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## The Energy Consumption-Economic Growth Nexus in Nigeria: What Evidence Exists?

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**Abstract:** The study investigated the energy consumption-economic growth nexus in Nigeria. Specifically, the study aimed to establish a comprehensive understanding of the nexus and causality between the variables in Nigeria. The study's significance is highlighted in the context of various energy policies implemented in Nigeria, including the elimination of fuel subsidies. In order to accomplish the goals of this research, data spanning the period 1980 to 2022 were utilised in the study. Additionally, various econometric techniques, including the autoregressive distributed lag (ARDL) technique and the causality test, were adopted in order to estimate the relationship and causality between the variables. This approach has several advantages especially given variables that were integrated of order,  $I(0)$ ,  $I(1)$  or the combination of both. The method used in this study is also extremely resilient in establishing a strong and uninterrupted correlation between variables. The results of the research uncovered various important discoveries, one of which highlights the presence of a lasting connection between energy consumption and economic growth in Nigeria. Specifically, the study showed the presence of co-integration between energy consumption and economic growth. The study also demonstrated that in the event of an economic shock or destabilisation, the economy will take a relatively longer time period to re-establish equilibrium. Additionally, the outcomes of the study implied that energy consumption had a short- and long-term beneficial influence on growth. The study therefore suggested the implementation of an effective energy strategy that promotes sustainable consumption, so facilitating a prompt return to equilibrium in the event of an economic shock. The study showed novelty in that, unlike previous studies in Nigeria which has placed more emphasis on the impact or the effect of energy consumption on economic growth, it examined both the short- and long-run nexus, as well as the

causality among the variables. This importance of the study cannot be overemphasised given the structural imbalances in Nigerian energy sector.

**Keywords:** consumption, Nigeria, growth, energy, causality, model.

## **Introduction**

The importance of energy in driving economic growth for any nation cannot be emphasised enough. It acts as a pivotal force that propels various sectors within a country's economy. The efficiency and effectiveness of the energy sector directly influence the viability and productivity of crucial sectors like healthcare, industry, education, and various others (Augutis et al., 2011). The growth and the energy consumption (EC) are closely interconnected, and the relationship between the two is complex and multifaceted. Energy potentially spurs growth, since it drives the rate of industrialisation, stimulates productivity levels, and enhances the human development (<https://unctad.org/>).

The energy is a fundamental production input of goods and services. Industries, businesses, and households rely on energy for various activities such as manufacturing, transportation, heating, cooling, and lighting (Paudel et al., 2020; Stern, 2000; Thapa-Parajuli et al., 2021). An adequate and reliable energy supply is essential for the economic productivity and efficiency. Certain sectors of the economy, such as heavy industries (e.g., steel, cement, and chemicals), transportation, and power generation, tend to be more energy-intensive. The performance of these sectors heavily influences the EC patterns in a country. The actualisation of a stable and secure energy supply is essential for sustained economic growth. Over-reliance on imported energy sources or vulnerability to supply disruptions can negatively impact an economy (Efayena et al., 2022; Pokharel, 2007).

## **Research Problem**

Nigeria has huge energy potentials, ranging from the various energy sources to favourable exploring environment. For instance, oil accounts for a comparable portion of the primary energy needs as does bio-energy. Nigeria aims to maximize the capacity of its refineries. Nevertheless, the economy seems to be deviled by the “resource curse” syndrome. The current capacity, for instance, is not enough to meet the local demand for petroleum products. Eighty percent of the products are thus imported from outside in order to meet this demand (PWC, 2017). Similarly, only about 60 percent of the population can assess electricity. This implies that about 16 million households lack access to electricity (IRENA, 2023). In terms of energy requirements in coal utilisation, Nigeria also has a huge deficit between production and consumption. For instance, in the period 2012–2021, Nigeria produced an average of 51,000 tons of coal, while the country consumed an average of 86,000 tons. The country thus imported an average of 35,000 tons between this period (EIA, 2023).

In terms of the energy sector's contribution to economic growth, the statistics have been dismally below optimal. The contribution of the energy to economic growth is relatively low. For instance, in the first quarter of 2022, the share of the oil sector to real GDP stood at 6.63 percent. This value was lower than that of the first quarter of 2021 which was 9.25 percent. The contribution of the electricity and gas sector to real GDP declined from 0.47 percent in the fourth quarter of 2021 to 0.19 percent in the first quarter of 2022 (National Bureau of Statistics, 2022). These dismay scenarios could be partly attributed to the economy's reliance on energy imports through the years.

Compared to other countries, Nigeria possesses abundant energy resources, including biomass, hydro, wind, and solar power, among others. If effectively harnessed, Nigeria has the potential to generate surplus energy that surpasses local demand, creating economic opportunities for trading the excess energy. Despite these potentials, Nigeria faces one of the lowest energy accessibility rates when compared to both advanced and developing countries. The country still heavily relies on conventional energy sources like Premium Motor Spirit (PMS) for internal combustion engines, while many rural

households depend on firewood for cooking and lighting. The aforementioned energy sources are responsible for the release of greenhouse gases, hence exerting a substantial influence on the phenomenon of global warming and the broader issue of climate change. The aforementioned complex scenario was further intensified by the Covid-19 episode. The Covid-19 pandemic not only impeded the already sluggish advancements in the energy sector pertaining to production, accessibility, and utilisation (Cozzi et al., 2020) but also redirected financial resources towards resolving the economic difficulties stemming from the health crisis (IEA, 2020). As a result, the pandemic exerts significant impact on the energy industry, further impeding its development and resilience. In addition, the recent fuel subsidy removal will further worsen the situation and potentially affect the economic growth in Nigeria. Consequently, it is crucial to examine EC level in Nigeria concerning its growth effect.

### ***Research Focus***

As the Nigerian economy faces a critical situation concerning the energy production and utilisation, the stakes are high if the government fails to establish a viable policy mix during the planning process. Hence, it is imperative to analyse the relationship that exists between the EC and the growth in order to evaluate its long-term implications. The study's findings are strongly policy-oriented, aiming to enhance EC levels in Nigeria and promote optimal growth. Thus, the study therefore, focused on the EC-economic growth relationship in Nigeria. This study is of significant interest to policymakers, economists, and researchers as it can have essential implications for sustainable development, energy policies, and environmental considerations. Understanding the dynamics of EC-economic growth nexus can help identifying the opportunities for promoting economic growth while ensuring efficient and responsible energy use.

### ***Research Aim and Research Questions***

The main research aim was the investigation of the EC-economic growth nexus in Nigeria. The study sought to answer the research questions: what is the nature of relationship between EC and growth in Nigeria? and what is the impact of EC on economic growth?

### ***Literature Review***

Numerous studies have extensively analysed the interconnection between energy usage (consumption) and the progress of the economy. For instance, Khan et al. (2020) adopted the ARDL approach to examine the association between EC and growth. The analysis utilised data spanning the years 1965 to 2015, and employed CO<sub>2</sub> emission per capita, per capita income (PCI), a proxy for economic growth, coal consumption, oil consumption, and natural gas consumption as variables in the model. The study placed significant emphasis on the notion that EC exerts a stimulating effect on long-term economic growth. In their study, utilising Bulgarian data between 1990 and 2016, Can and Korkmaz (2019) evaluated the EC-growth. The renewable energy consumption (percentage of total final energy consumption), the renewable electricity output (percentage of total electricity output) and economic growth were utilised. The obtained results revealed that while EC had an effect on the growth, it did not exhibit statistically significant long-term consequences. In addition, Gessesse and He (2020) examined the correlation between EC and growth; using CO<sub>2</sub> emissions, energy consumption and per capita GDP between 1971 and 2015 in China. The study employed an ARDL limits test approach and discovered empirical support for a co-integrating the relationship among variables in both terms.

The study conducted by Soukiazis et al. (2019) employed a 2-way system approach to examine data from 28 OECD countries spanning the years 2004 to 2015. The research findings have substantiated the existence of a favourable correlation between EC levels and growth. Shafiei and Salim (2014) conducted a comprehensive analysis of 29 OECD economies, utilising a dataset that encompassed the years 1980 to 2011. Specifically, the study employed GDP per capita, renewable and non-renewable dataset among the countries employed. The research findings unveiled a reciprocal cause-and-effect association when examining both the levels of energy use and growth. The aforementioned research

employed diverse approaches and time-frames to examine the correlation between EC and growth in OECD economies. The findings consistently indicate a positive impact and a reciprocal causal relationship, respectively.

Hung-Pin (2014) conducted a study that had a narrower scope, focusing on a subset of OECD nations in comparison to previous research endeavours, employing renewable energy consumption and real GDP per capita. The study focused on analyzing the causal association between EC levels and growth in nine OECD economies from 1982 to 2011. This investigation employed both ARDL and VEC (vector-error correction) methods. Out all the sampled countries, only five exhibited empirical evidence of both co-integration and causality. In contrast, Kasperowicz (2014) conducted a study on twelve European economies spanning from 2000 to 2013. The study employed GDP, gross fixed capital, total energy consumption and total employment dataset among the countries. The study revealed a positive correlation between the variables within these nations. In a similar vein, the study conducted by Benavides et al. (2017) examined the correlation between levels of EC and growth in Austria during the period spanning from 1970 to 2012. Specifically, the study employed the following variables: GDP, methane emissions, electricity production, and trade openness. The study's findings unveiled a causal association that persisted over an extended period of time and operated in a single direction. In addition, the study conducted by Esen and Bayrak (2017) sought to investigate the potential relationship between elevated EC levels and growth in nations that significantly depend on energy imports. The study conducted utilized a sample of seventy-five countries that rely on net energy imports. The data spanned from 1990 to 2012, and the findings revealed a significant correlation between increased EC and sustained growth in the long run. The study which examines different time periods and country cohorts, generally indicate a favourable influence of EC levels on economic growth, whether through causal connections or one-way associations.

Hossain and Saeki (2011) conducted an analysis of the relationship between energy consumption per capita and per capita GDP among 6 countries between 1971 and 2007. The study revealed the existence of a long-run co-integrating nexus among these countries. Dhungel (2017) also found similar results. In his study, Dhungel x-rayed a panel of 5 South Asian economies for the period of 2000 to 2011, employing co-integration tests between growth and EC levels. The findings indicated a long-run nexus, with EC leading to growth in a unidirectional manner.

Numerous empirical studies conducted in Africa have explored the nexus between EC and growth. For example, Efayena et al. (2022) explore the EC-growth nexus in 10 emerging economies in Africa. The research aimed to address the significant energy demand-supply gap prevalent on the continent. To achieve this, the study utilised EC data from 1980 to 2020, along with real GDP per capita (RGDPPC), within a nonlinear econometric framework. The panel ARDL and PMG methods were employed to analyze the data. The findings of the study indicate a positive effect of EC on growth in the examined countries. Furthermore, the research revealed long-run nexus and bidirectional causality between EC and growth in Sub-Saharan Africa. The overall evidence strongly suggests that EC possesses growth-stimulating properties in the region.

In the same vein, Efayena et al. (2022) examined the potential energy crisis arising from the significant energy demand-supply gap in 10 emerging economies in Africa. The study focused on understanding the EC-growth nexus in these countries, employing energy consumption per capita and GDP per capita. Using a non-linear modeling technique and data spanning from 1980 to 2020, the study identified causal and co-integrated relationships between EC and growth in Nigeria, South Africa, Ghana, Ethiopia, and Kenya. Moreover, the study revealed various forms of causality across different countries and time periods. One notable policy implication of the research is that energy policies might not have a significant impact on economic growth in Côte d'Ivoire, Angola, Benin, Cameroon and DR Congo, possibly due to country-specific characteristics. As the energy demand-supply gap looms,

understanding these dynamics becomes crucial for formulating effective policies and addressing potential energy challenges in these economies.

Olayeni (2012) used the co-integration methodology to x-rayed potential effects of energy conservation policies on growth in various African economies. The study found an adverse effect in countries like Gabon, Cote d'Ivoire, and Nigeria during the period 1971–2008. However, no such influence was observed in Benin, Kenya, and Sudan. In a specific case, Ibrahiem (2015) analyzed data from Egypt spanning from 1980 to 2011 employing real GDP per capita, net consumption of total renewable electricity, and net inflows of foreign direct investment. The study demonstrated that the level of EC had a positive influence on the growth, and the causal relationship was bidirectional. In the empirical study of Odhiambo (2021), the effect of Botswana EC level on the economy's growth was investigated by disaggregating energy sources and using a non-linear estimation technique. The findings of the study indicated that causality runs only in the direction of growth-to-EC. It should be noted that the study disaggregated EC into motor gasoline, gas/diesel oil, total energy consumption, fuel oil, liquefied petroleum gas, and electricity consumption. The study also incorporated trade openness and inflation, in addition to the economic growth variable.

Similarly, Menyah and Wolde-Rufael (2010) examined the influence of EC level on the growth in South Africa. Their research revealed a unidirectional causal relationship, along with a long-run co-integrated nexus between variables. These findings were corroborated in a South African study by Khobai and Le Roux (2018), utilizing data for the period 1990–2014. Both studies contribute valuable insights into the EC-growth nexus, particularly in Botswana and South Africa.

Twerefou et al. (2018) aimed to investigate the causal relationship between EC levels and economic growth across seventeen West African countries. While the study did not find short-run causal nexus, it established the presence of a long-run causality, indicating that EC positively impacts economic growth. These findings align with those of Ouedraogo (2013), who also explored the EC-growth nexus focusing on ECOWAS economies from 1980 to 2008, utilising the FMOLS econometric technique. Ouedraogo's study revealed a significant and positive nexus between the variables.

Attiaoui et al. (2017) utilised ARDL method to investigate the relationship between EC levels and economic growth across 22 nations in the period 1990–2011. The comprehensive research revealed a statistically significant positive correlation between the variables. The finding was similar to those of da Silva et al. (2018). Furthermore, Amoah et al. (2020) utilised the DOLS methods to examine the economic performance of 32 African economies over the period of 1996 to 2017.

In contrast, the study conducted by Nyiwul (2017) revealed non-significant nexus between EC levels and growth in Africa. Notwithstanding this discrepancy, the combined results of these research provide useful insights into the nexus between EC and growth in the African environment. In their comprehensive study, Odugbesan and Rjoub (2020) undertook an extensive examination aimed at comprehending the character and magnitude of the correlation between the EC levels and growth within the MINT economies. The study utilised data spanning from 1993 to 2017. The study found a unidirectional nexus between the economies of Indonesia and Nigeria, whereas a bidirectional relationship was observed in the case of the economies of Mexico and Turkey. Moreover, a sustained correlation was identified among the variables in each of the four countries.

On the other hand, Fotourehchi (2017) focused on examining the EC level-growth relationship in 42 developing countries between 1990 and 2012. The study identified a unidirectional causal nexus running from EC to growth. Imandojemu and Akinlosotu (2018) estimated the relationship in Nigeria employing data of 1990 to 2017. The findings indicated a positive influence of EC on growth, with unidirectional relationship running from growth to EC.

The studies analysed above collectively contribute valuable insights into the EC-growth nexus, showcasing the varying directions and intensities of the relationships in different economies and time

periods. An extensive analysis of prior scholarly investigations indicates a dearth of agreement concerning the nexus between the EC levels and growth. Several studies indicated a positive correlation or association, although other studies propose a negative or neutral viewpoint. Furthermore, there are divergent findings pertaining to the underlying causality between levels of energy use and economic growth. Several studies have suggested the presence of a bidirectional causal relationship, although other studies argue for a unidirectional relationship or even the absence of any causality.

Given these conflicting outcomes, it becomes essential to conduct a critical investigation concerning the EC-growth relationship in Nigeria. The drive is the promotion of sustainable development in Nigeria. By understanding the intricate EC-economic growth nexus, policymakers can devise effective strategies to foster economic prosperity and environmental sustainability in Nigeria. This study will ensure that policies elicited therein are country-specific and more relevant for decision-making (Efayena & Buzugbe, 2021).

## Research Methodology

### General Background

This study was based on the Solow (1956) and Swan (1956) growth model. The model is expressed in a Cobb Douglas form as:

$$Y_t = K_t^\alpha (A_t L_t)^{1-\alpha} \quad (1)$$

The expression denotes the output expressed as a function of the factors of production. Specifically,  $Y$  denotes the output;  $K$  represents the capital;  $L$  denotes the labour; while  $A$  represents the efficiency variable. The efficiency variable,  $A$ , can be expressed as:

$$A = A_0 e^{g_t + \rho_t \theta} \quad (2)$$

In equation (2),  $g$  denotes the rate of technological progress. This variable is assumed constant;  $\rho$  represents the vector of factors which determine the technological level of the economy including the investment and the energy consumption level. While  $\theta$  captures other exogenous variables at time,  $t$ . According to Amar (2012), the efficiency level can be obtained from the Solow (1956) output model employing the expression below:

$$\ln(y_{i,t})^* = \ln(A_{0,i}) + \theta_i EC_{i,t} + \frac{\alpha}{1-\alpha} \ln(s_{k_{i,t}}) - \frac{\alpha}{1-\alpha} \ln(n_{i,t} + g + \delta) \quad (3)$$

From equation (3), EC represents energy consumption level. In tandem with Twerefou et al. (2018), the subsequent empirical model was formulated to comprehend the EC-economic growth nexus:

$$RGDPPC_t = \alpha + \beta TEC_t + \varepsilon_t \quad (4)$$

Specifically, real GDPPC represents the per capita GDP, and TEC denotes the total energy consumption per capita. The study employed the ARDL bounds test (Pesaran et al., 2001) in testing the long-run co-integrating relationship among the variables. The ARDL technique was selected for two main reasons. Firstly, it can be utilised irrespective of whether the variables are stationary at level, first difference, or a combination of both. Secondly, the ARDL method offers an advantage in cases of limited data, as co-integrating the relationship estimates remain robust and do not suffer from low power estimation (Narayan, 2005). The model is specified thus;

$$RGDPPC_t = \alpha_1 + \sum_{i=1}^{p_1} \phi_{1i} \Delta RDGPPC_{t-i} + \sum_{j=1}^{q_1} \gamma_{1j} \Delta TEC_{t-j} + \beta_1 RGDPPC_{t-1} + \beta_2 TEC_{t-1} + \mu_t \quad (5)$$

Eq. (2) centers around the first difference operator ( $\Delta$ ). The co-integrating relationship between the variables can be established by analysing the F-statistics. The null hypothesis for this relationship is given as  $H_0: \beta_1 = \beta_2 = 0$ , while the alternative hypothesis is given as  $H_1: \beta_1 \neq \beta_2 \neq 0$ . The null hypothesis

that there is no co-integrating relationship is rejected if the F-statistics are greater than the upper bound. In contrast, if the F-statistics are lower than the lower bound, the null hypothesis is deemed to be accepted. Nevertheless, when the F-statistics fall within the range of the bounds, the outcome remains equivocal. In the event that a co-integrating relationship is seen, the investigation will proceed to estimate the stated short-run as well as long-run models given below:

$$RGDPPC_t = \alpha_2 + \sum_{i=1}^{p_2} \eta_{2i} \Delta RDGPPC_{t-i} + \sum_{j=0}^{q_2} \delta_{2j} \Delta TEC_{t-j} + \mu_{2t} \text{ [short-run dynamics]} \quad (6)$$

$$RGDPPC_t = \alpha_3 + \sum_{i=1}^{p_3} \eta_{3i} \Delta RDGPPC_{t-i} + \sum_{j=0}^{q_3} \delta_{3j} \Delta TEC_{t-j} + \tau \varepsilon_{2t} + \mu_{2t} \text{ [long-run dynamics]} \quad (7)$$

The variable  $\varepsilon$  represents the error correction term, and it is anticipated to be negative. This negative coefficient indicates the speed at which the economy of interest converges to their equilibrium. Additionally, the study conducted the Engle and Granger (1978) causality tests.

### **Instrument and Procedures**

The dataset comprised two main variables: real GDP per capita, and total EC, measured by the energy consumption per capita. Secondary data for the study were sourced from Energy Information Agency (EIA) and World Bank databases.

### **Data Analysis**

The study covered the EC and economic growth data between 1980 and 2022 in Nigeria. The data were analysed using several methods. These included the unit root test, autoregressive distributed lagged co-integration test, and causality test.

## **Research Results**

### **Stationarity Test**

To assess the appropriateness of ARDL technique, a stationarity test was conducted to examine the econometric properties of the used data. The test was employed to determine whether a dataset was stationary or not, which had significant implications for forecasting capability of the specified model. In addition, the test was crucial to ensure the variable conformity according to the assumption of the model (Pesaran et al., 2001).

The results of the Augmented Dickey-Fuller (ADF) and the Phillip-Perron tests are presented in Table 1. The criteria for the tests are the comparison between the t-value computed and the statistic values at 5 percent and 1 percent. If the computed t-value exceeds the given t-value at any significance level, such variable is said to be stationary. The unit root is computed at level and at first difference. The outcomes from Table 1 indicate that the data under investigation attain stationarity at in first difference.

**Table 1**

#### *Unit Root Test*

Variable	Augmented-ADF		Phillip-Perron (PP)	
	Intercept	Trend & Intercept	Intercept	Trend & Intercept
<b>Level</b>				
EC	-0.018	-1.412	-0.771	-1.609
Real GDP Per Capita	-0.426	-0.923	-1.215	-1.885
<b>First Difference</b>				
EC	-3.682***	-3.833***	-4.036***	-5.721***
Real GDP Per Capita	-2.006**	-2.071**	-3.517***	-3.907***

Note. \*\* and \*\*\* denotes 5% and 1% statistical significance, respectively

Source: Author's computation.

Based on the above findings, it becomes crucial to estimate the ARDL model to determine the presence of a co-integration relationship among the variables.

### **ARDL Co-integration Test**

In estimating the co-integration relationship between EC and growth, the Bound test was employed. Table 2 shows the F-statistic obtained. The F-statistic value of 7.63 that is higher than the upper bound value at 5 percent (5.32). Table 2 indicates the presence of co-integration between EC and growth in Nigeria. This finding strongly suggests a long-run nexus between the variables. A similar finding was established in Efayena et al. (2022) and Iyke (2015).

**Table 2**

*Co-integration Test*

	<b>F-statistics</b>	<b>Outcome</b>
	7.63	Co-integration
<b>Critical Bounds Value</b>		
<b>Significance</b>	<b>I(0)</b>	<b>I(1)</b>
10%	2.37	3.03
5%	3.09	5.32
1%	5.63	8.11

*Note.* Significant at the 5 percent.

*Source:* Author's computation.

Therefore, accurately estimating an error correction model is crucial in order to depict the speed at which equilibrium is restored following an economic shock.

### **The long-run Relationships and Diagnostic Tests**

Table 3 presents the long-run nexus between the variables, along with diagnostic tests which ensures the validity and the viability of economic policies proffered.

**Table 3**

*Tests of Causality*

$H_0$	<i>Short-run GC</i>		<i>Long-run GC</i>		<i>Strong GC</i>	
	$\Delta(TEC)$ ↓ $\Delta(GDPPC)$	$\Delta(GDPPC)$ ↓ $\Delta(TEC)$	$\Delta\epsilon$ ↓ $\Delta(GDPPC)$	$\Delta\epsilon$ ↓ $\Delta(TEC)$	$\Delta(TEC), \Delta\epsilon$ ↓ $\Delta(GDPPC)$	$\Delta(GDPPC), \Delta\epsilon$ ↓ $D(TEC)$
Coefficient	1.27	2.09	0.15	8.37***	3.12	9.47***
p-value	(0.41)	(0.71)	(0.55)	(0.00)	(0.81)	(0.00)

*Note.* \*\* and \*\*\* denotes 5% and 1% statistical significance, respectively;  $\Delta$  (first difference); GC (Granger Causality).

*Source:* Author's computation.

The presented causal relationship has important implications for energy policies in Nigeria. This relationship shows that there is a one-way causality from economic growth to energy consumption (EC) in Nigeria over the long term. Furthermore, the findings indicate a strong and one-way causality from economic growth to energy consumption (EC) in Nigeria. Due to these findings, it is essential to x-ray the long-run changes of the EC-economic growth relationship in Nigeria. The estimates are presented in Table 4:

**Table 4***Diagnostic Tests and Long-run Dynamics*

	<i>Variable</i>	<i>Statistics</i>
<i>Long-run Statistics</i>	<i>ECT(-1)</i>	-1.64**
	<i>Test</i>	<i>p-value</i>
<i>Diagnostic Test</i>	<i>Normality</i>	0.224***
	<i>Serial Correlation</i>	0.016
	<i>Heteroscedasticity</i>	0.529**

Note. \*, \*\* significant at 10 percent and 5 percent level, respectively.

Source: Authors' computation.

The outcomes presented above indicate that Nigeria exhibit statistically significant ECT(-1) coefficient, surpassing 100 percent. This finding shows that in the event of a shock, the economy will take a considerably longer time to restore equilibrium. This highlights the urgent need for energy policies to ensure a swift adjustment towards equilibrium.

To examine for serial correlation and heteroskedasticity, the study utilised the Breusch–Pagan–Godfrey and Breusch–Godfrey Serial Correlation LM (Lagrange multiplier) heteroskedasticity tests. As evident from Table 4, these tests indicate that the estimated models satisfy the criteria for normality, heteroscedasticity, and serial correlation. Therefore, these models can be reliably used for policy formulation and assessment. Specifically, the Breusch Pagan Godfrey chi-square value of 0.529 that is higher than 5 percent, is indicative of the fact that heteroskedasticity does not constitute an econometric issue in the study. The LM statistic (0.224) indicates that the employed data in the study does not suffer from the issue of serial correlation.

## Discussion

The investigation of the EC-growth nexus is highly essential for appraising the level of economic growth in a country. This relationship was the subject of numerous studies worldwide, and exploring its manifestation in the Nigerian context provides valuable insights into the dynamics of energy use and growth in this West African nation. As seen in the obtained results, there is nexus between EC (proxied by total energy consumption per capita) and economic growth (proxied by real GDP per capita). This is not surprising since Nigeria, endowed with vast energy resources, including oil and gas, has a unique historical context when it comes to the energy-growth relationship. Since the 1970s, the oil industry has played a vital role in shaping the economic history of the country, with Nigeria being heavily reliant on it for growth. The nation's EC benefited greatly from the substantial increases in oil production and exports, positioning Nigeria as a notable proponent of the theory that energy-driven growth leads to economic prosperity. The study has thus presented empirical evidence of the nature of nexus that existed between EC and growth in Nigeria. The findings have several facets. For one, the empirical analysis found the presence of co-integration between growth and EC in Nigeria. In other words, there is the presence of a long-run nexus between the growth and energy consumption in Nigeria. These findings are corroborated in previous studies (Can & Korkmaz, 2019; Efayena et al., 2022; Iyke, 2015). For instance, Efayena et al. (2022) showed that there is a long-run nexus between energy consumption and economic growth among selected African countries. The study also showed that such nexus exists in Nigeria as well. The result of the study was also in tandem with those of Apergis et al. (2023) which investigated the nexus in Uzbekistan between 1985 and 2020 using the ARDL method. The implication of this finding is that appropriate utilisation of energy will spur or stimulate growth in Nigeria in the long-run.

The study also revealed that there was the presence of a long-run unidirectional Granger causality from growth to EC in Nigeria, and a robust (strong) and unidirectional Granger causality running from

economic growth to EC. These causal relationships corroborated the studies of, Efayena et al. (2022), Gnangoin et al. (2022), and Voumik et al. (2023). Other studies with similar conclusion include Esen and Bayrak (2017), and Fotourehchi (2017). One implication of this finding is that, energy consumption has not sufficiently and significantly influence economic growth. There is thus a need to design an efficient and effective framework in energy consumption in order to affect economic growth. In addition, the study found that the economy takes a longer time to recover after an economic disequilibrium. Such economic foundation has the potential to influence energy policies in the economy and beyond.

### **Limitation of the Study**

A clear constraint of the study is the failure to incorporate energy policies in the specified model. This is primarily due to the incomplete implementation of energy policies in the Nigerian economy, where these policies either exist only in theory or have been poorly executed. Therefore, it was deemed more appropriate to exclude the variable of energy policies from the specified model. Furthermore, considering that the main goal of the study is to establish the hypothesis of energy consumption-led economic growth, this omission does not pose a significant drawback.

### **Conclusions and Implications**

This study investigated the relationship between EC and growth in Nigeria during the period from 1980 to 2022. The primary motivation for this study stemmed from the country's pressing energy concerns, both established and emerging. By offering novel empirical insights into the EC-growth nexus, the study holds crucial policy implications.

The empirical analysis revealed a unidirectional causal nexus from the EC to the growth for Nigeria. This underscored the significance of designing, formulating and implementing energy conservation programs and policies that can positively stimulate the economic growth, thus mitigating potential adverse effects of the energy-economic growth trade-off. Emphasising the adoption of cleaner and more efficient alternative energy sources, capable of reducing CO<sub>2</sub> emissions and greenhouse effects, becomes imperative for the Nigerian economy. It was therefore crucial to focus on stimulating the energy sector to fully optimise the economic potential within this domain. By fostering the growth and efficiency in the energy sector, Nigeria can reap substantial benefits and achieve enhanced economic performance. Ultimately, the study has established that a better understanding of the EC-economic growth nexus can guide policymakers in formulating effective energy policies, fostering sustainable economic development, and addressing challenges related to environmental sustainability and energy security.

Despite this study's robustness, it serves as a starting point for future research on the relationship between EC and growth. Future studies could include the effect on household consumption since this will expand the applicability of energy policies. With availability of macroeconomic data, a study of this nature can be extended to other developing countries. The impact of incorporating fiscal and monetary policies on the EC-growth nexus cannot be overemphasised to ensure a more robust and viable framework for energy policies.

### ***Suggestions for Future Research***

Using the Nigerian economy as a point of reference, the study has thoroughly examined the hypothesis of economic growth driven by energy consumption by means of an extensive x-ray analysis. The outcomes of the study act as a springboard for future research studies. Further studies can be carried out employing household data in order to investigate the impact of energy consumption on economic growth at the micro level. This will involve the inclusion of demographic variables such as marital status, household income level, age, and education. This will help capture the growth process of energy consumption at the household level. The model can further be expanded to include volatility of global energy prices and climate change in order to capture structural change(s) in the consumption

level. Dynamics in global energy prices have the potential of influencing local energy policies which can impact energy consumption levels. Thus, appraising the effect of such dynamics will potentially impact economic growth. Further research can be carried out by comparing the energy consumption led-economic growth hypothesis between countries or in a panel of countries. Such studies can be carried out among countries in Africa and beyond. Another approach can be a comparative analysis between two countries or a few economies. Such an approach will help improving the robustness and policy applicability of such studies.

Further studies can be carried out in terms of the energy consumption-growth nexus by incorporating energy policies into the model. Studies can be carried out to appraise the impact of the various energy policies on economic growth. In this scenario, energy policies can be used to introduce structural breaks in the estimated model(s). The Chow Test can be utilised for such studies. It is also expected that energy policies might exert interactive effects on the energy consumption-growth model. This can be comprehensively analysed in future studies. In order to arrive at a more robust conclusion, there is also need to carry out a comprehensive study on the effect of the various energy sources on economic growth in Nigeria. This does not negate the need to appraise the consumption levels of these energy sources at the household level. Such a comprehensive approach will help the government in structuring its energy policies to boost the welfare level of households and stimulate the economic growth. Such a study can adopt household data from survey studies such as the general household survey (GHS). Such longitudinal dataset contains important household variables that will enhance the outcomes of estimating the energy consumption-economic growth model at the household level.

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