Assessing the Impact of Public Infrastructure Investment on Economic Performance: the Case of India

Gaurav Aakar[1]
Vaibhav Agarwal[2]
Varun Chotia[3]

Abstract

The objective of this paper is to analyze the effects of Public Infrastructure Investment on the economic performance of the Indian economy. We have employed a Structural Vector Autoregressive (SVAR) approach for estimation of linear interdependencies of India's output. For this study, we have categorized four composite infrastructure sectors which encompass ten major sub sectors of infrastructure. The analysis emphasized that special focus should be paid on Infrastructure Investment in transport sub sector of infrastructure because of its maximum positive returns on output. The policy implications of the results will aid the government to counter the economic and budgetary dilemma.

Keywords: Public Infrastructure Investment, Structural Vector Autoregression (SVAR), Stationarity, Economic growth

JEL Classification: C32, E22, E62, H54, O47

1. Introduction

In the recent years, Infrastructure investment has been highly recognized as a means of achieving fast and sustained economic growth of a nation. The share of public infrastructure investment in the public capital investment has shown a noticeable surge over the past few decades. Therefore, investment in

[1] Undergraduate Student, Department of Economics and Finance, 6165, New Academic Block, Birla Institute of Technology and Science, Pilani, Rajasthan, f2013545@pilani.bits-pilani.ac.in

[2] Undergraduate Student, Department of Economics and Finance, 6165, New Academic Block, Birla Institute of Technology and Science, Pilani, Rajasthan, f2013751@pilani.bits-pilani.ac.in

[3] Assistant Professor, Economics LM Thapar School of Management, Thapar University Punjab, India, varun.chotia@thapar.edu

infrastructure plays a pivotal role in strengthening the economy. Due to this prominent effect of public infrastructure investment on the economic growth, this field of economics has evoked interests of researchers around the globe.

From the past decade, Public Infrastructure Investment has been looked as a key driver for the ever so growing economy of India. Academicians and policymakers have always been vocal in mentioning the importance of Infrastructure sector and have the view that Infrastructure sector is instrumental in spurring India's overall development by drawing attention of government in policy development and implementation that would ensure quick deployment of funds for creation of world class infrastructure. There are many areas pertaining to Infrastructure which are operating at capacity such as rail lines, ports, roads and airports, which point out the fact that the nation's growth depends further on its capacity to expand and absorb the benefits from the new technology and advancement in Infrastructure. Lately, there has been a shift in focus of government of policies from liberalization and expansion of service industry towards enhancing public and private investment in developing infrastructure. The notion substantiating this view says that for a developing nation like India to grow at its highest potential, the major policy focus should be on infrastructure development and related infrastructure investment. Motivated by this, this study makes an attempt to understand the varied effects of investment in different sectors of infrastructure on the Indian economy as a whole.

In this paper we have aimed to encapsulate the effects of Public Infrastructure Investment on the overall output of the Indian economy using the Structural Vector Autoregression (SVAR) Model. We have also attempted to provide answer for the question "Does all of the Public Infrastructure Investment have an equal impact on the growth of output in the context of Indian economy? And How Investment in different sectors of Infrastructure impacts the economic growth differently?"

Section 2 summarizes the Literature Review on this topic. Data and Methodology have been discussed in the Section 3. Section 4 illustrates the results of Empirical Analysis. The Conclusions and Policy Implications of the study are presented in Section 5 and Section 6 respectively. Finally, the Scope for Further Research is mentioned under Section 7 of the paper.

2. Literature Review

There have been early mentions of infrastructure in the studies of development economists such as Rosenstein-Rodan (1943), Lewis (1955), Hirschman (1958), Myrdal (1958), Hansen (1965), and many others, because of its huge impact on the aggregate economy. But over the past few decades, the studies of Aschauer (1989), Munnell (1990), Gramlich (1994) and others discussing the

role in enhancing regional economic performance, its provisioning and other aspects related to it, have been comprehensively conferred by distinguished academicians, renowned researchers, and other stakeholders.

In the late eighties, the argument regarding the impact of infrastructure investment on the economy was brought into light by Aschauer (1989), as he examined the positive relationship between public capital and private sector output. He gave statistical evidence of the relationship by estimating the elasticity to be 0.39, i.e. a 1% increase in public capital investment will lead to an increase in private sector output by 0.39%. However, the researchers following the study adduced issues like non-stationarity of the data, potential spurious correlation and potential endogeneity to be associated with Aschauer's study. Gramlich (1994) raised many probable endogeneity issues on the grounds of inability of many researchers to confirm Aschauer's results. But these studies opened a whole new area of research to pursue.

These studies are immediately followed by the World Development Report by Estache (1994). In the report, he states that "Infrastructure represents the wheels of an economic activity" and mentions that the capacity of infrastructure helps us compare one country's success and failure with another in terms of economic growth. Infrastructure, in simple terms, is an underlying base or foundation especially for an organization or system and for an economy; it is defined as public stock of social and economic overhead capital. The World Development Report by Estache (1994) had also proclaimed that there exists a strong association between the availability of certain basic infrastructure and economic development measured in terms of GDP, with a clause that infrastructure investment alone may or may not lead to economic growth. However, there are evidences from annual and multi-year regressions that suggest positive impact of investment (Sutherland et.al, 2009). As estimated by WDR 1994, a 1% increase in total stock of infrastructure capital leads to 1% increase in the gross domestic product (GDP), across almost all countries. However, empirical studies in the past decades show substantial variation in the estimates for different nations. (Ramirez, 2004; Lambrinidis, 2005; Dasgupta and Shimomura, 2006).

Sutherland et al. (2009) assumed the other side of the argument by challenging the universality of infrastructure investment and economic growth relation. Through his study, he addressed the non-linearities associated with this relationship and showed the changing impacts on economic growth as investment progresses. He proposed that initial investments have minor effects on economic growth and as investment progresses, significant positive effects can be perceived. Beyond a threshold level, further investments tend to have small or no payoffs.

The results even revealed negative impact for certain sectors in countries like Australia, New Zealand and Ireland.

Focusing on the recent studies done in this field of infrastructure investment and economic growth, we see that Snieska and Simkunaite (2015) have aimed to analyze both theoretically and empirically the different aspects of this critical relationship between infrastructure investment and economic development by examining the relationship for the Baltic States. The study by Nedozi et al. (2014) attempted to evaluate infrastructural development and economic growth of Nigeria, using simultaneous analysis.

In context of India, a significant work has been done by Pradhan and Bagchi (2013) in examining the nexus of transportation infrastructure on economic growth in India using the causality approach. Using Vector Error Correction Model (VECM), the study stressed on the fact that although the link between transport infrastructure's growth causing economic growth in developing countries like India appears to be weak but outcomes of policies that aim to improve efficiency of transport sector seems efficacious. The study concluded with an interesting result stating bidirectional causality between roads and economic growth while a unidirectional causality between railways and economic growth. Ahluwalia (2000) analyzed the determinants of economic growth for Indian states by using plan expenditure as proxy for Public Investment. Jena (2004) did a state level study and examined the impact 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 cultures, infrastructure, natural endowments, etc., which have the ability to influence their local economic growth either directly or indirectly.

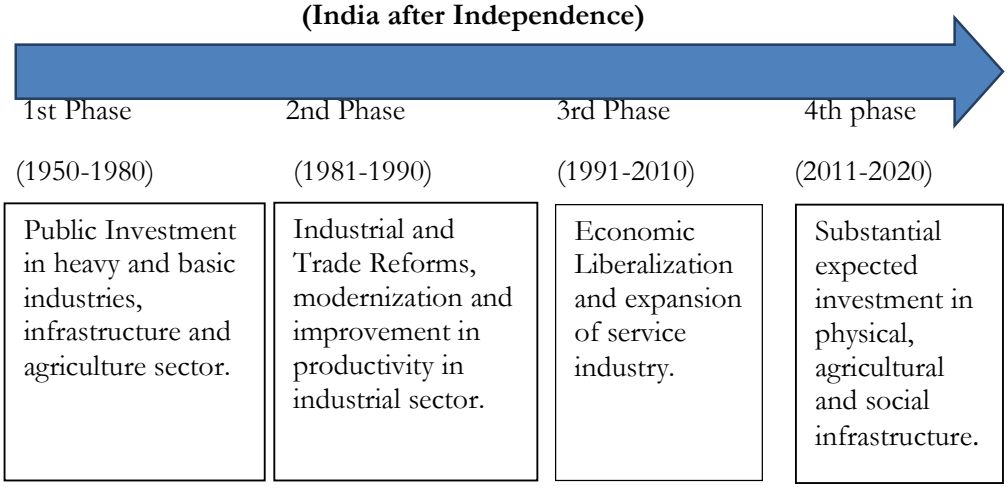
Though there have been studies which have analyzed the different aspects of the role of infrastructure in terms of achieving economic growth, however, there is still insufficiency of research works when it comes to particularly analyze the Public Infrastructure Investment and economic growth relationship. For this study, we have made use of the latest comprehensive data set for infrastructure investment in India covering the time period from 1995 to 2015 and hence the study enhances the scope of the analysis of the impact of Public infrastructure investment by considering four major sectors of infrastructure discussed in the Data and Methodology section.

2.1 Infrastructure in India

In India, Infrastructure problems were not the central focus of policy when the reforms began in mid-1991. The agenda for reforms in early post liberalization period is dominated by domestic and external stabilization. With the aim of achieving macro-economic stability reforms were aimed at deregulating the

domestic economy, reforming exchange rate and trade policies, and liberalizing foreign investment policy. It was only after first articulation of a strategy for infrastructure development in the reform programme concerning in the Eighth Five Year Plan at the end of 1992, that brought need for infrastructure investment into light. Let's have a look over changing growth drivers over the period of time that was of utmost importance for the rapid economic growth of India at that particular period.

GROWTH DRIVERS
(India after Independence)



3. Data And Methodology

We have collected public investment data of India in all major infrastructure sub sectors namely, roads and bridges, railways, shipping, civil aviation, ports and lighthouses; education, sports and arts, medical and public health, communication, power. We have taken Gross Domestic Product (GDP) as measure of economic growth for India. The source of data is Annual Union Government Budget Reports from year 1995 to 2014.

For simplicity of model we have put together these chosen sub sectors under a broad sector of Infrastructure for the feasibility of our model.

- Transport - roads and bridges, railways, shipping, civil aviation, ports and lighthouses
- Social Infrastructure- education, sports and arts; medical and public health
- Communication- telecommunications, postal services and satellite system
- Power – all power generation projects

Further, we have taken the log of all variables for our analysis. $\log I_{TRAN}$, $\log I_{POW}$, $\log I_{SOC}$, $\log I_{COMM}$ represent the log of investment in Transport, Power, Social Infrastructure and Communication sectors respectively. $\log Y$ represents the log of GDP. The Structural Vector Autoregression methodology has been opted for studying the effects of Public Infrastructure investment in these four major sectors.

Following the studies done by Pereira (2000) and Pereira and Andraz (2005) for Portugal, a five variable structural vector autoregression model is estimated. The stationarity test revealed the existence of unit root in data for the variables: GDP, Communication and Social infrastructure, whereas no unit root was found for the sectors: Transport and Power. Accordingly, the investments variables pertaining to Transport and Power ($\log I_{TRAN}, \log I_{POW}$) were included in the model in the logarithmic form only while the variables which had presence of unit root ($\log I_{SOC}, \log I_{COMM}, \log Y$) were differenced and the stationarity test was once again applied to check for presence of unit root in the differenced variables. The first differenced logarithmic form variables pertaining to GDP, communication and social infrastructure came out to be stationarity and hence they were included in the model in their first differenced form.

The structural VAR is represented by the following equation:

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

Where:

Vector $X_t = [\Delta d \log Y \ \Delta \log I_{TRAN} \ \Delta \log I_{POW} \ \Delta d\log I_{SOC} \ \Delta d\log I_{COMM}]^T$ is the vector of endogenous variables.

Vector $e_t = [e_t^{TRAN} \ e_t^{POW} \ e_t^{SOC} \ e_t^{COMM}]^T$ is the vector of orthogonal independent shocks to the variables.

Let Σ_e denote the covariance matrix of e_t.

We first rewrite the model in the standard VAR Notation which is as follows

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

Where $u_t = A^{-1}e_t$ is termed as 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 Vector Autoregression is a set of reduced form equations which can be estimated using Ordinary Least Squares (OLS). This gives estimates for Σ_u and B_i^*.

4. Results and discussion

This section presents and discusses the empirical analysis and results pertaining to this study.

4.1 Stationarity Tests

We begin the analysis by testing the stationarity of time series involved in our analysis. Augmented Dicky-Fuller (ADF) Test was used to test for the presence of unit roots.

As discussed earlier, all the time series were taken in logarithmic form. The stationarity test revealed that the time series of GDP, Communication and Social infrastructure are non-stationary, while time series pertaining to Transport and Power are stationary. For GDP, Communication and Social infrastructure, the null hypothesis of presence of unit root is rejected at 5 % level of significance while for Transport and Power we fail to reject this hypothesis. Hence, $(\log I_{SOC}, \log I_{COMM}, \log Y)$ were differenced and the first differenced logarithmic form variables pertaining to GDP, communication and social infrastructure came out to be stationarity. Table 1 given below present the results for the ADF test.

Table 1

ADF test results

VARIABLES	LEVELS	FIRST DIFFERENCES
$\log I_{TRAN}$	-3.013*	-
$\log I_{POW}$	-3.029*	-
$\log I_{SOC}$	-2.568	-6.530*
$\log I_{COMM}$	-2.435	-4.699*
$\log Y$	-2.688	-3.330*

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

4.2 Determination of Lag Length

The next step of the analysis involves determining the lag length or in other words the order of the VAR. The optimal lag length obtained from tests is 2. Thus, we include 2 lags in our model. The Akaike's Information Criterion

(AIC), Schwarz's Bayesian information criterion (SBIC) and Hannan and Quinn information criterion (HQIC), all lead to the same conclusion.

4.3 Structural VAR

Now that we have determined the optimal lag length, our model specification is now complete. We estimate a Structural Vector Autoregression with the identification restrictions corresponding to the Choleski decomposition. We also restrict the covariance matrix to be an identity matrix. Since we include only one time period lag the summation of lag terms in the Autoregressive form of the VAR model reduces to just one term.

4.4 Testing for Stability

The validity of the Vector Autoregression is established by testing for the dynamic stability of the Structural VAR. All the eigenvalues lie within the unit circle, In other words all the eigenvalues have magnitude less than one. Thus we can conclude with certainty that the VAR is stable. The stability has important implications for the impulse response functions. It means that the impulse response must converge to zero. The interpretation of this is that one-off shocks to the variables do not have permanent effect.

Table 2

Eigenvalue stability condition

Eigenvalue	Modulus
-.9456415	.945641
.9456415	.645641
.7167946	.716795
-.7167946	.716795
-.360601 + .559.459i	.665256
.360601 - .559.459i	.665256
.360601 + .559.459i	.665256
.360601 + .559.459i	.665256
3.501e-16 + .5738296i	.57383
3.501e-16 - .5738296i	.57383

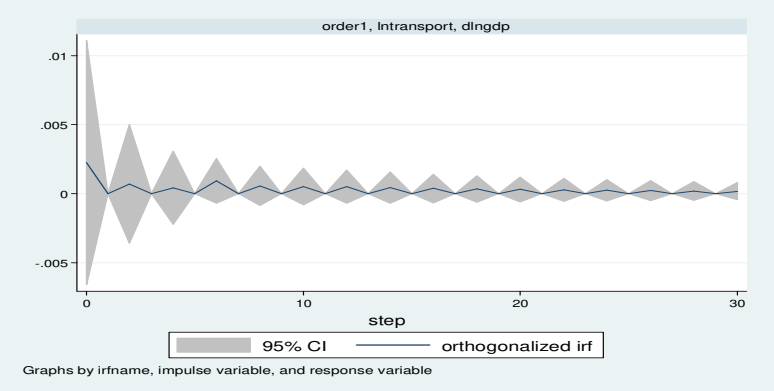
Note: All the eigenvalues lie inside the unit circle. VAR satisfies stability condition.

4.5 Interpretation of Impulse Response Functions

This section gives a comprehensive overview of the Impulse Response Functions along with their interpretation for each of the considered sub sectors of Infrastructure under this study.

Figure 1

Response of Gross Domestic Product to a shock in Investment in Transport



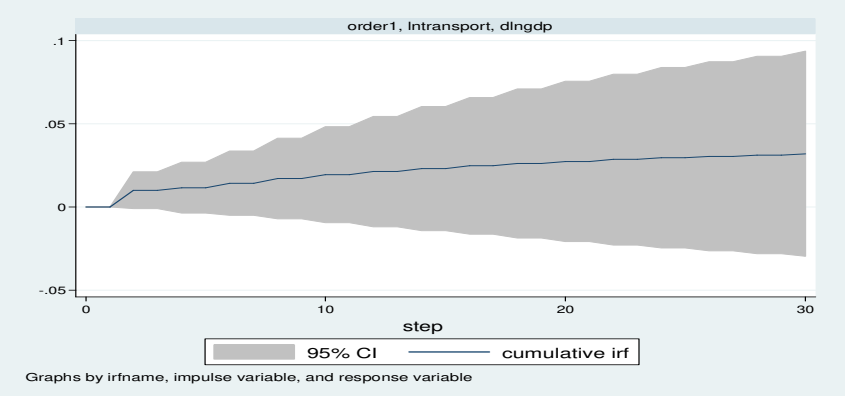
Source: Computer Software Output

The figure above charts the response of the logarithmic growth rate of GDP to a unit standard deviation change in logarithmic growth rate of investment in transport. The response of Output (GDP) to investment in transport is maximum and positive at the same period. This implies that 1% change in investment in transport will lead to .22% increase in GDP in same time period.

The interesting point is even after lag of k years the response of GDP to investment in transport is positive. Thus an investment in transport will always have a positive impact on GDP, even in long term. This can also be seen in the Cumulative IRF.

Figure 2

Cumulative IRD: Response of Gross Domestic Product to a shock in Investment in Transport



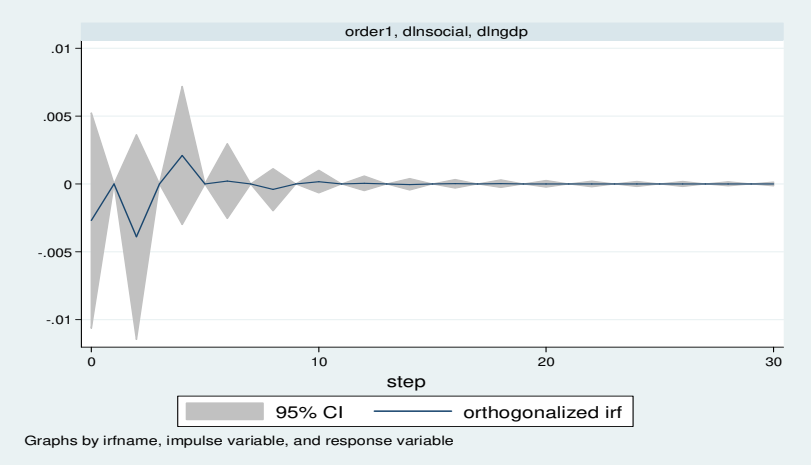
Source: Computer Software Output

The above graph charts the cumulative impulse response of the logarithmic growth rate of Gross Domestic Product to a unit standard deviation change in logarithmic growth rate of investment in Transport. Cumulative Response at a lag k means the sum of the individual impulse responses from lag 0 to lag k.

The cumulative response of output continuously increases over time. The increase is expected as the orthogonalized Inverse response function is positive. This implies that an investment in transport will have a positive impact on GDP even after lag of K years.

Figure 3

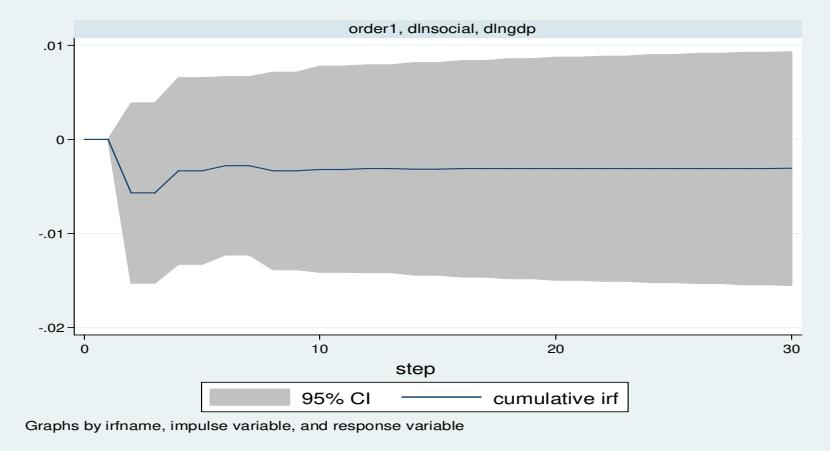
Response of Gross Domestic Product to a shock in Social Investment



The figure above shows the response of the logarithmic growth rate of private Gross Domestic Product to a unit change in standard deviation for logarithmic growth rate of social investment. The response of Output to social investment is maximum after 2 lags. Initially, the response is negative. 1% change in Investment in social will lead to .66% decrement in the output in the same time period. But after lag of 2 years, response comes out to be positive. After a lag of 5 years, the impulse stabilizes and remains constant thereafter.

Figure 4

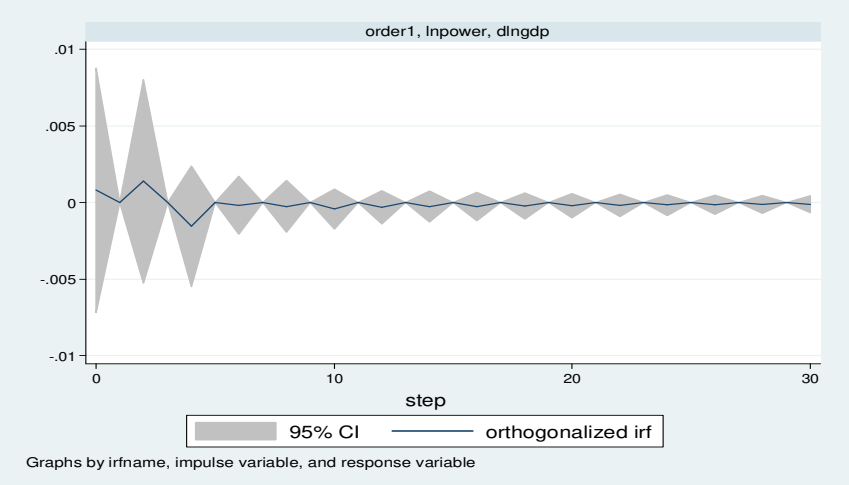
Cumulative IRF: Response of Gross Domestic Product to a shock in Social Investment



The above graph charts the cumulative impulse response of the logarithmic growth rate of Gross Domestic Product to a unit standard deviation change in logarithmic growth rate of Social Investment. Cumulative Response at a lag k means the sum of the individual impulse responses from lag 0 to lag k. The response is negative and maximized after a lag of 3 years but then gradually become less negative as the lag increases.

Figure 5

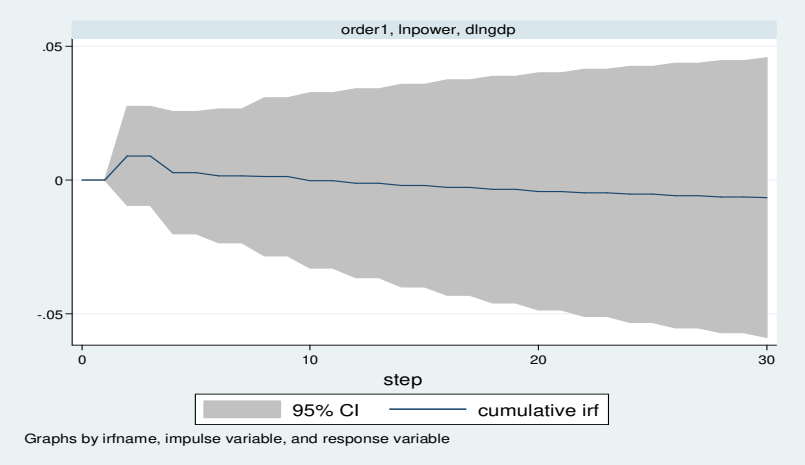
Response of Gross Domestic Product to a shock in Investment in Power



The figure above charts the response of the logarithmic growth rate of Output to a unit standard deviation change in logarithmic growth rate of Investment in power. The response of Output to Investment in power is maximum during the same period. The meaning is that 1% change in investment in power will lead to a .33% increase in the output in the same time period. After a lag of 2 years, the response is negative.

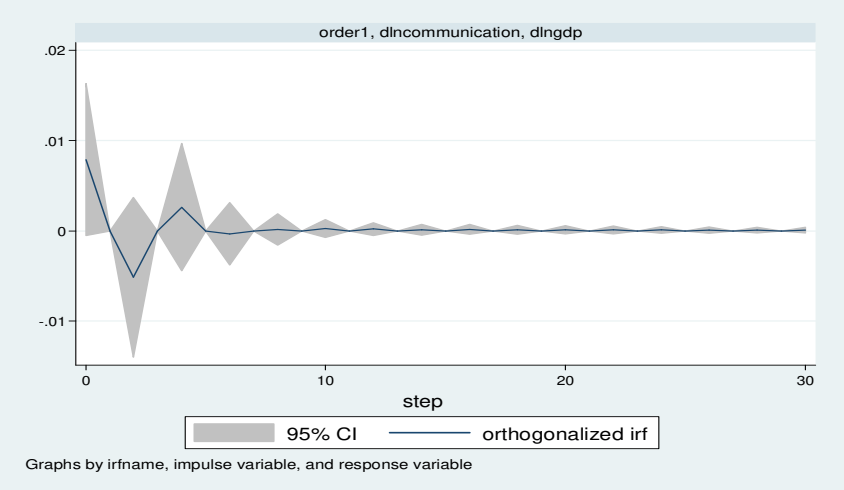
Figure 6

Cumulative IRF: Response of Gross Domestic Product to a shock in Investment in Power



The above graph charts the cumulative impulse response of the logarithmic growth rate of Gross Domestic Product to a unit standard deviation change in logarithmic growth rate of investment in Power. Cumulative Response at a lag k means the sum of the individual impulse responses from lag 0 to lag k. Clearly, after a lag of 2 years the return to GDP is maximized. Thereafter, as the lags increases the returns decreases and eventually becomes negative.

Figure 7
Response of Gross Domestic Product to a shock in Investment in Communication

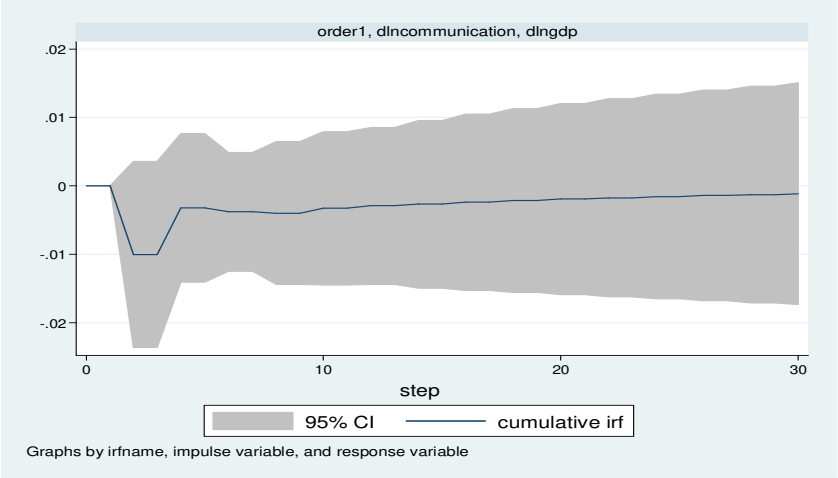


The figure above charts the response of the logarithmic growth rate of Gross Domestic Product to a unit standard deviation change in logarithmic growth rate of investment in communication. The response of Output (GDP) to investment in transport is maximum during the same period. This implies that 1% change in investment in transport will lead to .37% increase in GDP in same time period. After a lag of 2 years, the response is negative but then it remains positive for each lag K.

The next graph charts the cumulative impulse response of the logarithmic growth rate of Gross Domestic Product to a unit standard deviation change in logarithmic growth rate of investment in Communication. Cumulative Response at a lag k means the sum of the individual impulse responses from lag 0 to lag k. The response is negative and maximized after a lag of 2 years. The response becomes less negative as the lags increases (after a lag a 2 years). This shows that an investment in communication does not have a positive impact on the economy.

Figure 8

Cumulative IRF: Response of Gross Domestic Product to a shock in Investment in Communication



5. Conclusions and policy recommendations

The Impulse Response functions obtained for the Indian economy clearly indicate that investment in the transport sector which includes roads, railways and bridges has a maximum positive effect on GDP in short run as well as long run. Transportation is one of the basic inputs in the production process; hence, an increase in investment in transport would be expected to have a positive effect on economic growth. When road transport steps up, both in quantity and quality, government can charge toll tax and that can contribute to government's revenue. Thus, since transport infrastructure is found to be a "big deal" for economic growth, a suitable transport policy should be retained to maintain sustainable economic growth in the country. Given the geographical spread of population and industries in India, a suitable modal mix of transport is deemed to be essential to promote economic growth.

Investment in Communication has a positive impact on GDP in the same time period. Communication has a significant role to play in the growth of various sectors of the economy and is a major source of economic development. However, after a lag of 2 years the graph shows a negative impact. From the policy perspective, government should figure out the reasons of such negative impacts as Information and communication technologies are extensively being used in services sector (including finance, business services, and trade) which are the backbone of development in India.

Social Investment has a negative impact on GDP initially but gradually it becomes positive after a lag of 2 years. Though, initially negative, social infrastructure plays a crucial role in the development of the nation. It is responsible for the basic utilities to the citizens of the nation such as medical facilities, education etc. Thus, Government policies should be effective and efficient in escalating investment in social infrastructure.

The statistical results of the study provide deep insights in terms of the policy implications from an Indian context. For achieving and maintaining the targeted growth levels, the government should not only keep major channeling funds in the infrastructure sector but should also devise ways of encouraging businesses to designate their funds in investment options to steer high levels of overall infrastructure investment and maximizes the growth.

6. Limitations of the study and scope for further research

The analysis performed was limited to annual time series data for 20 years from fiscal year 1995 96 to fiscal year 2013-14 due to lack of data for the years before 1995. Moreover, main aspects which affect the quality of infrastructure sectors across regions, such as the identity of operators, the nature of the regulatory framework and the nature of the political economy process that drive Infrastructure Investment, are not considered in this study.

The results of our study open possibilities for further studies. The study can be extended to pursue selective studies of the investment patterns in various infrastructures across the different Indian states with careful examination of other regional factors aiding and opposing growth in that particular region.

References

Ahluwalia, M.S., 2000. Economic performance of states in post-reforms period. Economic and Political weekly, pp.1637-1648

Aschauer, D. A. (1989). Is public expenditure productive?. Journal of monetary economics, 23(2), 177-200.

Dasgupta, D., & Shimomura, K. (2006). Public infrastructure, employment and sustainable growth in a small open economy with and without foreign direct investment. Journal of International Trade & Economic Development, 15(3), 257-291.

Estache, A. (1994). World Development Report: Infrastructure for Development (No. 2013/44144). ULB--Universite Libre de Bruxelles.

Gramlich, E. M. (1994). Infrastructure investment: A review essay. Journal of economic literature, 32(3), 1176-1196.

Hansen, N. M. (1965). Unbalanced growth and regional development. Economic inquiry, 4(1), 3-14.

Hirschman, A. O. (1958). The strategy of development.

Jena, P.R., 2004. Public Expenditure and Growth: A Decomposed Expenditure Analysis for States in India. The Asian Economic Review, 46(2), pp. 247-262

Lambrinidis, M., Psycharis, Y., & Rovolis, A. (2005). Regional allocation of public infrastructure investment: the case of Greece. Regional Studies, 39(9), 1231-1244.

Lewis, W. A. (1955). The theory of economic growth. Lewis350The Theory of Economic Growth, 350.

Munnell, A. H., & Cook, L. M. (1990). How does public infrastructure affect regional economic performance?. New England economic review, (Sep), 11-33.

Myrdal, G. (1958). Rich lands and poor: the road to world prosperity (No. HD82 M9 1958).

Nedozi, F. O., Obasanmi, J. O., & Ighata, J. A. (2014). Infrastructural Development and Economic Growth in Nigeria: Using Simultaneous Equation.

Pereira, A. M. (2000). Is all public capital created equal? Review of Economics and Statistics, 82(3), 513-518.

Pereira, A. M., & Andraz, J. M. (2005). Public investment in transportation infrastructure and economic performance in Portugal. Review of Development Economics, 9(2), 177-196.

Pradhan, R. P., & Bagchi, T. P. (2013). Effect of transportation infrastructure on economic growth in India: the VECM approach. Research in Transportation Economics, 38(1), 139-148.

Ramirez, M. D. (2004). Is public infrastructure spending productive in the Mexican case? A vector error correction analysis. The Journal of International Trade & Economic Development, 13(2), 159-178.

Rosenstein-Rodan, P. N. (1943). Problems of industrialisation of eastern and south-eastern Europe. The economic journal, 53(210/211), 202-211.

Sims, C. A. (1986). Are forecasting models usable for policy analysis?. Federal Reserve Bank of Minneapolis Quarterly Review, 10(1), 2-16.

Snieska, V., & Simkunaite, I. (2015). Socio-economic impact of infrastructure investments. Engineering Economics, 63(4).

Sutherland, D., Araujo, S., Égert, B., & Kozluk, T. J. (2009). Infrastructure investment: links to growth and the role of public policies.