INFRASTRUCTURE INVESTMENT AND ECONOMIC GROWTH IN INDIA: AN EMPIRICAL ANALYSIS

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Abstract

Infrastructure sector is a key driver for the Indian economy. Infrastructure may be termed as physical infrastructure which may include social infrastructure. Importance of infrastructure in economic growth cannot be overemphasized. Infrastructure is the lifeline of an economy and the fate of the economy is intricately linked to the development or otherwise of its infrastructure. The objective of the paper is to examine the effect of infrastructure investment on economic growth of India. Gross Capital Formation (GCF) and Gross Domestic Product (GDP) are considered as infrastructural development macroeconomic variable and economic growth variable respectively. The data have been collected for a period of 57 years i.e. 1960 – 2016 (World Bank). Different charts and graphs have been used to analyse the status of infrastructure investment during the study period. Short run and long run relationships between infrastructure investment and economic growth have been examined using time series econometric tools like VECM and Cointegration test. It is found that infrastructure investment and economic growth of India is integrated in long run which implies that there is a long run relationship between them.

Key Words: *Infrastructure; Investment; Economic Growth; VECM; Cointegration.*
JEL Classification: *H54, E62, O40*

1. Introduction

"Poor infrastructure impedes a nation's economic growth and international competitiveness (*The World Bank,* 2006)**.** Lack of adequate infrastructure also represents a major cause of loss of quality of life, illness and death (Willoughby, 2004). The infrastructure has gained prominence over the years and has a wider coverage with the advancement of technology and urbanization. Infrastructure is a key growth driver for any economy.

Generally, 'Infrastructure' means those basic facilities and services which facilitate different economic activities and thereby help in economic development of the country. Education,

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health, transport and communication, banking and insurance, irrigation and power, science and technology, etc. are the examples of infrastructure. These are also called social capital. These do not directly produce goods and services but induce production in agriculture, industry and trade by generating external economies. For example, an industry situated on or near the railway line or national highway will produce commodities at lesser cost. Here, railway line and / or national highway are the examples of economic infrastructure. They generate external economies and thus induce investment.

Infrastructure may be broadly classified into two categories - economic infrastructure and social infrastructure. Economic infrastructure functions within production, distribution, transport and communication system, power or energy, banking system, co-operatives, irrigation, etc. and social infrastructure contributes to the production process from outside the system by providing services related to education, health, training, housing, etc.

Infrastructure investment assists in increasing income, employment, productivity and consequently, the competitiveness of an economy. The World Economic Forum's (WEF) Global Competitiveness Report 2016-17 shows that India's global competitiveness ranking has improved significantly in 2016-17. India's rank jumped 16 places higher vis-à-vis 2015-16, from 55th place to 39th place in 2016-17. The biggest contributors to this improvement are infrastructure, the macroeconomic environment, education and performance of institutions. In terms of infrastructure, India's ranking improved dramatically in 2016-17 to 68 from 81 in 2015-16. The construction phases are related with the short-term effects and are a consequence of the decisions in the public sector that could affect different macroeconomic variables like GDP, employment, public deficit, inflation, etc.

The Government of India has considered the infrastructure as one of the key factors for the growth of the economy. Both from the public and the private sectors, investment must be required for overall infrastructure development, especially in the areas of health, education, sanitation, renewable energy, highways, ports and railways, etc.

As per the Planning Commission of India[1] , the infrastructure sector primarily comprises of electricity, roads, telecommunications, railways, irrigation, water supply and sanitation, ports and airports, storing facilities, and oil and gas pipelines. Given is the fact that strong infrastructure facilities form the backbone of a nation, as was evident from the 11th and 12th Five Year plans. During that time, the Government of India began to shift its focus on infrastructure development. The Planning Commission identified inadequate infrastructure as a significant barrier to economic growth. It instigated the Government to undertake different initiatives on infrastructure development.

However, growth drivers for any economy are government policies and initiatives, capital

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[1] Presently known as NITI Aayog (National Institution for Transforming India)

market efficiency, international investment, infrastructure development, human resource development, etc. Economic growth is measured by the annual increase in GDP, GNP, GDP per capita, or GNP per capita, employment, labour productivity, health, life expectancy and others.

Infrastructure may affect aggregate output in two main ways: (i) directly, considering the sector contribution to GDP formation and as an additional input in the production process of other sectors; and (ii) indirectly, raising total factor productivity by reducing transaction and other costs thus allowing a more efficient use of conventional productive inputs. Infrastructure can be considered as a complementary factor for economic growth.

Exhibit-1 shows how the infrastructure investment share in India's total investment had increased from 23.3 percent in 2007 to 32.5 percent in 2015.
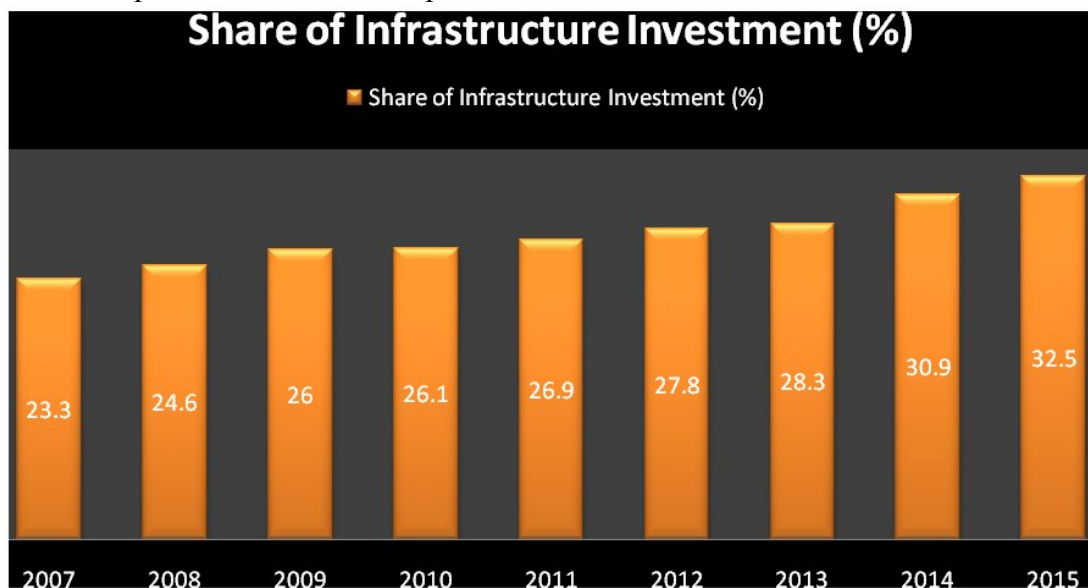

Share of Infrastructure Investment (%)

■ Share of Infrastructure Investment (%)

2007	2008	2009	2010	2011	2012	2013	2014	2015
23.3	24.6	26	26.1	26.9	27.8	28.3	30.9	32.5

Exhibit 1: Infrastructure Investment Share in India's Total Investment
Source: ASSOCHAM Economic Research Bureau and CMIE.

It appears from the above exhibit that share of infrastructure finance increased from 23.3% to 32.5% from the year 2007 to 2015.

Literature on importance of infrastructure in economic growth cover a wide range of issues, both in developed and developing countries. However, the present study will try to investigate the nature of the relation between infrastructure investment and growth in the Indian economy.

The present study is divided into nine sections including references. Section two discusses brief review of literature. Significance of the study is mentioned in section three. Objectives are highlighted in section four. Section five focuses on database and research methodology.

Empirical analysis and results are discussed in section six. Conclusion is mentioned in section seven. Limitations of the study are highlighted in section eight.

2. Literature Review

To identity research gap of the study, an attempt has been made to review the available literature on the selected topic:

Cohen et. al. (2000) analysed five different types of public infrastructure of U.S economy–highways and streets; transportation and power; sewer and water; health, educational, office, and public safety buildings; and conservation, development and nonmilitary equipment. They used sensitivity analysis in their study to find that there was an economic impact of infrastructure financing.

Yoshino and Nakahigashi (2000) examined the relationship between infrastructure and economic development. Their study focused on its effect on production activities, and estimated the effect of infrastructure on productivity, using the data from Thailand, a medium income country, and pre-war Japan, as there was a relative paucity of the empirical literature that examined such country and period. They also stated that infrastructure was the capital stock that provided public goods and services and therefore, it might have led to the reduction in income disparities. To evaluate this effect, they also analyzed data to see whether infrastructure was a significant factor in reducing income disparities and whether infrastructure also affected production activities in the developing countries, implying a close relationship between infrastructure and economic development.

O'Fallon (2003) highlighted linkage between infrastructure and economic growth and the implications about this for the management of infrastructure services in New Zealand. He concluded that there was a definite link between infrastructure investment and economic growth, particularly in the longer-term. It had not been confirmed that the link was a casual one (in either direction) and instead, physical infrastructure and the services provided could be regarded as a form of "complementary capital" that required the existence of available productive capital (whether physical or human) for investment (and innovation) in order to realize the economic growth potential. According to that study, the macroeconomic evidence of a link between infrastructure and economic growth was not in itself helpful to policy development for variety of reasons.

World Bank Discussion Paper (2006) stated in its report on 'Financing Infrastructure: Addressing Constraints and Challenges' that the then present state of physical infrastructure in India would be hard pressed to sustain 7 percent plus annual GDP growth over the medium term and be it in power, roads, ports, airports, water, railways, urban facilities or even telecoms, the country's infrastructure needs were enormous. According to that report, there was a massive and urgent need to increase investment in those sectors. In the recent past, efforts

have been made by the Government of India to step-up investment in infrastructure, and particularly to catalyze greater private investment. Report also analysed the reasons why more private finance had not been forthcoming for the different infrastructure sectors. In doing so, it examined the barriers posed by the absence of a sufficiently sophisticated financial sector, fiscal barriers, red tape and procedural inefficiencies that had contributed to project delays and discouraged private investors. Constraints arising from the absence of adequate infrastructure regulation exacerbated risks and uncertainties for investors. The report also suggested some practical ways to mitigate those constraints and policy reforms to facilitate more sustained private investment and Public Private Partnerships (PPPs) in infrastructure.

Narayanamoorthy and Munir (2006) made a study based on secondary data covering 256 districts drawn from 13 states in India and those districts together accounted for nearly 93 per cent of the rural population in 1999-2000 and for more than 80 per cent of the cropped area in India. Their study established strong linkages between rural infrastructure development and value of agricultural output and they recommended that there were significant scope for increasing agricultural output by improving rural infrastructure such as irrigation, roads, education, electrification, etc.

Chakrabarti et. al. (2012) showed the effect of physical and financial infrastructure on FDI inflows on the basis of dataset of district-level FDI in India. They found that there was indeed a positive relationship between physical infrastructure and FDI inflows; the relationship was essentially non-linear with a "threshold level" of infrastructure after which the positive effect became significant.

Croce & Gatti (2014) stated in their study that different governments of European countries had started to recognize that they needed to reconsider their approach to financing to secure new sources of capital to support infrastructure development. According to their opinion, developed and developing countries were in effect competing to attract institutional investors to infrastructure. They also mentioned the importance of the overall level of investment in infrastructure by institutional investors and that the infrastructure financing market had gone through a process of radical transformation starting from the mid-2000s due to different reasons.

Agrawal (2015) observed in his study that good social and physical infrastructure facilities were crucial for rapid economic growth, rapid human development, and poverty reduction. He compared the levels of development of the social and physical infrastructure in India with those in other major emerging countries as well as developed countries. He suggested that there was a very urgent need to go for rapid development of social and physical infrastructure. The study also tried to identify key challenges to infrastructure development and discussed some possible ways in which some of these challenges could be addressed.

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Discussion Paper of Third International Conference on Financing for Development (2015) stated about the huge needs of infrastructure in the Asia-Pacific Region. It was found that due to increase in population and rapid urbanization in several developing economies of the region, the bulk of infrastructure investments in the Asia Pacific Region were financed by tax revenues and public borrowing. Tax financing and borrowing from capital markets were identified to be the most significant sources of infrastructure financing for most of the countries in the Asia Pacific region.

Ismail and Mahyideen (2015) in their study considered both the hard and the soft infrastructure. They revealed that hard infrastructure, often referred to as physical infrastructure, actually meant roads, airports, ports, and rail; indicators included both quality and quantity and the information and communications technology (ICT) sector was also regarded as physical infrastructure, comprising indicators of the use, availability, absorption, and government prioritization of ICT.

From the above brief review of the relevant literature, it appears that while some extensive works had been done at the international level, a few works have also been done at the national level. A few studies have specifically focused on the relevance of infrastructure to growth in East Asia. An attempt has been made by the present researchers to identify the gap and to examine the relationship between infrastructure investment and economic growth in India.

3. Significance of the Study

Ostensibly, it can be said that the infrastructure is a key driver for the development of any economy. The sector is highly responsible for propelling India's overall development and enjoys intense focus from the Government for initiating policies that would ensure time-bound creation of world class infrastructure in the country. Importance of infrastructure in economic growth cannot be over emphasized. Infrastructure is the life line of an economy and the fate of an economy is intricately linked to the development or otherwise of its infrastructure. But in the light of present stand point of our government, this topic is very important because the infrastructure investment is continuously increasing over the last couple of decades and there is a noticeable change in the last five years.

As per the present situation of our country, infrastructural development is very useful issue because it corroborates the strategy of the present Government which is likely to be adopted to boost the Indian economy like 'Make in India', '100 Smart Cities', 'liberalized FDI regime', 'Digital India' and the like. The Government of India gives high priority to infrastructure and has taken a number of policy decisions and the budget allocation supports the same. In Union Budget 2017-2018, the total allocation for infrastructure development stood at Rs 3,96,135 crore whereas total allocation in the year 2016-2017 was Rs. 2,21,246 crore; it shows a significantly increasing trend. The same trend has been followed in the budget allocation in 2018-2019 also.

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4. Objectives of the study

The objectives of this study are:

i) To analyse the long term and short term relationships between growth in economy and Infrastructure; and

ii) To examine the long term and short term association between Gross Domestic Product and Gross Capital Formation.

5. Database and Methodology

5.1 Variables used

Only government initiatives in connection with infrastructure have been considered. So, Gross Capital Formation (GCF) for infrastructural development and Gross Domestic Product (GDP) are considered as the two indicator-variables for macroeconomic growth and economic growth respectively. There is no doubt that a lot of other influencing variables have been excluded from this study. Brief descriptions of the selected variables are appended below:

(i) Gross Domestic Product (GDP)

"For Policy makers, creating wealth and/or increasing Gross Domestic Product (GDP) is the prime importance for any economy" (Joshi, 2013). GDP is the final value of the goods and services produced within the geographic boundaries of a country during a specified period of time, normally a year. GDP growth rate is an important indicator of the economic performance of a country. Real gross domestic product (GDP) is an inflation-adjusted measure that reflects the value of all goods and services produced by an economy in a given year, expressed in base-year prices, and is often referred to as "constant-price," "inflation-corrected" GDP or "constant dollar GDP." Unlike nominal GDP, real GDP can account for changes in price level and provide a more accurate figure of economic growth.

(ii) Gross Capital Formation (GCF)

Gross Capital Formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales (Aparna Raja, 2013).

5.2 Database

The secondary data have been collected from different books, journal articles, conference papers, and reports of different organisations, Planning Commission of Government of India,

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World Bank and different websites. The data have been collected for a period of 57 years i.e. $1960 - 2016$ from the World Bank database and Planning Commission Government of India and NSSO. The data is time series in nature and requires examining whether it is stationary or not.

5.3 Methodology and Hypotheses

Methodology

The following steps are adopted in methodology:

Step 1: The researchers have examined whether this data set supports time series or not (testing of stationarity) by applying Augmented Dickey-Fuller (ADF) Unit Root Test.

Step 2: Johansen Test of co-integration has been applied to check whether both the variables are having any long run relationship among them in future as the variables are having same order of integration. The Johansen approach to cointegration test is based on two test statistics, viz., trace statistic, and maximum eigenvalue statistic (Patel, 2012). After that error correction mechanism has been applied to know the long term and short term causality between relevant variables and the direction of causal relationship.

Cointegration relationships reflected the long term balanced relationship between relevant variables. In order to cover the shortage, correcting mechanism of short term deviation from long term balance was adopted. At the same time, as the time series had limited number of years, the above test results could cause limitations. Therefore, under the circumstances where long term causalities existed, short term causalities were also tested. The following error correction model is used:

$$d\ lgdpit = \eta i + \Sigma\alpha 1 d\ lgdpi, t - 1 + \Sigma\beta 1 d\ gcfi, t\text{-}1 + \lambda\ ECMit + \varepsilon it \ldots\ldots..(1)$$

Where t represents year, d represents first difference calculation, $ECMit$ represents the errors of long term balance. If $\lambda = 0$ is rejected, error correcting mechanism happens, and the tested long term causality is reliable, it could be unreliable. If $\beta 1 = 0$ is rejected, and then the short term causality is not proved to exist.

Hypotheses formulated

Six hypotheses have been formulated and the test results are shown in empirical section:

Null Hypothesis $H_0 1$: There is no cointegration between the variables.

Null Hypothesis $H_0 2$: There is no long term causality between GDP and GCF.

Null Hypothesis $H_0 3$: Gross Capital Formation (GCF) of Lag 4 & 5 cannot jointly influence Gross Domestic Product (GDP).

Null Hypothesis $H_0 4$: There is no Serial Correlation Effect

Null hypothesis $H_0 5$: There is no ARCH effect.

Null Hypothesis $H_0 6$: Residual is not normally distributed.

6. Empirical Analysis and Results

As the objective of this study is to examine the long term and short term association between Gross Domestic Product and Gross Capital Formation, the researchers have tried to formulate a simple (bi-variate) linear regression model initially and the linear regression is typically estimated using OLS (ordinary least squares). The form of model is:

$$Y_i = \beta_0 + \beta_1 X_i + u_i \qquad [\ i = 1...n]$$

Where, Y_i = i^{th} observation on the dependent variable

X_i = i^{th} observation on the independent (control or regressor) variable

u_i = i^{th} observation on the error term or disturbance

β_0, β_1 = the parameter estimates

n = number of observations

To satisfy the specific objective, the outline of the model has been settled as:

$$GDP_i = \beta_0 + \beta_1 GCF_i + u_i$$

Where, GDP_i = Gross Domestic Products

β_0, β_1 = the parameter estimates

GCF_i = Gross Capital Formation

u_i = i^{th} observation on the error term or disturbance

Test of Stationarity

To check the stationarity the researchers have used Augmented Dickey-Fuller (ADF) Unit Root Test. The null hypothesis ($H_0 1$) of no unit roots for all the variables is not rejected at their levels in both the models (i.e. constant and constant & trend) since the ADF test statistic values are higher than the critical values as shown in **Table 1**. After taking the first difference again, ADF test statistics are compared with critical values, and it is found that null hypothesis of unit root is rejected for all the variables. Thus, all the variables are stationary and integrated of the first order, i.e., I (1). As all the variables are stationery at first difference, the researchers have applied co-integration test. Cointegration analysis, which is mentioned above, with time series has been adopted in this study for testing whether there exists long term or short term stationary causality between GDP and GCF, and for testing the unit root of each variable to confirm their Stationarity.

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Table 1: Results of Augmented Dickey-Fuller Unit Root Test

Name of the variables	At Level		At First Difference	
	Constant	**Constant & Trend**	**Constant**	**Constant & Trend**
	ADF Test Statistic probability	ADF Test Statistic probability	ADF Test Statistic probability	ADF Test Statistic probability
lgdp	0.9967	0.7249	0.0000	0.0000
gcf	0.6153	0.4362	0.0000	0.0000

Source: Authors' own estimate by using E-Views Software.
Note: Test Critical Value has been checked at 1%, 5% and 10% level of significance respectively but only probability of Augmented Dickey-Fuller Test Statistic is shown in the above Table.

Findings

Null Hypothesis H_01: There is no cointegration between the variables. The null hypothesis is rejected because the probability is less than five percent. It means there is cointegration between the variables.

Alternative Hypothesis: There is at least one cointegrating variable. The alternative hypothesis is accepted at five percent probability **(Table 2).**

First model can be interpreted as follows:

D(GDP) = C(1)*(GDP(-1) + 1385.89300716*GCF(-1) - 54323.6838575) + C(2)*D(GDP(-1)) + C(3)*D(GDP(-2)) + C(4)*D(GCF(-1)) + C(5)*D(GCF(-2)) + C(6)

This equation is our Error Correction Model and GDP is dependable variable. C (1) is the coefficient of the integrating equation. C(1)*(GDP(-1) + 1385.89300716*GCF(-1) - 54323.6838575) will be the cointegrating equation. This is for long term causality (Table 3) and for short term causality, the equation is: C(4)*D(GCF(-1)) + C(5)*D(GCF(-2)).

Second model is not required for this study as we are trying to check the impact of infrastructure (represented by GCF) on economic growth (represented by GDP).

Null Hypothesis H_02: This Null Hypothesis states that there is no long term causality between GDP and GCF. The probability is 0.0002 percent which means the hypothesis is rejected but since the value of coefficient is positive (0.057109), we can say that there is no long term causality. C (1) is the residual of one period lag of co-integrating vector GDP and GCF. 0.057109 is one period lag and it is significant but the coefficient is not negative. It means that GCF has no long run causality on GDP **(Tables 3 & 4).**

Table: 2 Results of Johansen Test of Cointegration

GDP= f(GCF)							
No. of Cointegration Equations	Eigenvalue	Trace Statistics	0.05 Critical Value	p-Value**	Max-Eigen Value	0.05 Critical Value	p-Value**
None *	0.246631	18.47861	15.49471	0.0172	15.57600	14.26460	0.0308
At most 1	0.051406	2.902602	3.841466	0.0884	2.902602	3.841466	0.0884

Source: Authors' own estimate by using E-Views Software.
Trace test and Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table: 3 Vector Error Correction Estimates

Dependent Variable: D(SENSEX)	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.057109	0.01431	3.98979	0.0002

Source: Authors' own estimate by using E-Views Software.

Table: 4 Estimation of Equation

D(GDP) = C(1)*(GDP(-1) + 1385.89300716*GCF(-1) - 54323.6838575) + C(2)*D(GDP(-1)) + C(3)*D(GDP(-2)) + C(4)*D(GCF(-1)) + C(5)*D(GCF(-2)) + C(6)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.057109	0.014314	3.989791	0.0002
C(2)	0.645421	0.150251	4.295617	0.0001
C(3)	-0.208954	0.159705	-1.308371	0.1970
C(4)	-38.90179	109.6670	-0.354726	0.7243
C(5)	51.86818	109.6763	0.472921	0.6384
C(6)	1632.759	414.5054	3.939054	0.0003
R-squared	0.957851	Mean dependent var		2777.916
Adjusted R-squared	0.953460	S.D. dependent var		4169.673
S.E. of regression	899.5254	Akaike info criterion		16.54605
Sum squared resid	38839003	Schwarz criterion		16.76705
Log likelihood	-440.7434	Hannan-Quinn criter.		16.63128
F-statistic	218.1629	Durbin-Watson stat		2.001622
Prob. (F-statistic)	0.000000			

Source: Authors' own estimate by using E-Views Software.

Null Hypothesis $H_0 3$: According to this Null Hypothesis, GCF of Lag 4 & 5 cannot jointly influence GDP. Probability of Chi square statistic is less than 5% which means null hypothesis is rejected. But here, probability of Chi square statistic is more than 5% which means null hypothesis is accepted that means the lag 4 and lag 5 of GCF do not jointly affect the GDP in short run (**Table 5).**

Table 5: Wald Test (Short Run Causality Test)

Test Statistic	Value	Probability
F-statistic	0.170972	0.8434
Chi-square	0.341944	0.8428

Source: Authors' own estimate by using E-Views Software.

Null hypothesis H$_0$4: Here it is hypothesized that there is no Serial Correlation Effect. The Probability value of observed R square is 5.4 percent which is more than five percent. Hence this null hypothesis is not rejected. It means there is no Serial Correlation effect among variables **(Table 6).**

Table 6: Tests for Normality, Autocorrelation and Heteroscedasticity

Diagnostic Tests	H$_0$	Accepted/ Rejected	Prob.
VEC Residual Breusch-Godfrey Serial Correlation LM Test	No serial correlation at lag	**Rejected**	>0.05
VEC Residual Heteroscedasticity Test: ARCH	Residuals are homoskedastic or no ARCH effect	**Rejected**	0.048239
VEC Residual Normality Tests	Residuals are normally distributed	**Accepted**	0.000000

Source: Authors' own estimate by using E-Views Software.

Null hypothesis H$_0$5: It states: 'There is no ARCH effect'**.** The Probability value of observed R square is 0.048239 i.e. 4.8 percent which is below five percent. Hence, this null hypothesis is rejected. It means there is ARCH effect among the variables (**Table 6).**

Null Hypothesis H$_0$6: This hypothesis states: 'Residual is normally distributed'. Results show that probability of Jarque-Bera test statistic is less than five percent. It means that this null hypothesis is not rejected. So, the residuals are normal **(Table 6)**.

7. Conclusion

The researchers have actually tried to find out the degree of influence of infrastructural development on economic growth of India. The results showed that the variables are having co-integration but there is no long term and short term causality between GDP and GCF. It means that there exists a long term association between the GDP and GCF but no causal relationship has been found. The model partially satisfies the objectives.

8. Limitations of the Study

All the indicators of infrastructure investment are not being considered here. Due to lack of time and limited available scope it was not possible for the researchers to take care of all the relevant macroeconomic variables.

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