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# Energy Consumption and Sectorial Value Addition on Economic Growth in Nigeria

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**Abstract** This study investigates the co-integrating and causal link between energy consumption and economic growth in three economic sectors of agriculture, manufacturing, and service sectors in Nigeria. Through the multivariate framework and quarterly data from $2000Q_1$-$2018Q_4$. The ARDL bounds test approach, and Error Correction Model are the key techniques of analysis, and the Clemente-Montanes-Reyes unit root approach for structural breaks in the series. Findings revealed estimated billing system, and energy demand-supply gap as factors negatively influencing energy distribution and consumption in various sectors of the economy. The results also revealed a co-integrating relationship between economic growth and sectorial value creation. The results also revealed a bidirectional causality between liquefied natural gas and energy consumption and a unidirectional causality between economic growth and petroleum oil consumption. On the contrary, there is a non-causal relationship between the service and agricultural sectors. Sufficient energy distribution and consumption stir economic growth through value additions in the agricultural, manufacturing, and service sectors. The study recommends a review of the billing system, pricing framework, and policies to support, value creation, and addiction in Nigeria.

**Keywords** Energy Consumption, Economic Growth, Petroleum Oil, Gas, Co-Integration, Granger Causality, ECM

**JEL Classifications:** C320, O13, O130, O44P28, Q430

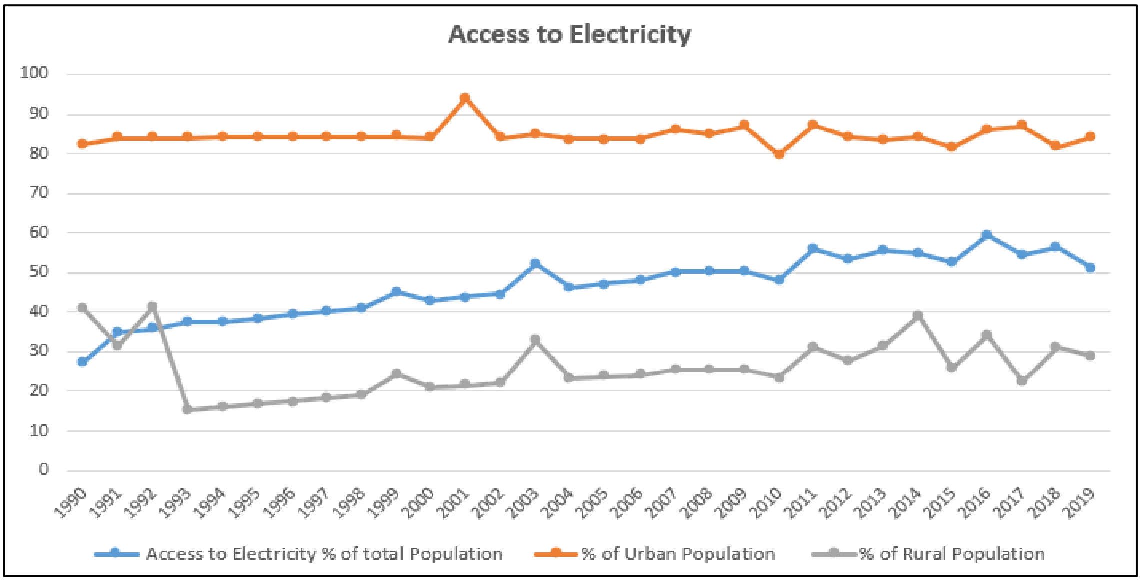
## 1. Introduction

Energy is an integral element in human civilization, the importance of energy has increased geometrically during the last decade, its undoubtedly a fulcrum for sustainable business, economic and financial growth, globally and especially for emerging economies like Nigeria. Nations with a higher per capita energy consumption and distributions are considered economically robust and industrialized vice-versa those with low levels of consumption and distribution. According to the classical school of thought, land, labour, and capital impact growth and output significantly (Enu and Havi [1]).

Other transitional inputs are fairly disregarded in the growth theories of energy supply-demand, and the pricing framework on output and economic growth. Energy comprises hydroelectric, geothermal, natural gas, lignite, coal, biomass, and in recent times solar, and wind energy among others. Energy efficiency and distribution increase revenue generation through small business development, sectoral output capacity, and utility cost reduction. Nigeria ranks as one of the largest and oldest oil producers in Africa and the 6th largest oil-producing country globally with around 37 billion barrels of oil and 47.2 billion cubic meters (bcm) of gas. The average production capacity is about 2.05million per day in 2019 accounting for more than 20.4% of total oil production in Africa in 2019 and gross domestic product contribution of over 91.2% of all export value and 8.73% single sector contribution in Nigeria.

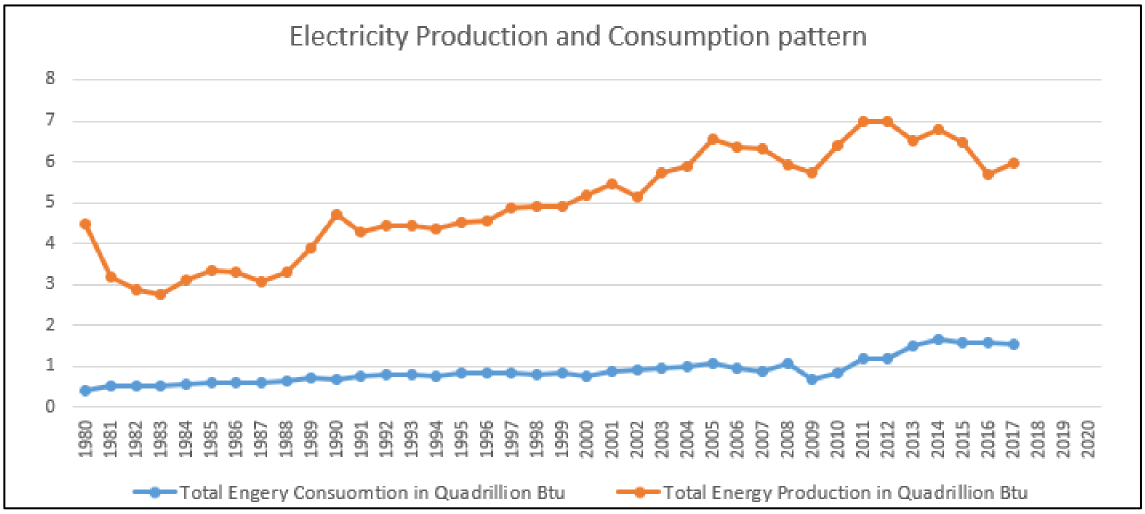
Notwithstanding, the vast sources of energy available in Nigeria, the gap between energy production, distribution, and consumption are still the major challenges affecting economic growth and product value creation and addition. The Nigerians total population is estimated at 200 million in 2020, about 55-60% of the rural populace lack access to electricity, while only, 40-45.5% of urban dwellers have access to electricity but at a very high cost, (**Figure 1**).

Such is evident in the gap between installation and actual operational capacity output not exceeding 4,000 MegaWatt (MW) per hour averaging less than 40%. Install capacity between 2014-2015 stood at 12,522MW from the 25 power stations, with an average available capacity of 7,141MW on the average operational capacity of 3,879MW/hr as against the estimated demand of 10,000MW per day (CBN Annual Reports, [3]). The manufacturing sector electricity consumption rate represents 48.2%, while other sector's consumption rate falls between 25.3%-47.3%. Coal, petroleum, natural gas, nuclear fuels, and biomass contributes about 25%-35% consumption rate. Energy production and consumption in Nigeria from 1980-2019 fluctuate between 2%-4.0% respectively (**Figure 2**).




**Source:** (Computed from World Development Indicator Database [2])

**Figure 1.** Access to Electricity % of the Population, Urban and Rural Dwellers




**Source:** (Computed from World Development Indicator Database [2])

**Figure 2.** Electricity Production and Consumption Patterns in Nigeria.

The ripple effect of poor access to electricity, for production, is evident in the poor and constant fluctuation in industrial, agricultural, and service sectors share contribution to GDP in the last 10year of 2009-2019. Specifically, in the industrial and service sectors between 2015-2017 (see **Table 1**).

**Table 1.** Share of the value-added of the three sectors in GDP (%) in Nigeria

| Year | Agriculture | Industry | Services (commercial & public) |
|---|---|---|---|
| 2009 | 26.75 | 21.24 | 50.98 |
| 2010 | 23.89 | 25.32 | 50.79 |
| 2011 | 22.23 | 28.28 | 49.24 |
| 2012 | 21.86 | 27.07 | 50.19 |
| 2013 | 20.76 | 25.74 | 52.37 |
| 2014 | 19.99 | 24.64 | 54.15 |
| 2015 | 20.63 | 20.16 | 58.12 |
| 2016 | 20.98 | 18.17 | 59.79 |
| 2017 | 20.85 | 22.32 | 55.8 |
| 2018 | 21.2 | 25.73 | 52.02 |
| 2019 | 21.91 | 27.38 | 49.73 |

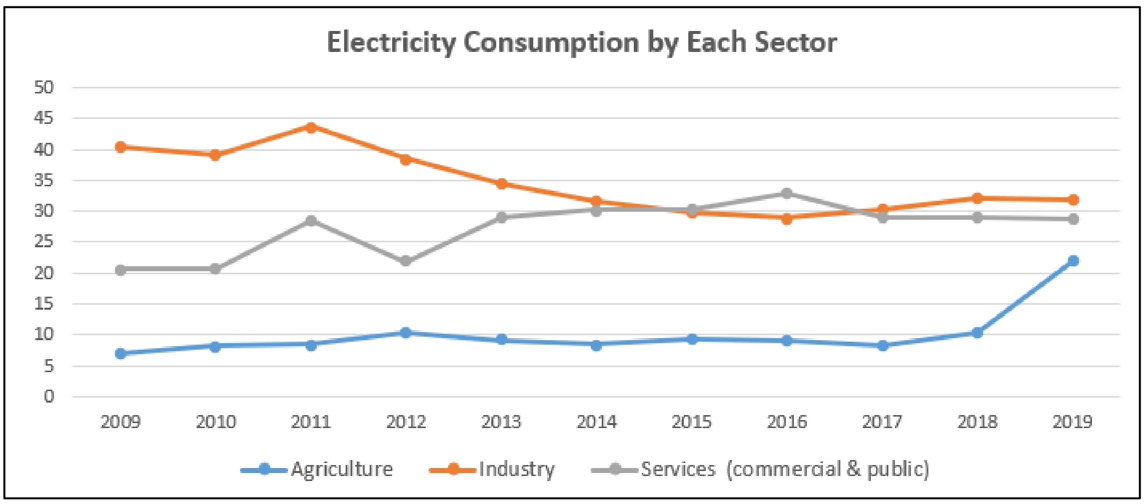
**Source:** (Computed from World Development Indicator Database [2])

Electricity consumption in the industrial, agricultural, and service sectors in Nigeria in the last decade has been on constant decease especially in the industrial sector, as a result of the estimated billing system, vandalization of electrical facilities, over-dependence on generating set, and the frequent collapse of the national grip among others (**Figure 3**).

Similarly, the telecommunications companies in Nigeria (MTN NG, Airtel Nigeria, Globacom, and 9mobile) spend about $100 million on diesel fuel to provide electricity and keep their telecommunication mast operational. MTN, controls a market share of 43%, spending about $40 million annually to supply its base stations electricity for 19hrs a day, 9mobile market share of (15%) Airtel Nigeria (20%), and Globacom (21%) on average spends $35 million to $40 million to run its base stations.

The growth of these economic sectors largely depends on stable, efficient, affordable, and accessible energy distribution and consumption. Figure 3 shows the share of electricity consumption by each sector (agriculture, industry, and service) in Nigeria as a percentage of total electricity consumption. Primary energy consumption in Nigeria consists of 55% of petroleum and other liquid gas, 42% of natural gas, 3% of renewable, and 0.0% coal.

In the bid to ensure stable, efficient, affordable, and accessible energy production, distribution, and consumption to drive economic growth successive governments in Nigeria developed diverse policy structures, and frameworks such as the; 1972 import substitution/indigenization policy, 1986 Structural Adjustment Program (SAP), the 2005 Electricity Power Sector Reform Act (EPSRA), and the 2007 National Integrated Industrial Development (NIID) blueprint among others. Regardless of these policy structures, available statistics revealed the gap between energy demand and supply affecting export goods value chain effect, high production cost, crowding out of 30%-35% domestic firms, and multinational firms to neighboring countries of Ghana and South Africa with a relatively stable power supply. The increase in carbon dioxide emissions in Nigeria can be accredited to dependence on natural gas and oil sources in electricity generation (Karanfil, [4]).




**Source:** (Computed from World Development Indicator Database [2])

**Figure 3.** Electricity Consumption by Each Sector

The geometric increase in carbon dioxide emissions makes it necessary for the government to bridge the gap between energy demand-supply, and reduce the polluting emissions without adversely affecting the economic growth either at the aggregate level or the sectoral levels. The objective of the study is to investigate the co-integrating and causal link between electricity consumption on economic growth and sectoral value creation and addition in three economic sectors, of agriculture, industrial, and services sectors.

This study contributes to the extant literature in two parts; firstly, to examine the causal and co-interning relationship between electricity consumption, economic growth, and sectoral value creation and addition in Nigeria.

Secondly, the present study comprises quarterly data period 2000$Q_1$-2018$Q_4$. The study employs the ARDL bounds test approach, Error Correction Model, and Granger causality to explore the co-integrating and causal relationship. Also, the Clemente-Montanes-Reyes unit root for structural breaks in the series.

## 2. Literature Review

Studies on energy consumption and economic growth in the last decades in single and cross-countries have reported diverse results due to country-specific heterogeneous factors of climatic conditions, institutional structural challenges, pricing systems, and stages of economic growth (Enu and Havi [1]). These studies concluded the existence of four hypotheses: (1) conservation hypothesis; (2) growth hypothesis; (3) feedback hypothesis, and (4) neutrality hypothesis, as a result of diverse periods, methodologies, and various energy consumption variables employed (Laurine, Ngundu, and Kupeta [5]). Empirical evidence from Molem, and Ndifor [6]); Chinedu, Daniel, and Ezekwe, [7]); Belaid, and Youssef [8]); Mawejje, and Mawejje [9]); Sharif, Jammazi, Raza, Shahzad, [10]); Laurine, Ngundu, and Kupeta [5]); Carfora, Pansini, and Scandurra, [11]) reported a unidirectional causality, between energy consumption and economic growth. Support the growth hypothesis of energy-led growth "unidirectional causality" energy availability, affordability, and accessibility influences economic growth, value creation, factors of production (labor and capital), social and technological advancement.

The conservation hypothesis supports the unidirectional causality from economic growth to energy consumption. Economic stability increases the demand for energy for production and consumption for industrial use and storage (Yu and Choi, [12], Ghosh [35] Halicioglu [36] Belaid, and Youssef, [8]).

Similarly, Karanfil, [4]; Enu and Havi [1]; Ibrahiem [13]; Osman, Gachino, and Hoque [14]; Ahmad, Zhao, Shahbaz, Bano, Zhang, and Wang [15; Adegboye and Babalola [16]; Ibrahiem [17] Sarwar, Chen, and Waheed [18]; (Wang *et al.*, [15] observed a bidirectional causality between energy consumption and economic growth supporting the feedback hypothesis of interdependence between the variables. Aminu and Aminu, [19]; Bah, and Azam [20]; Egbichi, Ojamaliya, Okafor, Godwin, and Oluwapelumi [21], and Odhiambo, [22] reported a non-causal relationship supporting the neutrality hypothesis. Energy consumption and economic growth are not mutually dependent on each other. The energy conservation policies may have no adverse effect on economic growth. A summary of these studies is shown in (**Table 2**).

Nathan and Liew [37] in Cambodia, examined the causal link between energy consumption and economic growth in various sectors. Findings supported mixed results of unidirectional causality running from energy consumption to agricultural, industrial, and transportation sectors, and unidirectional causality from the services sector to energy consumption. Country studies ignored the heterogeneous factors that are inherent in specific countries. Therefore, a single-country study would explain the effect and causality in terms of each countries stages of economic and energy sector development among others.

**Energy Sector in Nigeria**

Energy sufficiency stirs global economic growth through renewable and non-renewable sources to stir production, job creation, and export goods value chain effect among others.

Non-renewable energy is the prevailing form of energy largely consumed in Nigeria. Crude oil accounts for over 79% of commercial energy consumption in Nigeria and is a major source of foreign earnings. The lack of operational energy infrastructures has led to the flaring of about 40% of the natural gas in Nigeria, accounting for about 20% of all gas flared globally.

The energy demand-supply gap has not only destabilized economic industrialization in Nigeria but has also truncated the achievement of the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) in Nigeria (Babanyara and Saleh, [23]). According to the United Nations Economic Commission for Africa, insufficient energy supply in Sub-Saharan Africa hinders economic growth and poverty alleviation programs of the government, with more than 67.8% of the rural and the urban dwellers in extreme poverty living below $2 per day and 23.5% in moderate poverty living below $3 per day without access to modern energy services for production, creativity and economic growth (Adegboye & Babalola, [16]).

Over 70.5% of the rural dwellers in Nigeria depend on firewood consuming over 50 million tonnes of firewood annually that surpasses the replenishment rate through various afforestation programs of the government. The rate of deforestation is about 350,000 ha/year. The rural areas are generally inaccessible due to the poor road network, little or no access to conventional energy such as electricity and petroleum products. The rural areas in Nigeria account for about 43.5% of micro, small, medium scale businesses. Petroleum products such as kerosene and gasoline are purchased in the rural areas at prices 150% above their official pump prices. Despite the huge investments and policy framework made in the power sectors over the years, there has been little or non-significant improvement in the supply of electricity in Nigeria. Notwithstanding the poor energy sector performance below par, there is a steady increase in economic growth over the years.

### 2.1. Theoretical Framework

Economic growth globally consists of people "labour force, energy, and matter. There is no economic growth and sectorial value addition and creation without the expense of energy. Energy is an integral factor in driving effective and efficient economic activities. Thus, energy influences and measures the level of economic growth through production and value creation and addition than product outputs.

The theoretical underpinning selected for this study includes; the physical theory of economic growth propounded by Kardashev (1964), which states that energy is vital for economic reproducibility and growth. The economic benefits of energy availability and accessibility on production cannot be overemphasis by natural scientists and ecological economists (Okorie and Manu [25]).

According to the proponents of the biophysical and theory of economic growth, energy is the only factor of production (Stern [33]). On the contrary, the classical (mainstream) economists explicitly ignored energy as a factor of production due to land imposed limitations on economic activities, in the agricultural sector. Energy is incorporated implicitly into the economy through the recognition of land as a factor in production in the agricultural sector (Babanyara and Saleh, [23]).

The neutrality hypothesis propounded by Yu and Choi, [12] states that energy and economic growth are not mutually dependent on each other. Energy conservation policies may have a neutral or minimal effect on economic growth. The ecological and mainstream economists recognize petroleum oil and other sources of energy as economic growth and industrial value addition as intermediary input while energy, labour, and land as primary factors of production (Aghion and Howitt, [24]).

This study adopted the unifying mainstream and ecological energy/growth model to explored the causal and co-integrating relationship between energy consumption, economic growth, and sectorial value addition in Nigeria using the conservation hypothesis; growth hypothesis; feedback hypothesis, and neutrality hypothesis.

The thermodynamics law provides the rationale for the model selection partly to the fact that energy/electricity is indispensable in all economic production thus supporting the criticism against mainstream energy/growth models that ignore energy in the production process. Similarly, energy/growth theories tries to explain growth exclusively as a function of energy, while disregarding the impact of information, knowledge, and institutions, on growth. Institutions significantly influence the link between energy and growth.

## Empirical Review

**Table 2.** Summary of Empirical Reviews

| Author and Year | Scope | Methodology | Result |
|---|---|---|---|
| **Studies Supporting "Unidirectional Causality Hypothesis"** | | | |
| Adegboye and Babal [16] | Nigeria (1981-2018 | ARDL and ECM | Energy →Economic growth |
| Tahar [26] | Morocco | Granger causality test | Energy →Economic growth |
| Belaid, and Youssef, [8] | Algeria 1980–2012 | Vector Error Correction Model | Economic growth → renewable electricity<br>Economic growth → nonrenewable electricity |
| Mawejje, and Mawejj [9] | Uganda Q12005–Q12015 | Granger causality | Electricity → industry (long run)<br>Service → electricity (short-run) |
| Sharaf [27] | Egypt 1980–2012 | Toda and Yamamoto Granger causality test | Economic growth → electricity |
| Sharif, Jammazi, Raza, and., Shahzad [10] | Singapore 1983–2016 (monthly data) | Wavelet approach | Electricity → Economic growth (long run)<br>Electricity ↔ Economic growth (medium run) |
| **Studies Supporting the "No Causal Relationship Hypothesis"** | | | |
| Aminu, and Aminu, [19] | Nigeria (1980-2011) | Granger causality test, impulse response, and variance decomposition analysis | No causal relationship between energy consumption and economic growth |
| Bah, and Azam, [20] | South Africa 1971–2012 | Toda and Yamamoto Granger causality test | No causality relationship between energy consumption and economic growth |
| **Studies Supporting the "Bidirectional Hypothesis"** | | | |
| Ibrahiem [17] | Egypt (1971-2013) | Johansen cointegration approach, and vector error correction model | Real output ↔ Electricity Consumption. |
| Ahmad, Zhao, Shahbaz, Bano, Zhang, Wang, Liu, [15] | India 1971–2014 | Vector error correction model | Electricity ↔ Economic Growth |
| Sarwar, Chen, and Waheed, [18] | 210 countries 1960–2014 | Panel vector error correction model | Electricity ↔ Economic Growth |
| Osman, Gachino, and Hoque [14] | Gulf Corporation Council Countries 1975–2012 | Panel VAR Granger causality Test | Electricity ↔ economic growth |
| **Studies Supporting the "Neutrality Hypothesis"** | | | |
| Ugwoke, Dike, and Elekwa [28] | Nigeria (1980-2014) | Double-log linear formulation. | A negative relationship between electricity consumption, trade openness, and industrial production |
| Molem, and Ndifor, [6] | Cameroon (1980-2014) | Generalized Method of Moments technique | A positive relationship between energy consumption on economic growth |
| Chinedu, Daniel, & Ezekwe, [7] | Nigeria (1980-2017) | Engle-Granger Co-integration test, error-correction mechanism | A positive relationship between energy consumption on economic growth |

**Source:** Authors Computation (2020)

# 3. Methodology

The multivariate Granger-causality model, Autoregressive Distributed Lag (ARDL), and the Clemente-Montanes-Reyes unit root test for structural breaks are employed in this study with quarterly data covering the period 2000Q-2018Q, obtained from the Central Bank of Nigeria and World Bank Development Indicators. Energy consumption in this study is disaggregated into petroleum oil, liquified natural gas, and electricity. The variables are transformed to their natural logarithmic form.

### Model Expression

The linear model expression:

$$RGDP = \beta_0 + \beta_1 ELECT + \beta_2 LIQOIL + \beta_3 PETOIL + \beta_4 CAFM + \beta_5 LABF + \beta_6 AGRI + \beta_7 MANU + \beta_8 SERV\ \mu \quad (1)$$

$$ELECT = \beta_0 + \beta_1 AGRI + \beta_2 MANU + \beta_3 SERV + \mu \quad (2)$$

### Symmetrical ARDL model

The bounds test procedure expression:

$$\Delta RGDP_t = \beta_0 + \sum_{i=1}^{m} \beta_1^{i} \Delta ELECT_{t-i} + \sum_{j=0}^{n} \beta_2^{i} \Delta LIQOIL_{t-j} + \sum_{j=0}^{n} \beta_3^{i} \Delta PETOIL_{t-j} + \beta_4 RGDP_{t-1} + \beta_5 LIQOIL_{t-1} + \beta_6 PETOIL_{t-1} + \mu_t \quad (3)$$

$$\Delta ELECT_t = \beta_0 + \sum_{i=1}^{m} \beta_1^{i} \Delta AGRI_{t-i} + \sum_{j=0}^{n} \beta_2^{i} \Delta MANU_{t-j} + \sum_{j=0}^{n} \beta_3^{i} \Delta SERV_{t-j} + \beta_4 AGRI_{t-1} + \beta_5 MANU_{t-1} + \beta_6 SERV_{t-1} + \mu_t \quad (4)$$

$H_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (there is no co-integration)

$H_1 = \beta_1 = \beta_2 = \beta_3 = 0$ (there is co-integration)

### Decision Rule

1. If the F-statistics falls above the upper bound critical value, there is a (co-integration)
2. If the F-statistics falls below the lower bound, there is (no co-integration) and
3. If the F-statistics falls within the two bounds the result is (inconclusive).

The Error Correction Model (ECM) measures the speed of convergence from disequilibrium cause in the short-run back to the long-run equilibrium. After establishing a long-run relationship. The ECM provides the short-run coefficient without losing the long-run information and specified as:

$$\Delta RGDP_t = \beta_0 + \sum_{i=1}^{m} \beta_1^{i} \Delta ELECT_{t-i} + \sum_{j=0}^{n} \beta_2^{i} \Delta LIQOIL_{t-j} + \sum_{j=0}^{n} \beta_3^{i} \Delta PETOIL_{t-j} + \delta ECT_{t-1} + \mu_t \quad (5)$$

$$\Delta ELECT_t = \beta_0 + \sum_{i=1}^{m} \beta_1^{i} \Delta AGRI_{t-i} + \sum_{j=0}^{n} \beta_2^{i} \Delta MANU_{t-j} + \sum_{j=0}^{n} \beta_3^{i} \Delta SERV_{t-j} + + \delta ECT_{t-1} + \mu_t \quad (6)$$

Where:
$\beta_0$ = Constant term,
$\beta_1$-$\beta_4$ = Regression coefficient and $\mu$ = Error Term.
**RGDP** = Real Gross Domestic Product is measured as (real GDP = GDP at Market Prices -indirect taxes net of subsidies)
**ELECT** = Electric power consumption
**LIQOIL** = liquefied natural gas consumption
**PETOIL** = Petroleum oil consumption
**AGRI** = agriculture sector value addition
**MANU** = manufacturing sector value addition and
**SERV** = service sector value addition (small business development)

The apriori expectations of the explanatory variables are as expressed as $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4 > 0$;

# 4. Results and Discussions

Preceding the model estimations and diagnostic tests an array of the pre-estimation tests was conducted on the series to confirm their stationarity properties.

### Pre-Test

Figure (4) describes the aggregated averages of the mean, median, and standard deviation, measuring the spread and variation. Skewness measures the degree of symmetry and kurtosis measures the peakedness. The Kurtosis is (>3), the variables are *leptokurtic*. The dataset produces more outliers than a normal distribution. The JB P-value is >5%.

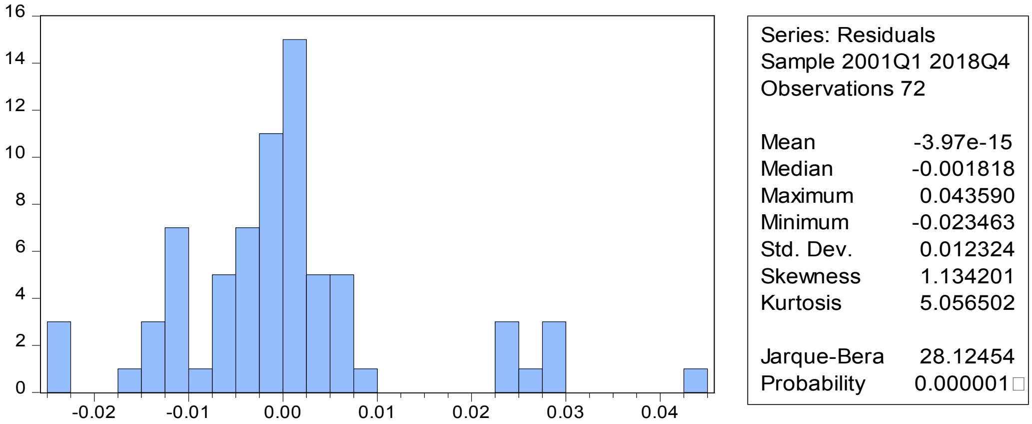



**Figure 4.** Variables description and characteristics.

### Unit Root Test

The unit root test was conducted using Augmented Dickey-Fuller (ADF) [29] and Phillips and Perron, (PP) [30] unit root technique to examine the stationarity properties of the variables. The null hypotheses of the ADF and PP tests are that the series has a unit root.

**The model expression:**

$$\Delta y_{t-1} = \alpha 0 + \lambda y_{t-1} + \alpha_{2t} + \Sigma^{p}_{i=2} \beta_j \Delta y_{t-1} + \mu_t.$$

Where y = dependent variable,

t = trend,

a=intercept,

μt = white noise and

p = lag level.

Table (3) shows the stationarity order of the variables at I (1) and I (0) integration. A combination of the I (1) and I (0) order of integration provides the theoretical underpinning for the adoption of the ARDL model. The Clemente-Montanes-Reyes unit root test was employed to examine for unknown structural breaks in the series not captured by the ADF and PP unit root tests.

**Table 3**. ADF and PP Unit Test.

| Variables | Test | Level @ 5% | Inference | Test | 1st Difference @ 5% | Inference |
|---|---|---|---|---|---|---|
| RGD | ADF | -3.457 (-2.032)*** | Stationary | ADF | -4.925(-3.150)*** | Stationary |
| | PP | -3.448 (-2.036)*** | | PP | -5.924(-3.159)*** | |
| ELECT | ADF | -3.527 (-1.209)*** | Stationary | ADF | -4.902 (-3.401)*** | Stationary |
| | PP | -3.560(-6.199)*** | | PP | -4.813(-3.590)*** | |
| LIQOIL | ADF | -1.261(-4.902) | Non-Stationary | ADF | -3.345(-5.569) | Non-Stationary |
| | PP | -1.450(-4.902) | | PP | -4.561(-5.120) | |
| PETOIL | ADF | -5.301(-4.308)*** | Stationary | ADF | -3.102 (-2.207)*** | Stationary |
| | PP | -6.201(-5.308)*** | | PP | -3.201(-1.723)*** | |
| AGRI | ADF | -3.560(-2.781)*** | Stationary | ADF | -6.701 (-3.618)*** | Stationary |
| | PP | -3.601(-3.450)*** | | PP | -5.135(-4.568)*** | |
| MANU | ADF | -3.901(-3.450)*** | Stationary | ADF | -6.193(-4.568)*** | Stationary |
| | PP | -5.902(-3.000)*** | | PP | -6.150(-4.123)**** | |
| SERV | ADF | -2.354(-3.349) | Non-Stationary | ADF | -6.451(-4.124) | Non-Stationary |
| | PP | -3.458(-3.349) | | PP | -5.431(-3.125) | |

Note: The asterisks *** indicate significance at 5%

**Table 4**. Clemente-Montanes-Reyes Structural Break Unit Root Analysis.

| | Model: Trend-Break Model | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Level data | | | | First difference data | | | |
| Variables | $T_{B1}$ | $T_{B2}$ | Test-statistics | K | $T_{B1}$ | $T_{B2}$ | Test-statistics | K |
| **RGDP** | $2000Q_4$ | - | -3.063 | 4 | $2003Q_4$ | - | -8.346** | 2 |
| | $2000Q_4$ | $2005Q_3$ | -2.901 | 2 | $2003Q_4$ | $2005Q_6$ | -6.730** | 8 |
| **ELECT** | $2005Q_1$ | - | -2.350 | 2 | $2006Q_6$ | - | -4.567** | 3 |
| | $2007Q_3$ | $2005Q_5$ | -3.890 | 3 | $2006Q_4$ | $2007Q_1$ | -6.891** | 7 |
| **LIQOIL** | $2008Q_2$ | - | -4.201 | 4 | $2009Q_1$ | - | -6.461* | 3 |
| | $2009Q_1$ | $2009Q_5$ | -4.714 | 6 | $2009Q_3$ | $2010Q_1$ | -5.781** | 5 |
| **PETOIL** | $2008Q_2$ | - | -2.913 | 4 | $2010Q_5$ | - | -3.567** | 3 |
| | $2009Q_2$ | $2010Q_6$ | -3.671 | 5 | $2010Q_1$ | $2010Q_4$ | -5.678** | 6 |
| **AGRI** | $2009Q_1$ | - | -3.783 | 2 | $2009Q_4$ | - | -2.345* | 4 |
| | $2010Q_2$ | $2011Q_8$ | -6.715 | 1 | $2009Q_5$ | $2011Q_4$ | -4.567** | 8 |
| **MANU** | $2000Q_1$ | | -4.871 | 3 | $2013Q_3$ | - | -6.567* | 5 |
| | $2006Q_3$ | $2008Q_6$ | -7.740 | 4 | $2013Q_5$ | $2015Q_4$ | -7.891* | 7 |
| **SERV** | $2016Q_1$ | - | -2.893 | 3 | $2016Q_3$ | - | -5.123** | 4 |
| | $2017Q_3$ | $2018Q_3$ | -7.491 | 4 | $2016Q_6$ | $2017Q_3$ | -6.567* | 6 |

Note: $T_{B1}$ and $T_{B2}$ denote the period of structural breaks; $K$ lag length; $*$ and $**$ significance at 1% and 5% levels, respectively.

The Clemente-Montanes-Reyes unit root test results in a table (4) revealed the order of the variables of integration at first difference along with their structural breaks in the series from 2005*Q*3, 2005$Q_5$,2007$Q_1$, 2008$Q_5$, 2009$Q_5$, 2010$Q_1$,2011$Q_4$, 2015$Q_4$,2018$Q_3$, and 2017$Q_3$ respectively. The structural breaks in the series represent periods of economic decline and growth. In this regard, the energy sector reforms were initiated in 2005 to improve energy efficiency for economic growth. The 2007 pipeline vandalization grossly affected oil the economic, business, and financial activities in Nigeria. The 2008-2009 Niger Delta amnesty program for militants significantly influenced oil production and regional stability. The activities of Boko Haram in 2009 and farmers and herder's clashes in the North and middle of 2009 and 2017 significantly influenced the negative increase in food prices and business activities in the agricultural sector. The 2018 economic and financial recession in Nigeria grossly affected the growth of the industrial and service sectors in Nigeria.

## Test of Hypothesis

**$H_0$:** There is no co-integrating relationship between electricity consumption and sector value addition on economic growth in Nigeria.

**$H_1$:** There is a co-integrating relationship between electricity consumption and sector value addition on economic growth in Nigeria**.**

**Table 5.** ARDL Estimation

| **Dependent Variable: ELECT** | | | | |
|---|---|---|---|---|
| Method: ARDL | | | | |
| Selected Model: ARDL(1, 0, 0, 0) | | | | |
| Variable | Coefficient | Std. Error | t-Stat | Prob.* |
| ELECT(-1) | 0.875 | 0.057 | 15.256 | 0.000 |
| LOGAGRI | -0.166 | 0.365 | -0.455 | 0.009 |
| LOGMANU | 0.560 | 0.303 | 1.848 | 0.000 |
| LOGSERV | -0.087 | 0.248 | -0.351 | 0.007 |
| C | 0.218 | 4.307 | 0.050 | 0.959 |
| R-squared | 0.90 | Durbin-Watson stat | | 1.934 |
| F-statistic | 168.239 | Prob(F-statistic) | | 0.000 |

Table (5) shows the ARDL results following the Pesaran, Shin, and Smith,[33] framework. The $R^2$ shows the goodness of fit of the model of 90% accounting for an unexplained Variation of 10% explained by the independent variables. The F- statistic of (168.2398, a p-value of 0.000) at a critical value of 0.05% shows the significance and reliability of the model for meaningful analyses. The Durbin Watson Stat of (1.99) is approximately (2). There is no evidence of a first-order serial autocorrelation (AR(1). By rule of thumb, if the DW statistics is approximately (2), it is evidence against the existence of a first-order serial correlation.

**Table 6.** The ARDL Long-Run Result

| F-Bounds Test | | | | |
|---|---|---|---|---|
| Selected Model | (1, 0, 0, 0) | | | |
| Test Statistics | Value | Signif. | I(0) | I(1) |
| | Asymptotic n= 1000 | | | |
| F-statistics | 9.871 | 10% | 2.37 | 3.2 |
| K | 3 | 5% | 2.79 | 3.67** |
| | | 2.5% | 3.15 | 4.08 |
| | | 1% | 3.65 | 4.66 |

** at 5% significance level

**Table 7.** Error Correction Regression

| ARDL Error Correction Regression | | | | |
|---|---|---|---|---|
| Dependent Variable: D(LOGGDP) | | | | |
| Selected Model: ARDL(1, 0, 0, 0) | | | | |
| Variable | Coefficient | Std. Error | t-Stat | Prob. |
| CointEq (-1)* | -0.124954 | 0.039726 | -3.145379 | 0.0000 |

Table (6) The bound test results shows that the F-statistic value of (9.871) is greater than the upper critical value of (3.67) and a lower bound critical value of (2.27) at a 0.05% p-level. The Bound test result confirms the presence of a long-run relationship between energy consumption, economic growth, and sectorial value addition in Nigeria.

Table (7) the CointEq(-1) of -0.12 and p-value of 0.000 shows the speed of convergence from disequilibrium cause in the short-run by energy supply-demand gap in production, distribution, and consumption, estimated billing system, vandalization, inadequate and poor energy sector infrastructure, frequent collapse of the national grip among others, back to a long-run equilibrium by 12%.

The short-run results are substantiated by the results of Sharif, Jammazi, Raza, and., Shahzad [10]; Belaid, and Youssef, [8]; Adegboye and Babalola [16]; Harkat and Tahar [31] among others in Nigeria and other countries.

## Pairwise Granger Causality Test

The granger causality was examined using the pairwise granger causality test. The test indicates that x causes y if the variable x increases the accuracy of the prediction of the variable y, and vice versa (Driouchi & Harkat, [32]).

**Table 8.** Granger Causality Test

| Null Hypothesis: | Obs | F-Statistic | Prob. | Decision |
|---|---|---|---|---|
| LOGLIQOIL → LOGGDP | 73 | 4.081 | 0.009 | causal relationship |
| LOGGDP → LOGLIQOIL | | 14.473 | 0.007 | causal relationship |
| | | | | |
| LOGPETOIL → LOGGDP | 73 | 3.558 | 0.052 | No causal relationship |
| LOGGDP → LOGPETOIL | | 3.062 | 0.074 | causal relationship |
| | | | | |
| ELECT → LOGGDP | 73 | 10.192 | 0.009 | causal relationship |
| LOGGDP → ELECT | | 18.0561 | 0.001 | causal relationship |
| | | | | |
| LOGAGRI → ELECT | 73 | 1.344 | 0.474 | No causal relationship |
| ELECT → LOGAGRI | | 1.012 | 0.120 | No causal relationship |
| | | | | |
| LOGMANU → ELECT | 73 | 9.766 | 0.0006 | causal relationship |
| ELECT → LOGMANU | | 4.334 | 0.0004 | causal relationship |
| | | | | |
| LOGSERV → ELECT | 73 | 1.264 | 0.2937 | No causal relationship |
| ELECT → LOGSERV | | 0.111 | 0.9534 | No causal relationship |

Table (8) the pairwise granger causality test revealed a two-way causality between energy consumption (natural gas), and economic growth, and economic growth to energy consumption (natural gas). The results support a bidirectional causality. A unit increase in natural gas and electricity consumption increases sectorial value addition proportionately on economic growth vis-visa sectorial value addition increasing the demand for natural gas and electricity consumption. Empirical evidence from Karanfil, [4]; Enu and Havi [1]; Ibrahiem [13]; Osman, Gachino, and Hoque [14]; Ahmad, Zhao, Shahbaz, Bano, Zhang, and Wang [15; Adegboye and Babalola [16]; Ibrahiem [17] Sarwar, Chen, and Waheed [18]; (Wang *et al*., [15] substantiated the findings of this study.

The result also revealed a one-way causality between economic growth and energy consumption (petroleum oil). The result supports a unidirectional causality. A unit increase in economic and sectorial value addition activities increases the demand for petroleum oil consumption for production and creativity. The findings of Molem, and Ndifor [6]); Chinedu, Daniel, and Ezekwe, [7]); Belaid, and Youssef [8]); Mawejje, and Mawejje [9]); Sharif, Jammazi, Raza, Shahzad, [10]); Laurine, Ngundu, and Kupeta [5]); Carfora, Pansini, and Scandurra, [11]) also substantiated the findings of this study.

On the other hand, a two-way causality was observed between electricity consumption and manufacturing sector value addition on economic growth. An increase in electricity supply increases the manufacturing sector value in addition to the economic growth effort of the government. Empirical evidence from Ibrahiem [17] Sarwar, Chen, and Waheed [18]; (Wang *et al*., [15] also confirmed the findings of this study.

A non-causal relationship between energy consumption, sectorial value addition from the (service and agricultural sectors) on economic growth was observed. Aminu and Aminu, [19]; Bah, and Azam [20]; Egbichi, Ojamaliya, Okafor, Godwin, and Oluwapelumi [21], and Odhiambo, [22] confirm the findings of this study in their respective studies reported a non-causal relationship and supporting the neutrality hypothesis. Energy consumption and economic growth are not mutually dependent on each other.

# 5. Conclusions

Regardless of the sufficient empirical studies on the nexus between energy consumption and economic growth, there is still a lack of consensus on the directional causality among the variables. This study examines energy consumption and economic growth, extending the frontiers to cover the agricultural, manufacturing, and service sector's value addition, small business development on economic growth. Through the multivariate framework and fitted econometric techniques.

The Clemente-Montanes-Reyes unit root test was applied to check for unknown structural breaks in the series. This study differs from previous studies using predominantly the bivariate framework approach. To the best of our knowledge, no study in Nigeria has extended the frontiers of the study to accommodate the effect on the agricultural, manufacturing, small business, and service sectors value addition.

The findings of this study include

1. The Clemente-Montanes-Reyes unit root test reported the presence of structural breaks arising variables.
2. The co-integrating test results confirm the existence of long-run equilibrium relationships. This finding supports the feedback hypothesis in Nigeria.
3. The pairwise granger causality test also revealed a mix of results of a bidirectional causality; a unidirectional causality and a non-causal relationship.

In general, the study does not uphold the hypothesis of a neutral relationship between energy consumption and economic growth. Except for service and agricultural sector value addition. Inefficient energy supplies directly diminish the competitive prowess of the economic and non-economic indicators in stimulating economic growth and industrialization. Nigeria's energy problem is not a lack of sources of energy, but its development and utilization. Based on the findings, we, therefore, recommend the review of the estimated billing system to a more cost-effective and appropriate energy pricing framework to stimulate economic and business value addition.

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