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Infrastructure and Economic Growth Nexus in Nigeria: A Macroeconometric Modelling Approach

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Abstract
This paper investigated the impact of infrastructure on economic growth in Nigeria A multivariate model of simultaneous equations was deployed. The paper also utilised three-stage least squares technique to capture the transmission channels through which infrastructure promotes growth. The research covered 40 years (1970 to 2010). The finding shows that infrastructural investment has a significant impact on output of the economy directly through its industrial output and indirectly through the output of other sectors such as manufacturing, oil and other services. The agricultural sector is however not affected by infrastructure. The results also show a bi-directional causal relationship between infrastructure and economic growth. The paper recommended increased investment in infrastructure. Also, the financing options for closing Nigeria's infrastructure gaps should focus on broadening the sources of finance and a better allocation of public resources. In this wise, the government should intensify the utilization of the public-private-partnership (PPP) framework.

Keywords: Infrastructure, Causality, Economic Growth, Economy of Nigeria, Macroeconometric Modeling.

1. Introduction

Nigeria is classified as a mixed economy or emerging market and has already reached middle income status according to The World Bank (2011). Nigeria is Africa's biggest oil producer and the 13th largest producer of oil in the world with daily production reaching about 2.4 million barrels. Nigeria also has the second largest proven oil reserves in Africa and the 10th largest in the world. The petroleum industry has been plagued by massive corruption, militancy, oil spills and oil theft but it remains the major export and biggest source of foreign earnings for Nigeria (African Vault 2016). The co-existence of vast wealth in natural resources and extreme personal poverty in developing countries like Nigeria is referred to as the 'resource curse' or 'Dutch disease' (Auty, 1993).

Statistics released by the National Bureau of Statistics (NBS, 2010) further shows that on an aggregate basis, the economy when measured by the Real Gross Domestic Product (GDP), grew by 7.87% in 2010 (Central Bank of Nigeria, 2013). Nigeria's GDP rebased from about USD 270 billion to USD 510 billion for 2013. The increase of about 90% was attributed to new sectors of the economy such as telecommunications, movies, and retail which were previously not captured or underreported. As a result of the rebasing, Nigeria is now the largest country in Africa and 26th largest in the world (National Bureau of Statistics, 2014).

Infrastructure, as defined by Akinyosoye (2010), is the "unpaid factor of production" which tends to raise productivity of other factors while serving as intermediate inputs to production. The services engendered as a result of an adequate infrastructure base will translate to an increase in aggregate output. A number of theoretical expositions that demonstrate the linkages between infrastructure and economic growth have been provided in the endogenous Growth theories. Canning and Petroni (2004) investigated the long run impact of infrastructure provision on per capita income in a panel of countries over the period 1950-1992 and provided evidence that in majority of cases infrastructure stimulated long run growth effects. Canning and Fay (1993) also found that the developing countries demonstrated a high rate of return on transport infrastructure which compared favourably with those of developed

countries. Udjo, Simelane and Booysen (2000) also identified infrastructure as having both direct and indirect impact on the growth of an economy.

Infrastructure as opined by Akinwale (2010) adds to economic growth and development by raising efficiency and providing facilities which enhance the quality of life. The level of infrastructure deficit in Nigeria has been identified by Sanusi (2012) as the major constraint towards achieving the nation's vision of becoming one of the 20 largest economies in 2020. He further proffered that about 70 percent of the 193,000 kilometres of roads in the country are in poor condition. In comparison with other African countries, Nigeria came 19th with only 132 kWh per capita of electricity consumption in the decade ended 2013 (World Bank, 2014).

The KPMG (2007) report recommends that for a developing country to sustain growth and development, not less than 6% of GDP should be invested on infrastructure. However, according to the National Bureau of Statistics (2010) over the last decade, Nigeria's infrastructure spending contributed only 1.9% (approximately $4 billion) per annum to GDP. The position taken by Sanusi (2010) is slightly different. He claimed that Nigeria has invested about 7 percent of GDP on infrastructure since independence which is above the average for Sub-Saharan Africa. He however expressed the need to increase this figure to at least 12 percent of the GDP for growth to be sustainable.

From above statistics, infrastructure can be said to be more than just being a factor of production, but rather a veritable condition for increased rate of economic growth. The endogenous growth model states that the steady-state growth rate is achieved when the propelling factors (innovation, technical change, population) are determined within the economy. In the prognosis of this model, investment in infrastructure leads to economic growth. This is complimented by the law of increasing state activity as propounded by Wagner (1893) which also states that as the economy develops over time, the activities and functions of the government which includes infrastructure increase.

Some of the growth literature (Ayogu, 2007; Fedderke & Bogetic, 2006; and Schwartz, 1995) found little or no significant positive relationship. Some others including Akinlabi, Kehinde and Jegede (2011),

Canning & Pedroni (2004) and Palei (2015) report positive relationship between the variables. Indeed, there is no consensus in the empirical literature as to the nature and direction of causality between infrastructure and economic growth. This paper therefore seeks to investigate the impact of infrastructure on economic growth in Nigeria. The study covers 40 years (1970 to 2010) which accounts for about 77 per cent of the life of the country since its independence.

2. Literature Review

This section is in two parts: the empirical review and the theoretical underpinning of the study. These are presented in turns.

2.1. Review of Empirical Literature

Some early studies on the relationship public infrastructure e.g. Aschauer (1989) have suffered from simultaneity bias and spurious correlation. Fedderke and Bogetic (2006) examined the impact of infrastructure investments in South Africa. They observed that past studies have found that the effect of public infrastructure investment on economic growth to be ambiguous. When the endogeneity of infrastructure investment was controlled, they found that infrastructure investment has a positive effect on economic growth and development.

Indeed, the literature is not conclusive on the effect of infrastructure on economic growth. There are studies that establish little or no significant positive relationship between infrastructure and economic growth (Garcia-Mila et al. 1996; Holtz-Eakin, 1994; Holtz-Eakin and Schwartz, 1995 and Ayogu, 2007). Snieska and Simkunaite (2009) observed that it is the characteristic of each country that determines the set of infrastructure components and the aspect of impact on social and economic development economic growth.

There is also body of works that have found some limited positive impact of infrastructure on growth (Aschauer, 1989; Barro, 1990; Canning and Pedroni, 2004 and Sanchez-Robles, 1998). In Nigeria, Akinlabi, Kehinde and Jegede (2011) examined the impact of investment in public infrastructures on poverty alleviation and economic development. Using Co-integration test which established the long run relationship between the variables and Causality test which tests the

causative relationships for the period of 1981 to 2006, the study reported that although infrastructure promotes GDP, fiscal deficit does not. Ijaiya and Akanbi (2009) found long term linkages between infrastructure and economic growth. The link between infrastructure and growth in African countries (South Africa, Nigeria, Uganda and others) has also been shown to be positive, by Foster (2009). In a recent research, Palei (2015) came to a positive conclusion on the relationship between the two variables.

2.3 Theoretical Framework

The possibility of a long run impact from innovations in infrastructure to income growth is intimately related to the issue of whether the data are generated by a neoclassical growth model, in which technical progress drives long run growth, or an endogenous growth model in which shocks to capital accumulation can have a long run impact. In the neoclassical growth model shocks to the infrastructural stock can only have transitory effects, but in an endogenous growth model, shocks to infrastructure can lead to permanent changes in per capita income (Canning and Pedroni, 2004).

The conceptual framework of the theoretical linkage between infrastructural investment and economic growth is presented in Figure 1. The channel of infrastructural transmission to economic growth is manifested only through the economic growth indicators. These are industrial production, employment, price stability, education, technology, openness, knowledge, innovation (Agénor & Neanidis, 2006; Brenneman & Kerf, 2002 and Helpman, 2004).

The nature of transmission, according to Onakoya, Tella and Osoba (2012) is determined by the role of infrastructure capital in the production function i.e. whether it is a direct or intermediate input. As a direct input, it can either be guided by market forces, in which case it is provided by the government as a public good. Where infrastructure capital is an intermediate input in the production process, the indirect transmission channel through which infrastructure affects growth is determined by three factors. These are productivity of physical capital which is in turn determined by reduction in adjustment costs and maintenance of existing infrastructure also derived from the facilitation of re-allocation of capital.

The second variable is higher labour productivity obtained from improved human capacity development. The transmission impact, through human development, can be realised through improving health better nutrition, education, better roads, access to electricity, telecommunications etc. The third factor is the externalities which transmit key technological innovations to other sectors leading to involve lower costs, and spill-over effects on other firms and therefore, on the economy as a whole.

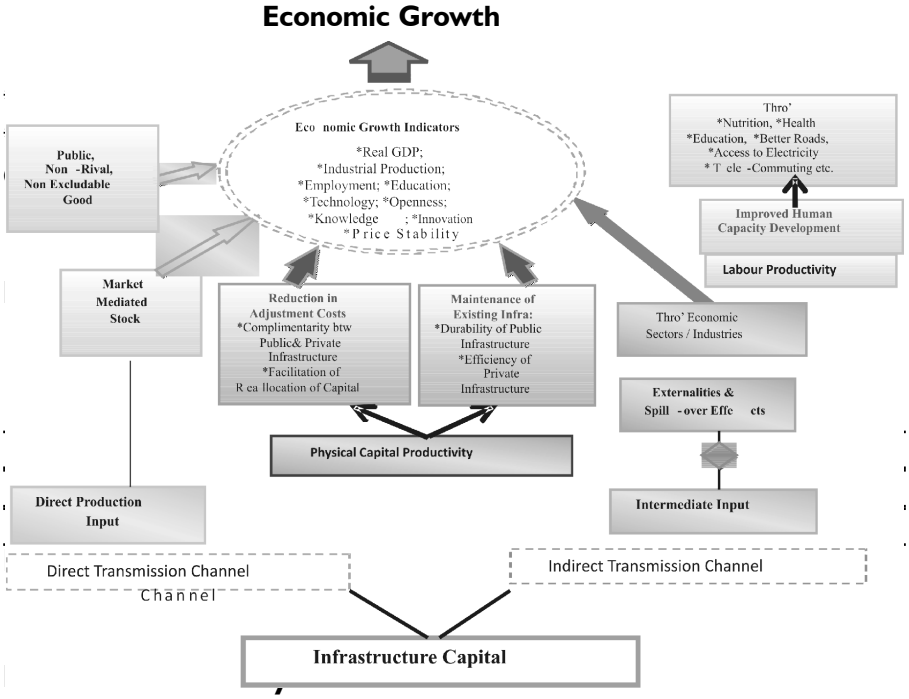


Fig.1: Theoretical Flow of the Transmission Channels through which Infrastructural Investment affect Economic Growth. Source: Adapted from Onakoya, Tella and Osoba (2012)

There is the need to determine the inter-sectorial linkage impact of infrastructure on the economy. This is under-scored by the fact that infrastructure, apart from serving as a direct input, can also be an intermediate input in the production process. Thus, activities of the real

sector of the economy are influenced by infrastructural investment and they consequently contribute to economic growth (Murty and Soumya, 2005, 2006). Theoretically, ignoring these sectorial multiplier effects, when in fact they exist, may lead to biased and inefficient results. This informs the methodology deployed which is presented in the next section.

3. Methodology and Model specification

3.1. Methodology

The paper deploys the Three-Stage Least Squares (3SLS) technique. By its design, the method incorporates lag terms of both the dependent and independent variables in the estimation process.

It takes care of any probable occurrence of non-stationarity between the variables and corrects contemporaneous correlation of error terms. The method therefore removes the possibility of spurious regressions.

In the estimated model of this study, the equations are all over-identified which satisfy the prerequisite condition for the use of 3SLS technique. We also performed posterior tests to ascertain the reliability of the results obtained. The normality test is used to examine whether the disturbances are normally distributed or not (Jarque and Bera, 1980). The serial correlation test examines whether the present value of the residuals depends on its past value. The estimation of the model was carried out with the use of E-Views™ (version 6.1).

3.2. Model Specification

The model specification for the paper is of the simultaneous equation regression which has been recommended by many scholars including Roller and Waverman (2001), Belaid (2004), Herrera (2001) and Cadot and Roller (2006). This method is considered appropriate especially when a dependent (endogenous) variable in one equation appears as explanatory variable in another equation which leads to a feedback distortion between the variables.

The structure of the macro-econometric model is tailored after the national accounting identity. The theoretical foundation of the model is predicated upon the IS-LM-BOP model. However, infrastructure capital

in the case of Nigeria is a function of the market size which determines the growth of the economy. The government was the major player in the provision of infrastructure prior to year 2001. When the market size expands, there is pressure on the public infrastructure which forces the government to increase investments in this sector. The limits in the capacity of the government to solely provide the economic infrastructure gave birth to the involvement of the private sector. The consequential effect of this is that government spending is exogenous and not market-determined. Private sector involvement is a recent feature. Its involvement in the industry commenced only in the last decade.

The macro-econometric model depicts the inter-linkages between the sectorial blocks of the economy. The supply block which is the aggregate output of the real sector of the economy is modelled as equation (1) to, (5). The sector consists of the output of infrastructure and those of the non-infrastructure constituents. The latter is made up of the outputs of manufacturing, agriculture, oil and services.

Supply Block

$$Y_{IF} = a_1 + a_2 GCR_{IF} + a_3 FDI_{IF} + a_4 K_{IF} + a_5 P_{IF} + e_1 \quad (1)$$

$$Y_{MFG} = a_6 + a_7 GCR_{MFG} + a_8 Y_{IF} + a_9 Y_{OIF} + a_{10} FDI_{MFG} + a_{11} K_{MFG} + a_{12} P_{MFG} + e_2 \quad (2)$$

$$Y_{AGRIC} = a_{13} + a_{14} GCR_{AGRIC} + a_{15} Y_{IF} + a_{16} Y_{OIF} + a_{17} FDI_{AGRIC} + a_{18} K_{AGRIC} + a_{19} RAIN + a_{20} P_{AGRIC} + e_3 \quad (3)$$

$$Y_{OIL} = a_{21} + a_{22} GCR_{OIL} + a_{23} Y_{IF} + a_{24} FDI_{OIL} + a_{25} K_{OIL} + a_{27} P_{OIL} + a_{27} OPEC + e_4 \quad (4)$$

$$Y_{SERV} = a_{28} + a_{29} Y_{IF} + a_{30} FDI_{SERV} + a_{31} K_{SERV} + a_{32} P_{SERV} + e_5 \quad (5)$$

The demand block is made up of three demand blocks made up of the private demand (consumption and investment), government expenditure and the external sector. In the private demand block, the consumption is made up of both food and non-food elements. Investment is represented by the infrastructure which is one of the major variables of interest to this study and non-infrastructure components. The non-infrastructural investment consists of manufacturing, agriculture, oil and services.

The demand block is modelled as equation (6) to (18) starting with the private demand block (6) to (12)

Demand Block

Private Demand Block

$$C_F = a_{33} + a_{34}P_F + a_{35}YDc + a_{36}IR + e_6 \quad (6)$$

$$C_{NF} = a_{37} + a_{38}P_{NF} + a_{39}YDc + a_{40}W + e_7 \quad (7)$$

$$INV_{IF} = a_{41} + a_{42}Y_{IF+a43}FDI_{IF} + a_{44}GCR_{IF} + a_{45}P_{IF} + e_8 \quad (8)$$

$$INV_{MFG} = a_{46} + a_{47}Y_{MFG} + a_{48}INV_{IF} + a_{49}IR + a_{50}FDI_{MFG} + a_{51}GCR_{MFG} + a_{52}P_{MFG} + e_9 \quad (9)$$

$$INV_{AGRIC} = a_{53} + a_{54}Y_{AGRIC} + a_{55}INV_{IF} + a_{56}IR + a_{57}YD + a_{58}GCR_{AGRIC} + a_{59}P_{AGRIC} + e_{10} \quad (10)$$

$$INV_{OIL} = a_{60} + a_{61}Y_{OIL} + a_{62}INV_{IF+a63}FDI_{OIL} + a_{64}GCR_{OIL} + a_{65}P_{OIL} + e_{11} \quad (11)$$

$$INV_{SERV} = a_{66} + a_{67}Y_{SERV} + a_{68}INV_{IF} + a_{69}FDI_{SERV} + a_{70}GCR_{SERV} + a_{71}P_{SERV} + e_{12} \quad (12)$$

Government Block

The components of the government block are government revenue, its expenditure and the fiscal deficit. The external block consists of the export, import and the reserves.

The goverment expenditure is modelled as equation (13), (14) and (15).

$$GE = a_{71} + a_{73}GRV + a_{74}(CG) + a_{75}EDS + a_{76}DDS + a_{77}Y + a_{78}FD + e_{13} \quad (13)$$

$$GRV = a_{79} + a_{80}Y_{IF} + a_{81}FDI + a_{82}NX + e_{14} \quad (14)$$

$$FDF = a_{83} + a_{84}FD + a_{85}NFA + a_{86}EXR + e_{15} \quad (15)$$

External Block

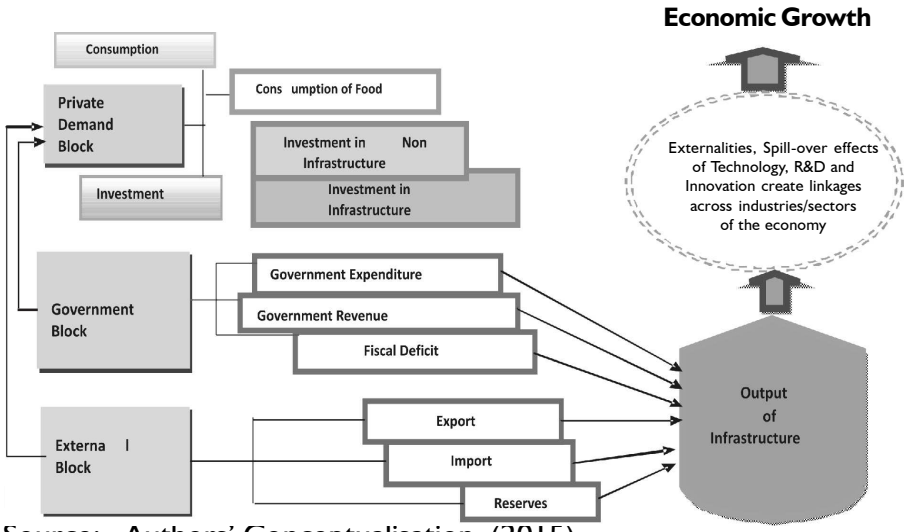
The external block is represented in equation (16), (17) and (18).

$$X = a_{87} + a_{88}Y + a_{89}TOT + a_{90}EXR + e_{16} \quad (16)$$

$$M = a_{91} = a_{92}TAR + a_{93}Y + a_{94}TOT + a_{95}EXR + e_{17} \quad (17)$$

$$RES = a_{96} + a_{97}Y + a_{98}NFA + a_{99}EXR + a_{100}FDI + e_{18} \quad (18)$$

Investment in infrastructure which is a variable of particular interest of this study is explained by the output of infrastructure (Y_{IF}), foreign direct investment in infrastructure (FDI_{IF}), government capital exponential ratio in infrastructure (GCR_{IF}), and the average price of infrastructure (P_{IF}). This is explicitly stated in equation (8). The conceptual framework of the macro-econometric model depicting the inter-linkages between the sectorial blocks of the economy is presented in Figure 2.



Source: Authors' Conceptualisation (2015)

3.3 Sources of Data

Time series data used for the estimation which covers 1970 to 2010, were obtained from the Nigerian Bureau of Statistics (2014), Central Bank of Nigeria (2013), the Nigerian Communications Commission (NCC, various years), International Petroleum Monthly, (2010) (http://www.eia.doe.gov), Energy Information Administration, International Petroleum Monthly (http://www.eia.doe.gov).

4. Data Analysis and Discussion

The results are presented in three parts: Investment in infrastructure and output; Output of infrastructure and economic growth and direction of the causality The result of the output infrastructural investment (Y_{IF}) as the dependent variable in Table 1 show that the Capital Stock of infrastructure (K_{IF}) is positively related to the output of infrastructure (K_{IF}) which is the main variable of the paper, serves as the proxy for Investment in infrastructure (INV_{IF}).

Table 1: System Estimation Report: Investment in Infrastructure and Economic Growth

Dependent Variable	Explanatory Variables					Estimated Equation No
	Constant	GCR_{IF}	FDI_{IF}	K_{IF}	P_{IF}	
Y_{IF}	1.2684	0.2402	0.1026	0.1884	0.1035	1
	(2.43)	(6.07)[a]	(2.10)	(2.93)[b]	(1.68)[a]	

Source: Authors' computation using E-Views™ (version 6.1).

$R^2 = 0.96$, $\overline{R^2} = 0.95$, SE = 0.4658, Durbin Watson (DW) Statistics = 2.03

Note: a, b imply 1% and 5% significance level respectively. *t*-statistic in parenthesis

The relationship is statistically significant with a t-value of (2.93) at 5 percent level. The coefficient value of (1.88) suggests that a percentage increase in capital stock would result in about 19 percent increase in the output of the infrastructural sector. The results of equation 1 reveal that the regressors account for 95 percent ($\overline{R^2} = 0.95$) in explaining the variation in the both the output of infrastructure (Y_{IF}). Although the adjusted coefficients of determination ($\overline{R^2}$) are rather high, the Durbin-Watson Statistics test (2.03) results is higher. Therefore, the results can be accepted as valid. Therefore, infrastructure can be said to have direct and positive effect on economic ggrowth in Nigeria through the impact of its own industry's output.

4.1 Output of Infrastructure and Economic Growth

The estimation result of equation 2 shows that about 96 percent (= 0.96) of the output of manufacturing (Y_{MFG}) is explained by the regressors. Also in equation 3, the dependent variables account for 98 percent of the variation in the outputs of agriculture (Y_{AGRIC}). In the same vein, about 99 percent of the variations of in the outputs of oil and services are accounted for by the explanatory variables in equations 4 and 5. The high values of adjusted coefficient of determination ($\overline{R^2}$) although indicative of a specious result, can be considered valid in view of the fact that the Durbin-Watson Statistics (DW) for each of the regression is higher than the respective $\overline{R^2}$.

Table 2: System Estimation Report: Output of Infrastructure in the Supply Block

Dependent Variables	Y_{IF} as Explanatory Variable	AdjR^2	Durbin- Watson Statistics	Estimated Equation No
Y_{MFG}	0.2636(2.63)[b]	0.96	1.09	2
Y_{AGRIC}	0.3085(2.44)	0.98	1.66	3
Y_{OIL}	0.37285(3.25)[a]	0.99	1.76	4
Y_{SERV}	1.2233(12.14)[c]	0.99	1.34	5

Source: Authors' computation using E-Views™ (version 6.1).
Note: a, b, c imply 1 percent, 5 percent and 10 percent significance level respectively. t-statistic in parenthesis

The results show that output of infrastructure (Y_{IF}) is not statistically significant in explaining the output of agriculture. It is however significantly related to the outputs of the oil at 1 percent. This is due to the prevalence of the use of information, communications technology and the crucial role of logistics both in the up and down streams of the oil and gas industry. The significance of infrastructure in the manufacturing and service sectors at 5 percent and 10 percent respectively bear testimony to the capital intensive nature of modern service sector. Indeed, the delivery of service is through infrastructure. Since the outputs of all these sectors are positively related to the output of the infrastructure, with three of the four sectors being significant, we can, surmise that the investment in infrastructure through the output of infrastructure indirectly affects the economic growth Nigeria.

The non-significance of the output of infrastructure to the output of agriculture is supported by the findings of Jagun et al. (2008) and Pyramid Research (2010) who reports that before the advent of the liberalisation of the sector, Nigerian farmers had little access to facilities.

4.2 Direction of Causality

In this section, we check the causal relationship between infrastructure and economic growth in order to know the extent and the predictive power of the relationship. This involves the examination of the causal relationship between the output of infrastructural investment (Y_{IF}) equation 1 and the investment in infrastructure (INV_{IF}) equation 8.

The results of equations 1 and 8 reveal that the regressors account for 95 percent and 97 percent ($\overline{R^2} = 0.95$ and $\overline{R^2} = 0.97$) respectively in explaining the variation in the both the output of infrastructure (Y_{IF}) and capital stock of infrastructure. Although the adjusted coefficients of determination ($\overline{R^2}$) are rather high, the Durbin-Watson Statistics (DW) test results are higher in both cases. Therefore, the results can be accepted as valid.

The results of equations 1 and 8 indicate that an increase in infrastructural investment leads to an increase in infrastructure output and a rise in output of infrastructure also brings about a rise in investment in infrastructure. Consequently, there is a bi-directional causality between infrastructural investment and output of infrastructure.

Table 3: System Estimation Report: Causal Relationship between Investments and the Output of Infrastructure

Dependent Variables	*Explanatory Variables*	*Adj R^2*	*Durbin-Watson Statistics*	Estimated Equation No.
Y_{IF}	0.1884 K_{TIF}(2.93)[b]	0.95	2.03	*1*
INV_{IF}	0.1827 Y_{IF}(4.51)[b]	0.97	1.34	*8*

Source: Authors' computation using E-Views™ (version 6.1).
Note: b implies 5% significance level. *t*-statistic in parenthesis

The preceding discussions indicate that investments in infrastructure have both direct and indirect impact on Nigeria's economic growth. The discussion also shows a bi-directional relationship between the two variables. In addition, the result supports the endogenous growth theory which indicates that the stock of infrastructure is determined endogenously within the model. The results further confirm the inter-sectorial linkage effects of infrastructure in the economy hitherto omitted in the literature.

Post Estimation Tests

The results of the post-estimation tests conducted to ascertain the reliability of the estimates show that the disturbances are normally distributed (see Table 4). The probability value (0.99) of the joint

estimation of the Jarque-Bera Test obtained shows that the Null hypothesis cannot be rejected.

Table 4: System Normality Tests (Joint Result)

Component	Jarque-Bera	df	Prob.
Joint	659.2963	10395	0.9917

Source: Author's computations.
Note: *df* is degrees of freedom for (approximate) chi-square distribution. Null Hypothesis: Residuals are multivariate normal.

In addition, the serial correlation tests show that the present value of the residuals do not depend on their past values. For the estimated result of the test, the research found that there is no serial correlation problem up to lag 4 for the system variable models. Specifically, the probability values for lag 1, 2, 3 and 4 in Table 5 are (0.1), (0.18), (0.13) and (0.22) respectively. These are far greater than the conventional level of significance of 5 percent (0.05). As a consequence, the study does not reject the Null hypothesis, implying that there is no serial correlation.

Table 5: System Portmanteau Tests for Autocorrelations

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	426.44	0.17	437.38	0.096	400
2	804.96	0.44	835.82	0.19	800
3	1,193.37	0.55	1,255.71	0.13	1.200
4	1,542.24	0.85	1,643.35	0.22	1.600

Source: Author's computation.
Note: *df* is degrees of freedom for (approximate) chi-square distribution.
Null Hypothesis: No residual autocorrelations up to lag *h*.

In the next section, the conclusion and recommendations are presented.

5. Conclusion and Recommendations

This paper has reviewed the impact of infrastructure on economic growth. The results of the paper are consistent with similar results of other countries. The study has ascertained that investments in infrastructure both directly and indirectly significantly affect economic growth in Nigeria. The paper also shows a bi-directional relationship between the two variables. The output of the industry is also considered an important determinant of output of other sectors with forward and backward linkages in the economy.

The results of the study further show that government should increase the funding of the development of infrastructure particularly in line with the lessons learnt from the Korean government which has invested in the post-war period on construction of roads, power stations, electricity and communication which created jobs, roused the economy, reduced the production costs indirectly and raised their productivity. The financing options for closing Nigeria's infrastructure gaps should focus on broadening the sources of finance and a better allocation of public resources In this wise, the government should intensify the utilisation of the public-private-partnership (PPP) framework as exemplified by the USD 385million Lekki-Epe toll road in Lagos and as obtained in Morocco where nearly two-thirds of electricity production is by private producers.

In conclusion, this paper has made a case for infrastructure investment in order to engender economic growth and development.

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