Journal of International Business and Economy (2016) **17**(1): 91-111 (21 pages)

JIBE
Journal of International Business and Economy

Naliniprava Tripathy, Maram Srikanth, and Lagesh Meethale Aravalath

INFRASTRUCTURE INVESTMENT AND ECONOMIC GROWTH: EVIDENCE FROM INDIA

ABSTRACT

This study examines the long-run and short-run relationship between investment in infrastructure and economic growth in the Indian economy by using Auto Regressive Distributed Lag Model, Error Correction Model, and Granger Causality Test. The study reports that there is no short-run relationship among gross domestic product, gross domestic capital formation, revenue of the governmentand exports. However, the study finds that unidirectional causality exists between employment and gross domestic product; gross domestic productandinflation. It implies that employmentlevel in organised sector and inflationinfluence the economic growth in India for a short period. The study finds that there is a long-run relation exists between economic growth, domestic investment, inflation and government revenue. Therefore, emphasis should be placed on capital formation, government income and inflation to accelerate growth and development in the Indian economy. The error correction term is indicating that long term relationship is stable and any disequilibrium created in short termwill be temporary and will correct over a period. However, it is suggested to maintain balance among inflation,gross domestic product, employment, exports, savings, investment and government revenue to keep an economy growing. These findings have important policy implications since an economy built on investment in infrastructural development.

Key Words: investment in infrastructure, economic growth, ARDL model, error correction model, unit root, Granger causality

Naliniprava Tripathy
Indian Institute of Management Shillong, Meghalaya, India

Maram Srikanth
Indian Institute of Management Shillong, Meghalaya, India

Lagesh Meethale Aravalath
Senior Quantitative Analyst, CRISIL, Pune, India

Correspondence: Naliniprava Tripathy
Indian Institute of Management Shillong, Meghalaya, India
E-mail: nalini_prava@yahoo.co.in, nt@iimshillong.in
Tel: 91-364-2308037
Fax: 91-364-2230041

https://doi.org/10.51240/jibe.2016.1.5

INTRODUCTION

It has been universally recognized that adequate supply of infrastructure services is an essential ingredient for productivity and growth of an economy. The empirical research on infrastructure in economic growth started with the seminal work by Aschauer (1989a, 1989b, 1989c). The majority of the studies in the existing literature (Aschauer, 1989; Calderón and Servén, 2003; Canning and Pedroni, 2004; Easterly and Rebelo, 1993; Roller and Waverman, 2001; World Bank, 1994) reported that there is a significant positive effect of investment in infrastructure on aggregate output and growth potential of the economy. Correspondingly, some cross-country studies have confirmed the significant impact of infrastructure on economic growth in developing countries (Canning and Pedroni, 1999). Investment in infrastructure directly contributes to the formation of GDP; and indirectlyfosters productivity, increasing competitiveness by reducing transactions costs. Productivity is higher in countries wherein adequate and efficient supplies of infrastructure services are available (World Bank, 1994).

World Bank (1994) indicates that 1% increase in the stock of infrastructure associated with 1% increase in the GDP across all countries. Good infrastructure is also an indicator of the country's high standard of living of citizens. Adequate infrastructure facilities result in improved productivity of businesses, households and the government at large (Sahoo, 2006). As advocated by the policy makers, economic growth will be inclusive and more balanced only when sizable investment in infrastructure takes place across all regions in a country to reduce disparities among its citizens and develop their quality of life. India annually spends 6% of its GDP on infrastructure whereas China invests about 11% of its GDP for its infrastructure development (Prasad, 2011). Countries like China, Japan, Malaysia, Singapore, and Korea, have been transformed, relatively in a short span of time primarily due to their large and lumpy investment in infrastructure segment (Kaur, Lakshmanan, Rajesh, and Kumar, 2010). Infrastructureand economy are closely connected because it affects production and consumption, creates positive and negative spillover effects, and contains massive inflow of expenditure. Hence, infrastructure investments and development outcomes are one of the most popular topics for debate in economic literature and research today.

Keeping in view, we have raised two critical research questions. We investigated whether economic growth is dynamically led by investment in infrastructure growth or vice versa by employing the Granger Causality Test. Secondly, we have used the Auto-Regressive Distributed Lag (ARDL) model and Error Correction Model to examine the long-run relationships and short-term dynamics of investment in infrastructure and economic growth to obtain new insights. Therefore, the present work improves the earlier studies and offers a value addition to the existing literature. The present study is important in the sense that policy makers in India may like to know the impact of investment in infrastructure on the economy during the period of study and can make future policy changes if any. Supplementary to this, the performances of economic growth are carefully analyzed by a large number of global players; this motivates us for exploring research on investment in infrastructure and economic growth to determine the efficiency of the Indian economy. This paper is organized into five sections. The second section reviews previous literature. The third section deals with data and research methodology. The results are discussed in section 4 and section 5 concludes the observation.

LITERATURE REVIEW

Specific studies have found that investment in infrastructure has a positive and significant impact on economic growth. Devarajan, Swaroop, and Zou (1996) use annual data from 43 countries and regression model to determine the link between the components of central government expenditure such as spendingfor defense education, health, transport, communication, and economic growth. The study finds that the relationship between the capital component of public expenditure with economic growth indicating a negative relation. It may be because excessive amounts of transportation and communication expenses in those countries make such expenditures unproductive. The study further reports that increasing the share of consumption expenditure has positive and statistically significant effects on economic growth whereas increases in the share of public investment expenditure have a substantial negative effect. Canning and Pedroni (1999, 2004) use data from a panel of 67 countries for the period 1960-1990. This study uses Granger causality test to determine the causal relation between investments in three types of economic infrastructure, such as kilometers of paved road, kilowatts of electricity generating capacity, and some telephones with GDP. The study finds that there is an evidence of two-way causality between each of the three infrastructure variables and GDP in most of the countries. In another study, they investigate the long-run effects of infrastructure on growth in a panel of countries between the periods 1950-1992. This study uses unit root test, causality tests, co-integration test, and error correction model to determine the long-term and short-term relation between public infrastructure(paved roads per capita, electricity generating capacity per capita, and telephones per capita) and growth (GDP per capita). The study finds that infrastructure induces long-term growth effects in the majority of countries but there is a great deal of variations in results across individual countries. The study concludes that long run effects of telephones, electricity generating capacity, and paved roads on growth are close to negligible on average across countries but there are significant long-term effects of growth found in individual countries.

Esfahani and Ramirez (2003) explore the relation between economic growth and infrastructure investment in 75 countries by applying the structural growth model. The study has taken variables such as population growth rate, growth rate of per capita telephones, private ownership in the telecoms sector, growth rate of per capita power production, and average years of secondary education, terms of trade change, exchange rate black market premium, population density, and urbanizations share of industry in GDP. The study finds that infrastructure made a positive and substantial contribution to GDP. The findings of this study also suggest that institutional capabilities that lend credibility and effectiveness to government policy play important roles in the development process through infrastructure growth. The effects indicate that countries can gain a great deal by improving investment and performance in infrastructure sectors. Calderón and Serven (2004) assess the impact of infrastructure development (telecommunication sector, the power sector, and the transportation sector) on economic growth GDP per capita and income distribution data of 121 countries by using the GMM model. The study finds that the volume of infrastructure stocks has a significant positive effect on long-term economic growth. The study also reports that infrastructure quantity and quality have a negative impact on income inequality. The results also stated that there is a causal effect of infrastructure on growth and inequality.

Fedderke, Perkins, and Luiz (2006) experiment the long run relationship between investment in economic infrastructure , such as roads, air travels, electricity, telephones and long-run economic growth (GDP) in South Africa by using bounds analysis of Pesaran, Shin and Smith's (2000) F test, Co-integration test, and Vector Error-Correction Mechanism. The study discovers that investment in infrastructure appears to lead economic growth in South Africa. It also finds that infrastructure seems to have both direct and indirect impact on output. The study notices that there is a causality effect running in both directions between infrastructural investment and economic growth. The study concludes that there is a forcing relationship moving from infrastructural fixed capital stock to GDP, suggesting that infrastructure leads to economic growth.

Fedderke and Bogeti (2006) investigate the impacts of productivity on infrastructure by taking panel data from 1970-2000 period with 19 infrastructure measures in South Africa. The study uses ARDL model and vector error-correction model. The study finds that there is a significant impact of infrastructure on labor productivity. The study also finds that net exports have a positive effect on labor productivity in the manufacturing sectors in South Africa. The study reveals that strong positive effects on manufacturing labor productivity that is attached to railway and ports infrastructure while roads infrastructure has the opposite effect, and telecommunications have little impact. These findings are invariant between the direct impact of infrastructure on labor productivity and the indirect effects of infrastructure on total factor productivity. However, this study measures the elasticity of various infrastructure investments on labor productivity and total factor productivity, instead of economic growth. Murty and Soumya (2006) explore the macroeconomic effects of changes in public investment in infrastructure in India over the period of 1978-1979 and 2002-2003 by using the structural, macro-econometric model. The study has taken important macroeconomic variables relating to four broad sectors- real, fiscal, monetary, and external sectors of the Indian economy. The real sector is further fragmented into four sub-sectors: agriculture, manufacturing, infrastructure, and services. The study reports that there is a significant crowding-in effect found between private and public sector investment in all the four sub-sectors in the real economy in India. The study also indicates that public sector investment in infrastructure has the potential to provide accelerated growth process in Indian economy. Herranz-Loncán (2007) examines the impact of infrastructure investment on economic growth by using the VAR model. The study finds that impact of infrastructure investment on growth is positive but returns to new investment in large nation-wide networks are not so favorable. Sahoo and Dash (2008) examine the effect of infrastructure in economic growth in four South Asian countries for the period from 1980 to 2005. The major infrastructure indicators considered in this study electricity power consumption, per capita energy use, Telephone line, Rail Density, air transport, freight million tons per kilometer, paved road and gross domestic capital formation per capita as a proxy for capital to examine the impact of infrastructure on growth. The study uses panel unit root, modified ordinary least square, co-integration test and error correction model to determine the long run relation between infrastructure stocks and economic growth. The study reveals that laborforce, investment, infrastructure capital, export, and expenditure on health and education have positive impacts on economic growth in South Asia. The study concludes that infrastructure development has a significant positive contribution to economic growth in South Asia.

Sahoo, Dash, and Nataraj (2010) investigate the role of infrastructure in promoting economic growth in China for the period from 1975 to 2007. The study uses Autoregressive Distributed Lag Model and Generalized Methods of Movements to evaluate the impact of infrastructure on output growth. The study also uses VECM to determine the causality between infrastructure development and growth. The study finds that investment, infrastructure stock and human capital play a significant role in economic growth in China. The study also finds there is a unidirectional causal relation between infrastructure development and output growth. The study concludes that infrastructure development has a significant positive contribution to economic growth in China. Nannan and Jianing (2012) examine the relationship between infrastructure investment and economic growth in China using a dataset for a 20-year periodbetween 1988 and 2007 by using the OLS model. The study has taken infrastructure variable such as the production and supply of electricity, gas and water, the management of water and the communication industry of transportation, storage, postal service, and telecommunication. The study finds that physical infrastructure development contributes positively to Chinese economic growth. The study concludes that the development of the infrastructure is still lagging behind the demands of the economy. Kumo (2012) investigates the causal relation among economic growth, economic infrastructure, and employment in South Africa over the period between 1960and 2009 by using a Bivariate vector Auto regressionmodel with and without structural break. The study finds that there is a definite causal relation between economic infrastructure investment and GDP growth. The study also finds a two-way causal relationship between economic infrastructure investment and public sector employment. The study further uses ARDL or bounds test to determine the long- term equilibrium relationship between economic growth and infrastructure investment and the control variables. The study indicates that there is a strong evidence of long-term cointegrating relationship in between economic growth, economic infrastructure investment, formal employment, exports and imports of goods and services.

If the investment in infrastructure accurately reflects the economic growth, investment in infrastructure can be employed as a leading indicator for future economic activities. Hence, long and short term relationship between investment in infrastructure and economic growth are necessary for the formulation of nation's economic policy. Though numerous studies have been conducted throughout the world on this theme, research with a focus on 'investment in Indian Infrastructure and its impact on economic growth' are few and far behind. Given the above background, the present study is undertaken to understand the effects of investment in infrastructure on the economic growth of India.

TIME SERIES DATA AND METHODOLOGY

The required yearly time series data were collected from the Handbook of Statistics on the Indian Economy and the World Bank's Database for 41 years from 1971-2012. This period is marked by pre and post liberalization of Indian economy. During this period, the Indian economy has undergone substantial policy changes. These changes have affected the movement of the economy in different ways. We have taken the variable such as gross domestic capital formation (GDCF), revenue of the government (GRV), public & private employment (organized sector) level in the Indian economy, employment (EMP), inflation (INF), exports from India (EXP). These variables are taken as proxies for investment in infrastructure.

GDP is considered as a dependent variable. Gross domestic products, the value of nation's goods and services which is regarded as an important indicator of an economy's health. GDP helps in forecasting economic progress, determining demand & supply, tracking buying power and behavior of the people, changes in per capita income and positioning the economy in the global arena. So we used GDP as the proxy for economic growth in our study.

Secondly, government needs funds from a variety of sources to perform from the general, social and economic point of view. These funds can be collected from the public in the form of taxes and non-tax levies. Tax revenue plays a critical role in correcting structural imbalances and anomalies in the economy. Revenue of the government comprising tax as well as non-tax receipts is deployed as another variable in our study.

Inflation typically means price level which increase on average or when the amount of currency increases. Inflation measures the change in prices of a basket of goods and services in a year. The increase in inflation causes economic policy tightened which lead to increase in the nominal risk-free rate and impacted on the capital formation of an economy. So we used inflation as a variable in our study.

Variability in export earnings results in uncertainty that adversely affects both the level and efficiency of capital. Due to the close link between government revenue and exports, the decline in exports leads to disruptions in public investment in the infrastructure. We have used Exports from India as a variable in our study.

Since investment and employment are inter-linked, employment is used as a variable in the study. Infrastructure reduces costs, expands markets, and facilitates trade; infrastructure fosters economic growth by enhancing the (factor) productivity of capital and labor thereby reducing the costs of production and increasing production, profitability, and employment and income levels. Domestic investments occupy a fundamental role in its growth process. The growth of domestic investment is measured by gross domestic capital formation. The gross domestic capital formation is essential to achieving a higher level of production, changes in production techniques and change in the economic outlook. Gross domestic capital formation used as a proxy for domestic investment.

Unit root test

In the case of non-stationarity data, ordinary least squares can produce spurious results. Therefore, before modeling any relationship, non-stationarity must be tested. The data considered for the study is time series, which is non-stationary. The present study uses time series data, unit root tests such as Augmented Dickey-Fuller (ADF) and KPSS tests to find "presence of stationarity" in the data.

Auto-Regressive Distributed Lag (ADRL) model

ADRL and ECM method are used in our study to examine the long-term and short term relationship between investment in infrastructure and economic growth. If they are cointegrated, it can be said that there exists a stable long-term relationship among variables. ECM is used to discover the short-term dynamics of the relationship.

It is accepted that Auto-Regressive Distributed Lag (Pesaran and Pesaran, 1997; Pesaran et al., 2000) approach was superior to conventional co integration techniques. It is because of its versatility such as the method can be used irrespective of whether the underlying regressors are pure I(0) or I(1) or mutually co-integrated. Also, it is very robust and more applicable when the sample size is small. In light of the above-cited advantages, ARDL model is used in the present paper. The ARDL approach involves estimation of conditional Vector Error Correction Model (VECM) for all the variables as per the Equation (1) given below.

$$\begin{aligned}\Delta \log GDP_t = {} & \alpha_0 + \sum_{i=1}^{n} \beta_{1i} \Delta \log GDP_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta \log GDCF_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta \log GRV_{t-i} \\ & + \sum_{i=1}^{n} \beta_{4i} \Delta \log EMP_{t-i} + \sum_{i=1}^{n} \beta_{5i} \Delta \log INF_{t-i} + \sum_{i=1}^{n} \beta_{6i} \Delta \log EXP_{t-i} \\ & + \gamma_1 \log GDP_{t-1} + \gamma_2 \log GDCF_{t-1} + \gamma_3 \log GRV_{t-1} + \gamma_4 \log EMP_{t-1} \\ & + \gamma_5 \log INF_{t-1} + \gamma_6 \log EXP_{t-1} + \varepsilon_t \qquad (1)\end{aligned}$$

α_o is the drift, ß are the long run multipliers and ε_t is the white noise error term.

Equation (1) is estimated in the ARDL approach in order to test the presence of long run relationship among the given variables; F-test is also conducted to test the joint significance of the coefficients of the lagged levels of the variables such as H_0: 1=2 =3=4=5=0.

Two asymptotic critical values (bounds) provide a test for co-integration when the independent variables are I(d) [(where 0 ≤d ≤1)]; a lower value assumed for regressors with I(0) and high value considered for regressor with I(1). If the F-statistic value is higher than critical value, the null hypothesis (no long-run relationship) can be rejected, even if the time series data are integrated. The null hypothesis cannot be rejected since the F-value is less than the lower critical value. The result is inconclusive if the statistical value is in between the lower and upper critical values (Narayan, 2005).

The Bounds test has many advantages compared to the conventional residual based cointegration analysis. It performs better irrespective of the degree of integration of the variables and hence pre-testing of the order of the variables is not required. The Bounds test does not push the short-run dynamics into the remaining terms as in the case of co-integration analysis (Banerjee, Dolado, Galbraith, and Hendry, 1993). The test is appropriate when the sample data set is small in size. Further, the Bounds test identifies specific variables to be normalized in the long-run relationship. However, the test is to be used only when the remaining variables explain one variable and not vice-versa (i.e., there should not be more than one long-run relationship among the variables, (Kumar, 2010).

Once co-integration is established, the conditional ARDL (m_1, n_1, n_2, n_3, n_4, n_5) long run model for GDP_t is estimated in the Equation (2) as shown below.

$$GDP_t = \alpha_0 + \sum_{i=1}^{m_1} \beta_1 GDP_{t-i} + \sum_{i=0}^{n_1} \beta_2 GDCF_{t-i} + \sum_{i=0}^{n_2} \beta_3 GRV_{t-i} + \sum_{i=0}^{n_3} \beta_4 EMP_{t-i} + \sum_{i=0}^{n_4} \beta_5 INF_{t-i} + \sum_{i=0}^{n5} \beta_6 EXP_{t-i} + \varepsilon_t \qquad (2)$$

By using Schwarz Bayesian Criterion (SBC), orders of ARDL (m_1, n_1, n_2, n_3, n_4, n_5) model is selected. Eventually, short term dynamics are estimated through the error correction model associated with the long-run estimates as shown in the Equation (3) given below.

$$\Delta GDP_t = \alpha_0 + \sum_{i=1}^{n} \beta_1 \Delta GDP_{t-i} + \sum_{i=0}^{n} \beta_2 \Delta GDCF_{t-i} + \sum_{i=0}^{n} \beta_3 \Delta GRV_{t-i} + \sum_{i=0}^{n} \beta_4 \Delta EMP_{t-i} + \sum_{i=0}^{n} \beta_5 \Delta INF_{t-i} + \sum_{i=0}^{n} \beta_6 \Delta EXP_{t-i} + \delta EC_{t-1} + \varepsilon_t \quad (3)$$

Where betas (ß) are the short run coefficients of the model's convergence to the equilibrium and δ is the speed of adjustment towards long term equilibrium path.

Granger causality test

The causal relation is examined by the Granger causality test. The Granger (1969) approach determines whether *x* causes *y*. This approach also shows much of the current *y* can be explained by past values of *y* and whether adding lagged values of *x* can improve the explanation or not. *y* is said to be Granger-caused by *x* if the coefficients on the lagged *x*'s are statistically significant. The two-way causation implies that *x* Granger causes *y* and *y* Granger causes *x*.

$$Y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_l y_{t-1} + \beta_1 x_{t-1} + \ldots + \beta_l x_{-l} + U_t \quad (4)$$

$$X_t = \alpha_0 + \alpha_1 x_{t-1} + \ldots \alpha_l x_{t-1} + \beta_1 y_{t-1} + \ldots + \beta_l y_{-l} + V_t \quad (5)$$

$$\beta_1 = \beta_2 = \ldots = \beta_l = 0$$

The null hypothesis is that *x* does not Granger cause *y* in the first regression and that *y* does not Granger-cause *x* in the second regression.

EMPIRICAL ANALYSIS

Table 1 indicates the results of unit root tests. Stationarity of our data is confirmed by ADF and KPSS test statistics. The series is assumed to be non-stationary under ADF test. Hence, failure to reject the null hypothesis implies that the time series has a unit root. Conversely, the KPSS test indicates that the series is stationary under the null against the alternative of non-stationarity of the series. The results show that null hypothesis of ADF unit root test rejected in case of EMP & INF at the level of the series. In the case of other variables viz., GDCF, GDP, GRV and EXP, the null hypothesis is rejected at 1% level of difference. KPSS test also exhibits results supporting ADF unit root test results.

Table 1. Results of unit root tests

Variables	ADF Test		KPSS Test	
	Level	Difference	Level	Difference
GDCF	1.187	-7.409*	0.794*	0.401
GDP	-1.202	-5.857*	0.281*	0.042
GRV	-0.920	-7.213*	0.159*	0.047
EMP	-7.854*	--	0.687	--
INF	-4.772*	--	0.277	--
EXP	1.759	-5.478*	0.790*	0.467

Notes: 1) *, ** and *** denote statistical significance at 1%, 5%, and 10% respectively. 2) ADF and KPSS Test statistics at first difference are not reported for the variables found stationary at level.

Based on the results depicted in Table 1, it can be inferred that variables viz., GDCF, GDP, GRV and EXP integrated of order one [I(1)] while EMP and INF integrated of order zero [I(0)]. After developing unit root properties of the variables, cointegration among the variables is tested by using ARDL model.

ARDL model, or bounds testing is used to assess the presence of both short- and long-term relationship between the impact of GDCF, EMP EXP, INF and GRV on GDP .Since the data are of annual frequency, a maximum lag order of 4 for the conditional ARDL-VECM is preferred under SBC. OLS regression estimated for the first differences and then tested for joint significance of the parameters of the lagged level variables. If the joint null hypothesis of the coefficients is equal to zero, it means long-term relationship does not exist (based on F-Statistics). Cointegration among the variables is accepted, if F-statistics rejects the null hypothesis at 95% critical bound value for small sample data set (Narayan, 2005). Results of the Bounds test is reported in Table 2.

Table 2. Bounds test for Cointegration

Dependent Variable (Intercept and no trend)	SBC Lag	F-statistic	Probability	Outcome
F(GDP/GDCF,EMP, GRV,INF,EXP)	4	6.57*	0.004	Co integration
F(EMP/GDCF,GDP, GRV,INF,EXP)	4	1.82	0.228	No-Co integration
F(GRV/EMP,GDCF,GDP, INF,EXP)	4	1.84	0.224	No-Co integration
F(INF/GRV,EMP,GDCF,GDP,EXP)	4	1.92	0.132	No-Co integration
F(EXP/GRV,EMP,GDCF,GDP, GRV)	4	1.44	0.319	No-Co integration

Critical Value (Narayan, 2005)

T	1% Level		5% Level		10% Level	
	I(0): Lower Bound	I(1) :Upper Bound	I(0): Lower Bound	I(1): Upper Bound	I(0): Lower Bound	I(1): Upper Bound
35	3.90	5.42	2.80	4.01	2.33	3.42
40	3.66	5.26	2.73	3.92	2.31	3.35

Note:*, ** and ***denote statistical significance at 1%, 5%, and 10% respectively.

F value is 6.57 as reported in Table 2. It is higher than the upper bound value at 1% level of significance. Hence, the null hypothesis is rejected indicating the existence of a long-term relationship among the variables GDP, GDCF, INF, EXP, GRV, and EMP. The finding suggests that investment in gross domestic capital formation, revenue of the government, exports from India, public and private employment (organized sector) level in the Indian economy and inflation contributes to the growth and plays an important role in increasing economic development of India. Investment in infrastructure not only promotes economic progress but also helps to release poverty and to improve living environments of India. It also brings macroeconomic stability in the nation.

Further, it is worth mentioning that when regressionis normalized on variables other than GDP, null hypothesis (of no co integration) is accepted at 95% critical bound value. Hence, it can be implied that there is only one long-run cointegrating relationship among the given set of variables, in line with the standard econometric theory. Subsequently, the long-run relationship between GDP and other independent variables GDCF, EMP, EXP, GRV and INF is estimated as per the Equation 2, and the results are reported in Table 3.

Table 3. Estimated long-run coefficient using ARDL model

ARDL(2,0,0,0,2,0) selected based on Schwarz Bayesian Criterion
GDP is Dependent Variable (GDP)

Regressor	Coefficient	Standard Error	T-Ratio	Probability
GDCF	0.650*	0.137	4.751	0.000
GRV	0.155**	0.078	1.994	0.050
EMP	-0.014	0.077	-0.183	0.856
INF	-0.012*	0.004	-3.086	0.005
EXP	-0.083	0.078	-1.063	0.297
C	5.902*	1.6034	3.681	0.001
R-Squared = 0.85386			DW Statistic = 2.4807	

Note:*, ** and ***denote statistical significance at 1%, 5%, and 10% respectively.

The estimation results of equation (2) using the ARDL model is reported in Table 3. The R-squared value is 0.85 which indicates the goodness of fit model. It is noticed from Table 3 that the estimated long-run coefficient of GDCF (0.650) is significant at 1% level and is having the highest effect on GDP. Thus, it indicates that there is a long-term relationship between domestic investment and economic growth in India. It implies that if investment in infrastructure increases, it leads to progress of the economy. Further investment in infrastructure augments the quality of life by creating amenities, providing consumption of goods and contributing to macroeconomic stability. It is reported from the Table 3 that economic advancement in India attributed to gross capital formation that includes spending on land improvements, plant, machinery, and equipment purchases; the construction of roads, railways, private residential dwellings, and commercial and industrial buildings.

The long term estimated the coefficient of INF is negative and is statistically significant at 1% level. The empirical evidence implies that long term relationship exists between inflation and GDP, but it is negatively related. So it indicates that if inflation decreases, it will lead to a reduction in(factor) costs thereby enhancing the contribution to GDP. It means that an increase of GDP growth equates to a level of reduction of the level of price. It also indicates that inflation and economic growth are incompatible, and inflation affects all sectors of investment,interest rates, exchange rates. It, in turn, increases the risks for potential trade partners, discouraging trade, increases the risk associated with the investment and production activity of firms and markets. The results indicate that negative inflation rate engaged in progress the economic development of India.

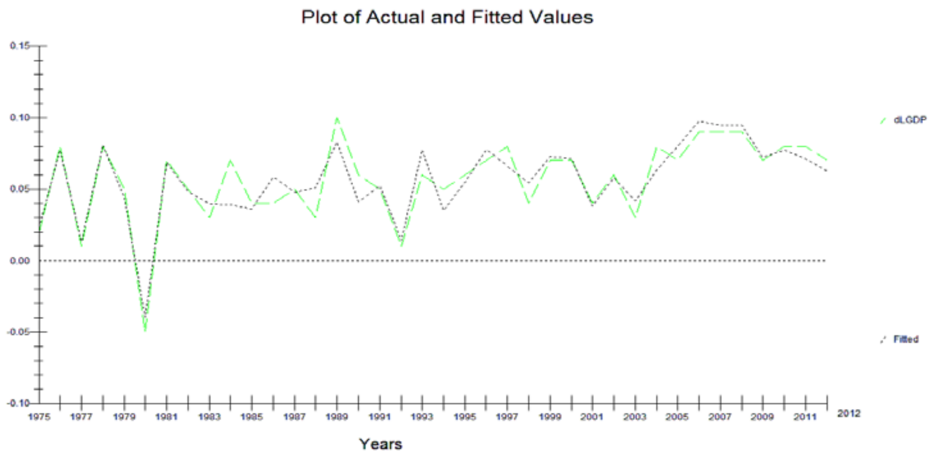
Table 3 stated that the estimated long-run coefficient of GRV is positive (0.155) and it is significant at 5% level. It proposes that if governments' revenue (through tax/non-tax receipts) increases, it will lead to higher GDP. So it suggests that governments' revenue and GDP correlated with each other and increase in governments' revenue leads to economic development of India. Tax revenues, growth and infrastructure, are all undoubtedly linked (Walsh, Park, and Yu, 2011). The rationale for this result is that income, demand and GDP is affected by a decrease in taxes. Disposal income increases when government decreases taxes thereby led to higher spending and increased GDP.

However, EMP is found to be insignificant, while establishing long run relationship with GDP. It is due to employment level that is reported in organized sector captures only a part of employment scenario and does not take unorganized employment figures into account. The reason is that unorganizedemployment data in India are not available. In fact, the unorganizedsector employs a substantial number of people mainly in the private sector. So it suggests an insignificant relationship. The other possible contributing factor may be due to nature of labor market including skill sets of people, low levels of unemployment and skill shortages lead to no long-term relationship between employment and GDP.

It is also evident from the Table 3 that EXP is found to be insignificant while establishing long-term relationship with GDP. Export expansion led to economic growth by increasing production efficiency through capital formation, employment creation and better resources allocation. However, our results do not find the significant contribution of exports in economic growth in India. It may attribute to slacker performance of the export sector and slow pace of poor infrastructure.

Further, to check the robustness of the model, we have explored whether actual GDP is deviated from the GDP fitted by the selected investment in infrastructure variables (Figure 1). It can notice from Figure 1 that actual GDP almost followed the fitted GDP line implying that there have been no major deviations in the actual GDP from its long-term path fitted by fundamentals in India during the study period.

Figure 1. Actual vs. fitted values of GDP



Subsequently, short-term dynamics between investment in infrastructure and economic growth has been estimated regarding error correction model based on ARDL approach. (Equation 3). The results are presented in Table 4.

Table 4. Error correction representation for the selected ARDL model

ARDL(2,0,0,0,2,0) selected based on Schwarz Bayesian Criterion GDP is Dependent Variable				
Regressor	**Coefficient**	**Standard Error**	**T-Ratio**	**Probability**
GDCF	0.203*	0.029	7.099	0.000
GRV	0.049***	0.029	1.659	0.100
EMP	-0.004	0.024	-0.181	0.858
INF	-0.004*	0.001	-5.247	0.000
EXP	-0.026	0.023	-1.151	0.259
C	1.845*	0.550	3.353	0.002
ECM	-0.313*	0.060	-5.183	0.000

Note:*, ** and ***denote statistical significance at 1%, 5%, and 10% respectively.

Table 4 presents the coefficients of error term (long-term effects) and lagged value of five variables (short-term effects). The estimated results show that domestic investment and government revenue are having a positive impact on economic progress for the period of study. It indicates that increase in the gross capital formation and government revenue will lead to increase economic progress in India. Our results indicate a positive contribution to infrastructure development on economic advancement in India. The results also show that employment and export has a negative impact on economic improvement. It is observed that inflation has a negative impact on economic growth, but it is significant at 1% level.

Error correction term is significant and negative at 1% level indicating that long run relationship is stable, and any disequilibrium created in the short run is temporary and will be corrected over a period. The negative and significant coefficient of the error correction indicates that unidirectional causality exists between GDP and inflation. Both domestic investment and government revenue have positive error coefficient with a value of 0.203 and 0.049 and have statistically significant at 1% and 10% level. The positive coefficients show the break from the equilibrium and suggest that the disequilibrium would grow more in government revenue and domestic investment. So it can be said that the equilibrium is not permanent in government revenue and domestic investment. The possible reason attribute to internal imbalance macroeconomic issues led to change in the behavior of government revenue and domestic investment.

The estimated coefficient of ECM (-0.313) denotes that the speed of adjustment for any past deviation from the long-term equilibrium is high since the coefficient has a very high value. It implies that 31% of the adjustment towards the long-term equilibrium relation occurs within a year. In other words, it will take a short time for any disequilibrium in the model to be corrected. The analysis finds that inflation, domestic investment, and government revenue have long-term and short-term effects on economic progression in India. However, lagged values of export and employment do not seem to have a significant contribution to economic development in India. Further, to check the robustness of the ARDL Model, diagnostic tests were conducted and results are reported in Table 5.

Table 5. Diagnostic tests of ARDL model

Test Statistics	Results
Serial Correlation	3.2737 [0.070]
Functional Form	1.8164 [0.178]
Normality	1.6327 [0.442]
Heteroskedasticity	1.0616 [0.303]

All the diagnostic tests are incorrect functional form. The results of the diagnostic tests show that the prediction errors from the modelis normally distributed and there is no problem of heteroscedasticity. Nevertheless, prediction errors are also free from the problem of serial correlation. Besides, functional misspecification errors are absent in the model.

Table 6. Granger causal relationship among GDP, GDCF, GRV, EMP, INF and EXP

Null Hypothesis:	F-statistics	P-Value
Inflation does not Granger Cause GDCF	0.45831	0.63701
GDFC does not Granger Cause Inflation	2.15962	0.13420
GDP does not Granger Cause GDCF	0.58988	0.55997
GDCF does not Granger Cause GDP	0.13430	0.87479
EMP does not Granger Cause GDP	9.09675	0.00068*
GDP does not Granger Cause EMP	0.24507	0.78402
GRV does not Granger Cause GDP	0.53109	0.59276
GDP does not Granger Cause GRV	1.18135	0.31915
EXP does not Granger Cause GDP	1.46015	0.24639
GDP does not Granger Cause EXP	0.19533	0.82348
GDP does not Granger Cause Inflation	2.76343	0.08030***
Inflation does not Granger Cause GDP	0.26721	0.76744

Note:*, ** and *** denote statistical significance at 1%, 5% and 10% respectively.

The Granger-causality test is conducted to study the causal relation among variables. The result is presented in Table 6. The result shows that causality between employment and gross domestic product; GDP and inflation appear to run in one direction only. It implies that employment level in organized sector and inflation influences the economic growth in India. So it indicates that any policy made on any one in India will have a spiral effect on others. It is observed from Table 6 that there is no causal relationships exist among GDP, EXP, GDCF, and GRV. So it implies that any change in policy on government revenue, exports, savings, and investment may not have an effect on economic growth in India for a short period. It may attribute to an indication of independence amongst the variables and due to some other determinants not captured in the model.

CONCLUSION

Infrastructure fosters economic growth by increasing the productivity of capital and labor thereby reducing the costs of production and raises production, profitability, employment, and income levels. Since infrastructure reduces costs, expands markets, facilitates trade, connects workers to industry, goods to the markets, and leads to inclusive growth, it is one of the most popular topics for debate in recent scientific, economic research today.

This paper examines the long-term and short-term dynamics of investment in infrastructure and economic growth in India by using ADRL approach, Error correction model, and Granger Causality test. The study also uses ADF and KPSS test to assess unit root in the concerned data series. The study finds that there is a long-run relation exists between economic growth, domestic investment and government revenue in India so it suggests that increase in savings, investments and government revenues lead to economic development in India. Since gross capital formation includes spending on land improvements, plant, machinery, and equipment purchases; the construction of roads, railways, private residential dwellings, commercial and industrial buildings, it is a prerequisite for India to invest heavily more on fixed assets to augment speedy economic growth.

The study also finds that there is a long-term relationship between inflation and GDP but it is negatively related. It attributes to inflation decreases and GDP increases. So it suggests that it is essential for India to maintain low inflation rate that will direct to advance the economic growth. Conversely, the findings did not find supporting evidence for exports and employment level to have a significant contribution to economic growth. Hence, it is suggested that government required to reducing taxes and control spending constant or maintain taxes constant and increase spending to encourage growth and reduce unemployment to foster domestic investment in the economy.

The study finds that there is a unidirectional causal linkage between GDP and employment, GDP and inflation. So it suggests that inflation and employment have short run effects on economic progression in India. The study observes that growth of economy coupled with tight labor market and decreased the inflation rate. This low inflation rate will have an exponential effect and leads to increase in economic growth and decrease the unemployment rate. The study suggests that it is fundamental to maintain a balance between inflation, GDP, employment, savings, investment, and government revenue to keep the economy growing in India. The progress of economy needs a combination of three elements: impulse growth in domestic investment, high rate of growth in income to raise the productivity and efficiency as it links between resources to factories, and people to jobs and products to markets. These findings have important policy implications since an economy is built on infrastructure. The study suggests that it is important for India to place a greater emphasis on infrastructure development for fostering economic growth in the country.

REFERENCES

Aschauer, D. A. 1989a. Is public expenditure productive? *Journal of Monetary Economics* 23 (2): 177-200.

Aschauer, D. A. 1989b. Public investment and productivity growth in the group of seven. *Economic Perspectives* 13: 17-25.

Aschauer, D. A. 1989c. Does public capital crowd out private capital? *Journal of Monetary Economics* 24: 171– 188.

Banerjee, A., J. J. Dolado, J. W. Galbraith, and D. Hendry. 1993. *Cointegration, error correction and the econometric analysis of non-stationary data*. New York: Oxford University Press.

Calderón, C. and L. Serven. 2003. The output cost of Latin America's infrastructure gap. In W. Easterly and L. Serven, editors, *The limits of stabilization: Infrastructure, public deficits, and growth in Latin America*. Palo Alto, CA: Stanford University Press; Washington D.C.: World Bank.

Calderón, C. and L. Serven. 2004. The effects of infrastructure development on growth and income distribution. Accessible at: elibrary.worldbank.org/doi/book/10.1596/1813-9450-3400.

Canning, D. and P. Pedroni. 1999. Infrastructure and long run economic growth. *Consulting Assistance on Economic Reform II, Discussion Papers* No. 57.

Canning, D. and P. Pedroni. 2004. The effect of infrastructure on long run economic growth. Available at: http://web.williams.edu/Economics/wp/pedroniinfrastructure.pdf.

Devarajan, S., V. Swaroop, and H. F. Zou. 1996. The composition of public expenditure and economic growth. *Journal of Monetary Economics* 37 (1): 313-344.

Easterly, W. and S. Rebelo. 1993. Fiscal policy and economic growth: An empirical investigation. *Journal of Monetary Economics* 3 (32): 417-458.

Esfahani, H. S. and M. T. Ramirez. 2003. Institutions, infrastructure and economic growth. *Journal of Development Economics* 70 (2): 443-477.

Fedderke, J. W. and Z. Bogeti. 2006. Infrastructure and growth in South Africa: Direct and indirect productivity impacts of 19 infrastructure measures. *Policy Research Working Paper* No. 3989. Washington D.C.: World Bank.

Fedderke, J. W., P. Perkins, and J. M. Luiz. 2006. Infrastructural investment in long-run economic growth: South Africa 1875-2001. *World Development* 34: 1037-59.

Granger, C. W. J. 1969. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica* 37 (3): 424-438.

Herranz-Loncán, A. 2007. Infrastructure investment and Spanish economic growth, 1850–1935. *Explorations in Economic History* 44 (3): 452-468.

Kaur, G., L. Lakshmanan, R. Rajesh, and N. Kumar. 2010. Infrastructure financing: Global pattern and the Indian experience. *The Reserve Bank Staff Studies SS (DEAP)* No. 2010: 4.

Kumar, S. 2010. Determining of real exchange rate in India: An ARDL approach. *Reserve Bank of India* 31 (1): 33-64.

Kumo, W. L. 2012. Infrastructure investment and economic growth in South Africa: A Granger causality analysis. *Development Research Department of the African Development Bank*, *Working Paper* No. 160.

Murty, K. N. and A. Soumya, 2006. Effects of public investment in infrastructure on growth and poverty in India. *Indira Gandhi Institute of Development Research Working Papers* No. 2006-006.

Nannan, Y. and M. Jianing. 2012. Public infrastructure investment, economic growth and policy choice: Evidence from China ICPM-2012. *Crisis Management in the Time of Changing World*, Atlantis Press.

Pesaran, H. M. and B. Pesaran. 1997. *Working with micro fit 4.0*. New York: Oxford University Press.

Pesaran, H. M., Y. Shin, and R. J. Smith. 2000. Structural analysis of vector error correction models with exogenous I(1) variables. *Journal of Econometrics* 97 (2): 293-343.

Prasad, S. 2011. How much does India invest on infrastructure? *The Economic Times Bureau* Febrary 18.

Roller, L. H. and L. Waverman, 2001.Telecommunications infrastructure and economic development: A simultaneous approach. *American Economic Review* 91 (4): 909-923.

Sahoo, P. 2006. FDI in South Asia: Trends, policy, impact and determinants. *ADBI Discussion Paper Series* No. 56.

Sahoo, P and R. K. Dash. 2008. Economic growth in South Asia: Role of infrastructure. *Working Paper Series* No. E/288/2008. Institute of Economic Growth, New Delhi, India.

Sahoo, P., R. K. Dash, and N. Nataraj. 2010. Infrastructure development and economic growth in China. *IDE Discussion paper* No 261.

Walsh, J. P., C. Park, and J. Yu. 2011. Financing infrastructure in India: Macroeconomic lessons and emerging market case studies. *IMF Working Paper* No. 11/181.

World Bank. 1994. *World development report 1994: Infrastructure for development*. New York: Oxford University Press.