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INFRASTRUCTURE DEVELOPMENT AND ITS IMPACT ON ECONOMIC GROWTH OF INDIA

Tushinder Preet Kaur* **and Kuldip Kaur****

Abstract: *The present study endeavors to analyze the link between economic growth and infrastructure development by utilizing the technique of co-integration and VECM. It has been observed that there exists a long run relationship between GDP, infrastructure development, gross capital formation and public debt. The causal relationship between GDP and GCF is positive and statistically significant along with the negative growth elasticity of employment. The co-integration analysis depicts the one percent increase in public debt increases the infrastructure by 0.22 percent which highlights the public financing of infrastructure in India. The negative and significant effect of existing infrastructure stock on next period GDP reflects the small dose of infrastructure investments may have no long lasting effect on output growth or ineffectiveness in use of infrastructure.*

Keywords: *Infrastructure, Unit Root, Co-integration, Vector Error Correction Model, Impulse Response Function*

JEL Code Classification: *C01, C32, O18*

INTRODUCTION

Growth of every economy depends upon the level of investment and infrastructure development. As infrastructure development is prerequisite and essential for providing take off to any economy, therefore, many studies on the ways to spur growth, reduce poverty, improving the quality of human life in low-income developing economies has stressed on the need to promote a large increase in public investment in infrastructure. If any nation wants to improve the socio-economic development of the people, it must give a big push to uplift the network of physical and social infrastructure. The cause and effect relationship between economic growth and infrastructure is of immense importance as less developed countries are deficit in infrastructure facilities yielding a negative sign to development path. The non-existence of critical level of infrastructure in these countries results in late and delayed doses of investments to the economy for development. But on the other hand presence of minimum level of social overhead capital could generate immense potential for capital formation thereby leading to the upliftment of social and economic welfare.

* Associate Professor, School of Business, Lovely Professional University, Punjab

** Professor of Economics, Punjab School of Economics, Guru Nanak Dev University, Amritsar

The availability of good and efficient infrastructure may have a positive effect on growth by improvingthe durability of private capital. This has important implications for spending onmaintenance and the quality of infrastructure. Lack of public spending oninfrastructure maintenance has been a recurrent problem in many developingcountries.According to the World Bank (1994), technical inefficiencies in roads,railways, power, and water in developing countries caused losses equivalent to aquarter of their annual investment in infrastructure in the early 1990s. Paved roads, inparticular, deteriorate fast without regular maintenance. Insufficient maintenance of arailroad system will cause frequent breakdowns and lower its reliability, creatingpotentially severe losses for users. Thus, increasing maintenance spending, byreducing power losses, telephone faults, and so on, would help to enhance theproductivity effects of public infrastructure on private production.

The empirical relationship between infrastructure capital and economic growth has been found to be controversial. Anumber of empirical studies have found very high returns to infrastructure investment (Aschauer, 1989; Canning and Fay, 1993). But, the robustness of the results has been questioned in otherempirical studies and surveys (Gramlich, 1994; Munnell, 1992). A major problem seems to bethat interactions between infrastructure and Gross Domestic Product (GDP) are mediated in the short run by a host ofvariables that cannot all be captured in statistical studies, and in the long run causality betweeninfrastructure and GDP cannot be established. While infrastructure may give rise to higherproductivity and output, past and future economic growth also tends to raise the demand forinfrastructure services and induce increased supply. Moreover, infrastructure inadequacies maynot have tangible output consequences in the short or medium run because infrastructure serviceshave substitutes and the assets may be used with different intensities. As a result, the empiricalbasis of the case for high returns to infrastructure investment has been elusive (Ramirez & Esfahani, 1999).

Moving essentially from Barro (1988) and Aschauer (1989) many studies analysing the relationship between infrastructures and the economic development have realised that there is a broad spectrum of theoretical viewpoints, some of them diametrically opposed to one another. A general consensus is achieved around the idea that basic infrastructure facilities are important features related *to* economic performance. Apart from this main idea, opinion differs greatly; that is why both magnitude and causality remain subjects of debate.

In the macroeconomic literature, a number of studies have found empirical support for a positive impact of infrastructure on aggregate output. Aschauer (1989) found that the stock of public infrastructure capital is a significant determinant of aggregate total factor productivity. The study has confirmed the significant output contribution by infrastructure development.

Easterly and Rebelo (1993) found that public expenditure on transport and communications significantly raises growth. Also, Sanchez-Robles (1998) found that summary measures of physical infrastructure were positively and significantly related to growth in GDP per capita. Easterly (2001) reported that a measure of telephone density contributes significantly to explain the growth performance of developing countries over the last two decades.

Calderon and Serven (2003) estimated the Cobb-Douglas production function and found the positive and significant output contributions of three types of infrastructure assets namely telecommunications, transport and power. The estimated marginal productivity of these assets significantly exceeds that of non-infrastructure capital. On the basis of these estimates, they have found that a major portion of the per-capita output gap that opened between Latin America and East Asia over the 1980s and 1990s could be traced to the slowdown in Latin America's infrastructure accumulation in those years.

The present study attempts to analyse the cause and effect relationship between infrastructure and economic growth of the country. Therefore, in order to examine the relationship between economicgrowth and infrastructure development the technique of co-integration analysis (Engleand Granger, 1987) and (Johansen and Juselius, 1990)has been utilized. The estimation procedure involves threesteps. The first step is to test for stationarity of the time series data with the help ofunit root tests. The presence of unit root makes the regression results spuriousand thus disturbs the accuracy of the parameters estimated. An application ofAugmented Dickey Fuller (ADF) and Phillip Perron (PP) tests is found suitable todetect whether the selected time series variables are stationary at their levels ornot. If data are not stationary at their levels, as most of the time series variablesare, then one way of achieving stationarity is to difference the time series datauntil stationarity is achieved. However, this solution is not ideal. If we differencethe variables, the model can no longer give a unique long-run solution and also this will result into loss of one degree of freedom (Asteriouand Hall, 2007). To resolvethis problem, the methodology of co-integration and Error Correction Mechanism(ECM) seem very useful.

In the present case the time series variables are non stationary at their levels, and theyaresaid to be co-integrated if any linear combination of these non-stationary variablesprovides a series which is stationary at levels. This type of relationship is known aslong-run relationship between the variables. Granger (1981) introduced aremarkable link between non-stationary processes and the concept of long-run equilibrium often called concept of co-integration. Engle and Granger (1987) further formalized this concept by introducing a very simple test for the existenceof co-integrating (i.e. long-run equilibrium) relationships. In such a case, aftertesting for the existence of co-integration, in case it exists, it becomes necessary toform the model in the equivalent ECM (Error Correction Model) to get causalrelationship between time series variables. The Granger representation theoremestablished that any co-integrated series have an ECM and its converse is also true (Engle and Granger, 1987). Therefore, co-integration is a necessary condition foran ECM to hold (Engle and Granger, 1991).

But if we have more than two variables in the model, then there is the possibility of having more than one co-integrating vector which could result in several equilibrium relationships governing the joint evolution of all the variables. In general for n number of variables we can have only up to n-1 co-integrating vectors. Therefore, when n=2 which is the simplest case, we can understand that if co-integration exists then the co-integrating vector is unique. However, when there ismore than one vector, there is a very serious problem that cannot be resolved by the EG single equation approach. Therefore, an alternative to the EG approach is needed and this is the Johansen approach for multiple equations.

The approach is given by extending the single equation error correction model to a multivariate one, let's assume that we have three variables, Y_t, X_t and W_t which are endogenous, i.e. we have that (using matrix notation for $Z_t = [Y_t, X_t, W_t]$)

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + --- + A_k Z_{t-k} + u_t \tag{1}$$

It can be reformulated in a vector error correction model (VECM) as follows:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + --- + \Gamma_{k-1} \Delta Z_{t-k-1} + \Pi Z_{t-1} + u_t \tag{2}$$

Where $\Gamma_i = (I - A_1 - A_2 - ... - A_k)$ and $\Pi = -(I - A_1 - A_2 - ... - A_k)$.

(i = 1, 2, … , k-1)

Here we need to carefully examine the Π matrix of order 3×3. The Π matrix contains information regarding the long run relationships. We can decompose $\Pi = \alpha\beta'$ where α will include the speed of adjustment to equilibrium coefficients while β' will be the long run matrix of coefficients. Therefore the $\beta' Z_{t-1}$ term is equivalent to the error correction term $(Y_{t-1} - \beta_0 - \beta_1 X_{t-1})$ in the single equation case, except that now $\beta' Z_{t-1}$ contains up to (n-1) vectors in a multivariate framework.

According to this approach, after examining the unit root test the next step is to find the appropriate lag length of the model. The issue of finding appropriate lag length is very important because we want to have Gaussian error terms (i.e. standard normal error terms that do not suffer from non-normality, autocorrelation, heteroskedasticity etc.). It is worth mentioning that the value of the lag length is affected by the omission of variables that might affect only the short run behavior of the model. This is due to the fact that omitted variables instantly become part of the error term. Therefore, very careful inspection of the data and the functional relationship is necessary before proceeding with estimation in order to decide whether to include additional variables or not.

The most common procedure in choosing the optimal lag length is to estimate a VAR model including all our variables in levels. This VAR model should be estimated for a large number of lags, then reducing down by re-estimating the model for one lag less until we reach zero lags (i.e. we estimate the model for 12 lags, then 11, then 10 and so on until we reach 0 lags). In each of these models we inspect the values of the AIC and the SBC criteria.The model that minimizes AIC and SBC is selected as the one with the optimal lag length. If any conflict arises between the minimum values of AIC and SBC then one should prefer the minimum of SBC to select optimal lag length.

Another important aspect regarding the formulation of the dynamic model is whether an intercept and/or a trend should enter in either the short run or the long run model, or in both models. In general there are five distinct models which are: *i)* No intercept or trend in CE or VAR ($\delta_1 = \delta_2 = \mu_1 = \mu_2 = 0$); *ii)* Intercept (no trend) in CE, no intercept or trend in VAR ($k \times k$); *iii)* Intercept in CE and VAR, no trends in CE and VAR ($\delta_1 = \delta_2 = 0$); *iv)* Intercept in CE and VAR, linear trend in CE, no trend in VAR ($\delta_2 = 0$); and *v)* Intercept and quadratic trend in the CE intercept and linear trend in VAR. It has been observed that the first and the fifth are not that realistic so it is very difficult to interpret these models from an economic point of view, especially since the variables are entered as logs, because a model like this would imply an implausible ever-increasing or ever-decreasing rate of change.

As we mentioned that the first and the fifth are not that realistic therefore the problem reduces to a choice of one of the three remaining models. Johansen (1992) suggests the method to test the joint hypothesis of both the rank order and the deterministic components by applying the so called *Pantula principle*. Further, in order to determine the rank or the number of co-integrating vectors Johansen and Juselius (1990) provides two methods namely Lambda Max (λ_{max}) and Trace Statistics which are based on propositions about Eigen values. As the former one is based on the maximum Eigen value and because of that is called the maximum Eigen value statistic however, the second method is based on a likelihood ratio test about the trace of the matrix and that's why it is known as the trace statistic. Further, it may be possible that the trace statistic and the maximum Eigen value statistic may yield conflicting results. For such cases, it is recommended that one should examine the co-integrating vector and base their choice on the interpretability of the co-integrating relations (Johansen and Juselius, 1990).

If the time series variables are integrated of sameorder, then the next step is to estimate the long-run equilibrium relationship viaestimating Co-integrating regression equation. Further, the estimation of the Error-Correction Model helps to analyze the long-run and short-rundynamics of the variables.

In order to establish empirical evidence, short-run and long-run causal relationship between infrastructure development and other major economic policy variables, the data has been squeezed out from Center for Monitoring Indian Economy (CMIE) infrastructure reports and "*Handbook of Indian statistics on Indian Economy*" provided by Reserve Bank of India (RBI). Further, the method of Principal Component Analysis has been utilised to construct the infrastructure index to represents all major infrastructure variables. Moreover, the impact of increase or decrease in prices on all policy variables has been neutralized at 2001-02 prices by using appropriate price deflators. To achieve the stationarity of the data available, natural log of all the variables have been considered. It would be helpful to achieve the stationarity in the less order of integration in case the log of these variables is non-stationary at levels. All the variables along with their abbreviations are summarized in Table 1.

Table 1
Summary of Variables

S.No	*Abbreviation of Variable*	*Variables Description*
1	LNGDP	Log of Gross Domestic Product
2	LNINFRA	Log of Infrastructure
3	LNDEBT	Log of Public Debt
4.	LNEMPL	Log of Foreign Direct Investment
5.	LNGCF	Log of Gross Capital Formation
6	LNWPI	Log of Wholesale Price Index (Inflation Proxy)

Source: Author's Elaboration

Empirical Substantiation

This section describes the econometric estimation about the existence of short-run and long-run relationship between the aforementioned variables. As the estimation procedure requires the stationarity of all variables, therefore in first step the time series impurity of non-stationarity and the presence of unit root in the variables has been reviewed. The Unit Root Test, proposed by Augmented Dickey Fuller (1979) and Phillips Perron (1988), for the stationarity of time series are performed on both levels and first differences for all the six variables and results are reported in Table 2. The results of both the tests confirm the rejection of null hypothesis of stationarity in the levels of the selected endogenous variable whereas the first differencing of all the variables yields acceptance of the null hypothesis of stationarity. Based on these results it is therefore concluded that the six variables namely, *LNGDP, LNINFRA, LNDEBT, LNGCFLNWPI* and *LNEMPL* are integrated of order one i.e., I(1). Since all these variables are integrated of same order we can test whether a long run relationship exists or not by applying cointegration analysis.

Table 2
Testing of Unit Root Test

Unit Root at Level

		AgumentedDicky Fuller Test			*Phillip Perron Test*		
S.No.	*Variable*	*With Drift*	*With Drift and Time Trend*	*Without Drift and Time Trend*	*With Drift*	*With Drift and Time Trend*	*Without Drift and Time Trend*
1	***LNEMP***	(-)6.935** (0.0000)	(-)2.176 (0.4872)	(-)0.595 (0.4509)	(-)6.26** (0.0000)	(-)2.105 (0.5253)	2.159 (0.9913)
2	***LNWPI***	(-)1.993 (0.2882)	(-)1.590 (0.7746)	2.153 (0.9910)	(-)2.50 (0.1239)	(-)1.553 (0.7909)	5.684 (1.000)
3	***LNGDP***	2.581 (1.0000)	(-)1.987 (0.5878)	9.944 (1.0000)	3.539 (1.000)	(-)1.888 (0.6394)	10.740 (1.000)
4	***LNGCF***	(-)0.469 (0.8826)	(-)4.923 (0.0025)	4.413 (1.0000)	(-)0.273 (0.9734)	(-)3.097 (0.1227)	2.763 (0.9980)
5	***LNINFRA***	(-) 2.756 (0.0756)	(-) 2.404 (0.3709)	13.103 (1.0000)	(-) 6.179** (0.0000)	(-) 2.384 (0.3809)	11.822 (1.0000)
6	***LNDEBT***	0.801 (0.9924)	(-) 2.793 (0.2103)	1.707 (0.9760)	1.926 (0.9997)	(-) 1.951 (0.6066)	2.996 (0.9989)

Unit Root at First Difference

		AgumentedDicky Fuller Test			*Phillip Perron Test*		
S.No.	*Variable*	*With Drift*	*With Drift and Time Trend*	*Without Drift and Time Trend*	*With Drift*	*With Drift and Time Trend*	*Without Drift and Time Trend*
1	***LNEMP***	(-)0.603* 0.0556	(-)5.704** (0.0002)	(-)1.365 0.1561	(-)4.494** (0.0011)	(-)5.704** (0.0002)	(-)3.835** (0.0004)
2	***LNWPI***	(-)4.131** 0.0028	(-)4.466** (0.0059)	(-)1.652 0.0923	(-)4.072** (0.0033)	(-)4.332** (0.0082)	(-)1.955* (0.0496)
3	***LNGDP***	(-) 6.135** (0.0000)	(-)7.542** (0.0000)	(-)0.651 (0.4277)	(-)6.145** (0.0000)	(-)10.955** (0.0000)	(-)1.748 (0.0763)
4	***LNGCF***	(-) 4.822** (0.0006)	(-)4.704** (0.0044)	(-)5.461** (0.0000)	(-) 6.185** (0.0000)	(-)6.188** (0.0001)	(-)5.462** (0.0000)
5	***LNINFRA***	(-)5.556** (0.0001)	(-)6.652** (0.0000)	(-) 1.142 (0.2250)	(-)5.173** (0.0002)	(-)10.022** (0.0000)	(-) 1.806 (0.0678)
6	***LNDEBT***	(-)1.842 (0.3535)	(-) 2.256 (0.4416)	(-) 2.277* (0.0239)	(-)3.087 (0.0370)	(-) 4.070** (0.0155)	(-) 2.209* (0.0281)

Notes: i) * and ** denotes significance at 5 percent level and 1 percent level respectively.
Source: Author's Calculations

Since the present study involves the more than two variables, therefore the co-integration technique developed by Johansen and Juselius (1990) has been used. The application of the above mentioned technique first requires the selection of lag length, therefore, a VAR system of various lag lengths, assuming all the selected variable are endogenous and no exogenous variable, has been estimated. The lag length varies from maximum permissible lag length (i.e., 5, feasible as per the size of the sample) to the minimum of the unity. For all the estimated models of diverse lag lengths the value of Log-Likelihood, Akaike's Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC) has been perceived.

Table 3
Choice Criterion for Selecting the Lag Length

S.No	*Order*	*Log Likelihood*	*Akaike Information Criterion (AIC)*	*Schwartz Bayesian Criterion (SBC)*
1	1-0	142.347	(-) 8.796	(-) 8.519
2	1-1	380.286	(-) 21.824	(-) 19.882*
3	1-2	425.935	(-) 22.447	(-) 18.839
4	1-3	499.856	(-) 24.893	(-) 19.620
5	1-4	613.31	(-) 29.873*	(-) 19.439
6	1-5	514.83	(-) 19.981	(-) 21.382

Note: * denotes the optimal lag length suggested by information criterion
Source: Author's Calculations

The above Table 3 reports the value of Log Likelihood, AIC and SBC by executing VAR models of different lag length. As per the existing literature on VAR modeling, that model which minimizes the AIC and SBC has been selected as one of the optimum lag length. Further, if any conflict between the lag length suggested by minimum values by AIC and SBC arises then one should prefer minimum of SBC to select the optimum lag length (Asteriou& Hall, 2007). Thus the minimum value of SBC in the above mentioned table is (-) 19.882 which suggests that the optimum lag length is one (*i.e.*1-1).

Before proceeding with the co-integration test it is necessary to identify one of the five models available in the econometric literature for explaining the long run relationship between the variables. The problem is which of the five different models is appropriate in the testing for co-integration. For the selection of the deterministic components Johansen (1991) suggests the need to test the joint hypothesis of both the rank order and the deterministic components, based on the so called *Pantula principle*.

To pursue the above said task the three alternative models have been estimated and the results are presented in Table 4. Furthermore, the trace statistic of all these three models together has been presented in Table 5 in order to select the appropriate model. In order to select the model, one should move with a smaller value of Co-integrating vector (i.e., r=0) and check whether the trace statistic for model 2 rejects the null hypothesis or not. If yes, then one has to proceed to the right, checking whether model 3 rejects null hypothesis or not and so on. The estimation of Trace statistics shows that in the present analysis model three (i.e., with intercept in CE and VAR) has been selected for the co-integration purpose because the value of trace statistic (i.e. 46.56) first time becomes less than the critical value at 5 percent level of significance.

Table 4
Estimation of Trace Statistics for Model Selection

S. No.	*Hypothesized No of CE (s)*	*Eigen value*	*Trace Statistics*	*5% Critical Value*	*p-Values*
Co-integration Test Results (Model 2)					
1	None*	0.7872	146.60	103.8473	0.000
2	At Most 1*	0.6063	93.97	76.9727	0.001
3	At most 2*	0.5660	62.27	54.0790	0.007
4	At most 3	0.3714	33.89	35.1927	0.068
Co-integration Test Results (Model 3)					
1	None*	0.7733	125.52	95.7536	0.000
2	At Most 1*	0.5674	75.05	69.8188	0.018
3	At most 2	0.5318	46.56	47.8561	0.065
4	At most 3	0.3035	20.75	29.7970	0.373
Co-integration Test Results (Model 4)					
1	None*	0.8012	155.35	117.7082	0.000
2	At Most 1*	0.6947	100.42	88.8038	0.005
3	At most 2	0.5360	60.08	63.8761	0.100
4	At most 3	0.3343	33.97	42.9152	0.289

Notes: i) * denotes rejection of the Hypothesis at 5 percent level of significance;ii) Trace Statistics indicates 2 Cointegrating equations at 5 percent level
Author's Calculations

Therefore, *Pantula Principle* prescribed model three as the best suited model for the data set to study the long-run relationship between infrastructure and economic growth along with the other policy variables such as public debt, employment and gross capital formation. After selecting the model used for evaluating Co-integrating equations the next step involves examining the presence of Co-integrating relationship among the variables specified in the model. Applying the Johansen and Juselius (1990) procedure on the results obtained from the present analysis reveals that there are two Co-integrating relationships among all the six variables in the model in long run.

Table 5
Pantula Principal Results (Trace Statistics)

S. No	*R*	*n-r*	*Model 2*	*Model 3*	*Model 4*
1	0	4	146.60	125.52	155.35
2	1	3	93.97	75.05	100.42
3	2	2	62.27	46.56*	60.08
4	3	1	33.89	20.75	33.97

Notes: i) Model 2 indicates intercept (no trend) in cointegration equation (CE)-no intercept in VAR; ii) Model 3 indicates intercept (no trend) in CE and VAR;iii) Model 4 represents intercept and trend in CE-no trend in VAR; iv) * indicates the first time acceptance of null-hypothesis of number of cointegration vectors, when moving from right to left; and v) The values without any symbol are significant at 5 percent level of significance.
Source: Author's Calculations

Tables 6 and 7 explain the validity of restrictions imposed upon the adjustment coefficients via comparing the calculated value ofChi-square (χ^2) at 5 percent level of significance with two degrees of freedom. It has been identified that *LNGDP* and *LNWPI* are weakly exogenous in short run. Further, by imposing row restrictions, in co-integrating vector it has been identified that *LNWPI* is weakly exogenous even in long run. Therefore, it can be excluded from the left hand side of VECM and it should be considered as exogenous variable while examining the long run co-integrating relationship.

Table 6
Testing Short-Run Weak Exogeneity of Variables

S.No.	*Variable Name*	*Restriction Imposed*	*Chi-Square Statistics*	*Critical Value (5%)*	*Result about Weak Exogeneity*
1	LNGDP	$\alpha_{11} = 0, \alpha_{12} = 0$	1.698	0.427	Yes
2	LNINFRA	$\alpha_{21} = 0, \alpha_{22} = 0$	5.177**	0.075	No
3	LNDEBT	$\alpha_{31} = 0, \alpha_{32} = 0$	4.172*	0.024	No
4	LNGCF	$\alpha_{41} = 0; \alpha_{42} = 0$	8.503*	0.014	No
5	LNWPI	$\alpha_{51} = 0; \alpha_{52} = 0$	1.142	0.564	Yes
6	LNEMPL	$\alpha_{61} = 0; \alpha_{62} = 0$	2.766*	0.025	No

Notes: i) Restrictions imposed represent the null hypothesis (H_0) to be tested; ii) * and ** represent the value is significant at 5 percent and 10 percent levels of significance, respectively.
Source: Author's Calculations

The next stage of our analysis is confined to explain the cointegration equations among the all six variables i.e. *LNGDP, LNINFRA, LNDEBT, LNGCF, LNWPI* and

Table 7
Testing Long-Run Weak Exogeneity of Variables

S.No.	*Variable Name*	*Restriction Imposed*	*Chi-Square Statistics*	*Critical Value (5%)*	*Result about Weak Exogeneity*
1	LNGDP	$\beta_{11} = 0, \beta_{21} = 0$	18.458*	0.000	No
2	LNINFRA	$\beta_{12} = 0, \beta_{22} = 0$	22.777*	0.000	No
3	LNDEBT	$\beta_{13} = 0, \beta_{23} = 0$	9.902*	0.007	No
4	LNGCF	$\beta_{14} = 0, \beta_{24} = 0$	14.431*	0.000	No
5	LNWPI	$\beta_{15} = 0, \beta_{25} = 0$	3.593	0.261	Yes
6	LNEMPL	$\beta_{16} = 0, \beta_{26} = 0$	18.990*	0.000	No

Notes: i) Restrictions imposed represent the null hypothesis (H_0) to be tested; ii) * represent the value is significant at 5 percent levels of significance
Source: Author's Calculations

*LNEMPL*which have been shown in Table 8. After normalization at β_{11} = 1 reveals that a one percent increase in *LNDEBT,* will increase the *LNGDP* by 0.5 percent approximately. The increase in public debt for developing country means greater spending by the government on productive and development activities. The country like India where a lot of responsibilities lie with government to develop infrastructure, the increase in debt(if spent on productive activities) or alternatively public financing of public infrastructure have great importance and have positive and remarkable impact on output (GDP). The causal relationship between *LNGDP* and *LNGCF* reveals that one percent increase in gross capital formation will increase the gross domestic product by 0.08 percent. Although the change is very small, yet it is positive and statistically significant. Further, the relationship between employment and GDP reveals that one percent increase in employment reduces the GDP or output by 0.03 percent. The negative growth elasticity of employment in organized sector can be justified on the ground that either the involvement of excess manpower or lack of capital has insisted decreasing returns to scale in organized sector over the study period.

Further, the normalization at β_{22} = 1 depicts that one percent increase in public debt increase the infrastructure by 0.22 percent, thus highlights the public financing of infrastructure in India. Further it has been observed that one percent change in infrastructure could lead to 9.8 percent (=1/ 0.102) decrease in GCF. The negative infrastructure elasticity of gross capital formation may be supported on the ground that excessive public financing of infrastructure may result in high tax rates in subsequent periods and increased rate of interest, because of selling of 'Gilt Edge' securities, may reduce the rate of return on private capital formation. The infrastructure also has positive and significant causal relationship with employment. As the infrastructure roads, railways, ports, etc. particularly the soft infrastructure such as telecommunication, information technology develop, given the positive impact on education the growth of organized employment will find an increase. It has been estimated that one percent increase in infrastructure could result in 6.7 percent increase in employment in organized sector.

Table 8
Estimated Co-integrating Vectors (Relationships)

After Normalizing Without Restrictions

S.No.	*Variable Name*	*Equation I*	*Equation II*
1	LNGDP	1.000	0.000
		(0.000)	(0.000)
2	LNINFRA	0.000	1.000
		(0.000)	(0.000)
3	LNDEBT	(-) 0.478	(-) 0.221*
		(0.069)	(0.047)
4	LNGCF	(-) 0.084*	0.102*
		(0.047)	(0.032)
5	LNEMPL	0.029	(-) 0.150*
		(0.404)	(0.049)
6	Constant	(-) 8.532	(-) 9.859

Notes: i) Figures in parenthesis of type ( ) are the z-values; ii) * represent the value is significant at 5 percent levels of significance.
Source: Author's Calculations

After using the normalizing restriction $\beta_{11} = 1$, $\beta_{21} = 1$, $\beta_{12} = 0$, $\beta_{22} = 0$, it has been observed that one percent increase in infrastructure index is accompanied by 1.07 percent increase in GDP. The development of infrastructure has a positive and significant impact on economic growth in long run. The result supports the hypothesis to invest more in infrastructure to achieve or maximize the economic growth in long run. As the infrastructure development has positive and significant impact on increase in output (GDP), domestic investment and organized employment thus the policy of increase in infrastructure is advocated on the ground of these externalities.

It has been observed that the error term in first co-integrating equation is negative and significant at 5 percent level of significance. The negative error correction term in the first co-integrating equation represents that the GDP in short run is below equilibrium (the disequilibrium is present) and any disequilibrium in gross domestic product will be corrected in 0.16 (=1/6.178) years period (if it is (-)1 then it will be corrected in next period). Therefore, considering the long run error equation

Table 9
Estimated Co-integrating Vectors (Relationships)

After Normalizing Using Restrictions			
S.No.	*Variable Name*	*Equation I*	*Equation II*
1	*LNGDP*	1.000 (0.000)	1.000 (0.000)
2	*LNINFRA*	(-) 1.072* (0.000)	0.000 (0.000)
3	*LNDEBT*	(-) 0.453* (0.000)	(-) 0.475* (0.000)
4	*LNGCF*	(-) 0.074* (0.000)	(-) 0.084* (0.000)
5	*LNEMPL*	0.044* (0.000)	0.029* (0.000)
6	*Constant*	(-) 7.533* (0.000)	(-) 8.532* (0.000)

Notes: i) Figures in parenthesis of type ( ) are the *z-values*; ii)* represent the value is significant at 5 percent levels of significance, respectively.
Source: Author's Calculations

$$LnGDP - 0.475LnDEBT - 0.084LnGCF + 0.0293LnEMPL - 8.532 = Error\,)$$

in order to put GDP on equilibrium track, there is need to decrease GCF and debt and at the same time increase in employment because of same sign with error term. However, it seems odd to reduce GCF in growing economy. As we know the GCF is stock and carry over concept therefore it cannot be reduced. It contributes to economic growth in both demand and supply side therefore, it is important to increase its efficiency what the Domar called capital efficiency in order to increase economic growth. Following Paveleseu (2008), the efficiency of gross capital formation is strongly influenced by the relativechange of domestic demand and trade deficits. Therefore, it advocates the policy to enhance the capital accumulation efficiency by reducing huge current account deficits.

As regards infrastructure, it has been found that the error term in first equation is positive and significant which means infrastructure is above the equilibrium level and the disequilibrium will be corrected in period of 0.27 (1/3.649) years. Moreover, it has been observed from second equation ($LnINFRA - 0.242LnDEBT + 0.102LnGCF - 0.150LnEMPL - 9.859 = Error$) that, the GDP will fall as the error term of second co-integrating equation is positive. It is interesting to note that, why the GDP falls despite the fact that GDP does not enter into the second equation. It is little convoluted as the error term is positive, it suggests that the infrastructure is above the equilibrium level and may decrease in stock as it remains unutilized. As the error term is positive and has negative sign with variable debt in long run it shows the debt is below equilibrium level and may increase as a consequence of this whereas it must fall to correct the equilibrium according to the first equation.

Further the negative and significant effect of $LNGDP_t$ on $LNINFRA_{t-1}$ reveals that in short run increase in infrastructure in current period may result in fall in output in next period. The fall of output because of infrastructure in short run may be advocated on the ground that, given the constant saving rate, investment in infrastructure has diversion of capital from other type of investments and as a result of which the share of other investmentsand output may decrease which may reduce the saving and future investment and thereby economic growth. This could happen because of small dose of infrastructure investments which may have no long standing effect on output. However, if large investment in infrastructure takes place in short period then effect is positive and long lasted.

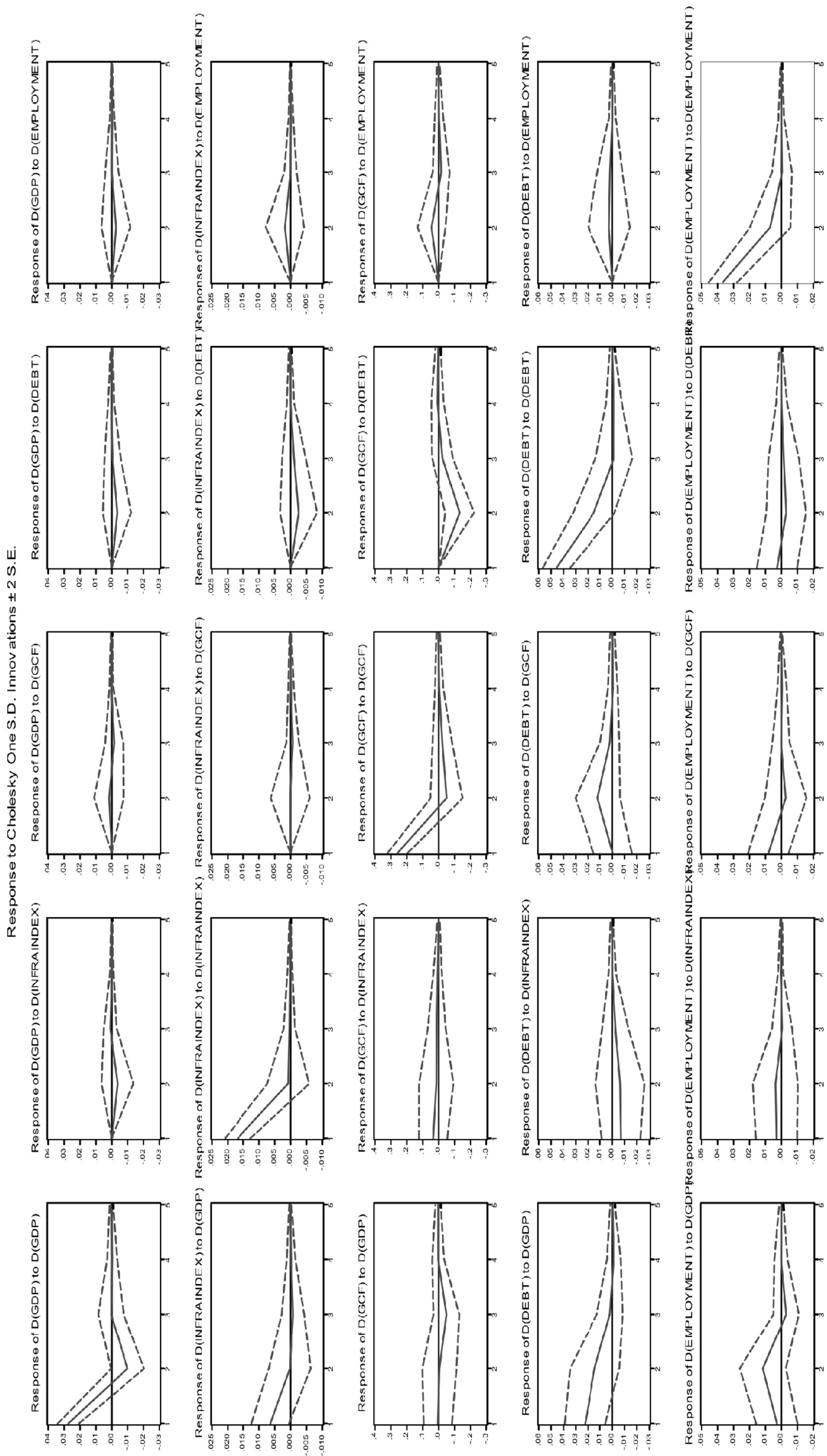
The literature on infrastructure expresses the need to apply more public investment in infrastructure which is necessary to raise the GDP in developing economies. In fact, many policy makers, planners and economists may advocate this. But the extent to which GDP rises with additional investment in infrastructure depends upon how efficiently it is used. Moreover, the magnitude of increase in

Table 10
Estimated Coefficient of Vector Error Correction Mechanism

		Dependent Variable				
		$\Delta LNGDP_t$	$\Delta LNINFR_t$	$\Delta LNDEBT_t$	$\Delta LNGCF_t$	$\Delta LNEMPL_t$
1	Error Eq.1	(-)6.178*	3.649*	1.940	8.959*	5.136
		[(-)1.973]	[2.755]	[0.336]	[3.389]	[1.226]
2	Error Eq. 2	5.761**	(-)3.467**	(-)1.330	(-)8.019	(-)4.437
		[1.937]	[(-)1.792]	[(-)0.248]	[(-)1.441]	[(-)1.138]
3	$\Delta LNGDP_{t-1}$	(-)0.068	0.001	(-)0.141	0.602	(-)0.017
		[(-)0.291]	[0.011]	[(-)0.333]	[0.310]	[(-)0.055]
4	$\Delta LNINFRA_{t-1}$	(-)0.626**	0.196	0.050	4.621	0.700
		[(-)1.723]	[0.832]	[0.077]	[1.549]	[1.271]
5	$\Delta LNDEBT_{t-1}$	(-)0.083	(-)0.042	0.266	(-)2.638*	(-)0.114
		[(-)0.860]	[(-)0.673]	[1.523]	[(-)3.307]	[(-)0.897]
6	$\Delta LNGCF_{t-1}$	(-)0.003	0.009	0.021	0.000	(-)0.026
		[(-)0.163]	[0.758]	[0.602]	[0.002]	[(-)1.031]
7	$\Delta LNEMPL_{t-1}$	0.007	0.030	(-)0.174	0.536	(-)0.040
		[0.054]	[0.335]	[(-)0.697]	[0.472]	[(-)0.225]
8	Constant	0.331	(-)0.247	0.681	(-)7.109	0.550
		[1.350]	[(-)1.547]	[1.539]	[(-)3.524]	[1.710]
9	$\Delta LNWPI_t$	(-)0.066	0.075	(-)0.170	(-)1.902*	0.139
		[(-)1.037]	[0.805]	[(-)1.473]	[(-)1.673]	[0.656]

Notes: i) Parenthesis of type [ ] consist of t-value.; ii) * and ** represents the level of significance at 5% and 10% respectively.

Source: Author's Calculations


Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of D(GDP) to D(GDP)
Response of D(GDP) to D(INFRAINDEX)
Response of D(GDP) to D(GCF)
Response of D(GDP) to D(DEBT)
Response of D(GDP) to D(EMPLOYMENT)
Response of D(INFRAINDEX) to D(GDP)
Response of D(INFRAINDEX) to D(INFRAINDEX)
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Response of D(INFRAINDEX) to D(DEBT)
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Response of D(EMPLOYMENT) to D(EMPLOYMENT)

output also depends upon effectiveness of its use. It is pertinent to note that low effectiveness with public investment in infrastructure may be detrimental to economy as it may reduce the output in short run because of crowding out effect of public spending.

Further, all the impact multipliers of *LNEMPL* are insignificant including the error term. Thus selection of this variable to design short run policy is irrelevant. The findings about this variable support *a-priori* expectation provided by the economic theory since it is difficult to reduce employment in short run because of existence of trade unions in organized employment sector. Further, in short period it becomes difficult to create full employment opportunities. Thus, it confirms that employment generation is long run phenomenon and hence finds little attention in short run planning.

Moreover, the graphs of impulse response function reflecting the Cholesky decomposition are presented in next section. Here, each variable responds to the unit shock equal to one standard deviation in all endogenous variables included in VECM. Each impulse is produced via interaction among all the variables. It is evident from graph that all shocks die down gradually and converge to zero over five to seven years.

CONCLUSION

In the present paper the link between economic growth and infrastructure development has been explored by utilizing the technique of co-integration and VECM. The resulting Co-integrating vectors indicate that there exists a long run relationship between GDP, infrastructure development, gross capital formation and public debt. It has been found that a one percent increase in *LNDEBT,*will reduce the *LNGDP* by 0.5 percent approximately. The country like India where a lot of responsibilities lie with government to develop infrastructure, the increase in debt(if spent on productive activities) or alternatively public financing of public infrastructure has great importance and has positive and remarkable impact on output (GDP). The causal relationship between *LNGDP* and *LNGCF* is positive and statistically significant. Further, the negative growth elasticity of employment in organized sector maybe either due to the involvement of excess manpower or due to lack of capital. The second co-inegrating vector depicts that one percent increase in public debt increases the infrastructure by 0.22 percent which highlights the public financing of infrastructure in India. Further it has been observed that one percent change in infrastructure could lead to 9.8 percent decrease in gross GCF. The negative infrastructure elasticity of gross capital formation may be due to excessive public financing of infrastructure. However, the infrastructure also has positive and significant causal relationship with employment. Therefore, the development of infrastructure has a positive and significant impact on economic growth in long run. The results support the hypothesis to invest more in infrastructure to achieve or maximize the economic growth in long run. As the infrastructure development has positive and significant impact on increase in output (GDP), domestic investment and organized employment, thus, the policy of increase in infrastructure is advocated on the ground of these externalities.

Further, the application of Vector Error Correction Model (VECM) reveals thatthe disequilibrium in gross domestic product will be corrected in 0.16 (=1/ 6.178) years. In order to put GDP on equilibrium track, there is need to enhance the capital accumulation efficiency by reducing huge current account deficits. The negative and significant effect of $LNGDP_t$ on $LNINFRA_{t-1}$ reveals that the fall of output because of infrastructure in short run may be due tothat small dose of infrastructure investments which may have no long standing effect on output or ineffectiveness of use of infrastructure.

Thus the above discussion comes to an end with a view that infrastructure is an important variable to augment economic growth. Investment in infrastructure can play a lead role through externalities to attract FDI inflows, expanding output, increasing employment opportunities. However it has been stated that infrastructure development will only be helpful in the development process when there is effective utilization of it along with proper maintenance and care.

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