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ENERGY CONSUMPTION EFFECT ON ECONOMIC GROWTH IN NIGERIA: MULTIVARIATE FRAMEWORK

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ABSTRACT

This study analyzes the causal relationship between energy consumption and economic growth in Nigeria using the multivariate framework from 2000Q1-2018Q4, the Autoregressive Distributed Lag (ARDL) bounds test approach, Error Correction Model (ECM), and the Clemente-Montanes-Reyes unit root for structural breaks in the series. Findings revealed a co-integrating relationship, a bidirectional relationship between petroleum, liquefied natural gas, and electricity consumption. A unit increase in energy consumption stimulates economic growth through product and service value addition. A unit decrease in electricity consumption increases petroleum consumption while decreasing economic growth as a result of distribution failure, estimated billing system and over-dependence on generating set as an alternative energy source. The non-causal relationship can be accredited to the energy demand-supply gap. The study recommends among other things review of the billing system, pricing framework, and policies toward supporting and ensuring efficient and responsive energy distribution and maintenance to spur value addition and economic growth.

JEL Classification: C320, O13, O130, O44, P28, Q430

Key words: Energy consumption, Economic growth, Gas-oil, Co-integration, Causality

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1. INTRODUCTION

Energy is one of the strategic stimulants and fulcrums of human civilization, industrial innovations, economic diversification, and sustainable development globally. Measured by the unit of Joule (J) among other measures of physical quantities of energy such as barrels for crude oil, cubic meters for gas, and liters for petrol and diesel oil, and kilowatt/hour (kWh) for electric energy, this energy is available to consumers at an affordable pricing framework. The economic and developmental impact of energy on human capital development through job creation for poverty and inequality reduction cannot be overemphasized in both developed and emerging economies. It is evident in the foreign earnings accrued from energy export for the overall growth in various aspects of economic and financial operational and business activities.

The energy sector on average supports more than nine million jobs, directly and indirectly, accounting for over 5% of America's total employment rate (Egbichi et al., 2018). In Nigeria, the gas, electricity, and air conditioning sectors between 2017-2018 accounted for about 10,000 new jobs. Energy sufficiency through a safe, green, and eco-friendly technique is central to actualizing the Sustainable Development Goal (SDGs) seven of access to affordable, reliable, sustainable, and modern energy for all Nigeria by 2030. Insufficient, unaffordable, unreliable, unsustainable, and lack of modern energy are some of the cardinal challenges in Nigeria diminishing human capital development, economic growth, and the possibility of actualizing the SDGs objective by 2030. The kWh is used to calculate the electricity consumption rate.

The classical school of thought recognized land, labor, and capital as vital factors of production with substantial influence on economic growth and production output (Enu and Havi, 2014). Vlahinic-Dizdarevic and Zikovic (2010) observed that the classical school of thought ignores other transitional inputs of energy demand-supply and pricing effect on output and economic growth. Nations with higher per capita energy accessibility, availability, and consumption rates are considered economically viable and industrialized, unlike those with lower rates such as Nigeria. Energy sufficiency increases revenue generation through small business development, sectoral output capacity, and utility costs reduction for manufacturing, and innovations.

The significance of energy sufficiency was further reflected in goal seven of the Sustainable Development Goals (SDGs) which emphasizes energy availability, affordability, and accessibility for economic growth and development. Nigeria is considered one of the largest oil-producing states with wide-ranging energy sources to spur economic and financial diversification. On the contrary, energy sufficiency in Nigeria remains a mirage characterized by chronic power deficiency and meager quality supply, dwindling the diversification prowess of the economic, and financial climate (Udo et al., 2021). Energy has been identified as one of the key factors responsible for the geometric increase in the unemployment rate at 65.8% in 2019, extreme poverty at about 76.5%, and moderate poverty at 37.8% in Nigeria. The primary objective of this study is to examine the long-short run co-integrating nexus between energy consumption and economic growth in Nigeria. This study uses the multivariate framework from 2000Q1-2018Q4, along with the contemporary econometric techniques of Autoregressive Distributed Lag (ARDL), Error Correction Model (ECM), and Clemente-Montanes-Reyes unit root to examine for the structural breaks in the series.

On value and knowledge addition our estimation procedure is novel. The pre-estimation tests focus on the basic statistical properties of the variables. This is essential as the choice of an appropriate estimation model should be preconditioned on the properties of the series parameters. The ARDL model form of regression was adapted because it shows simultaneously lagged and contemporaneous relationships among the variables under study and it outwitted some diagnostic problems associated with the regular Ordinary Least Square (OLS). The diagnostic tests were conducted to confirm the legitimacy and reliability of our estimates and consistency with the underlying assumptions of the choice estimation model to address the following research questions and also to test the hypotheses:

Research questions:

1. To what extent has the co-integrating relationship between energy consumption and economic growth existed in Nigeria?

2. To what degree is the significant causal relationship between energy consumption and economic growth in Nigeria?

Research hypotheses:

H1: There is no co-integrating relationship between energy consumption and economic growth in Nigeria.

H2: There is no causal relationship between energy consumption and economic growth in Nigeria.

2. LITERATURE REVIEW

Empirical studies on energy consumption and economic growth in single and cross-country studies over the period reported diverse results due to differences in methodologies, various measures of energy employed, and country-specific heterogeneous factors (Ahmed and Azam, 2016; Enu and Havi, 2014). Molem and Ndifor (2016), Chinedu, Daniel, and Ezekwe (2019), Belaid, and Youssef (2017), Mawejje, and Mawejje (2016), Laurine, Ngundu, and Kupeta (2018), and Carfora, Pansini, and Scandurra (2019) observed a unidirectional causality, from energy consumption to economic growth, supporting the energy-led growth hypothesis; of energy availability, affordability, and accessibility stimulating economic growth, social and technological advancement.

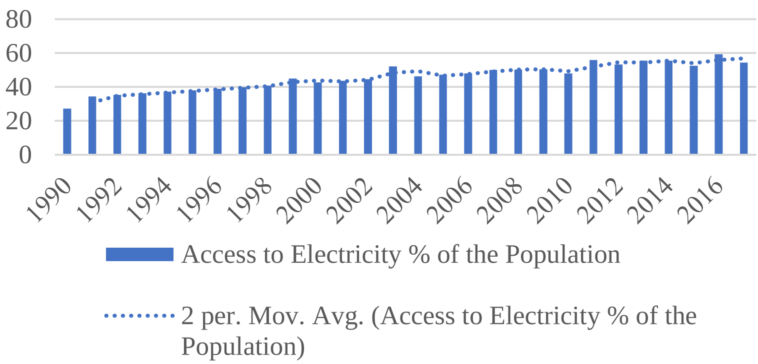
On the directional causality, diverse results are reported; economic growth to energy consumption supports the growth-led energy hypothesis (Ozcan, Tzeremes, and Tzeremes, 2020; Ibrahiem, 2018; Adegboye and Babalola, 2017; Sarwar, Chen, and Waheed, 2017; Osman, Gachino, and Hoque, 2016; Ahmad et al., 2016; Wang et al., 2016; Karanfil, 2015; Ibrahiem, 2015; Enu and Havi, 2014; Yu and Choi, 1985), supported the feedback hypothesis that energy and economic growth Granger cause each other. Aminu and Aminu (2015), Bah, and Azam (2017), Egbichi et al. (2018) supported the neutrality hypothesis of non-causal relationship that energy and economic growth are not mutually dependent. Energy conservation policies have a non-adverse effect on economic growth. A single-country study explains the impact and causality significantly due to the stages and level of economic growth and energy sector development.

2.1 ENERGY SECTOR IN NIGERIA

Energy sufficiency drives the global economy through renewable and non-renewable sources. Non-renewable energy sources are the prevailing form of energy largely consumed in Nigeria from petroleum products, to hydrocarbon gas liquids, natural gas, coal, and nuclear energy. Petroleum products account for over 79% of commercial energy consumption in Nigeria; petroleum is also a major source of foreign earnings. Nigeria is heavily endowed with vast deposit of natural gas estimated.

The lack of operational infrastructure in the energy sector has led to the flaring of about 40% of the natural gas in Nigeria, accounting for about 20% of all gas flared globally. The failure of the electricity sub-sector to resourcefully close the energy demand-supply gap has not only destabilized the industrialization process but also truncated achievement of SDG goal seven and the Millennium Development Goals (MDGs) in Nigeria. Over 55%-60% of the population are unconnected to the national grid while about 40%-45.5% of urban dwellers access electricity at a very high cost and 20%-25% of the rural dwellers are cut off the grid (see Figure 1) (Udo et al., 2021).

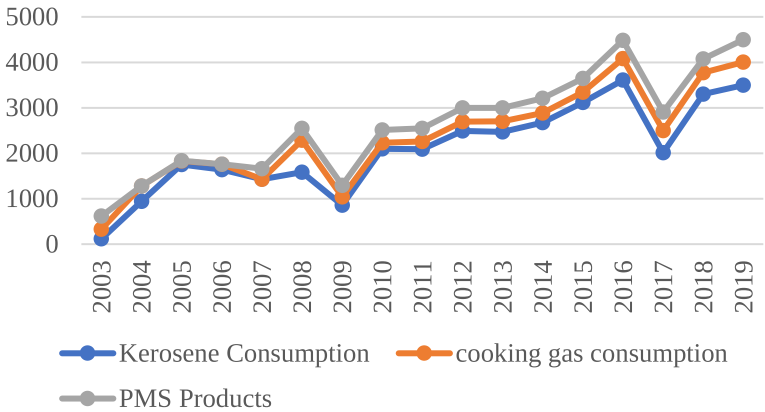
FIGURE 1
Access to Electricity % of the Population



Source: Authors Computation (2020)

The gap between electricity supply-demand created a high demand for petrol (PMS), kerosene (AGO), and cooking gas as an alternative source of energy for residential use (see Figure 2). The hikes in prices of kerosene, petrol (PMS), and cooking gas, on the other hand, led to deforestation, degradation, desertification, global warming, climate change, and carbon dioxide emission (CO_2) as a result of over-dependence on fuel-wood especially by the rural dwellers constituting over 65.5% of the total population (Babanyara and Saleh, 2010).

FIGURE 2
Petrol (PMS), Kerosene (AGO), and Cooking Consumption



Source: Authors Computation (2020)

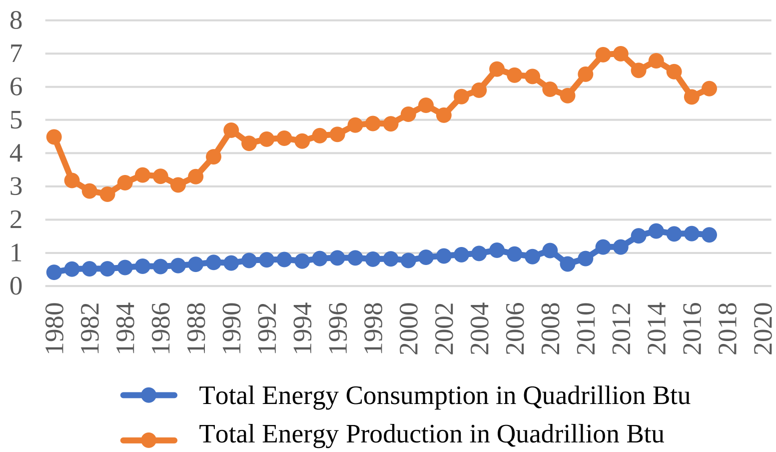
The energy sufficiency and its efficient deployment enhance development, innovation, job creation, economic growth, and human capital development. Energy insufficiency adversely affects economic, business, human capital development, and government poverty alleviation programs (Adegboye and Babalola, 2017).

Since the nexus between energy and economic growth was first discussed in the middle of the 19th century, the curiosity in the nexus was renewed in the 1970s and 2000s by the energy crisis in major industrial nations of Germany, the United States, Canada, among others resulting in a near-collapse of the economic, business, and financial climate. Iwayemi (2012) opined that the lingering electricity crisis specifically in emerging economies such as Nigeria shows the energy challenge in a more visible dimension.

The cost of alternative sources of energy supply in Nigeria is on the geometric increase as a result of the demand-supply gap, successively influencing the prices of products and services. The ripple effect is also evident in the crowding-out of the formal and informal industries to other neighboring countries of Ghana, South Africa, and Kenya with their relatively sufficient energy distribution among other non-macroeconomic factors.

Negative impact of this crisis across the various economic sectors begs the question: are there other factors influencing the causal and co-integrating nexus between energy and economic growth? The causal factors in the energy crisis include price control, feeble concern for cost recovery, and scarcity of economic inducements to state-owned corporations (NNPC and PHCN) to invest. Also institutional and governance let downs encouraged inadequacy in production, investment choices, and high operating costs among others. This is evident in the epileptic electricity supply fluctuating between 2%-4.0% respectively from 1980-2019 (NBS, 2018) (see Figure 3). Primary energy consumption in Nigeria stood at 1.54 Quadrillion Btu in 2017, the manufacturing sector accounts for a 50%-60% electricity consumption rate, while other forms of energy such as coal, petroleum, natural gas, nuclear fuels, and biomass represent a 25%-35% consumption rate (Udo et al., 2021).

FIGURE 3
Electricity Production and Consumption Patterns in Nigeria



Source: Source: Authors Computation (2020)

Notwithstanding the ascending trend in total energy production, the consumption rate is slow as a result of lack of accessibility and affordability. The gap between installation and actual operational capacity output not exceeding 4,000 MegaWatt (MW) per hour averaging less than 40% provides another support for the slow trend in consumption rate. Electricity capacity generation in 2013 increased by 23.1% above that of 2012.

Installed 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, 2017).

The economic sectors electricity consumption in the last decade of 1990-2000 fall below par with a slight increase in 2005 after the Electricity Power Sector Reform Act (EPSRA). The telecommunications companies (MTN NG, Airtel Nigeria, Globacom, and 9mobile) spent about US$100 million on *diesel* fuel to provide and keep their networks running as a result of the fluctuating supply of electricity annually.

To achieve the SDGs in Nigeria by 2030 successive governments have developed various policy structures, and frameworks; such as the 1972 import substitution/indigenization policy, 1986 Structural Adjustment Programme (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 and frameworks empirical evidence revealed deterioration and near collapse of the various economic sectors via lack of export goods value chain effect, high production cost, crowding-out of multinational firms.

2.2 THEORETICAL FRAMEWORK

The physical theory of economic growth propounded by Kardashev (1964) identifies technological advancement, economic and financial diversification, and sustainability as a function of energy sufficiency. Similarly, natural scientists and ecological economists acknowledged the cause-benefit effect of energy availability and accessibility on production and growth processes (Hall et al., 2003 cited in Okorie and Manu, 2016). The biophysical theory of economic growth recognizes energy as the only factor in the production process and it must be exogenously determined. The classical theory of economic growth on the other hand corroborated the claims of the biophysical theorists of energy as a factor of production but as a result of land-imposed limitations, particularly in the agricultural sector.

The neutrality hypothesis propounded by Yu and Choi (1985) argued that energy and economic growth are not mutually dependent on each other. Energy has a non-adverse or minimal effect on economic growth. The ecological and mainstream economics also argued that energy is an intermediate input in the production process (Aghion and Howitt, 2009).

To examine the nexus between energy and economic growth in Nigeria the unifying energy and growth models, integrating the mainstream and ecological economic theories were adopted. The mainstream economic growth ignores the impact-benefit of energy to the economy, while the ecological economists on the other hand are critiques of the mainstream theory.

2.3 EMPIRICAL REVIEW

The diverse methodologies, various energy variables, and country-specific heterogeneous factors account for the inconclusive empirical evidence on the nexus between energy consumption and economic growth over the decades as examined below.

Apergis and Payne (2010) employed the multivariate framework to examine the nexus between renewable energy consumption and economic growth in 20 OECD countries from 1985–2005. The findings supported a long-run equilibrium nexus and bidirectional in both long and short run causalities.

Adegboye and Babalola (2017) examine energy effect on economic growth from 1981-2018 through the ARDL bounce test and ECM. Findings revealed a long-run co-integrating relationship and a short-run result revealing the speed of convergence at 0.25% from disequilibrium caused by energy deficiencies back to long-run equilibrium.

Tahar (2020) in Morocco examined energy impact on economic growth through the Granger causality framework. Findings showed a unidirectional causality.

Belaid and Youssef (2017) in Algeria for the period 1980–2012 employed the Vector Error Correction (VECM) to investigate economic growth on renewable and non-renewable energy. Findings revealed a unidirectional causality.

Mawejje and Mawejje (2016) in Uganda employed quarterly data from Q1 2005–Q1 2015 to examine electricity consumption in the industrial and service sectors through the Granger causality framework. Findings revealed a long-run relationship between electricity and the industrial sector and a short-run relationship between the service sector and electricity.

Sharaf (2016) in Egypt adopted annualized time-series data from 1980–2012 to examine the causal relationship between economic growth and electricity consumption. Findings supported a unidirectional causality.

Aminu and Aminu (2015) in Nigeria adopted the annual data from 1980-2011 to investigate the causal relationship between energy consumption and economic growth using the Granger causality test, impulse response, and variance decomposition analysis. Findings supported a non-causal relationship. Bah, and Azam (2017) also employed the Granger causality test to examine energy consumption effect on economic growth in South Africa from 1971–2012. Findings again supported a non-causal relationship.

Ibrahiem (2018) in Egypt examined the real output on electricity consumption for the period 1971-2013 using the Johansen cointegration approach and VECM. Findings supported a bidirectional relationship. Similarly, Ahmad et al. (2016) in India examined the electricity consumption effect on economic growth, using the VECM for the period 1971–2014. Findings also supported a bidirectional relationship. Sarwar et al. (2017) studied 210 countries by employing the panel VECM to examine the energy electricity effect on economic growth for the period 1960–2014. Their findings revealed a bidirectional relationship.

Osman et al. (2016) studied the impact of electrical energy on economic growth in Gulf Corporation Council Countries from 1975–2012. They used the panel VAR Granger causality test and their findings revealed a bidirectional relationship.

Ozturk and Acaravci (2011) examined electricity consumption effect on economic growth in 11 Middle East and North Africa (MENA) countries from 1971-2006, using the ARDL bounds-testing approach. The findings support the neutrality hypothesis. Ozturk and Acaravci (2010) also examined the effect of electricity consumption on economic growth in Turkey from 1968–2005 using the ARDL bounds-testing approach. Findings also supported the neutrality hypothesis.

Meanwhile, Narayan and Prasad (2008) studied 30 OECD countries employed the bootstrapped causality tests to examine electricity consumption effect on economic growth. Findings support the neutrality hypothesis in Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Japan, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Republic of Slovenia, Spain, Sweden, Switzerland, Turkey, and the USA.

Ugwoke, Dike, and Elekwa (2016) studied electricity consumption, trade openness, and industrial production on economic growth from 1980-2014 in Nigeria. Findings showed a negative relationship.

Molem and Ndifor (2016) in Cameroon examined the energy consumption effect on economic growth using the Double-log linear formulation. Findings showed a negative relationship. Molem and Ndifor (2016) in Cameroon from 1980-2014 examined the nexus between energy consumption on economic growth using the Generalized Method of Moments technique. Findings showed a positive relationship between variables.

Pirlogea and Cicea (2012) examined the comparative relationship between energy consumption and economic growth in Spain, Romania, and the European Union from 1990-2010. Findings supported the energy-led-growth hypothesis.

Chinedu et al. (2019) in Nigeria examined the effect of energy consumption on economic growth from 1980-2017, using the Engle-Granger Co-integration test, error-correction mechanism. Findings showed a positive relationship between variables. Udo et al. (2021) examined the co-integrating and causal link between energy consumption and economic growth in three economic sectors of agriculture, manufacturing, and service sectors in Nigeria. Using quarterly data from 2000Q1-2018Q4, findings showed mixed results; a co-integrating relationship between economic growth and sectorial value creation, bidirectional causality between liquefied natural gas and energy consumption, and a unidirectional causality between economic growth and petroleum consumption.

3. METHODOLOGY

The Granger-causality model, ARDL, and the Clemente-Montanes-Reyes unit root test for structural breaks were adopted in this study. Data for this study are obtained mainly from secondary sources such as the Central Bank of Nigeria Statistical Bulletin (2019) and World Bank Development Indicators (2018). The quarterly time series data covers the period 2000Q1-2018Q4.

The linear model expression:

(1) $RGDP = \beta_0 + \beta_1 ELECT + \beta_2 LIQOIL + \beta_3 PETOIL + \mu$

3.1 SYMMETRICAL ARDL MODEL

The bounds test procedure is captured with the following representation:

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

The *F*-test value test for the null hypothesis of no co-integration against the alternative of a long-run relationship.

$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$ (there is no co-integration)
$H_1 : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq 0$ (there is co-integration)

Decision Rule:

1. *F*-statistics fall above the upper bound critical value, H_0 is rejected (the variables are co-integrated).
2. *F*-statistics fall below the lower bound, H_0 cannot be rejected (the variables are not co-integrated).
3. *F*-statistics fall within the two bounds; the result is (inconclusive).

The ECT measures the speed of convergence from disequilibrium caused 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 is specified as:

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

where

β_0 = Constant term,
β_1-β_4 = Regression coefficient and μ = Error Term.

RGDP = Real Gross Domestic Product (GDP at Market Prices – indirect taxes net of subsidies)
ELECT = Electric power consumption
LIQOIL= liquefied natural gas consumption
PETOIL= Petroleum oil consumption

The a priori expectations of the explanatory variables are as expressed as $\beta_1, \beta_2, \beta_3 > 0$.

4. RESULTS AND DISCUSSION

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

4.1 PRE-TEST

Table 1 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 peakness of the observations. All the variables show positive skewness except logGDP with a negative skewness of (-0.469) showing a negative departure from the mean.

The Jarque-Bera statistical test result shows that all the variables are largely leptokurtic since the Kurtosis is greater than three. By implication, the dataset produces more outliers than a normal distribution.

TABLE 1
Variables Description and Characteristics

	LOGGDP	ELECT	LOGPETOIL	LOGLIQOIL
Mean	10.557	18.425	12.620	9.242
Std. Dev.	0.906	3.670	0.215	0.458
Skewness	-0.469	0.618	0.629	-0.062
Kurtosis	1.964	2.147	2.441	1.652
Jarque-Bera	6.192	7.143	6.0024	5.796
Probability	0.0452	0.0281	0.049	0.055
Observations	76	76	76	76

Source: Authors Computation (2020) using Eviews-10.

4.2 UNIT ROOT TEST

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

The model expression; $\Delta y_{t-1} = \alpha_0 + \lambda y_{t-1} + \alpha_2 t + \Sigma^{p}_{i=2} \beta_j \Delta y_{t-1} + \mu_t$.

where

y = dependent variable,
t = trend,
α_0 = intercept,
μ_t = white noise and
p = lag level.

The results in Table 2 show the variables attained stationarity at Order 1 and level integration. A combination of I (1) and I (0) order of integration provides the theoretical underpinning for the ARDL model according to the Pesaran, Shin, and Smith (2001) framework. The Clemente-Montanes-Reyes unit root test was employed to check for unknown structural breaks in the series not captured by the ADF and PP unit root tests. ARDL approach has several advantages over other previous and traditional methods. Such as it is flexible, as it allows the analysis with I(0), I(1), or a combination of both data and is relatively more proficient in the case of small and finite sample data.

Identification of the structural breaks in the series would proffer long-run policy support in formulating an all-inclusive energy plan to enhance value addition on economic growth, and pricing framework embracing these structural breaks. The Clemente-Montanes-Reyes unit root test results revealed that the variables are integrated at first difference along with their structural breaks in series from 2005Q3, 2005Q5, 2007Q1, 2008Q5, 2009Q5, 2010Q1, 2011Q4, 2015Q4, 2018Q3, and 2017Q3 respectively. In this regard, the 2005 energy sector reforms were initiated to enhance energy efficiency through privatization. The 2007 pipeline vandalization decreased oil production and consumption along with the economic, business, and financial activities.

TABLE 2
ADF and PP Unit Test

Variables	Test	Level @ 5%	Inference	Test	1st Difference @ 5%	Inference
LogRGD	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	-3.56 (-6.199)***		PP	-4.813 (-3.590)***	
LogLIQOIL	ADF	-1.261 (-4.902)	Non-Stationary	ADF	-3.345 (-5.569)	Non-Stationary
	PP	-1.45 (-4.902)		PP	-4.561 (-5.120)	
LogPETOIL	ADF	-5.301 (-4.308)***	Stationary	ADF	-3.102 (-2.207)***	Stationary
	PP	-6.201 (-5.308)***		PP	-3.201 (-1.723)***	

Note: The asterisks *** indicate significance at 5%
Source: Authors Computation (2020) using Eviews-10.

The federal government between 2008-2009 granted militants in the Niger Delta amnesty which translated to an increase in oil production and peace in the region. In 2009, Boko Haram bombed and destroyed major agricultural facilities in the North, and middle belt. In 2015-2018, economic and financial recession crowded out both domestic and multinational companies in Nigeria.

TABLE 3
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
LogRGDP	2000 Q_4	-	-3.063	4	2003 Q_4	-	-8.346**	2
	2000 Q_4	2005 Q_3	-2.901	2	2003 Q_4	2005 Q_6	-6.730**	8

TABLE 3 *(continued)*

Model: Trend-Break Model								
	Level data				First difference data			
Variables	T_{B1}	T_{B2}	Test-statistics	K	T_{B1}	T_{B2}	Test-statistics	K
ELECT	2005 Q_1	-	-2.350	2	2006 Q_6	-	-4.567**	3
	2007 Q_3	2005 Q_5	-3.890	3	2006 Q_4	2007 Q_1	-6.891**	7
LogLIQOIL	2008 Q_2	-	-4.201	4	2009 Q_1	-	-6.461*	3
	2009 Q_1	2009 Q_5	-4.714	6	2009 Q_3	2010 Q_1	-5.781**	5
LogPETOIL	2008 Q_2	-	-2.913	4	2010 Q_5	-	-3.567**	3
	2009 Q_2	2010 Q_6	-3.671	5	2010 Q_1	2010 Q_4	-5.678**	6

Note: T_{B1} and T_{B2} denote the period of structural breaks; K lag length; $*$ and $**$ significance at 1% and 5% levels, respectively.
Source: Authors Computation (2020) using Eviews-10.

4.3 MODEL STABILITY

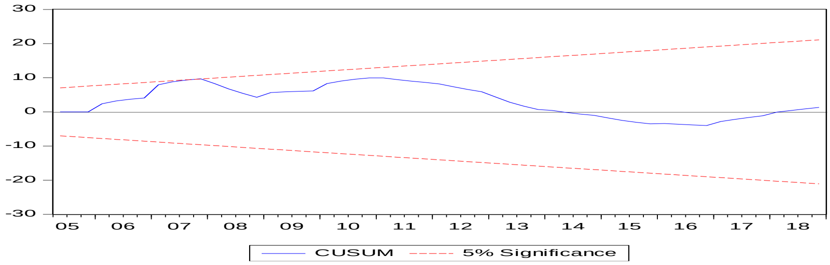
Figure 4 gives the cumulative sum (CUSUM) that was performed to test the model stability. The model stability of the ARDL regression coefficient is valued by a stability test showing whether or not the regression equation is stable over time. It is apt in time series data, because of the uncertainty associated with it. If the plot of these statistics remains within the critical bound of upper and lower at a 5% significance level, the parameters of the models are stable within their critical bounds.

Test of Hypothesis

H1: There is no co-integrating relationship between energy consumption and economic growth in Nigeria.

H2: There is a co-integrating relationship between energy consumption and economic growth in Nigeria.

FIGURE 4
The Cumulative Sum (CUSUM)



Source: Authors Computation (2020) using Eviews-10.

The results in Table 4 show the goodness of fit of the ARDL model measured by the R^2 of 0.99% with an unexplained Variation of 0.01%. The *F*- statistic of 3945.293 and probability value of 0.000, confirms the model reliability. The Durbin Watson Stat of 2.99 rules out possible first-order positive autocorrelation.

TABLE 4
ARDL Estimation

Dependent Variable: LOGGDP
Method: ARDL
Selected Model: ARDL(4, 0, 0, 0)

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.*
LOGGDP(-1)	0.2017	0.0752	2.6795	0.0094
LOGGDP(-2)	2.1401	0.0794	2.690011	1.0000
LOGGDP(-3)	-5.0611	0.0794	-6.30011	1.0000
LOGGDP(-4)	0.7673	0.0746	10.2821	0.0000
ELECT	-0.0106	0.0394	-2.6936	0.0009
LOGLIQOIL	0.0165	0.0135	1.2251	0.2250
LOGPETOIL	0.1244	0.0537	2.3135	0.0239
C	-0.7587	0.6310	-1.2024	0.0006
Other Parameters Estimate				
R-squared	0.997688	Durbin-Watson stat		2.994549
F-statistic	3945.293	Prob(F-statistic)		0.000000

Source: Authors Computation from Eview Result (2020)

The coefficients of the variable show that unit decrease in electricity supply-demand decreases economic growth, value addition, foreign earnings and the operational and business activities of telecommunications companies (MTN NG, Airtel Nigeria, Globacom, and 9mobile) significantly by 0.10%. Failure of the electricity sub-sector to resourcefully close the energy demand-supply gap has not only destabilized the industrialization process but has caused economic and developmental woes.

Findings of Ugwoke et al. (2016) substantiate the findings of this study. The negative result reported is traceable to the energy supply and demand gap in Nigeria, electricity pricing and estimated billing framework; electricity and non- electricity related factors of corruption in the electricity sector, vandalization and lack of electricity infrastructures among others.

A unit increase in petroleum and natural gas without gas flaring and operational infrastructures in the energy sector positively and significantly influences economic growth, value addition and foreign earnings by 16% and 12% respectively. The findings of Chinedu et al. (2019), and Pirlogea and Cicea (2012) also support findings of this study. The positive relationship reported is also traceable to the relative peace in the Niger Delta among other government and non-governmental interventions.

The *F*-statistic value of 50.648 in Table 5 exceeds the upper critical value of 3.67 and a lower bound critical value of 2.27 at the 5% probability level. The Bound test result confirms the presence of a long-run relationship between electricity consumption, petroleum, natural gas, and economic growth in Nigeria. Mawejje and Mawejje (2016), Adegboye and Babalola (2017) as well as Apergis and Payne (2010) confirm the findings of this study through the energy led growth model.

TABLE 5
The ARDL Long-Run Co-Integrating Result.

F-Bounds Test				
Selected ARDL Model	(4, 0, 0, 0)			
Test Statistics	Value	Sig.	I(0)	I(1)
		Asymptotic n= 1000		
F-statistics	50.648	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
Source: Authors Computation from Eview Result (2020)

The CointEq(-1) coefficient of (-0.030), with a *p*-value of (0.000) in Table 6 is statistically significant, showing the speed of convergence from disequilibrium cause in the short-run by the gap in demand and supply of energy supply, estimated billing system back to a long-run equilibrium by 30%. The results are substantiated by the results of Belaid, and Youssef (2017) and Adegboye and Babalola (2017).

TABLE 6
Error Correction Regression

ARDL Error Correction Regression Dependent Variable: D(LOGGDP) Selected Model: ARDL(4, 0, 0, 0)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CointEq(-1)*	-0.30872	0.001882	-16.40336	0.0000

Source: Authors Computation from Eview Result (2020)

4.4 GRANGER CAUSALITY TEST

The directional 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 and Harkat, 2017).

The pairwise Granger causality test (Table 7) revealed a bidirectional causality from natural gas and electricity consumption to economic growth, and from economic growth to natural gas and electricity consumption. A unit increase in natural gas and electricity consumption increases economic growth and small business development proportionately, vice-versa. The result also revealed no causality flows from economic growth and small business development to petroleum oil consumption vice versa.

TABLE 7
Pairwise Granger Causality

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	No causal relationship
ELECT → LOGGDP	73	10.192	0.009	Causal relationship
LOGGDP ← ELECT		18.0561	0.001	Causal relationship

Source: Authors Computation from Eview Result (2020)

5. CONCLUSION

Theoretical and empirical literature fairly established that energy deficiency is one of the non-energy factors instigating poor economic growth, extreme and moderate poverty, income inequity, unemployment, and underemployment rates among others in Nigeria.

Poor energy management practices have also resulted in energy-deficiency in the urban, suburban, and rural areas while increasing extreme poverty rate, unemployment rate, high business utility cost, crowding-out of multinational companies, and overall poor economic growth among others.

To achieve the desired economic growth through energy sufficiency and the goal seven of SDGs, there is a dire need for an efficient, reliable, and decentralized clean energy system in Nigeria to reduce impact on the climate, improve the standard of living, and life expectancy. Energy sector infrastructural development, affordable pricing, and bill frameworks are needed.

This study among other things advocates for efficient energy management practices, availability, accessibility, and affordability to close the supply-demand gap. The findings of this study showed the deficiencies in the Nigerian energy situation, billing system, consumption, and distribution pattern, among others. The findings also revealed that non-energy factors such as corruption, vandalization, poor maintenance, and lack of management prowess significantly disrupt energy distribution and consumption rates.

Policies on energy development and efficiency are urgently needed to ensure sufficient distribution, maintenance, and management practices while eliminating the estimated billing system and other non-energy factors affecting the sector.

Empirical results of the study showed a bidirectional relationship from natural gas, and electricity consumption to economic growth, from economic growth to natural gas, and electricity consumption. No causal relationship was dictated among petroleum oil consumption and economic growth variables.

The major limitation of this study is the lack of contemporary literature; most studies on energy consumption on economic growth over the period focus on other countries outside Nigeria. There is a lack of data specifically from the firms in the energy sector in Nigeria.

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