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MEETING NIGERIA'S ENERGY CONSUMPTION DEMAND BEYOND 2020: A RETHINK OF POLICY OPTIONS FOR GROWTH

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Abstract
Following the inauguration of the Nigeria's present administration on May 29, 2015, the government realized that the development of the various sectors of their economy depend heavily on reliable, adequate and economically prized power supply, Thus, they accorded the power sector a top priority of its economic growth. This was well articulated in the Economic Recovery and Growth Plan (ERGP) which aimed at optimizing the delivery of at least 10GW of operational capacity by 2020. Till date, energy supply remained a challenge especially the small and medium scale sub-sector of the economy. We recommended that for energy supply and consumption to be competitive and efficient in Nigeria, efforts must be put in place to reduce gas flaring. The flared gas can be processed to augment power generation, given that the present stage of Nigeria's production structure and activities are energy intensive.

Introduction

The importance of energy in the economic development process particularly of developing countries is well known and documented in the literature Orubu, 2004; Erdal, Erdal, and Esengün, 2008; Apergis, and Payne 2009 and Bhattacharya et al, 2016). The extensive use of energy and energy based inputs in the production process of nations cannot thus be overemphasised. Although the positive impact of energy use is well acknowledged, its negative impact is also well articulated in the literature. For instance, sharp rise in anthropogenic emissions such as carbon monoxide (CO), hydrocarbons (HCs), sulphur dioxide (SO_2), carbon dioxide (CO_2) among others are greenhouse – enhancing and part causes of global warming.

The significance of energy in the growth and development process gained more prominence following the quadrupling of oil price accretion in 1973 and 1974 and further price increases in 1979 and 1980[1] and thereafter. Although rapid industrialization and economic progress before the 1973 era was due to relatively cheap and abundant energy in the developed world, the rate at which energy consumption has increased, closely follow the rate at which economies have expanded globally (Iwayemi, 1998). This raises issues of relationships and causality.

The salvo on the causality between economic growth and energy consumption was first postulated in the seminal paper of Kraft and Kraft (1978). Their study reported a strong causality running unidirectionally from Gross National Product (GNP) to energy consumption for the period 1947 – 1974 using annual data of the USA. They averred that "while the level of economic activity may influence energy consumption, the level of gross energy consumption has no causal influence on economic activity". The implication being that energy conservation policies can be intimated without aggravating the side effects of economic growth. Other studies that have found unidirectional relationship running from economic growth to energy consumption are Soytas and Sari (2002) for Italy and Korea; Fatai, Oxley and Scrimgeour (2004) in New Zealand; Ghosh (2002) for India (using electricity consumption), Yu and Choi (1985) for South Korea and Yang (2000) for Taiwan (using coal consumption); Cheng and Lai (1997) in Taiwan Province of China; Ageel and Butt (2001) for Pakistan among others.

Yu and Choi (1985) for the Philippines, Soytas and Sari (2002) in Turkey, France, Germany and Japan; Oh and Lee (2004) for Taiwan, Altinay and Karagol (2005) for Turkey, Wolde-Rufael (2005) for Cameroon, Morocco and Nigeria, Mehrara (2007) for 11 oil exporting countries, Lee and Chang (2008) for 16 Asian countries and Apergis, and Payne 2009 for eleven countries of the Commonwealth of Independent States are some other studies that have also found unidirectional relationship; but from energy consumption to economic growth and not the other way round unlike the earlier examples.

Similar studies have also established bidirectional causality between economic growth and energy consumption. Examples are Glausure and Lee (1977) for South Korea and Singapore; Chang, Fang and Wen (2001) in Taiwan; Soytas and Sari (2002) in Argentina; Jumbe (2004) for Malawi; Ghali and El-Sakka (2004) for Canada; Oh and Lee (2004) for Korea; and Guttormsen (2004) for France, Greece, Germany, Italy, Japan, Argentina, India, Indonesia and Philippines, Wolde-Rufael (2006) for Egypt, Gabon and Morocco, Erdal, Erdal and Esengün (2008) for Turkey, Belloumi (2009) for Tunisia, Apergis and Payne (2009b) for 11 countries of the Commonwealth of Independent States (CIS), Ouedraogo (2010) for Burkina-Faso, Ozturk et al. (2010) for Middle income countries, Belke, Dobnik and Dreger (2011) for 25 OECD countries are other examples that confirmed the absence of any causality between economic growth and energy consumption.

Some observations that can be deduced from the survey of studies summarized above are, firstly, the studies focused more on developed economies and Asia countries. Second, the different economies and at some different time periods reported mixed results. Thirdly, more of the surveyed studies clearly state that a relationship exists between economic growth and energy consumption, although it is also not out of place to infer that the different methodologies may also be alluded to the different results. For instance, Ebohon (1996) is one documented study from the literature search that has investigated the causality between energy consumption and economic growth for Nigeria. Although, Ebohon’s study also investigated this causality for Tanzania, the result established a simultaneous causal relationship between energy consumption and economic growth for Nigeria (and Tanzania).

The lack of more studies using Nigerian data is thus worrisome. Altinay and Karagol (2005) investigates the causal relationship between real GDP and electricity consumption in Turkey for the period of 1950–2000. They used VARs in levels, as well as standard Granger causality test. Their results suggest an evidence of causality running from the electricity consumption to the income. Lee (2005) re-investigate the co-movement and the causality relationship between energy consumption and GDP in 18 developing countries. The results provide clear support of a long-run co integration relationship after allowing for the heterogeneous country effects. Mehrara (2007) examines the causal relationship between the per capita energy consumption and the per capita GDP in a panel of 11 selected oil exporting countries using panel unit-root tests and panel co integration analysis. The results show a unidirectional strong causality from economic growth to energy consumption for the selected oil exporting countries.

Comparing studies on Tunisia, Belloumi (2009) employed the Johansen multiple co integration test and vector error correction model. Their results report the existence of a long-run relationship. Hossain (2011) employed time series data from nine newly industrialized countries (NIC) for the period 1971–2007. The study concludes that there is a co integration vector among the variables. However, the Granger causality test did not show any evidence of long-run causal relationship, but a unidirectional short-run causal relationship from economic growth to energy consumption. In their investigation between the effects of renewable energy consumption on the economic growth, Bhattacharya et al., (2016), findings confirmed strong evidence of long-run dynamics between economic growth and energy consumption. Furthermore, their results suggest a significant positive impact on the economic output for the selected countries.

Cheng and Lai (1997) also used Taiwan data by employing the Hsiao's version of Granger causality technique. Cheng and Lai concluded in their study that no long-run equilibrium relationship exists. Yang (2000a) employed the two-step Engle-Granger co integration and Granger causality test on Taiwan's data. Their study provided evidence of bidirectional causality between energy consumption and economic growth (GDP). However, Yang (2000b) application of the two-step Engle-Granger co integration and Granger causality method using Taiwan's data confirmed the presence of unidirectional causality from economic growth to coal consumption[2]. Some other causality tests explored in previous studies other than the ones so far summarised are Sims (1972) causality test and the direct Granger (1969) causality test.

To begin to narrow this knowledge gap, this paper modestly investigates the causal relationship between energy consumption and real GDP in Nigeria and compares the results with those of Guttormsen (2004) for India and Ageel and Butt (2001) for Pakistan. The paper employs Hsiao's granger causality test after establishing co integration of the series since most economic time series seem to be non-stationary. Moreover, at the theoretical level, the establishment of causal relations between economic variables engenders better understanding of the economic phenomena which would enhance the optimization of economic policy.

The paper has four main sections. Following the introduction which also briefly discussed the literature on causality between energy and development in section 1, section 2 presents a recent profile of Nigeria's energy consumption, while section 3 reviews some versions of causality tests. These are mainly the Johansen (1988) test and Hsiao (1981) test. Section 4 discusses the empirical results for Nigeria and compares them with those of existing studies for India and Pakistan. The last section summarizes and concludes the paper with some remarks.

Nigeria's Energy Production and Consumption Profile

Nigeria like some other developing countries is an energy intensive growing economy. according to International Energy Association report (IEA, 2014) the total primary energy supply (excluding electricity trade and oil imports) for Nigeria in 2014 was 127,142 ktoe as against 69810 ktoe in 1990. The primary energy supply mix includes 85.5% bio fuels and waste, 11.3% natural gas, 2.8% crude oil and 0.4% hydro respectively. However, the Nigerian Energy Mix Chart (2017), shows that energy consumption mix of the country is dominated by natural gas (62.2%) Small Medium Hydro Power (SMHP) (2%) and Large Hydro Power (LHP) (26%), Solar PV (10%), wind (0.8%) and Biomass (0.8%). The electricity (power) sub-sector operates below its estimated capacity with frequent power outrages.

Table 1: Nigeria's Electricity Production Profile (1980 -2016)

	1980-1989	1990-1999	2000-2009	2010-2016
Electric power consumption (kWh per capita)	78.904	87.480	110.756	146.077
Electricity production from coal sources (% of total)	0.045	0.028	N/A	N/A
Electric power transmission and distribution losses (% of output)	32.165	38.280	26.047	13.329
Electricity production from hydroelectric sources (% of total)	31.088	36.920	32.215	20.017
Electricity production from oil, gas and coal sources (% of total)	68.912	63.080	67.785	79.618
Electricity production from oil sources (% of total)	18.066	10.361	N/A	N/A
Electricity production from natural gas sources (% of total)	50.801	52.691	67.785	79.983
Energy intensity level of primary energy (MJ/$2011 PPP GDP)	N/A	10.241	8.311	5.978
Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP)	N/A	244.613	198.510	144.250

Author's compilation (Source of data: World Development Indicator (WDI, 2018)

To compensate for the power deficit, the domestic, commercial and industrial sectors persistently use private operational generators. The average energy intensity level has consistently been on

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decline. Between 1999 and 2016 the energy intensity level of primary energy declined by over 41 per cent (See Table 1), while the average population growth rate stands at average of 2.5 percent within the period (Central Bank of Nigeria, 2006) within the same period. Although natural gas has been judged to be one of the cheapest and cleanest sources of energy supply, electricity production and consumption from natural gas, oil and coal have consistently been on the increase. From an average of 131.16 and 330.95 quad btu in 1989, total average energy production and consumption grew by an average of 11 and 16 per cent to 145.09 and 383.96 quad btu respectively in 2016 (see table 2)

Table 2: Nigeria's Primary Energy Profile – Production and Consumption (Quadrillion Btu) (1980-2016)

	1980 - 1989		1990 - 1999		2000 - 2009		2010 - 2016	
	Prod	Consum	Prod	Consum	Prod	Consum	Prod	Consum
Coal	108.74	109.57	44.64	31.20	22.63	23.67	45.58	57.19
Oil and Liquids	3.20	212.30	4.28	265.39	4.93	265.75	5.00	303.51
Renewables & Others	0.03	N/A	0.06	N/A	0.07	N/A	0.05	N/A
LPG	3.73	2.48	18.28	2.83	51.50	1.42	58.00	2.11
Electricity	15.46	6.61	25.27	8.36	32.82	15.93	36.46	21.16
Total	**131.16**	**330.95**	**92.53**	**307.78**	**111.94**	**306.78**	**145.09**	**383.96**

Author's computation (Source of data: U.S. Energy Information Administration (EIA) 2018)

The Lack of infrastructure in many of the Nigeria's fields accounts for the waste for energy losses especially in the oil and electricity sectors. Although there has been significant improvement in curtailing energy lose through appropriate legislation and budgeting, the amount of energy lose is still significant. It thus implies that given the developmental stage at which the Nigerian economy is; the country certainly faces energy supply constraints and demand management policy bottlenecks. This invokes interest to study energy consumption and economic growth relationship for any policy formulation in the energy sector.

Methodology

As earlier presented in the preceding section, different techniques have been used in various studies to test the relationship and direction of causality between energy consumption and economic growth. This section sets out to review some of these tests.

Johansen Co integration and Granger Causality

The Johansen test for co integration and its application in causality test shall be briefly reviewed in this section after a brief summary of its counterpart – the Engel-Granger Representation Theorem which is based upon an error correction representation of a VAR(q) model with a Gaussian error term:

$$\Delta L_t \alpha + \sum_{k=1}^{q-1} \beta_k \Delta L_{t-k} + \delta \Delta L_{t-q} + \mu i \qquad (1)$$

where L_t is an $m \otimes 1$ vector of I(0) variables (in this case, m = 2), β_k and δ are $m \otimes m$ matrices of unknown parameters, and μi is a Gaussian error term.

Equation 1 can be estimated by a maximum likelihood procedure under the hypothesis of a reduced rank $r < m$ of δ,

$$G(r): \delta = - \Gamma \Omega' \qquad (2)$$

where Γ and Ω are $m \otimes r$ matrixes, and as demonstrated by Johansen (1988), that under certain conditions, the rank condition of matrix implies stationarity of $\Omega' L_t$. Moreover, the existence of co integration between the variables implies a framework within which causality can be examined. For instance, Granger (1988) has shown that in the presence of co integration, there must be at least one direction of 'Granger – causality'.

Under the co integration and causality relationship, the first stage in establishing the existence and direction of causality is to establish the order of integration and the existence or otherwise of co integration. Depending on the order of integration therefore, three procedures can be used to establish the direction of causality.

If the variables are integrated of order 1, that is I(1), and co integrated, the hypothesis of non-causality can be tested at levels of the variables vis-à-vis Equations (3) and (4).

$$LY_t = \alpha + \sum_{i=1}^{k} \lambda_i LY_{t-i} + \sum_{j-1}^{l} \varphi_j LZ_{t-j} + \varepsilon_t \qquad (3)$$

$$LZ_t = \psi + \sum_{ii=1}^{r} \chi_i LZ_{t-i} + \sum_{j-1}^{s} \gamma_j LY_{t-j} + \eta_t \qquad (4)$$

where the null-hypothesis of non-causality is determined by the significance of φ and γ.

If the variables are I(1) and co integrated, an alternative form of testing the hypothesis of non-causality is to first – differenced the variables (denoted Δ) and add the error-correction term (ECM) from the co integrating regression as stated below.

$$\Delta LY_t = \alpha + \sum_{i=1}^{k} \lambda_i \, \Delta LY_{t-i} + \sum_{j-1}^{l} \varphi_j \, \Delta LZ_{t-j} + \xi ECM_{t-1} + \varepsilon_t \qquad (5)$$

$$\Delta LZ_t = \psi + \sum_{i=1}^{r} \chi_i \, \Delta LZ_{t-i} + \sum_{j-1}^{s} \gamma_j \, \Delta LY_{t-j} + \phi ECM_{t-1} + \eta_t \qquad (6)$$

In the case of equations (5) and (6), other than the significance of φ and γ, the significance of λ and χ can establish the direction of causality.

Alternatively, if the variables are I(1) and not co integrated, the variables must be differenced to establish stationarity as in Equations (5) and (6). However, in this case, the test of causality should not include the lagged ECM term:

$$\Delta LY_t = \alpha + \sum_{i=1}^{k} \lambda_i \, \Delta LY_{t-i} + \sum_{j-1}^{l} \varphi_j \, \Delta LZ_{t-j} + \varepsilon_t \qquad (7)$$

$$\Delta LZ_t = \psi + \sum_{i=1}^{r} \chi_i \, \Delta LZ_{t-i} + \sum_{j-1}^{s} \gamma_j \, \Delta LY_{t-j} + \eta_t \qquad (8)$$

The initial lags of k, l, r and s are chosen for Equations (3) – (8), using the Akaike Information Criteria. The Wald and LM tests are then used to test the direction of causality.

Some drawbacks of the Granger test have been identified in the literature. According to Granger (1986), the Granger test is valid only if the variables are not co integrated. Second, Granger causality results are sensitive to lag length. Thus, if the chosen lag length is more, the irrelevant lags could make the estimates to be inefficient. On the other hand, if the lag length is less than the true lag length, this can cause bias (Ageel and Butt, 2001:103). To overcome these problems, Hsiao (1981) developed a synergic method that combines Granger causality and Akaike's Fiscal Prediction Error (FPE), defined as the mean square prediction error. The Hsiao method is a systematic autoregressive approach applied in the choice of optimum lag length for each variable in a model.

Granger Causality – the Pair wise Granger Causality Modelling Approach

The methodology employed in this study is based on Granger (1969). The idea of Granger causality test is simple: if a variable X with information included in its previous lag values can statistically forecast variable Y while all past information on Y is also present, then variable X Granger cause Y. Thus, the structure of Granger (non)-causality test builds on two following regression equations:

$$Y_t = \alpha_{1,0} + \sum_{k=1}^{m} \gamma_{1,k} Y_{t-k} + \sum_{S=1}^{n} \gamma_{1,k} S + \varepsilon_{1t} \qquad (9)$$

$$X_t = \alpha_{2,0} + \sum_{k=1}^{q} \gamma_{2,k} Y_{t-k} + \sum_{S=1}^{r} \gamma_{2,k} S + \varepsilon_{2t} \qquad (10)$$

n is the number of lag lengths chosen to satisfy dynamic structure where the n+1 and the higher lags coefficients are not significant, and the error terms in both equations should be white noise and uncorrelated (Hamilton 1994, Stern 2011). In each equation, if the jointed parameters of $\gamma_{1,S}$ are statistically significant, then e.g. the null hypothesis H0 : $\gamma_{1,1} = \gamma_{1,2} = \cdots = \gamma_{1,S} = 0$ in the first equation, i.e. variable X does not Granger cause Y, can be rejected. Similarly, in the second equation, if the coefficients of variable Y are significant, then the null hypothesis (H0: $\gamma_{2,1} = \gamma_{2,2} = \cdots = \gamma_{2,S} = 0$) of Y does not Granger cause X is rejected. Moreover, if rejection happens in both equations simultaneously, then a bilateral or feedback relationship can be defined between variables X and Y. Granger non-causality test has a few limitations. First, the basic Granger causality formula is used only for linear models. The formulated nonlinear versions, e.g. Ancona et al. (2004), and Chen et al. (2004) - used in neuroscience - are difficult to use with complex statistical information. Secondly, in Granger non-causality test it is assumed that the variables are covariance stationary.

Therefore, it is important to make the optimum lag length of VAR system high enough to make sure that variables have not stochastic trends. Thirdly, the Granger non-causality test is a theoretic because it uses less prior information (Gujarati, 2004), i.e. it is useful to find the direction of relationship between variables but not for estimating the exact effect coefficients. Like other econometrics tests there are alternatives for Granger causality test e.g. Sims causality test proposed by Sims (1972) where the leading values of exogenous variable is added to Granger causality test. Note that this leads to decrease the degrees of freedom (Hamilton, 1994). Hence, in case of health economics where we face to lack of data availability at the time, the degree of freedom is low, the use of Sims non-causality test is not recommended.

Basically, the Granger causality corresponds to idea that when a relationship between two or more-time series is statistically significant on some lags and we seek for the direction of effects (causality) between them. Note that all this means causality only in weak temporal sense, i.e. predictability power. Also, the null hypothesis demands non-causality and its rejection does not say necessarily anything about true causality. Thus, the test name is Granger non-causality test, for evident theoretical and econometrical reasons14. There are several different extended versions of Granger causality test in both time series and panel analysis such as Hsiao (1981), Toda and Yamamoto (1995), Hurlin (2004a, 2004b), and Dumitrescu and Hurlin (2012). The Granger tests for this study involves the estimation of the equations (6) and (7) u**sing the Pair wise Granger causality model**

Data

In this paper so far, the terms 'economic growth' and 'energy consumption' have been used without sufficient definition. In the literature, the most commonly used proxies for economic growth are gross domestic product (GDP), gross national product (GNP) and industrial production (IP). In relation to energy consumption; common proxies are electricity use, coal, gas and oil. In this paper, in order to illustrate the relationship between electricity use and GDP by applying the Pairwise granger causality tests, GDP at 2011 factor cost is used as proxy for economic growth. Other variables used as proxies for energy consumption are electricity consumption, primary energy consumption, liquefied petroleum gas (LPG) and domestic oil consumption. Yearly (annual) data from 1980 – 2016 was collected from the World Development Indicator (WDI) and U.S. Energy Information Administration (EIA 2018) statistical data. All data are transformed to natural logarithms.

Empirical Results and Discussion

This section presents the results of the estimations. First, the results of the unit roots of the individual variables, second the co integration results and lastly the Hsiao's causality results.

Test for Unit Roots

Table 2 reports the results of the unit roots. The degree of integration of each variable has been determined in the analysis using the **Levin, Lin & Chu t*** tests. In the level form, the tests indicate that all the series are non-stationary as all the probability values are above the 5 percent acceptable benchmarks. However, they are all stationary at first difference, and integrated of order I(1) (see Table 2).

Test for Co integration

Since all the series were found to be non-stationary at levels, the analysis further proceeded to investigate the possibility of co integration between the individual variables in relation to the GDP. The co integration analysis uses the Unrestricted Co integration Rank test by applying the Trace and Maximum Eigen value test statistics on the numbers of co integrating variables. In Table 3, the results showed that although the Trace statistic is greater than the critical value, indicating acceptance of the Null hypothesis, the probability value is less than 5 percent.

Table 2: Summary of Group Unit Root (Levin, Lin & Chu t* test)

	At Level		At First Difference*	
	Statistic	Prob.**	Statistic	Prob.**
Individual Intercept	1.262	0.897	-12.818	0.000
Intercept and Trend	-0.728	0.233	-13.060	0.000
None	2.885	0.998	-13.806	0.000

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*Significant at 1%

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Null: Unit root (assumes common unit root process)

Series: GDP (Gross Domestic Product); Coal consumption; Electricity consumption; Liquefied Petroleum Gas consumption; Primary Energy consumption, and Petroleum Oil consumption.

However, the Trace test indicates that there are at least three equations are co integrated at 5 percent level. Similarly, the Max-eigen value test indicates also indicates that at least one equation is co integrated at 5 percent level.

Table 3: Co integration Results

Unrestricted Co integration Rank Test: Trace and Maximum Eigen value Statistic Results

	Trace Statistic				Maximum Eigen value Statistic			
Hypothesized No. of CE(s)	Eigen value	Trace Statistic	5% Critical Value	Prob.**	Eigen value	Max-Statistic Eigen	5% Critical Value	Prob.**
None *	0.807	128.029	95.754	0.000	0.807	55.958	40.078	0.000
At most 1	0.505	72.071	69.819	0.033	0.505	23.919	33.877	0.462
At most 2	0.449	48.152	47.856	0.047	0.449	20.274	27.584	0.323
At most 3	0.401	27.879	29.797	0.082	0.401	17.437	21.132	0.152
At most 4	0.236	10.442	15.495	0.248	0.236	9.163	14.265	0.273
At most 5	0.037	1.279	3.841	0.258	0.037	1.279	3.841	0.258

Trace test indicates 3 co integrating equation(s) at the 0.05 level

Max-eigen value test indicates 1 co integrating equation(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Pair wise Granger Causality Test

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The analysis of the Pair wise version of Granger causality is based on equations 9 to 10. And the lag selection is Akaike's (AIC) and/or Hannan-Quinn information (HQ) criterion. From Table 4, the results of the estimation indicate that there is no bidirectional relationship among the variables. Further observation of the results showed that only electricity Granger cause economic growth. This result is in line with theoretic underpin and empirical findings of Altinay and Karagol (2005); Lee (2005); and Mehrara (2007). Their studies investigated the causal relationship between electricity consumption and real GDP and found a long-run association between the two variables. Although various studies have reported different lag periods, the optimum lag period of 4 years as reported in our result is an indication that the electricity sector is capital intensity with long gestation period.

Table 4: Results of Pair wise Version of Causality Tests**

Null Hypothesis:	F-Stat	Prob.	F-Stat	Prob.	F-Stat	Prob.	F-Stat	Prob.
	(1)		(2)		(3)		(4)	
COAL does not Granger Cause GDP	3.974	0.055	1.489	0.242	1.140	0.351	0.627	0.648
GDP does not Granger Cause COAL	0.135	0.716	0.059	0.943	0.294	0.829	0.662	0.624
ELECTRICTY does not Granger Cause GDP	2.014	0.165	6.790	**0.004**	4.926	**0.007**	3.266	**0.028**
GDP does not Granger Cause ELECTRICTY	2.265	0.142	0.860	0.434	1.376	0.271	1.376	0.272
LPG does not Granger Cause GDP	4.066	0.052	1.516	0.236	1.127	0.356	0.707	0.595
GDP does not Granger Cause LPG	0.279	0.601	0.387	0.683	0.363	0.780	0.522	0.721
PENERGY does not Granger Cause GDP	0.012	0.912	0.301	0.742	0.369	0.776	0.329	0.856
GDP does not Granger Cause PENERGY	5.413	**0.026**	1.808	0.182	2.438	0.086	1.769	0.168
PETROLEUM does not Granger Cause GDP	0.292	0.593	3.159	0.057	1.998	0.138	0.924	0.466
GDP does not Granger Cause PETROLEUM	4.632	**0.039**	1.705	0.199	2.561	0.076	3.436	**0.023**

**The values in parenthesis are the optimum lags. The optimum lag length of four (4) for m; n; q and r, are determined on the basis of Akaike's (AIC) and/or Hannan-Quinn information (HQ) criterion.

Apart from the electricity and GDP long-run association, our results also show that GDP Granger cause primary energy and petroleum oil consumption at lags 1 and 4 periods respectively. The lag 4 period reported for GDP and petroleum is also indicative that the petroleum oil industry is capital intensive with long gestation period. Although the result is in opposition to the neutrality hypothesis, which proposes that the cost of energy is a small proportion of GDP (Guttormsen, 2004) in developing countries and as such cannot lead economic growth, the result conforms with the findings by Cheng and Lai (1997); Yang (2000a); Hossain (2011); and Bhattacharya et al., (2016). They investigated the effects of renewable energy and petroleum oil consumption on the economic growth and found a strong evidence of long-run dynamics between economic growth, primary eenergy and petroleum oil consumption. Although the impact of economic growth on the two sectors is very significant, a higher GDP growth rate beyond 2.6 and 3.9 percent will improve the contributions of the two sectors in the growth of aggregate output within the economy.

Concluding Remarks

Primary energy consumption in Nigeria is mainly derived from oil, natural gas and hydroelectricity. Of these three, crude oil is the dominant source. Since the last two decades however, the collapse of the power sub-sector has created energy supply deficits which has been augmented by large quantities of imported generators. While over 50 percent of natural gas produced which could have been converted into power generation is flared, the implication of the recent available data is that any policy initiation should take into cognisance the causal relationship between energy consumption and economic activities. This constitutes the basic focus of this paper.

Issues of empirical analyses of causality and relationships have been an integral part of time series econometrics. There is also an enormous and bourgeoning literature on the relationships between energy use and economic growth. This paper among others abridged the extensive literature. The summary of the studies establishes the existence of a relationship between energy use and economic growth. The causality test results are however mixed.

This paper modestly attempted to determine the direction of the causal relationship between energy use and economic growth by disaggregating energy use into coal, electricity and domestic oil consumption. The method of analysis is based on the Pair wise Granger causality test. The Pair wise Granger causality version uses the differential data to obtain a mean square prediction error from a systematic autoregressive method for choosing an optimum lag length for variable in an equation. The estimates indicate that generally, energy consumption and economic growth are unidirectionally related in Nigeria despite the existence of no co integrating relationship of variables that are not co integrated.

The policy implication of the findings suggests with a caution that energy conservation policy will inhibit economic growth in Nigeria and as such, energy growth policies particularly electricity, oil and renewable energy should be adopted and enhanced to amplify the economic growth of Nigeria. Finally, for energy supply and consumption to be competitive and efficient in Nigeria, efforts must be put in place to reduce gas flaring. The flared gas can be processed to augment power generation, given that the present stage of Nigeria's production structure and activities are energy intensive.

One limitation of this paper is its inability to incorporate gas flaring in the causality test. Future research should not only look at this direction, concerns about the impact of increased energy consumption on the environment via a decomposition methodology could be studied.

Note

1. Since these eras, oil price has further quadrupled.

2. Appendix 1 reports an overview of the empirical studies in chronological order – summarising both results and methodology employed. It is to be emphasised that most of the survey chronological are abridged from Guttormsen (2004).

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Appendix 1: Survey of Results

Article	Methodology	Countries and Results
Belke, Dobnik and Dreger (2011).	Principal component analysis, co integration analysis and Dynamic panel causality	25 OECD countries from 1981 to 2007. Bi-directional causal relationship between energy consumption and economic growth.
Altinay and Karagol (2005).	the Dolado–Lu¨tkepohl test, and the standard Granger causality	Turkey: Unidirectional causality running from the electricity consumption to the income.
Hossain (2011)	Johansen Fisher panel co integration test and Granger causality test	Newly industrialized countries (NIC): no evidence of long-run causal relationship, but there is unidirectional short-run causal relationship from economic growth and trade openness to carbon dioxide emissions, from economic growth to energy consumption
Narayan and Smyth (2008)	panel unit root, panel co integration, Granger causality and long-run structural estimation.	G7 countries: energy consumption and real GDP are cointegrated; capital formation and energy consumption Granger cause real GDP positively in the long run.
Lee (2005)	panel unit root, heterogeneous panel co integration, and panel-based error correction models	18 developing countries: Unidirectional causal relationship of long-run and short-run between consumption to GDP, but not vice versa.
Gelo (2009)	vector auto-regression model (VAR), Granger causality test and unit root test	Croatia: GDP Granger causes total energy consumption not energy consumption Granger causes GDP.
Bhattacharya et al., (2016)	Panel estimation techniques	38 developed countries: long-run dynamics between economic growth, and traditional and energy related input
Ghosh (2002)	Phillips–Perron tests	India: absence of long-run equilibrium relationship among the variables but there exists unidirectional Granger causality running from economic growth to electricity consumption
Ouédraogo (2010)	Bounds test	Burkina Faso: bidirectional relationship between GDP and capital formation co integration between electricity consumption, GDP, and capital formation.
Wolde-Rufael (2005).	Bounds test	19 African countries: Long run relationship between the two series for only eight countries and causality for only 10 countries
Belloumi (2009).	Johansen co integration test and vector error correction model (VECM)	Tunisia: long-run bi-directional causal relationship between the two series and a short-run unidirectional causality from energy to gross domestic product (GDP)
Asafu-Adjaye (2000)	Johansen multiple co integration test and Granger causality	India and Indonesia: unidirectional Granger causality from energy to income Thailand and Philippines: bidirectional Granger causality from energy to income
Yang (2000a)	Two step Engle-Granger co integration and Granger causality	Taiwan: bidirectional causality between total energy consumption and GDP. It was further found that different directions exist between GDP and various kinds of energy consumption.
Yang (2000b)	Two step Engle-Granger co integration and Granger causality	Taiwan: unidirectional causality from economic growth to coal consumption
Stern (2000)	Single equation static co integration and multivariate dynamic co integration	USA: Energy is significant in explaining GDP.
Ferguson, Wilkinson and Hill (2000)	Correlation analysis	More than 100 countries in the world: Wealthy countries have a stronger correlation between electricity use and wealth creation than between total energy use and wealth.
Chang, Fang and Wen (2001)	Johansen multiple co integration and vector error correction models	Taiwan: bidirectional Granger causality for employment-output and employment-energy consumption, but only unidirectional causality running from energy consumption to output
Glasure (2002)	Johansen multiple co integration test	Korea: found no co integration
Ageel and Butt (2001)†	Co integration and Hsiao’s version of Granger causality	Pakistan: Economic growth causes total energy consumption, but no causality between economic growth and gas consumption. In the power sector, electricity consumption leads economic growth without feedback. Energy

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		consumption also directly cause employment.

Hondroyiannis, Lolos and Papapetrou (2002)	Johansen multiple co integration and vector error correction models	Greece: long-run relationship between energy consumption, real GDP and price development, supporting the endogeneity of energy consumption and real output
Ghosh (2002)	Johansen multiple co integration test and traditional Granger causality tests	India: found no co integration
Soytas and Sari (2003)	Johansen multiple co integration and vector error correction models	Argentina: bidirectional causality Italy and Korea: causality running from GDP to energy consumption Turkey, France, Germany and Japan: causality from energy consumption to GDP
Yemane (2004)	A modified version of the Granger (1969) causality test	Shanghai: unidirectional Granger causality running from coal, coke, electricity and total energy consumption to real GDP but no Granger causality running in any direction between oil consumption and real GDP
Jumbe (2004)	Two step Engle-Granger: Co integration and Granger causality	Malawi: bidirectional causality between kwh and GDP; one way causality running from non agricultural GDP to kwh
Oh and Lee (2004)	Johansen multiple Co integration test and traditional Granger causality tests	Korea: long-run bidirectional causal relationship between energy and GDP, and short-run unidirectional causality running from energy to GDP
Morimoto and Hope (2004)	Two step Engle-Granger: Co integration and Granger causality	Sri Lanka: current as well as past changes in electricity supply have a significant impact on real GDP.
Ghali and El-Sakka (2004)	Johansen multiple: Co integration and Vector Error Correction models	Canada: short-run dynamics of the variable indicate that Granger causality is running in both directions between output growth and energy use.
Guttormsen (2004)†	Multivariate Johansen Co integration using vector auto regression (VAR)	France, Germany, Greece, Italy, Japan, Argentina, India, Indonesia, and Philippines: bidirectional causality
Fatai, Oxley and Scrimgeour (2004)†	Granger causality test. Co integration using ARDL*	New Zealand and Australia: unidirectional link from real GDP to aggregate final energy consumption.

*ARDL Autoregressive Distributed Lag

†Order than these studies, others were abridged from Guttormsen (2004)