0.5 and 0.9, slightly lower the estimated multiplier for advanced economies. However, the magnitudes depend on the efficiency of implementation as well.[2]IMF has pointed out that there is a possibility that both emerging and advanced economies face downward trend in potential growth rate (World Economic Outlook of April 2015[3]). There is a need for higher infrastructure spending to remove critical logjams, and structural reforms must be directed at business conditions to increase the growth rate and potential growth rate of the emerging economies.

Infrastructure is an area which has been in focus in recent time as well. In the budget 2015-16, Indian government has announced Rs 70,000 crore for infrastructure development. There has been increase in the outlay for roads sector and increase in gross budgetary support for railways.[4] Compared to China, the investment in infrastructure is meager in India. However there seems to be an effort to increase the public spending in infrastructure in order to remove the structural bottlenecks of the economy. The analysis focuses on infrastructure improvement as most crucial to push up the growth rate and the even the potential growth in emerging market economies.

The existing literature available on this subject is largely unambiguous for the idea of infrastructure development contributing positively to growth. This paper adds to the existing literature primarily by creating a physical infrastructure index for India which is not available and secondly by analyzing the role of infrastructure in short term and long term growth of the country's economy. This analysis is crucial to take the decision whether and when to invest in infrastructure especially for developing economies which face shortage of funds. The paper specifically tries to address the question of impact of infrastructure development on manufacturing sector. In view of this, the objective of the paper is two-fold: - first, To find an infrastructure index (physical infrastructure) for India and Second, To check how big the contribution of infrastructure has been in aggregate performance of the economy, specifically in manufacturing sector.

[1] IMF, "Is it Time for an Infrastructure Push? The Macroeconomic Effects of Public Investment", World Economic Outlook, Chapter 3, October 2014.
[2] Economic Survey 2014-15
[3] IMF World Economic Outlook April 2015
[4] Budget 2015-16

The following is the scheme of the paper Section 2 is brief description of the literature on the subject, Section 3 discusses the state of physical infrastructure in India and section 4 explains the coverage of infrastructure sector. In Section 5, the methodology and the data sources used are discussed. Section 6 contains the empirical results of the exercise and Section 7 gives the forward and backward linkages of the infrastructure sector. Section 8 concludes the paper.

2. Review of Literature

Several studies have been under taken examine the impact of infrastructure on various indicators of economy, using various methodologies. Many studies found a constructive relationship between the level of economic development (measured by per capita income or other indicators), and indicators like quality of housing, access to basic amenities like electricity, safe drinking water, toilets etc. (Human Development Report of India 2011). Some papers elucidated this by evaluating impact of telecommunications infrastructure on economic development (Roller and Waverman (2001)) or analyzing the productivity effects of changes in road infrastructure (e.g. Fernald (1999)). Others followed the approach of a comprehensive index of infrastructure (e.g. Sahoo et al (2010)) and using the index to find bearing on other variables. Although growth-enhancing impact of public capital may be different across studies, there is consensus that public capital promotes economic growth.

Aschauer (1989) in his landmark paper indicated that the stock of public infrastructure capital is indeed a significant determinant of total factor productivity growth. The research based on US data found out that decline in U.S. productivity that occurred in the 1970s was precipitated by declining rates of public capital investment. Munnell (1990 and1992) on analysis in national and sub national level, found that public capital has a positive impact on several measures of state-level economic activity: output, investment, and employment growth.

Agenor and Moreno-Dodson (2006) consider labour productivity as another channel whereby public infrastructure indirectly increases growth. Better access to infrastructural facilities aids workers to get to their jobs more easily and perform their job-related tasks more efficiently. The seminal papers of Romer (1986, 1990), Lucas (1988) and Barro (1990) have conceived the emergence of an entire class of endogenous growth models that seek to explicitly categorize human capital accumulation and infrastructure as two main components of the aggregate production function. Canning (1999)[5]explains that even though infrastructure has productivity enhancing effects, it is difficult to quantify even private productivity of infrastructure, as infrastructure services are often provided by the public sector and are mostly not priced at all or priced at lower rates.

Canning and Pedroni (2004) tested the consequences of provision of infrastructure on long term growth for many countries and found that in majority of cases infrastructure does induce long run growth effects. Esfahani (2002) using cross-country data found that the contribution of infrastructure services to GDP is indeed considerable and in general exceeds the cost of provision of those services.[6]

In case of China, there are studies to assess the role infrastructure has played in its growth story. In a study by Sahoo et al. (2006), the role of infrastructure in promoting economic growth in China after controlling other important variables such as investment (both private and public), labour force, and human capital, is analyzed using Auto Regressive Distributed Lag techniques for the period 1975 to 2007. It is found that infrastructure played an important role in promoting economic growth. Further, the causality analysis shows that there is unidirectional causality from infrastructure development to output growth. Chatterjee (2005) and Stephane et al. (2007) in their research found that China's sustained high economic growth and increased competitiveness has been supported by a massive growth of physical infrastructure. Sahoo (2006) points out that infrastructure development is one of the major determinants of FDI inflows.

In the context of India, Patra and Acharya (2011) examine the spatial disparities in infrastructural facilities across 16 major states and their impact on economic growth in them. The paper suggests that there is a positive relationship between Infrastructure Development Index & Per Capita Net State Domestic Product and negative relationship between Infrastructure Development Index and poverty. Bhatia (1999) constructed an index of rural infrastructure and his found that infrastructure significantly influences the per hectare yield of food grains in the state.

Mitra et al. in paper "Estimating impact of infrastructure on productivity and efficiency of Indian manufacturing" depicted that core infrastructure availability mattered in determining Total Factor Productivity (TFP) and Technical Efficiency (TE) of the

5 Infrastructure's Contribution Of the major kinds of physical infrastructure, electricity to Aggregate Output , accessible at

http://www.wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2000/01/06/000094946_99122006330269/Rendered/PDF/multi_page.pdf

6Institutions, infrastructure, and economic growth, Journal of Development Economics (2003) sectors. The results suggest that the impact is rather strong on both TFP and TE (with an elasticity of 0.32 and 0.17, respectively). This finding is of particular importance in India, which is characterized by infrastructure bottlenecks, at the same time strongly supports the view that lack of infrastructure can hamper growth.[7]

Rodrik and Subramanian (2005)[8] while analyzing India's productivity surge around 1980, recognized a productivity boosting role of public infrastructure investments (in contrast to the demand creating effects). Their results indicate that allowing the appropriate lag between public infrastructure spending and growth, the former can explain around 1.5-2.9 percent of overall growth, pointing to the significance of infrastructure in India's growth trajectory.

There is a class of literature which points towards the possibility of two way causality between infrastructure development and economic growth of an economy. While infrastructure is expected to improve productivity and output, economic growth can also increase the demand of infrastructure services, which is likely to cause an upward bias in the estimated returns to infrastructure if problem of endogeneity is not addressed. Sahoo et al. (2010) found that there is a one-way causality link from infrastructure stocks to growth and two-way causality link from infrastructure stocks to public-private sector investments. Wolassa (2012) depicted the presence of steady-state long-run equilibrium relationship between infrastructure and economic development and that there is a strong causality between economic infrastructure investment and GDP growth. Wolassa shows that the causality is mutual, implying that economic infrastructure investment drives the long term economic growth in South Africa while improved growth feeds back into more public infrastructure investments.

3. State of Infrastructure in India

The literature on infrastructure status in India is unanimous that there is huge deficit of infrastructure in the country. On one hand, we are the fastest growing economy in the world and on the other hand, there are areas in the country which are untouched by rail or road or have no access to electricity. There are studies demonstrating the lack of infrastructure development as a major roadblock in India emerging as a manufacturing hub. Nataraj (2014) in her book says, "Estimates suggest that this lack of adequate infrastructure reduces India's GDP growth by 1-2 per cent every year". She further states that the fast growth of the Indian economy in recent years has placed increasing stress on physical infrastructure, such as electricity, railways, roads, ports, airports, irrigation,

7Estimating impact of infrastructure on productivity and efficiency of Indian manufacturing, Applied Economics Letters, 19:8, 779-783

[8]Rodrik, D. & A. Subramanian, "From "Hindu Growth" to Productivity Surge: The Mystery of the Indian Growth Transition" 2005, IMF Staff Papers, 52(2)

water supply, and sanitation systems, all of which already suffer from a substantial deficit.

Global Competitiveness Index (GCI) Report[9] annually published by World Economic Forum since 2005 defines 12 aspects in which they recognize "Infrastructure" as a pillar of competitiveness. They have categorized the pillars in 3 parts – (a) Basic requirements sub index, (b) Efficiency enhancer sub index, (c) innovation and sophistication factors sub index - and it is conspicuous that "infrastructure is a part of basic requirements". The weight attached to different pillars varies for different set of countries. For developing or less developed countries (with per capita GDP < $2000) which are still at factor driven stage of growth, the basic requirements are assigned a weight of 60%, thus pointing to the compelling role infrastructure plays in fulfilling the basic requirements of competitiveness for developing nations.

Prabir (2008)[10] differentiates between the hard infrastructure (like road, rail, power) and soft infrastructure (like telecom, air services, port services) and finds that from 1990-2005, soft infrastructure has grown at a faster pace while the growth of hard infrastructure has been comparatively slower.

GCI 2010-11 reports that India ranks below all other BRICS countries and even countries like Cambodia, Indonesia, and Sri Lanka in terms of competitiveness[11]. According to GCIR report 2014-15, India is at 71st position out of 144 countries and is still the lowest ranked among BRICS countries.[12] Within the infrastructure category, its position varies from being one of the worst performing countries in mobile subscription to being a better performer in the airline sector. India has been ranked lowest in the 12 pillars in technological readiness (121st). Despite mobile telephony being quite pervasive, India is one of the least digitally connected countries in the world. Only 15 percent of Indians access the Internet on a regular basis and broadband Internet is a privilege of few. Transport and electricity infrastructure require upgrading (87th rank). The table below shows that India is at 90th position in terms of infrastructure ("infrastructure" covers all modes of transportation, as well as telecommunication, sanitation, and irrigation infrastructures), even lower than the overall competitiveness rank, hence demonstrating the urgency for development of infrastructure in India.

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[9] Accessed at www.weforum.org/gcr

[10] De, P. (2008), 'Infrastructure Development in India', in Kumar, N. (ed.), International Infrastructure Development in East Asia – Towards Balanced Regional Development and Integration, ERIA Research Project Report 2007-2, Chiba: IDE-JETRO, pp.105-130.

[11] The Global Competitiveness Report 2010-11: World Economic Forum

[12] http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2014-15.pdf

In 2005, India had a score of 3.50 for infrastructure and was ranked 62 out of 125 countries and till 2014-15, the score of infrastructure has increased only to 3.7 which are lower than BRICS and many neighboring countries.

Table 1: Infrastructure Status of India (GCI 2014-15 Report)

Indicator	Value	Rank
Quality of overall infrastructure	3.7	90
Quality of roads	3.8	76
Quality of railroad infrastructure	4.2	27
Quality of port infrastructure	4.0	76
Quality of air transport infrastructure	4.3	71
Available airline seat km/week, millions*	3448	12
Quality of electricity supply	3.4	103
Mobile telephone subscriptions/100 pop.*	70.8	121
Fixed telephone lines/100 pop.*	2.3	118
Source: Global Competitiveness Report 2014-15 *Note: Values are on a 1-to-7 scale unless otherwise annotated with an asterisk (*)*		

4. What Comprises Infrastructure?

Of the varied definitions 'infrastructure' provides, the standard definition as per Oxford dictionary is, "The basic physical and organizational structures and facilities (e.g. buildings, roads, and power supply) needed for the operation of a society or enterprise". In India different institutions have used their own definitions of infrastructure. In order to remove the ambiguity, this paper has adopted the 'harmonious definition of infrastructure' (given by the committee set up by the government to find a uniform definition of infrastructure), which broadly includes the following sectors: Transport, Energy, Water Sanitation, Communication and Social and commercial infrastructure

along with a detailed list of sub-sectors.[13]

Infrastructure comprises of both physical and social infrastructures. However, in this paper only the notion of physical infrastructure has been considered and a Physical infrastructure index has been formulated based on the harmonious definition of infrastructure. The sectors used to create this index include Electricity, Transport

[13] http://pib.nic.in/newsite/erelease.aspx?relid=80634

Services including railway, air and road, and Communication.[14] The output from these sectors could be used to construct the index. While capturing the availability of output of these sectors in the economy, the problem encountered is that in addition to the infrastructure component, the output (approximately indicated by Gross Value Added (GVA) of the sectors) will include the compensation of employees and other expenditure. Therefore appropriate physical indicators that reflect the infrastructure sectors may be used. Also, there is an argument saying that net capital stock is the key determinant of productivity, and investment flows do not provide any information on the share of investment required to replace depreciating capital stock. [15] This is why investment in these sectors may not be an appropriate measure to capture the impact.

These physical indicators are used to capture the above mentioned infrastructure categories and are then used to construct the physical infrastructure index using appropriate methodology.

5. Methodology and Data Sources

Empirical studies exploring the relationship between growth and infrastructure have faced the challenge of defining the term infrastructure concretely. Different studies have used varied definitions/approach like harmonious definition, World Bank definition, indicators of physical/social infrastructure etc. In this paper, we use PCA technique to construct the infrastructure index using the ten physical indicators mentioned above. **PCA** is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called **principal components**. This transformation is defined in such a way that the first principal component has the largest possible variance (that is, accounts for as much of the variability in the data as possible).[16] This is also used as a data reduction technique, as it estimates the variance explained by different variables. The variable 'factor loadings' (also called as component loadings in case of principal component analysis) calculated from the principal component analysis is used to assign weights to the different sectors to combine these individual sectors to form an index.

Data collected for all the infrastructure indices is from 1981-2011. The reason for using this time period is that data for all physical indicators is available only from 1980's -2011.

[14]The detailed set of indicators included to construct the Physical infrastructure index is given in Appendix.

[15]**Serkan Arslanalp** , **Fabian Bornhorst** , **Sanjeev Gupta** Investing in Growth , Finance & Development, March 2011, Vol. 48, No. 1: (http://www.imf.org/external/pubs/ft/fandd/2011/03/arslanalp.htm)

[16]http://support.sas.com/publishing/pubcat/chaps/55129.pdf

Infrastructure Index = factor loading of infrastructure category 1 * (Infrastructure category 1) + factor loading of infrastructure category 2 (Infrastructure category 2) + ………. + factor loading of infrastructure category n * (Infrastructure category n)

Before estimating the econometric model, it is important to investigate time series properties of each individual series .The first is to investigate the unit root(using Augmented Dickey-Fuller unit-root test) for the infrastructure index, GDP, Manufacturing GVA and the expenditure on health and education (as a control variable in the analysis). Once the order of integration (stationarity of the series) has been determined, the possibility of long run relationship within the variable of interest is also examined. The Johansen Maximum Likelihood approach is subsequently used to test the presence of Co-integration in a Vector Error Correction Model (VECM). Trace statistics and maximal Eigen values are used to check the number of co-integrating vectors.

After the study of long run relationship, the dynamics of the relationship has been examined using VECM. VECM model has proven to be useful for describing the dynamic behavior of economic time series. Given the issue of endogeneity and causality in time series data, using VECM can be highly advantageous. The VECM specifications force the long run behavior of the endogenous variables to converge to their co integrated relationships, which accommodates short run dynamics. However, there is a need to use other control variables as well. To assess the impact on GDP, other variable i.e. Government expenditure on health and education is used as control variable as it contributes to the human capital and hence affect the per capita income as well. Further, to assess the short run impact of infrastructure and expenditure on health and education, Wald Test is used. The Wald Test approximates the Likelihood Ratio (LR) Test, but with the advantage that it only requires the estimation of one model. It tests how far the estimated parameters are from zero (or any other value hypothesized under null) in standard errors (Fox) (1997). This test works by testing the null hypothesis that a set of parameter is equal to some value. If the test fails to reject the null hypothesis at a chosen level of significance, it can be concluded that there is no short impact, and the contrary if null hypothesis is rejected.

CUSUM Stability Test is also used to check for stability of error correction model. This test applied on residuals indicates that the model is stable, by creating parameter bound at a given level of significance and the plot in the graph being within the bound points towards the stability of the model. This method is used to test whether the infrastructure has had a significant impact on GDP of India and specifically for manufacturing sector. Apart from this, in order to assess the impact of other sectors and overall economy in general, Input-Output matrix has been used. Forward and backward linkages are calculated from input-output tables that capture the tangible effects of investment in infrastructure and show the interconnectedness of the sector with rest of the economy. The absorption matrix portrays the direct use of a commodity/industry by other industries to produce other services/commodities. However, the Leontief matrix gives usage of the commodity directly or indirectly by other industries. The Leontief matrix is used to find out the output multiplier, i.e. backward linkage of the infrastructure sector which depicts worth of additional inputs demanded from other sectors for the production of an additional unit of value of infrastructure services. It is also used to find the forward multiplier showing the amount of infrastructure used by other sectors.

GDP = f (Infrastructure Index, Health and education expenditure by Government)

Manufacturing GVA = f (Infrastructure Index)

The data for GVA for various sectors, Public Investment, Private investment in various sectors, Input output table is taken from Ministry of Statistics and Programme Implementation. World Development Indicators database of World Bank is used to get data on all physical indicators, GDP per capita, population. The Statistical Year Book and India Stat database is used to get the data on road length.

6. Results

The data collected on these 10 infrastructure indicators show varied growth rates in this time period. As the table below shows, the categories of hard infrastructure namely electricity availability, rail transport, road transport grew at relatively lower rate than the soft infrastructure such as internet services and mobile subscription.

Table 2: Average Annual Growth Rate for different infrastructure categories

S.No.	Infrastructure Category	Average Annual Growth Rate	Time period
1	Electric power consumption (Kwh per capita)	5.2%	1981-2011
2	Rail lines (per lakh persons)	-1.6%	1981-2011
3	Railways, goods transported (million ton-km)	4.4%	1981-2011
4	Railways, passengers carried (million passenger-km)	5.2%	1981-2011
5	Telephone lines (per 100 people)	7.4%	1981-2013
6	Air transport, freight (per lakh people)	3.6%	1981-2013
7	Air Transport, passengers(per 1000 people)	6.4%	1981-2013
8	Road (km per 1000 people)	0.9%	1981-2008
9	Internet users (per 100 people)	46.0%	1997-2013
10	Mobile cellular subscriptions (per 100 people)	59.9%	1997-2013

The infrastructure index that has been calculated shows that the infrastructure has grownover the years. The complete list of infrastructure index is shown in the appendix (Appendix A2). As reported in Table 3, all variables are non-stationary at level form but stationary at first difference (based on results of Augmented Dickey-Fuller Unit roots test).

Table 3: Stationarity results of the variables

Variable	Stationarity Status
GDP per capita	I(1) at 5% level of significance
Manufacturing GVA	I(1) at 5% level of significance
Infrastructure Index	I(1) at 10% level of significance
Expenditure on health and education per capita	I(1) at 5% level of significance

The variables are used in log form, as it gives the growth rate of a variable with respect to another, which serves as a better measure to find out the impact of infrastructure on output. The equation used for finding out the impact of infrastructure on GDP is the following:

$$\text{Log (GDP per capita)} = \alpha + \beta *(\text{Log (Infrastructure Index)}) + \gamma * (\text{Expenditure on health and Education per capita})$$

As the variables are all I(1), using Johansen Co-integration Test shows that there is 1 co-integrating equation at 5% level of significance, pointing towards the possibility of long term relation between the variables. The coefficient of infrastructure of the co-integration equation has a positive sign which is significant, showing a long run association of per capita income to infrastructure. The Co-integration equation shows:

$$\text{Log (GDP per capita (-1))} = 6.724 + 4.506 *(\text{Log (Infrastructure Index (-1))}) - 0.870 * (\text{Log (Expenditure on health and Education per capita (-1))})$$

1% improvement in Infrastructure Index results in 4.5% increase in per capita GDP in the long run, exhibiting the proportion of long term benefits of investment in infrastructure on the economy. To find the Co-integration relationship in short term between these 2 variables i.e. presence of long run relationship between Infrastructure and GDP per capita, VECM model is used. The detailed results are shown in Table 4:

Table 4: VECM results

Error Correction	D(LOGINCOME)
CointEq1	-0.077035
	[-3.62590]
D(LOGINCOME(-1))	0.074335
	[0.44529]
D(LOGINCOME(-2))	-0.187184
	[-1.04166]
D(LOGINFRA(-1))	0.444957
	[2.98993]
D(LOGINFRA(-2))	-0.023589
	[-0.13790]
D(LOGSOCIAL(-1))	0.118408
	[1.53478]
D(LOGSOCIAL(-2))	-0.146155
	[-2.12968]
C	0.104934
	[4.68510]
NOTE: The figures in [ ] indicate t values	

The coefficient of the Δ Log (Infrastructure Index (-1)) and the constant are statistically significant, showing the short term impact of Infrastructure Index on per capita income. It shows that infrastructure improvement has positive impact on output with lag of a year. Results also show that in short run public expenditure on health and education have negative and statistically significant impact with lag of two years. The negative and crucial coefficient of the 'co-integrating equation 1' in the VECM result establishes the stable long run equilibrium of the variables of interest (Table 4).

Further using the WALD test, which is used to test the true value of the parameter based on the sample estimate, it is established that the coefficients of Infrastructure Index and Expenditure on education and health are significantly different from zero (Table 5). Further, CUSUM test manifests the stability of the model as the diagram of the equation remains within 5% bounds (See in Appendix).

Table 5: Wald Test Statistic

D(LNGDP) = C(1)* (LNGDP(-1) - 4.50 *LNINFRA(-1) + 0.87*LNSOCIAL(-1) + 6.724) + C(2)*D(LNGDP(-1)) + C(3)*D(LNGDP(-2)) + C(4)*D(LNINFRA(-1)) +C(5)*D(LNINFRA(-2)) + C(6)*D(LNSOCIAL(-1)) + C(7)*D(LNSOCIAL(-2)) + C(8)		
Test Statistic	Value	Probability
Null Hypothesis: C(4)=C(5)=0		
Chi-square	9.916673	0.0070
Null Hypothesis: C(6)=C(7)=0		
Chi-square	6.179972	0.0455
Null Hypothesis: C(4)=C(5)=C(6)=C(7)=0		
Chi-square	17.46337	0.0016

To determine the relationship of manufacturing GVA with the infrastructure, similar analysis is carried out without any control variable. The equation used for analysis is:

$$\text{Log (Manufacturing GVA)} = \mu + \lambda * (\text{Log (Infrastructure Index)})$$

The Johansen Co-integration test shows that there is a co-integrating relationship between manufacturing GVA and infrastructure.

$$\text{Log (Manufacturing GVA (-1))} = 0.5392 + 2.653 * (\text{Log (Infrastructure Index (-1))})$$

The coefficient from the co-integration equation shows that 1% change in Infrastructure Index leads to 2.65% increase in GVA of Manufacturing. However, VECM and further tests show that in the short run, infrastructure has a positive but negligible impact on manufacturing output. This could the outcome of the time taken by manufacturing to benefit from improved infrastructure due to various reasons like lag in taking decisions for higher investment in manufacturing etc. It can be concluded that although infrastructure in the short run has no statistically significant impact on manufacturing sectors' output, in the long run it does have an imperative positive influence to push up the GVA of manufacturing sector. VECM results for the same are summarized in Table 6 and Wald Test results verify the statistical significance of short run results and that is represented in Table 7.

Table 6: VECM Result

Error Correction	D(LOGMANU)
CointEq1	-0.106342
	[-1.85706]
D(LOGMANU(-1))	0.408297
	[2.16917]
D(LOGMANU(-2))	-0.247703
	[-1.38642]
D(LOGINFRA(-1))	0.619937
	[1.82286]
D(LOGINFRA(-2))	-0.307286
	[-0.81769]
C	0.089710
	[3.34721]
Note: The values in [ ] indicate t values	

Table7: Wald Test Result

D(LOGMANU) = C(1)*(LOGMANU(-1) - 2.65*LOGINFRA(-1) + 0.53) + C(2)*D(LOGMANU(-1)) + C(3)*D(LOGMANU(-2)) + C(4)*D(LOGINFRA(-1)) + C(5)*D(LOGINFRA(-2)) + C(6)		
Null Hypothesis: C(4)=C(5)=0		
Test Statistic	Value	Probability
Chi-square	3.333116	0.1889

7. Backward and Forward Linkages of the Inftrastructure Sectors

Hirschman in his 'Theory of Unbalanced Growth' introduced the concept of backward and forward linkages. A forward linkage is created when investment in a particular project encourages investment in other sectors which are associated with subsequent stages of production. A backward linkage is created when a project encourages investment in facilities that enable the project to succeed, i.e. the industries from where the industry sources its factor of production from. Normally, all sectors are interrelated to others, though by varying degrees, and hence have both backward and forward linkages. The input output matrix helps in finding the linkages of sector with rest of the economy. The absorption matrix shows the direct linkages of the sectors, i.e. the way the output of one sector is used by other sectors for production as an intermediate consumption and also as final product by consumers. So, there may be certain sectors in which products are used more for final consumption than in other industries whose products turn inputs. The former kind of industries or sectors will have lower level of connectedness with other industries and hence push for production in these sectors may not be accompanied by significant increased activity in other sectors. For instance, agricultural commodities serve mostly as final products than for intermediate use when compared to steel industries which have high potential of use for inputs like coal, iron ore and could initiate further production in various industries. However the Leontief matrix shows the complete linkages (indirect as well as direct) between the sectors. This matrix shows the use of output of any sector in all other sectors in economy directly or indirectly via any other sector which has used that particular output. The multipliers calculated from Leontief Matrix will be used further for years 1993-94; 1998-99, 2003-04, and 2007-08 (input output tables are available for these years with latest for 2007-08). Benefit of using this input output analysis is that it can assess the tangible impact of infrastructure separately in the role of input to other sectors and to production as a whole.

The backward linkage of a sector is shown by the column sum of the Leontief inverse matrix, which shows the direct and indirect requirements of the inputs (from all other sectors) for the production of 1 unit worth of output in each particular sector. The row sum of the respective sectors shows the amount of output of these sectors being used by other sectors in production of 1 unit worth of their respective outputs.

The infrastructure sectors have high forward and backward linkages with rest of the sectors of the economy. The backward linkages show the dependency of the sector on others which are used as an input in the production in that sector. High backward linkages imply that the increase in production in Infrastructure sector will subsequently increase the demand for inputs thus escalate the output in those linked industries. Similarly, high forward linkages imply the output being used in various other sectors, and the demand facilitates production. High forward linkages are consistent with the general understanding that well developed infrastructure is crucial for all sectors including manufacturing, various services etc.

The infrastructure sectors which are used here to construct the infrastructure index are namely Electricity, water supply, Railway, Other transport, Communication. Different physical infrastructures have been used for them. The backward and forward linkages using the Leontief matrix are shown in the table below:

Table 8: Backward Linkages of infrastructure sectors

Sector	1993-94	1998-99	2003-04	2007-08
Electricity	2.2	2.3	2.3	4.6
Water supply	1.6	1.7	2.6	1.3
Railway transport services	1.9	2.1	2.2	3.3
Transport by other means	2.0	2.1	6.2	18.8[17]
Communication	1.3	1.3	1.5	2.4

[17]This needed to be interpreted separately. Change in classification over years. This includes transport by pipelines also which was started recently.

Table 8 shows the linkages of various infrastructure categories with rest of the economy. It is seen that all have multiplier greater than 1 in all the years, validating that pushing the investment in infrastructure sector by 1 rupee will expand the output of other sectors by more than a rupee. In most categories, the backward multiplier also called as output multiplier shows an increase over the years.

Table 9: Forward Linkages of infrastructure sectors

Sector	1993-94	1998-99	2003-04	2007-08
Electricity	10.0	11.3	9.0	3.1
Water Supply	1.2	1.2	1.2	1.5
Railway transport services	3.4	3.3	3.4	2.4
Other transport	9.2	7.1	10.9	6.4
Communication	2.2	2.1	3.7	2.3

The forward linkages of the infrastructure are requisite to understand the implication of dependence of sectors such as manufacturing on infrastructure. However the decreasing number for certain categories over years may be due to poor infrastructure status of the country or corollary to the fact that the infrastructure sector has not kept up with the demands of economy. The high linkages of the infrastructure sectors add to the rationale of investing in the infrastructure sectors as it will have multiplier effect on the economy.

8. Conclusion

In the recent wake of focus towards making India a manufacturing hub and increasing the contribution of this sector in the Gross Domestic Product of economy with the help of various measures like the ‘Make in India’ initiative, the lack of “Infrastructure” has been highlighted as a hurdle, and has become a focus sector for the growth leap. The budget 2015-16 and recent measures of the government have promised higher investment for infrastructure development, aiming at tackling the bottlenecks in the sector.

The paper attempted to compute an infrastructure index, considering the time period from 1980 to the recent years. The index demonstrates that there has been an improvement in physical infrastructure over these years. The value of index (increased from 50 to 265) shows increasing trend, testifying the improvement of infrastructure over the years. It is evident that there is significant impact of infrastructure on GDP of the country in the long run and in short run as well; proving that adding to infrastructure can help boost the productive capacity of the economy the GDP via various channels. The analysis shows that infrastructure improvement has contributed to the surge in the economy. This is consistent with the common theory that infrastructure is a major contributor to growth.

Further, it is seen from the results that manufacturing sector Gross Value Added is affected positively by the improvement in the infrastructure in the long run, though not very significantly in the short run. This is not surprising as infrastructure encourages productive capacity of other factors of production and is a major input in manufacturing sector. The effect is not clearly visible in the short run due to factors like the time taken in decisions to invest in manufacture etc. The extensive interconnectedness of infrastructure sectors with the rest of the economy via huge backward and forward linkages captures the tangible impact of producing more infrastructures in the economy.

However, the analysis has certain shortcomings. One major issue is problem of heterogeneity. The contribution of output by infrastructure sectors may vary across the country and time periods depending on many factors – starting with the heterogeneous quality of infrastructure assets themselves, network concerns that create nonlinearities, institutional factors that constrain the efficient use of infrastructure assets etc - all of which could not be captured in this analysis. Second, the marginal productivity of infrastructure may vary at different levels of availability, being high at lower level of infrastructure and decreasing over time, is unaccounted for in this analysis[18]. But considering that India is still at a much lower level of infrastructure development, this should not affect the results.

The analysis shows the grim picture of the availability of infrastructure and compares how we fare globally. Hence there is an urgent need for the policy to take this into account and invest in infrastructure development. India is one of the fastest growing major economy in recent years[19] and in order to continue the momentum and attract further investment, there is a need to improve the infrastructure availability. This is also required on urgent basis to improve India's position as a favored investment destination. Another important aspect that the study highlights is that the infrastructure development must be done in strategic manner, taking in to account the backward and forward linkages of the specific sectors. Sectors with high linkages can help in development of many other sectors. Also, in the long run high economic growth cannot be sustained without proper provision of infrastructure.

The paper thus shows how improvement in infrastructure can lead to commendable positive spillovers in the nation, which helps make the case for infrastructure improvement strongly in India.

[18] http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:22629797~pagePK:64165401~piPK:64165026~theSitePK:469382~isCURL:Y,00.html

[19] IMF world Economic Outlook (April 2016)

Appendix

A1. Principal Component Analysis Result (From STATA)

S. No.	Variable	Factor Loadings
1	Air Transport, freight(million ton-km per lakh people)	0.1174
2	Road (kilometers per 1000 people)	0.3096
3	Air Transport, passengers carried (per 1000 people)	0.3128
4	Electric Power Consumption (KwH per capita)	0.3491
5	Rail lines (total route-km per lakh population)	-0.3491
6	Railway, goods transported(million ton-km per 100 people)	0.3398
7	Railway, passenger carried (million passenger-km per 100 people)	0.3471
8	Telephone lines (per 100 people)	0.321
9	Internet users(per 100 people)	0.3549
10	Mobile cellular subscriptions (per 100 people)	0.2895

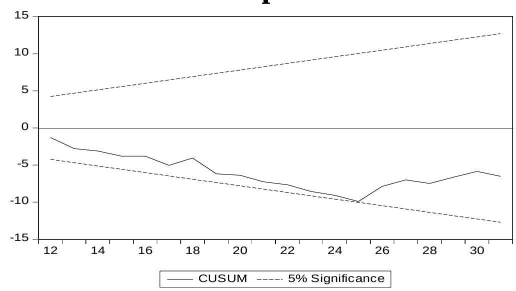
A2. Cointegration and Vector Error Correction Method result for impact on output

Cointegrating Equation	
LOGINCOME(-1)	1.000000
LOGINFRA(-1)	-4.506448 [-5.22877]
LOGSOCIAL(-1)	0.870071 [2.39848]
C	6.724843

Error Correction Results	
CointEq1	-0.077035 [-3.62590]
D(LOGINCOME(-1))	0.074335 [0.44529]
D(LOGINCOME(-2))	-0.187184 [-1.04166]
D(LOGINFRA(-1))	0.444957 [2.98993]
D(LOGINFRA(-2))	-0.023589 [-0.13790]
LOGSOCIAL(-1)	0.118408 [1.53478]
D(LOGSOCIAL(-2))	-0.146155 [-2.12968]
C	0.104934 [4.68510]
quared	0.759938
. R-squared	0.675917
ke information criterion	-13.32722
warz criterion	-12.04260

Note: t-statistics in [ ]

CUSUM Test Result for stability of results for impact of infrastructure on output



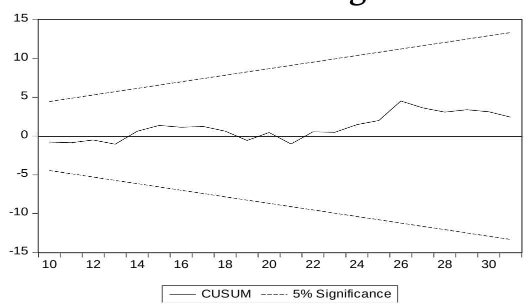
A4. Cointegration and VECM Result for impact on manufacturing GVA

Cointegrating Equation	
LOGMANU(-1)	1.000000
LOGINFRA(-1)	-2.653048 [-28.8925]
C	0.539273

Error Correction Results	
CointEq1	-0.106342 [-1.85706]
D(LOGMANU(-1))	0.408297 [2.16917]
D(LOGMANU(-2))	-0.247703 [-1.38642]
D(LOGINFRA(-1))	0.619937 [1.82286]
D(LOGINFRA(-2))	-0.307286 [-0.81769]
C	0.089710 [3.34721]
R-squared	0.437806
Adj. R-squared	0.310035
Akaike information criterion	-8.295530
Schwarz criterion	-7.629428

Note: t-statistics in [ ]

CUSUM Test Result for stability of results for impact of infrastructure on manufacturing GVA



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