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Facilitating Economic Growth by Leveraging on Infrastructure Development

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ABSTRACT: To achieve most of the United Nations' Sustainable Development Goals (SDGs) such as the elimination of poverty and hunger, the establishment of good health and well-being, provision of quality education, creation of decent work and economic growth, infrastructure development is central. Thus, the study aimed at determining Nigeria's priority infrastructure based on the endogenous growth framework. The study covered a period of forty years; from 1981 to 2020. Data was sourced from the Global Economy Data (2020) and the World Development Indicators (2020). Using Autoregressive Distributed Lag (ARDL) technique, the study found that in the short-run, communication, electricity, education and health infrastructures had positive impact on the real gross domestic product (GDP), while transport infrastructure had a negative impact on the real GDP. In the long-run, communication, electricity and education had a positive impact on the real GDP, while transport and health infrastructures had a negative impact on the real GDP. Also, the study found that of all the infrastructure components, electricity infrastructure was most impactful as it positively influenced all the components of GDP both in the short-run and in the long-run. Therefore, the study recommended that the Nigerian Communications Commission should work on reducing the high tariff on communication infrastructure. The Nigerian Ministry of Education should review the current educational curriculum to accommodate the needs of firms in terms of the quality of labour. Finally, the Nigerian government should spend more in providing electricity, transport, education and health infrastructure; but electricity should be given priority attention.

KEYWORDS: SDGs, Infrastructure, ARDL, Nigeria

JEL Classification: H54, O4

1. INTRODUCTION

In the past decade, the relevance of infrastructure as fundamental for economic growth differentials has become pronounced worldwide. Luu, et al. (2019) articulated the importance of infrastructure by stressing its central role in bringing about structural transformation in developing economies. Infrastructure can be defined as a set of facilities necessary for the functioning and maintenance of a society. Infrastructure is pivotal to the socioeconomic well-being of the society. Infrastructure can be categorized into hard and soft components. Hard infrastructure includes railroads, highways, bridges, electricity, water and transport among others. On the other hand, soft infrastructure deals with human capital; education and health (Davies, et al., 2019). With improved infrastructure, investors are attracted to developing countries (Ndikumana & Verick, 2008). Inadequate infrastructure will make potential investors direct their resources into sub-optimal activities, which contributes little or nothing to gross domestic output (GDP). Estache and Garsous (2012) noted that poor infrastructure has contributed to low output in developing countries.

Several empirical studies have reported the relevance of infrastructure to economic growth and development across different countries and regions of the world. Straub and Terada-Hagiwara (2010) found that infrastructure development has spurred economic growth in many developing Asian countries. Also, Kaupa (2015) noted that improvement in electricity infrastructure and water supply has significantly and positively influenced per-capita output in South Sumatera Province as well as the agricultural, manufacturing and trade sectors of the economy. However, the study found that road infrastructure shows no significant impact on the economy. On the contrary, Ng, et al. (2019) using fixed-effects panel linear regression analysis found that growth in road length per thousand population contributed positively to economic growth in Malaysia. Similarly, Raboloko (2019), using the autoregressive distributed lag technique found that health infrastructure positively and significantly impacts economic growth in Botswana in the long-run. However, these studies have not investigated the dominant channel through which infrastructure impacts growth. In addition, studies in this area did not examine the impact of infrastructure on the components of gross domestic product (GDP). This is necessary for policy direction. Disaggregating GDP into household consumption expenditure,

firm investment expenditure and government expenditure will provide insight into the expenditure component that is mostly affected by infrastructure.

Moreover, the lumping of the various types of infrastructure despite their distinct contributions to growth process in the economy may not give a clear view into which infrastructure component is most central for long-run economic growth. Hence, infrastructure was first unbundled into social and economic infrastructure as in Familoni (2011). Thereafter, social infrastructure was further divided into education and health infrastructure, while economic infrastructure was sub-divided into transport, communication and utilities (proxy by electricity infrastructure). Unbundling infrastructure into the various components will help to rest the question of the development of which infrastructure component the government should concentrate on first. The study will address the fundamental problem of lumping all infrastructure components under the same sub-category and provide policy-makers with the answer to the disturbing question on the development of which infrastructure component to embark on first, based on its influence on the Nigerian economy. Previous studies have examined the impact of infrastructure components on the Nigerian economy. For example, Davies, et al. (2019) noted that in Nigeria, infrastructure is crucial in poverty reduction and the socioeconomic development. Ejiogu, et al, (2020) posited that not only does infrastructure contribute to socioeconomic development but enhances the quality of life in Nigeria. Ekiran and Olasehinde (2019), who worked on the Nigerian economy noted that a society with inadequate infrastructure will find the expansion of its local manufacturing industries difficult; causing a huge setback in the primary sector. However, each of these studies focused on a particular infrastructure component. The current study is distinct for examining three infrastructure components which are commonly used by many Nigerians; to be able to identify the particular infrastructure component to be given priority attention.

Furthermore, the study will provide guidance to policy-makers on the component of GDP that should be their major focus in the delivery of infrastructure. Therefore, the objective of the study is to examine the influence of infrastructure components (education, health, transport, communication and electricity) on the Nigerian economy. Also, the study will examine the impact of infrastructure on the components of GDP. The rest of the paper is structured as follows: Section Two covers the review of theoretical and empirical literature on the subject matter. Section Three explains the theoretical basis for the study describes data and discusses the methodology of the study. Section Four presents the empirical results and findings. Finally, Section Five concludes the study and proffers policy recommendations.

2. REVIEW OF THEORETICAL AND EMPIRICAL LITERATURE

The neoclassical economists, particularly Solow (1956) posited that economic growth is dependent on capital and labour inputs and the level of technology. According to the neoclassical economists, steady-state growth is driven by exogenous forces – technological progress and the dynamics of population. Therefore, the theory neglects the critical role played by firms in determining long-run growth and the effect of government policies like infrastructure development. Thus, the neoclassical theory implies that public infrastructure can only be relevant in determining the level of output but, does not necessarily impact on the rate of growth of the economy (Easterly & Rebelo, 1993). Hence, infrastructure development impacts on growth only in the short-run. On the other hand, the new growth theory recognized the invaluable role of public infrastructure in the growth process. The new growth theory dwelt on the creation of technological knowledge and the transmission of same. Emphasis was placed on the propelling force behind innovation and invention, which is the major driver of growth. Scholars in the new growth school include Romer (1986, 1990), Grossman and Helpman (1991).

Generally, the new growth models assumed that there is constant returns to scale of inputs and that the level of technology depends on a set of inputs. For example, Romer (1986) identified technological progress as a function of the level of research and development. Romer (1986, 1990), Lucas (1988) and Barro (1990) ushered in the endogenous growth theory that views human capital accumulation and infrastructure development as the two main factors influencing economic growth. Lucas (1988) argued that the productivity of each worker depends on the average level of human capital. Barro (1990) noted that the contribution of productive public services (for example, infrastructure) to private production spurs economic growth. Endogenous growth models propose that improvement in capital (infrastructure development) and the generation of new processes and products stimulate growth. Infrastructure-led growth is another view on how infrastructure influences economic growth. In this case, infrastructure impacts the economy either directly as part of input in the production process or indirectly by influencing total factor productivity (Agénor & Moreno-Dodson, 2006). For example, the construction of new roads will open up inaccessible areas for siting productive investments. Infrastructure also generates externalities which pose indirect effects on the economy. These effects could either be positive or negative. For example, improvement in infrastructure (information and communication technology) could lead to extra costs in terms of maintenance. Also, even though information and communication technology come with positive externalities like time saving and improved labour productivity, it requires extra cost in human capital development (Straub, 2008).

The empirical literature on the relevance of infrastructure development to the economy has been explicit. Studies have shown that infrastructure development impacts the economy positively (Beaton, Cebotari & Komaromi, 2017; Govinda, Gal & Ze, 2020; Olaoye, 2019). Calderon and Serven (2004) examined the effects of infrastructure development on growth and income distribution using the system generalized method of moments (GMM-SYS). The study found that the stock of infrastructure assets encourages economic growth. In addition, the authors noted that with high quantity and quality of infrastructure, inequality in income declines. This finding aligns with Lopez (2004), who posited that infrastructure stimulates economic growth and reduces income inequality; thus, infrastructure may be crucial to poverty reduction.

Dao (2008) examined the determinants of infrastructure development in developing countries using the ordinary least square (OLS) method. The study found that infrastructure indicators linearly depend on the share of public expenditure in pensions in GDP, the share of public expenditure on health in GDP, public expenditure on education as percentage of government expenditures, public saving as a percentage of GDP as well as civil service wages as a fraction of government spending. The study further noted that only private spending on telecommunication as a percentage of GDP was statistically significant in explaining cross-country variation in the number of fixed and mobile telephone lines.

In another study on the role of infrastructure in promoting economic growth in Iran, Sojoodi, Zonuzi and Nia (2012), using the autoregressive distributed lag (ARDL) model found that transport infrastructure, specific length of railway and road as well as telecommunication positively and significantly impact economic growth of Iran. However, electricity production capacity insignificantly impacts growth in per-capita output. Therefore, considering different infrastructure types and regions, there might be divergent views. For instance, Portugal-Perez and Wilson (2012), using gravity model examined the influence of hard and soft infrastructure on export performance and trade facilitation. The study found that per-capita income seems to be declining as transport infrastructure becomes more efficient and export improves. This contradicts the view that infrastructure positively impacts the economy. Notwithstanding, recent studies support the view that infrastructure positively impacts exports (Ding & Hadzi-Vaskov, 2017; Nwaogwugwu & Olaoye, 2018). However, the influence of infrastructure on other components of GDP (household consumption expenditure, firm investment expenditure and government expenditure is yet to be investigated.

In another study on the impact of infrastructure on trade and economic growth in selected Asian countries, using augmented gravity model, Ismail and Mahyideen (2015) found that inadequate infrastructure impedes economic growth. In addition, the study noted the crucial role played by infrastructure in integrating markets. Therefore, improvement on infrastructure delivery is imperative for trade facilitation and improvement in national competitiveness (Palei, 2015). Using OLS, Palei (2015) established the positive role of infrastructure in enhancing production capacity and reducing input costs; increasing the productivity of workers; job creation; increasing human capital as well as providing access to the poor. On the other hand, Obialor (2017) in the study of the effect of government infrastructure investment on economic growth in sub-Sahara Africa, using the error correction model, found that in Nigeria, communication and rail infrastructure are negatively related to economic growth. In addition, communication and rail infrastructure are insignificant in explaining the changes in economic growth. Furthermore, power infrastructure was insignificant in explaining the changes in economic growth in Nigeria, though power is positively associated with economic growth. The same study noted that in South Africa, communication and rail infrastructure have significant positive relationship with economic growth, while power infrastructure has significant but negative effect on economic growth. Finally, the study found that in Ghana, communication and power infrastructure are inversely related with economic growth. Hence, the study concluded that government infrastructure financing has insignificant negative effect on economic growth in sub-Sahara Africa (SSA).

Despite the increase in public investment in infrastructure, Gurara, Klyuev, Mwase and Presbitero (2018) noted that the quantity, quality and accessibility of infrastructure in developing countries remain considerably lower than in emerging economies. Therefore, it is needful to investigate how well-developing countries can use infrastructure to spur economic growth. Yousaf and Erum (2018) assessed the role of infrastructure in promoting domestic investment in Pakistan, using ARDL method found that infrastructure positively impacts domestic investment, which is a vital component of GDP. Similarly, in a more recent study on the contribution of infrastructure to economic growth in Africa, Gachunga and Kuso (2019) used the OLS method to find that infrastructure positively impacts growth in the economy.

Summarily, literature agrees that infrastructure in general positively impacts growth but, unbundling infrastructure into different components might yield varying results. Also, the impact of infrastructure differs from country to country. Hence, the current study intends to distinctly present the influence of different infrastructure components on the Nigerian economy.

3. METHODOLOGY

This study derives its stance from the endogenous growth theory, which argues that economic growth is generated from within a system. Thus, long-run economic growth depends on internal forces in the economy. According to the theory, harnessing a

nation's capital will lead to economic growth by developing new forms of technology and efficient and effective means of production. It is believed that growth is created and sustained from within the country and not through trade. The model mathematically explains technological advancement. Therefore, this study draws from the version of the endogenous growth model presented by Futagami, Morita and Shibata (1993), where private and public capital stock was introduced in the growth model. Thus, infrastructure is viewed as input alongside other factors influencing output growth.

Following the modified Solow's production function specified by Romer (1996), we have;

$$Y_t = K_t^{\alpha}\left[A_t L_t\right]^{\beta} \quad \text{(i)}$$

The economic model can be specified as:

$$Y_t = f(L_t, K_t) \quad \text{(ii)}$$

Where Y represents output, L represents labour, K represents capital, t represents time and f shows functional relationship. The model can further be adapted as:

$$Y = f(frt) \quad \text{(iii)}$$

Where frt represents infrastructure. Infrastructure is further unbundled into components. Also, in practice and according to empirical literature, other variables affect output such as interest rate and inflation. Therefore, the model can be modified as follows to incorporate interest rate and inflation, which are pivotal to national output:

$$Y = f(edu, hlt, trp, com, elc, \text{int}, \text{inf}) \quad \text{(iv)}$$

Where edu represents education infrastructure (proxy by mean year of schooling), hlt represents health infrastructure (proxy by life expectancy ratio), trp represents transport infrastructure (proxy by the total length of railroad lines in kilometers), com represents communication infrastructure (proxy by mobile cellular subscribers per 100 inhabitants), elc represents electricity infrastructure (proxy by electricity consumption measured in billion kilowatt hours), int represents real interest rate (measured as lending rate minus deposit rate, %) and inf represents inflation (GDP deflator, annual %). The selection of variables is based on data availability as there are other proxies for which data is not readily available.

The econometric version of the model with variables in the natural logarithm form can be specified as:

$$\ln Y_t = \alpha_0 + \alpha_1 \ln edu_t + \alpha_2 \ln hlt_t + \alpha_3 \ln trp_t + \alpha_4 \ln com_t + \alpha_5 \ln elc_t + \alpha_6 \ln \text{int}_t + \alpha_7 \ln \text{inf}_t + \mu_t \quad \text{(v)}$$

On the impact of infrastructure on the components of GDP, the models can be specified thus:

$$\ln hh_t = \beta_0 + \beta_8 \ln edu_t + \beta_9 \ln hlt_t + \beta_{10} \ln trp_t + \beta_{11} \ln com_t + \beta_{12} \ln elc_t + \beta_{13} \ln \text{int}_t + \beta_{14} \ln \text{inf}_t + \upsilon_t \quad \text{(vi)}$$

$$\ln fm_t = \phi_0 + \phi_{15} \ln edu_t + \alpha_{16} \ln hlt_t + \phi_{17} \ln trp_t + \phi_{18} \ln com_t + \phi_{19} \ln elc_t + \phi_{20} \ln \text{int}_t + \phi_{21} \ln \text{inf}_t + \varepsilon_t \quad \text{(vii)}$$

$$\ln gov_t = \gamma_0 + \gamma_{22} \ln edu_t + \gamma_{23} \ln hlt_t + \gamma_{24} \ln trp_t + \gamma_{25} \ln com_t + \gamma_{26} \ln elc_t + \gamma_{27} \ln \text{int}_t + \gamma_{28} \ln \text{inf}_t + \eta_t \quad \text{(viii)}$$

Where α_0 is the intercept, the parameter estimates with subscripts 1-28 are the coefficients of the explanatory variables. $\ln hh_t$, $\ln fm_t$ and $\ln gov_t$ represent household consumption expenditure, firm investment expenditure and government expenditure respectively in the natural logarithm form.

Table I. Description of Variables

Variable	Description	Source
Real gross domestic product	This is the output from the productive sectors of the economy.	World Development Indicators (2020)
Education infrastructure	This is a measure of the level of education in the country.	World Development Indicators (2020)
Health infrastructure	This is a measure of the health condition of citizens of the country.	World Development Indicators (2020)
Transport infrastructure	This is a measure of the country's level of development in terms of the ease of transportation of goods and services.	The Global Economy data of World Bank (2020)
Information and communication technology	This is a measure of the country's development in terms of communication and internet services.	The Global Economy data of World Bank (2020)
Electricity infrastructure	This is a measure of the quantity of electricity enjoyed by Nigerians.	The Global Economy data of World Bank (2020)
Inflation rate	This measures the rate of change in the general price level of goods and services.	World Development Indicators (2020)
Interest rate	This is the rate of return-on-investment set by the monetary authority.	World Development Indicators (2020)

Source: Compiled by author, 2021

Data for the study was sourced from the Global Economy data (2020) and World Development Indicators (WDI, 2020); both publications of the World Bank. Annual time series data covering a period of forty years, from 1981-2020, was used to get a robust result. The parameters are expected a priori to positively influence output except for interest rate and inflation which are expected to impact the explained variables negatively. μ , υ , ε and η are the error terms which capture other variables that are not included in the models.

Literature has established the fact that macroeconomic variables are usually non-stationary at level. Non-stationarity at level implies that the variables are integrated of a higher order, while stationarity at level implies that the series are integrated of order one. When variables are integrated of order one, the ordinary least square (OLS) regression method can be used to estimate the changes in the explained variable as a result of changes in the explanatory variables. Otherwise, OLS will present misleading results about the direction and magnitude of the influence of the explanatory variables on the explained variables. The coefficients will therefore be inconsistent and inefficient; violating the assumptions of OLS. Therefore, the variables were subjected to preliminary test for unit root using the Augmented Dickey-Fuller Unit root test, which can control for higher-order serial correlation in the series. Dickey and Fuller (1979, 1981) unit root test is a parametric approach which accounts for autocorrelation in the first differences of a series by estimating the additional nuisance parameters. The ADF test equation is expressed as:

$$\Delta G_1 = \beta_1 + \beta_{2t} + \partial G_{t-1} + \sum_{i=1}^{m} \alpha_1 \Delta G_{t-1} + \varepsilon_t \qquad \text{(ix)}$$

Where G_1 is the variable of interest; ε_t is the white noise error term; t is time trend; Δ is the difference operator; $\beta_1, \beta_2, \partial$ and α_1 are the parameters. The result of the unit root test will indicate the level of stationarity of the variables.

Thereafter, based on the above-stated objectives, Autoregressive Distributed Lag (ARDL) method was used to examine the short-run and long-run relationships among the variables. Pesaran, Shin and Smith (2001) noted that ARDL approach is most suitable for examining the influence of explanatory variables on the explained variable when there is a combination of integration of order zero and one. In addition, ARDL allows for variation of optimal lag lengths for the variables. This reduces the problem of serial correlation in the explanatory variables. Therefore, in order to examine the influence of infrastructure on the Nigerian economy the ARDL model is specified thus:

$$\begin{aligned}\Delta \ln Y_t &= \alpha_0 + \sum_{i=1}^{x} \alpha_1 \Delta \ln Y_{t-1} + \sum_{i=1}^{x} \alpha_2 \Delta \ln edu + \sum_{i=1}^{x} \alpha_3 \Delta \ln hlt + \sum_{i=1}^{x} \alpha_4 \Delta \ln trp + \sum_{i=1}^{x} \alpha_5 \Delta \ln com \\ &+ \sum_{i=1}^{x} \alpha_6 \Delta \ln elc + \sum_{i=1}^{x} \alpha_7 \Delta \ln \text{int} + \sum_{i=1}^{x} \alpha_8 \Delta \ln \text{inf} + \lambda_1 \ln Y_{t-1} + \lambda_2 \ln edu_{t-1} + \lambda_3 \ln hlt_{t-1} + \lambda_4 \ln trp_{t-1} \qquad \text{(x)} \\ &+ \lambda_5 \ln com_{t-1} + \lambda_6 \ln elc_{t-1} + \lambda_7 \ln \text{int}_{t-1} + \lambda_8 \ln \text{inf}_{t-1} + \mu_t\end{aligned}$$

Equation (x) is the unrestricted version of the ARDL model, where $\alpha_1 - \alpha_8$ are the elasticities of the corresponding explanatory variables, Δ is the difference operator, $\lambda_1 - \lambda_8$ are the long-run multipliers of the explanatory variables. In order to estimate the influence of infrastructure on Nigerian household consumption expenditure, the ARDL model is specified thus:

$$\begin{aligned}\Delta \ln hh_t &= \beta_0 + \sum_{i=1}^{x} \beta_1 \Delta \ln hh_{t-1} + \sum_{i=1}^{x} \beta_2 \Delta \ln edu + \sum_{i=1}^{x} \beta_3 \Delta \ln hlt + \sum_{i=1}^{x} \beta_4 \Delta \ln trp + \sum_{i=1}^{x} \beta_5 \Delta \ln com \\ &+ \sum_{i=1}^{x} \beta_6 \Delta \ln elc + \sum_{i=1}^{x} \beta_7 \Delta \ln \text{int} + \sum_{i=1}^{x} \beta_8 \Delta \ln \text{inf} + \omega_1 \ln hh_{t-1} + \omega_2 \ln edu_{t-1} + \omega_3 \ln hlt_{t-1} + \omega_4 \ln trp_{t-1} \qquad \text{(xi)} \\ &+ \omega_5 \ln com_{t-1} + \omega_6 \ln elc_{t-1} + \omega_7 \ln \text{int}_{t-1} + \omega_8 \ln \text{inf}_{t-1} + \nu_t\end{aligned}$$

Where $\beta_1 - \beta_8$ are the elasticities of the corresponding explanatory variables in the short-run, $\omega_1 - \omega_8$ are the long-run multipliers of the explanatory variables. Similarly, in estimating the influence of infrastructure on firm investment expenditure in Nigeria, the ARDL model is presented thus:

$$\begin{aligned}\Delta \ln fm_t &= \phi_0 + \sum_{i=1}^{x} \phi_1 \Delta \ln fm_{t-1} + \sum_{i=1}^{x} \phi_2 \Delta \ln edu + \sum_{i=1}^{x} \phi_3 \Delta \ln hlt + \sum_{i=1}^{x} \phi_4 \Delta \ln trp + \sum_{i=1}^{x} \phi_5 \Delta \ln com \\ &+ \sum_{i=1}^{x} \phi_6 \Delta \ln elc + \sum_{i=1}^{x} \phi_7 \Delta \ln \text{int} + \sum_{i=1}^{x} \phi_8 \Delta \ln \text{inf} + \psi_1 \ln fm_{t-1} + \psi_2 \ln edu_{t-1} + \psi_3 \ln hlt_{t-1} + \psi_4 \ln trp_{t-1} \qquad \text{(xii)} \\ &+ \psi_5 \ln com_{t-1} + \psi_6 \ln elc_{t-1} + \psi_7 \ln \text{int}_{t-1} + \psi_8 \ln \text{inf}_{t-1} + \varepsilon_t\end{aligned}$$

Where $\phi_1 - \phi_8$ are the short-run estimates of the corresponding explanatory variables, Δ is the difference operator, $\psi_1 - \psi_8$ are the long-run estimates of the explanatory variables. To estimate the influence of infrastructure on Nigerian government expenditure, the ARDL model is specified thus:

$$\Delta \ln gov_t = \gamma_0 + \sum_{i=1}^{x} \gamma_1 \Delta \ln gov_{t-1} + \sum_{i=1}^{x} \gamma_2 \Delta \ln edu + \sum_{i=1}^{x} \gamma_3 \Delta \ln hlt + \sum_{i=1}^{x} \gamma_4 \Delta \ln trp + \sum_{i=1}^{x} \gamma_5 \Delta \ln com$$
$$+ \sum_{i=1}^{x} \gamma_6 \Delta \ln elc + \sum_{i=1}^{x} \alpha\gamma_7 \Delta \ln \text{int} + \sum_{i=1}^{x} \gamma_8 \Delta \ln \text{inf} + \tau_1 \ln gov_{t-1} + \tau_2 \ln edu_{t-1} + \tau_3 \ln hlt_{t-1} + \tau_4 \ln trp_{t-1} \quad \text{(xiii)}$$
$$+ \tau_5 \ln com_{t-1} + \tau_6 \ln elc_{t-1} + \tau_7 \ln \text{int}_{t-1} + \tau_8 \ln \text{inf}_{t-1} + \eta_t$$

Where $\gamma_1 - \gamma_8$ are the elasticities of the corresponding explanatory variables in the short-run, Δ is the difference operator, $\tau_1 - \tau_8$ are the long-run estimates of the explanatory variables. Finally, post-estimation tests were carried out to validate the results obtained. These included normality test, test for serial correlation as well as test for heteroskedasticity.

4. RESULT AND DISCUSSION

The result of the various tests carried out is presented and discussed in this section. In the empirical literature, it has been established that macroeconomic variables are usually non-stationary at level. Therefore, Augmented Dickey-Fuller (ADF) unit root test was used to address the problem of endogeneity common among macroeconomic variables.

From Table II, only inflation and interest rate were integrated of order zero; meaning that the variables were stationary at level. Other variables were integrated of order one; hence stationary at first difference. The result implies that the OLS regression method will not be sufficient in estimating the model.

Table II. Result of ADF Unit Root Test

Variable	ADF value	Level	First Difference	Remark
Y	2.94	1.08	3.79	I(1)
com	2.94	0.51	4.84	I(1)
elc	2.94	0.72	7.60	I(1)
trp	2.94	3.10	5.93	I(1)
edu	2.94	1.78	3.12	I(1)
hlt	2.94	2.37	4.75	I(1)
inf	2.94	13.93	16.38	I(0)
int	2.94	7.39	9.91	I(0)
hh	2.94	1.86	6.17	I(1)
fm	2.94	1.00	4.02	I(1)
gov	2.94	1.06	5.95	I(1)

Source: Author's computation, 2021 [Underlying data from WDI (2020) and The Global Economy data (2020)]

The result of the Bounds test shows that a long-run relationship exists among the variables. This is evidenced by the F-statistic value, which is greater than the upper bounds at different significance levels. Also, the Akaike information criteria graph (Appendix I) shows that the selection of explanatory variables is okay.

Table III. Result of ARDL Bound Test

Test Statistic	Value	k
F-statistic	5.00	5
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

Source: Author's computation, 2021 [Underlying data from WDI (2020) and The Global Economy data (2020)]

Table III presents the results of both the short-run and long-run estimates of the impact of infrastructure components on the Nigerian economy. The Akaike Information Criteria graph (Appendix 1) shows that the model is well-fitted with the dependent variable at lag 3. The regressors were captured at lag 3 and lag 4. Furthermore, the short-run result reveals the existence of at least one cointegrating equation and provides evidence to support the statistical significance of the result at the 10% significance

level (lsf). The short-run result shows that the speed of adjustment of the real GDP to changes in infrastructure is negatively significant and less than one. This implies that infrastructure components have joint statistical significance in explaining changes in the Nigerian economy. The result further shows that the dependence on the previous level of real GDP will pose a negative impact on the Nigerian economy. Also, communication infrastructure was statistically and positively significant in explaining changes in the real GDP in Nigeria at the 10% lsf. A unit improvement in communication infrastructure will lead to an approximately 0.04unit increase in real GDP. Similarly, lagged transport and education infrastructure will positively and significantly influence real GDP at the 10% lsf. This result implies that a unit increase in lagged transport and education infrastructure will lead to an approximately 0.4unit increase and 0.2 unit increase in real GDP respectively. Therefore, improvement in transport and education infrastructure will be beneficial to the Nigerian economy.

In the long-run, all the regressors were statistically insignificant in explaining changes in real GDP, but communication, electricity and education infrastructure positively correlated with real GDP. Transport and health infrastructure were negatively signed; showing an inverse relationship with real GDP. This result contradicts Sojoodi, Zonusi and Nia (2012), who found that transport infrastructure positively impacts economic growth and Palei (2015), who support the notion that health infrastructure positively impacts economic growth. The contradictory result corroborates the fact that transport and health infrastructure are underdeveloped in Nigeria. Also, the non-significance of infrastructure variables shows that infrastructure development in Nigeria is still far below the desirable state. In addition, inflation and interest rates show inverse relationship with real GDP. Thus, the monetary authority in Nigeria need to examine the current inflation and interest rates in order to ensure that in the long-run, the influence of these macroeconomic variables does not negatively impact on the economy. The result further shows that the intercept was statistically significant in explaining changes in real GDP at a 5% lsf. In addition, the coefficient of the constant term was positively associated with real GDP. This result implies that a unit increase in the fixed spending on infrastructure will lead to an approximately 88 units increase in the real GDP. Hence, in the long-run, consistent spending on infrastructure will significantly benefit the Nigerian economy.

Table IV. Impact of Infrastructure on the Nigerian Economy

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(Y(-1))	-0.67	0.24	-2.81**	0.03
D(Y(-2))	0.33	0.25	1.32	0.23
D(COM)	0.04	0.02	2.52**	0.05
D(COM(-1))	0.01	0.02	0.28	0.79
D(COM(-2))	0.03	0.02	1.70	0.14
D(COM(-3))	-0.02	0.01	-1.75	0.13
D(ELC)	0.01	0.00	1.73	0.14
D(ELC(-1))	-0.00	0.01	-0.72	0.50
D(ELC(-2))	-0.01	0.01	-1.49	0.19
D(ELC(-3))	-0.01	0.01	-0.99	0.36
D(TRP)	-0.06	0.29	-0.22	0.83
D(TRP(-1))	-0.60	0.44	-1.35	0.23
D(TRP(-2))	0.43	0.19	2.27*	0.06
D(EDU)	0.17	0.10	1.75	0.13
D(EDU(-1))	0.19	0.09	2.21*	0.07
D(EDU(-2))	0.11	0.12	0.87	0.42
D(EDU(-3))	-0.15	0.12	-1.23	0.26
D(HLT)	0.03	1.25	0.03	0.98
D(HLT(-1))	0.09	0.91	0.10	0.92
D(HLT(-2))	0.88	0.84	1.05	0.34
D(HLT(-3))	-0.67	0.76	-0.89	0.41
D(INF)	-0.00	0.00	-0.54	0.61
D(INT)	-0.00	0.00	-0.04	0.97
CointEq(-1)	-0.26	0.12	-2.13*	0.08

Cointeq = Y - (0.06*COM + 0.10*ELC -3.88*TRP + 0.43*EDU
-9.73*HLT -0.01*INF -0.00*INT + 87.60)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COM	0.06	0.04	1.38	0.22
ELC	0.10	0.05	1.88	0.11
TRP	-3.88	2.79	-1.39	0.21
EDU	0.43	0.91	0.48	0.65
HLT	-9.73	7.02	-1.39	0.21
INF	-0.01	0.01	-0.55	0.60
INT	-0.00	0.01	-0.04	0.97
C	87.60	32.09	2.73**	0.03

Note: *, **, *** indicate 10%, 5% and 1% level of significance respectively

Source: Author's computation, 2021 [Underlying data from WDI (2020) and The Global Economy data (2020)]

To capture Objective 2, the study used the ARDL method to examine the impact of infrastructure on components of GDP. The results are presented in Tables V-X. Therefore, the study tested the variables for long-run relationship using the ARDL Bounds test. The result of the Bounds test is presented in Table V.

From Table V, the result of the Bounds test provides evidence of the existence of a long-run relationship among the variables. The F-statistic value is greater than the lower and upper bounds at the different levels of significance. The selection of explanatory variables is justified by the Akaike information criteria graph (Appendix IV).

Table V. Bound Test on Infrastructure and Household Consumption Expenditure

Test Statistic	Value	k
F-statistic	9.93	5

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	1.81	2.93
5%	2.14	3.34
2.5%	2.44	3.71
1%	2.82	4.21

Source: Author's computation, 2021 [Underlying data from WDI (2020) and The Global Economy data (2020)]

Table VI shows the impact of infrastructure on household consumption expenditure in Nigeria. The Akaike information criteria graph (Appendix IV) shows that the model is well-fitted with the dependent variable at lag one. The first regressor was captured at lag 2, while other regressors were captured at the static level and at lag 2. The short-run result further shows that at least one cointegrating equation exists and the model is significant at 5% lsf. The speed of adjustment of household consumption expenditure to changes in infrastructure was negative and less than one. This implies that infrastructure components have joint statistical significance in explaining changes in household consumption pattern in Nigeria.

In the short-run, only lagged communication infrastructure influences household consumption expenditure. However, an inverse relationship exists between communication infrastructure and household consumption expenditure. The result shows that at 10% lsf, a unit increase in communication infrastructure will lead to an approximately 1.6 unit decrease in household consumption expenditure. The result implies that communication infrastructure affects household consumption expenditure negatively. The result suggests that household expenditure on other items reduces due to their consumption of communication infrastructure. Due to a high tariff, household expenditure on call credit and data will reduce the amount of household income available for other consumption expenditure. Thus, a trade-off exists between household consumption expenditure and the satisfaction derived from the consumption of communication infrastructure. Therefore, improvement in communication infrastructure may be detrimental to household consumption expenditure if the telecommunication sector is not properly regulated. This result is similar to Obialor (2017), who found that communication infrastructure negatively influences the Nigerian

economy; though statistically insignificant. Also, inflation and interest rate were statistically significant in explaining changes in household consumption expenditure at 1% lsf. Inflation and interest rates were positively associated with household consumption expenditure. The result shows that a unit increase in inflation and interest rate will lead to an approximately 0.7 unit increase and 1.1 unit increase in household consumption expenditure respectively. The implication of this result is that mild inflation and a slight increase in interest rate will have ripple effect on household consumption expenditure.

In the long-run, all infrastructure variables were statistically insignificant in explaining changes in household consumption expenditure. The long-run result shows that communication, education and transport infrastructure positively but insignificantly influence household consumption expenditure. On the other hand, health infrastructure negatively but insignificantly influences household consumption expenditure. This result shows that the current health infrastructure is grossly inadequate and unsustainable. Moreover, in the long-run, inflation and interest rate influence household consumption expenditure positively at the 5% lsf. A unit increase in inflation and interest rate will lead to an approximately 2.9 units and 4.5 units increase respectively in household consumption expenditure. The implication of this result is that fluctuations in monetary variables significantly impact household consumption expenditure. In the long-run, household consumption expenditure increases as inflation and interest rates rise; thereby reducing the real income of households. Hence, monetary authorities should factor in the influence of monetary variables on households in their policy making process.

Table VI. Impact of Infrastructure on Nigerian Household Consumption Expenditure

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(COM)	-0.21	0.83	-0.25	0.80
D(COM(-1))	-1.62	0.86	-1.89*	0.07
D(EDU)	0.42	5.58	0.08	0.94
D(HLT)	-71.11	54.26	-1.31	0.20
D(TRP)	21.04	20.08	1.05	0.30
D(TRP(-1))	27.80	18.77	1.48	0.15
D(ELC)	0.34	0.44	0.77	0.45
D(INF)	0.68	0.13	5.36***	0.00
D(INT)	1.07	0.18	5.99***	0.00
CointEq(-1)	-0.24	0.10	-2.47**	0.02

Cointeq = HH - (2.97*COM + 1.76*EDU -296.35*HLT + 130.83 *TRP + 1.40*ELC + 2.85*INF + 4.45*INT)

Long-run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COM	2.97	3.10	0.96	0.35
EDU	1.76	23.10	0.08	0.94
HLT	-296.35	255.37	-1.16	0.26
TRP	130.83	108.72	1.20	0.24
ELC	1.40	1.71	0.82	0.42
INF	2.85	1.10	2.58**	0.02
INT	4.45	1.81	2.46**	0.02

Note: *, **, *** indicate 10%, 5% and 1% level of significance respectively

Source: Author's computation, 2021 [Underlying data from WDI (2020) and The Global Economy data (2020)]

Table VII shows the result of the Bounds test to examine whether there is a long-run relationship among the variables. The value of F-statistic is greater than the upper bounds at the different significance levels, this shows that there is a long-run relationship among the variables. Also, the Akaike information criteria graph (Appendix VII) shows that the model is well-fitted.

Table VII. Bound Test on Infrastructure and Nigerian Firm Investment Expenditure

Test Statistic	Value	k
F-statistic	5.77	5
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	1.81	2.93
5%	2.14	3.34
2.5%	2.44	3.71
1%	2.82	4.21

Source: Author's computation, 2021 [Underlying data from WDI (2020) and The Global Economy data (2020)

Table VIII shows the impact of infrastructure on firm investment expenditure in Nigeria. The Akaike information criteria graph shows that the dependent variable is captured at lag 4, while the regressors are captured at the static level and lags 2, 3 and 4. The short-run result shows that at least one cointegrating equation exists. The speed of adjustment of firm investment expenditure to changes in infrastructure is negative, less than one and significant in the short-run at 1% lsf. This implies that infrastructure components have joint statistical significance in explaining changes in Nigerian firm investment. The result further shows that in the short-run, lagged firm investment was statistically significant in explaining changes in current firm investment. The impact of lagged investment could be positive or negative according to the short-run result. In addition, communication infrastructure was statistically significant in explaining changes in communication infrastructure at the 5% lsf. Communication infrastructure was inversely related to firm investment. A unit increase in communication infrastructure will lead to an approximately 0.1unit decrease in firm investment. This contradicts Yousaf and Erum (2018), who found that infrastructure positively impacts investment.

Similarly, lagged electricity infrastructure was statistically significant but inversely related with firm investment at the 5% lsf. A unit increase in lagged electricity infrastructure will lead to an approximately 0.1unit decline in firm investment. This implies that improvement in electricity infrastructure will reduce the investment of firms in some capital equipment, like power generating set, which was usually acquired to maintain production level during electric power outages. Thus, the associated cost of fuelling power generating set will be eliminated; thereby reducing the cost of production. Consequently, prices of goods fall and the resultant effect of increase in lagged electricity will yield benefits not only to firms but the entire economy.

In the long-run, electricity significantly explains changes in firm investment at the 10% lsf. The result shows that electricity infrastructure positively impacts firm investment. A unit increase in electricity infrastructure will lead to an approximately 0.1unit increase in firm investment. This implies that increase in electricity infrastructure will benefit firm investment expenditure in the long-run. Furthermore, the long-run result shows that education infrastructure negatively impacts on firm investment expenditure but insignificantly. This means that the Nigerian educational system will be harmful to firm investment expenditure in the long-run. This might be due to the fact that the kind of educational knowledge acquired in the current Nigerian educational system is not tailor-made for the firms. Therefore, firms have to expend hugely in retraining of graduates recruited from the Nigerian educational system. All other regressors positively but insignificantly influence firm investment expenditure in the long-run.

Table VIII. Impact of Infrastructure on Nigerian Firm Investment Expenditure

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FM(-1))	0.27	0.13	2.10**	0.05
D(FM(-2))	-0.31	0.14	-2.23**	0.04
D(COM)	-0.09	0.04	-2.39**	0.03
D(ELC)	0.02	0.02	1.00	0.33
D(ELC(-1))	0.00	0.02	0.04	0.97
D(ELC(-2))	-0.01	0.02	-0.47	0.65
D(ELC(-3))	-0.05	0.02	-2.31**	0.04
D(TRP)	-0.46	0.80	-0.58	0.57
D(TRP(-1))	1.71	1.08	1.58	0.13
D(TRP(-2))	-0.97	0.79	-1.22	0.24

D(EDU)	0.23	0.35	0.65	0.52
D(EDU(-1))	0.62	0.45	1.39	0.19
D(EDU(-2))	0.60	0.38	1.56	0.14
D(HLT)	3.94	3.65	1.08	0.30
D(INF)	0.01	0.01	1.51	0.15
D(INT)	0.01	0.01	1.49	0.16
CointEq(-1)	-0.75	0.18	-4.11***	0.00

Cointeq = FM - (0.01*COM + 0.11*ELC + 1.64*TRP -0.75*EDU + 5.27*HLT + 0.01*INF + 0.02*INT)

Long-run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COM	0.01	0.02	0.42	0.68
ELC	0.11	0.06	1.92*	0.07
TRP	1.64	2.04	0.81	0.43
EDU	-0.75	0.69	-1.08	0.30
HLT	5.27	4.28	1.23	0.24
INF	0.01	0.01	1.25	0.23
INT	0.02	0.02	1.25	0.23

Note: *, **, *** indicate 10%, 5% and 1% level of significance respectively

Source: Author's computation, 2021 [Underlying data from WDI (2020) and The Global Economy data (2020)]

Table IX presents the result of the Bounds test for the long-run relationship among the variables. Since the value of the F-statistic is greater than the upper bounds, the null hypothesis of the non-existence of a long-run relationship was rejected. Therefore, there exists a long-run relationship among the variables. Furthermore, the Akaike information criteria graph (Appendix X) shows that the variables in the model were well selected.

Table IX. Bound Test on Infrastructure and the Nigerian Government Expenditure

Test Statistic	Value	k
F-statistic	5.83	5

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	1.81	2.93
5%	2.14	3.34
2.5%	2.44	3.71
1%	2.82	4.21

Source: Author's computation, 2021 [Underlying data from WDI (2020) and The Global Economy data (2020)]

The dependent variable is captured at the static level, while the regressors are captured at lags 1, 2 and 3. The short-run result shows that at least one cointegrating equation exists and the result is statistically significant at 1% lsf. The short-run result shows that the speed of adjustment of the Nigerian government expenditure to changes in infrastructure is negative and less than one. This implies that infrastructure components have joint statistical significance in explaining changes in the Nigerian government expenditure.

In the short-run, both current and lagged education infrastructure were statistically significant in explaining changes in government expenditure at the 10% and 5% lsf. Current education infrastructure positively influences government expenditure, while lagged education infrastructure negatively influences government expenditure. A unit increase in current education infrastructure will lead to an approximately 2unit increase in government expenditure. Conversely, a unit increase in education infrastructure will lead to an approximately 1.5 unit fall in government expenditure. This result implies that the impact of government expenditure on education infrastructure is not immediately felt. Therefore, the benefit of education infrastructure lies in the fact that it is an asset and has the ability to reduce future liabilities of government.

The short-run result further shows that both current and lagged communication infrastructure were statistically significant in explaining changes in government expenditure at the 1% lsf. A unit increase in current and lagged communication infrastructure will lead to an approximately 0.2unit decline in both current and lagged communication infrastructure. Increase in communication infrastructure causes a decline in government expenditure; probably due to the fact that the Nigerian telecommunication sector has been privatized. Also, current and lagged electricity infrastructure was statistically significant at the 1% lsf. Current electricity infrastructure positively influences government expenditure, while lagged communication infrastructure negatively influences government expenditure. A unit increase in both current and lagged electricity infrastructure will lead to an approximately 0.1unit increase and 0.1 unit decrease in government expenditure. This implies that only current electricity infrastructure positively influences government expenditure. Therefore, it has become imperative to constantly spend on electricity infrastructure to improve the generation and transmission of same for the benefit of citizens.

Current health infrastructure was insignificant and inversely related to government expenditure. The short-run result shows that a unit improvement in current health infrastructure will lead to an approximately 5% decline in government expenditure. On the other hand, a unit increase in lagged health infrastructure will lead to increase in government expenditure. This implies that there is an inverse relationship between current health infrastructure (proxy life expectancy ratio) and government infrastructure. Therefore, the stock of health infrastructure should be consistent for a reduction in government expenditure. This will ensure readiness in the health sector at all times to handle cases of emergency and epidemics. Such prompt health interventions will help to reduce loss of lives of the citizens. In the same vein, government intervention in terms of public spending on building and equipment of emergency health centres will be reduced.

The short-run result further shows that current transport infrastructure was positively and statistically significant in explaining changes in government expenditure at 1% lsf. The result shows that a unit increase in transport infrastructure will lead to an approximately 4 units increase in government expenditure. This implies that transport infrastructure is relevant in boosting output through an expansionary fiscal policy of increase in government expenditure.

In the long-run, electricity infrastructure was positively and statistically significant in explaining changes in government expenditure at 5% lsf. A unit increase in electricity infrastructure will lead to an approximately 0.3unit increase in government expenditure. This implies that improvement in electricity infrastructure will lead to increase in government expenditure and output. However, on health infrastructure, the long-run result contradicts that of the short-run. While the coefficient of lagged health infrastructure was positively signed in the short run, in the long-run, the sign turned negative at the 5% lsf. Also, the magnitude of the coefficient of health infrastructure is larger in the long-run. This long-run result on health infrastructure disagrees with Palei (2015), who concluded that health infrastructure positively impacts economic growth. The current study shows that health infrastructure poses a significantly negative long-run impact on government expenditure and consequently on long-run economic growth as shown in Table 4.3. This might be fallout of the quality of health facilities available in the country. Finally, in the long-run, transport infrastructure was statistically significant in influencing government expenditure at 1% lsf. The result suggests that a unit improvement in transport infrastructure will lead to an approximately 23 units increase in government expenditure, thereby boosting output.

Table X. Impact of Infrastructure on the Nigerian Government Expenditure

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EDU)	1.70	0.56	3.06***	0.01
D(EDU(-1))	-1.49	0.60	-2.46**	0.02
D(COM)	-0.17	0.06	-2.90***	0.01
D(COM(-1))	-0.24	0.07	-3.49***	0.00
D(ELC)	0.11	0.04	2.99***	0.01
D(ELC(-1))	-0.11	0.03	-3.73***	0.00
D(HLT)	-4.85	6.87	-0.71	0.49
D(HLT(-1))	3.80	7.83	0.49	0.63
D(HLT(-2))	10.35	5.87	1.76*	0.09
D(TRP)	4.17	1.44	2.89***	0.01
D(INF)	0.00	0.01	0.51	0.61
D(INT)	-0.00	0.01	-0.25	0.81
CointEq(-1)	-0.36	0.11	-3.25***	0.00

Cointeq = GOV - (4.15*EDU + 0.15*COM + 0.26*ELC-60.12*HLT
+ 22.98*TRP + 0.01*INF -0.01*INT)

Long-run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EDU	4.15	2.72	1.53	0.14
COM	0.15	0.09	1.59	0.13
ELC	0.26	0.12	2.16**	0.04
HLT	-60.12	25.87	-2.32**	0.03
INF	0.01	0.03	0.51	0.62
INT	-0.01	0.04	-0.25	0.81

Note: *, **, *** indicate 10%, 5% and 1% level of significance respectively

Source: Author's computation, 2021 [Underlying data from WDI (2020) and The Global Economy data (2020)]

5. CONCLUSION AND RECOMMENDATIONS

The study examined the effect of infrastructure components on the real GDP and its components. The endogenous growth framework formed the basis of the study and the ARDL technique was adopted to estimate both the short-run and long-run impacts. The study found that in the short-run, communication, electricity, education and health infrastructure positively influence real GDP, while transport infrastructure negatively impacted on the real GDP. In the long-run, communication, electricity and education infrastructure positively influence the real GDP, while transport and health infrastructure negatively influenced the real GDP. In both the short-run and long-run, the influence of the infrastructure variables on the real GDP was insignificant, except for communication infrastructure which significantly influenced real GDP in the short-run. Transport infrastructure negatively impacted real GDP both in the short-run and long-run. This implies that the current state of transport infrastructure in Nigeria is unsustainable. The short-run positive impact of health infrastructure turned negative in the long-run. This result might be due to lag effect or might suggest that health infrastructure in Nigeria is unsustainable in the long-run.

On the impact of infrastructure on the components of GDP, the study found that communication infrastructure had negative impact on consumption and investment in the short-run, probably due to high tariff. However, in the long-run, the impact of communication infrastructure turned positive. This means that in the long-run, communication infrastructure will benefit Nigerians. Electricity infrastructure positively impacted all the components of GDP both in the short-run and long-run. This result shows that electricity infrastructure is most impactful and should be given priority attention. The positively significant impact of electricity infrastructure on investment in the long-run shows that it has serious implication for sustainable development. Also, the positively significant impact of electricity infrastructure on government expenditure reveals the pivotal role of government spending in enhancing the generation and transmission of electricity infrastructure in Nigeria.

Furthermore, in the short-run, transport infrastructure positively impacted on consumption and government expenditure, but negatively impacted on investment. This implies that the current level of transport infrastructure is not sufficient in driving investment. In addition, the long-run positively significant relationship between transport infrastructure and government spending shows that government expenditure on transport infrastructure will be beneficial to Nigerians in the long-run. In the short-run, education positively influenced consumption, investment and government expenditure. This result shows that education will benefit consumption, investment and government expenditure in the short-run. In the long-run, education positively impacted consumption and government expenditure, but negatively impacted investment. This result shows that consumption and government expenditure will benefit from education. However, the current educational system in Nigeria will not be beneficial to firm investment.

In the short-run, health infrastructure positively influenced investment but negatively impacted consumption and government expenditure. This might be due to huge household expenditure to get healthcare. Also, the result suggests that government expenditure will reduce as health infrastructure improves. In the long-run, a negative impact of health infrastructure on consumption and government expenditure was recorded, while health infrastructure positively influenced investment. This implies that in the long-run, health infrastructure in Nigeria may not be sustainable. In addition, the significant fall in long-run government expenditure suggests that improvement in current health infrastructure will ensure sustainability in the Nigerian health sector and there will be no need for fire brigade approach to government expenditure in the event of any national health challenge.

Based on the findings, it is recommended that the regulatory body for telecommunication infrastructure, the Nigerian Communications Commission (NCC) should be more proactive. The operations of the private communication firms should be

checked particularly with respect to the fixation of tariff on communication infrastructure. This is necessary to prevent the adverse effect of high tariff on the end-users of communication infrastructure. The Ministry of Education should work on the review of the current curriculum in the Nigerian educational system to suit the need of firms. This will make Nigerian graduates employable and more relevant in the labour market. Also, more government expenditure is required in the provision of electricity, transport, education and health infrastructure. This will help to reduce the cost of enjoying these facilities by citizens. However, electricity infrastructure being the most impactful should be given priority in terms of government expenditure.

Finally, future studies could investigate the impact of the quality of infrastructure components on the Nigerian economy since the current study used indicators of quantity of infrastructure.

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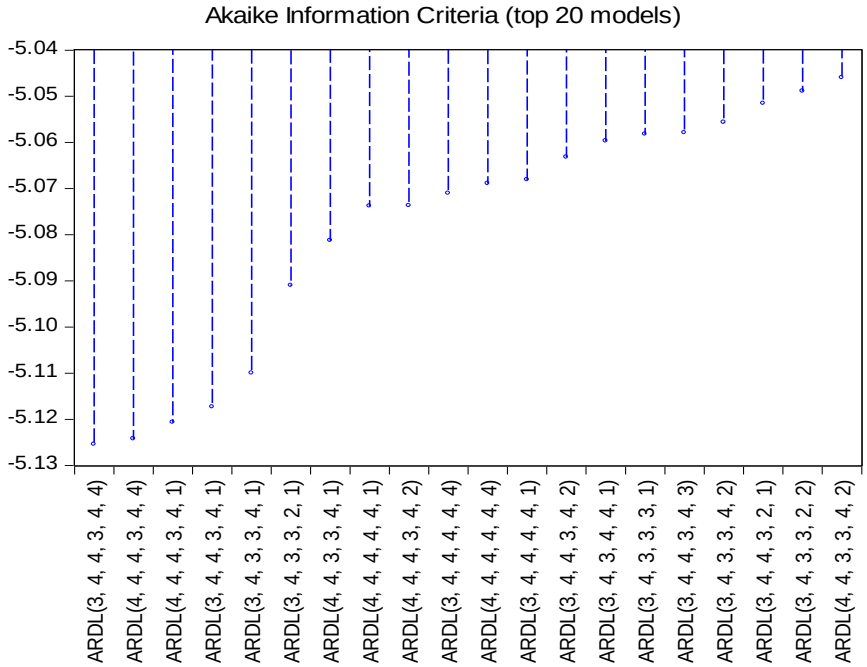
APPENDICES

Appendix I. Akaike Information Graph on the Nigerian Economy



Source: Author's computation, 2022

Appendix II. Test for Serial Correlation (The Nigerian Economy)

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	3.974236	Prob. F(2,4)	0.1121
Obs*R-squared	23.94825	Prob. Chi-Square(2)	0.2314

Source: Author's computation, 2022

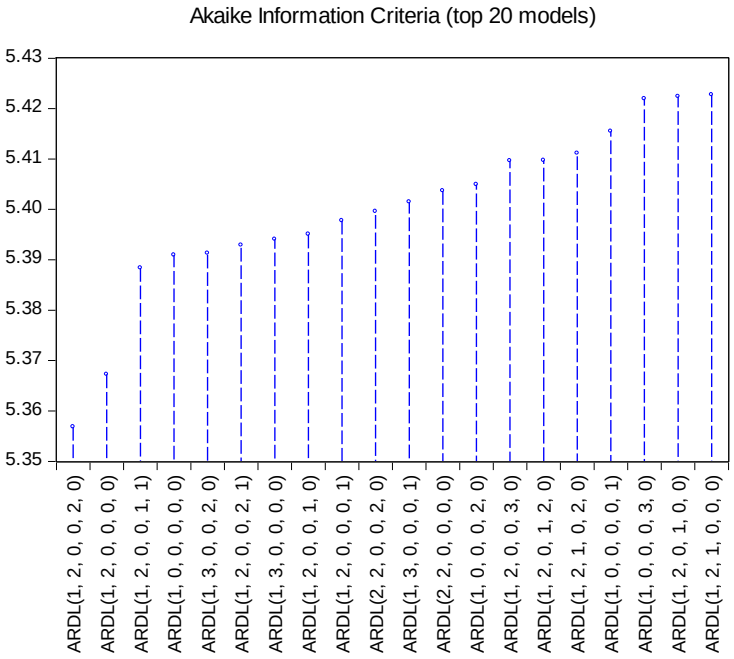
Appendix III. Test for Heteroskedasticity (The Nigerian Economy)

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.907634	Prob. F(29,6)	0.6148
Obs*R-squared	29.31712	Prob. Chi-Square(29)	0.4486
Scaled explained SS	2.110563	Prob. Chi-Square(29)	1.0000

Source: Author's computation, 2022

Appendix IV. Akaike Information Graph on Consumption Expenditure



Source: Author's computation, 2022

Appendix V. Test for Serial Correlation (Consumption Expenditure)

F-statistic	1.257630	Prob. F(2,24)	0.3024
Obs*R-squared	3.604713	Prob. Chi-Square(2)	0.1649

Source: Author's computation, 2022

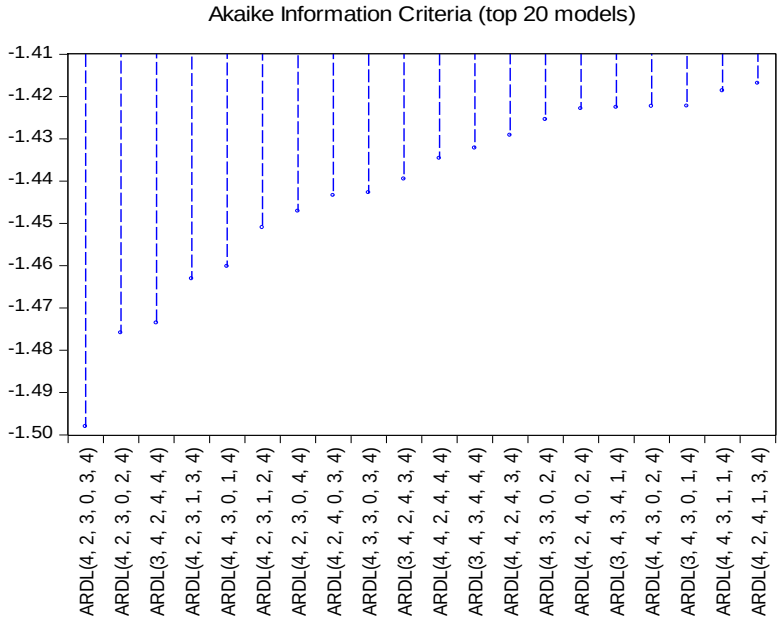
Appendix VI. Test for Heteroskedasticity (Consumption Expenditure)

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.927290	Prob. F(26,9)	0.5894
Obs*R-squared	26.21430	Prob. Chi-Square(26)	0.4514
Scaled explained SS	2.139573	Prob. Chi-Square(26)	1.0000

Source: Author's computation, 2022

Appendix VII. Akaike Information Graph on Investment Expenditure



Source: Author's computation, 2022

Appendix VIII. Test for Serial Correlation (Investment Expenditure)

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.600339	Prob. F(2,13)	0.5631
Obs*R-squared	3.043826	Prob. Chi-Square (2)	0.2183

Source: Author's computation, 2022

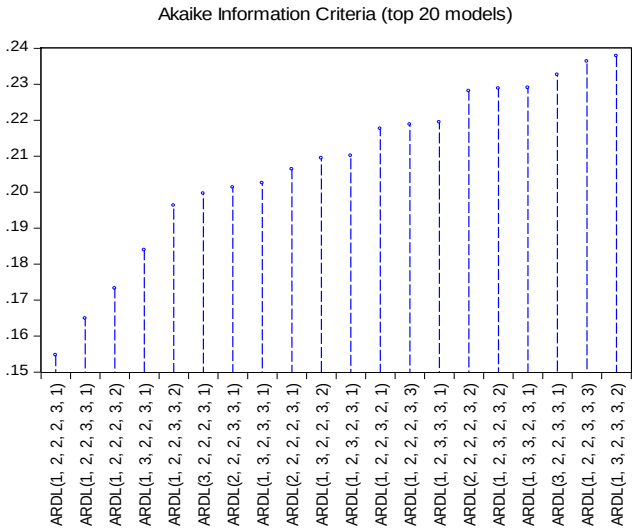
Appendix IX. Test for Heteroskedasticity (Investment Expenditure)

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.237503	Prob. F(21,14)	0.3467
Obs*R-squared	23.39608	Prob. Chi-Square (21)	0.3232
Scaled explained SS	3.042123	Prob. Chi-Square (21)	1.0000

Source: Author's computation, 2022

Appendix X. Akaike Information Graph on Government Expenditure



Source: Author's computation, 2022

Appendix XI. Test for Serial Correlation (Government Expenditure)

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.125292	Prob. F(2,13)	0.8833
Obs*R-squared	0.699714	Prob. Chi-Square(2)	0.7048

Source: Author's computation, 2022

Appendix XII. Test for Heteroskedasticity (Government Expenditure)

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.173539	Prob. F(18,18)	0.3690
Obs*R-squared	19.97707	Prob. Chi-Square(18)	0.3341
Scaled explained SS	7.747964	Prob. Chi-Square(18)	0.9822

Source: Author's computation, 2022