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Energy Consumption and Economic Growth in Nigeria: A Causality Analysis

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Abstract
The paper is set out to re-examine the causal relationship between energy consumption and economic growth using Nigeria's data from 1980 to 2011 in a multivariate frameworkby including labour and capital in the causality analysis. Applying Granger causality test, impulse response and variance decomposition analysis; the results of the causality test reported absence of causality and that of variance decomposition found that capital and labourare more important in affecting output growth compared to energy consumption.
Keywords: Capital, Causality, Economic growth, Energy consumption, Labour

I. INTRODUCTION

Since the oil crisis in 1970th, the relationship between energy consumption and economic growth has been a hot issue in domestic and foreign academic research. (Zhixin and Xin, 2011). This interest has been stimulated by the persistent increase in the awareness of global warming and climate change. Government, professionals and academics alike are concerned about the impact of energy consumption on the economy. Similarly, it evaluates whether the economic benefit from the high energy consumption can neutralise the positive externality inflicting on the society or not? (Adelman, 1993).

Today, Nigeria is seen as one of the greatest developing nations in Africa with highly endowed natural resources including potential energy resources. However, increasing access to energy in Nigeria has proved to be not only a continuous challenge but also a pressing issue with the international community (Odularu and Okonkwo, 2009).

Thus to meet its growing needs of energy, Nigeria must address its persistent energy crisis which according to Iwayemi (2008), has weakened the industrialization process, and significantly undermined the effort to achieve sustained economic growth, increased competitiveness of domestic industries in domestic, regional and global markets and employment generation. The current concern about global warming also poses a question about how can economic growths in Nigeria will be reconciled with stabilization in the use of both traditional and fossil fuels. However, for any such policy making it is essential to determine the causal relationship between energy consumption and general economic activities.

Although the causal relationship between energy consumption and economic growth has been widely studied, no consensus regarding this so-called energy consumption-growth nexus has yet been reached. (Chima and Freed, 2005; Belke et al, 2010; Magazinno, 2011; Alam et al, 2012).

It is glaring from the foregoing that sustainable development needs sustainable supply of energy resources and an effective and efficient utilization of the energy resources.

Several studies have examined the causal relationship between energy consumption and economic growth using a production framework. It was observed from the literature that researches about African countries are mostly based on bivariate causality model with energy consumption as the only input. This study will improve on those studies by including additional variables. This according to Stern (2003) is important because changes in energy use are frequently countered by the substitution of other factors of production resulting in an insignificant overall impact on output. Moreover, the multivariate methodology has altered the results on the direction of causality.

In the case of Nigeria there are few empirical studies of the relationship between energy consumption and economic growth. To the knowledge of the researcher, Ebohon, (1996) is the maiden investigation whose work is not country specific. Others are Olusegun, 2008; Omotor, 2008; Odularo and Okonkwo, 2009; Aliero and Ibrahim 2012; and DantamaAbdullahi and Inuwa (2012). These studies used energy consumption and GDP as variables where energy consumption was further disaggregated into oil, electricity, coal and gas in Omotor, 2008 and Aliero and Ibrahim, 2012; oil electricity and coal in Odularo and Okonkwo, 2009 and Dantama et al 2012; and Oil electricity and gas in Olusegun 2008. Only Odularo and Okonkwo included labor and capital in their study. The studies used different methodology almost all in bivariate model and reported different results. While Ebohon (1996) and Omotor (2008) reported a bidirectional causality, Aliero and Ibrahim.opcitdocumented the absence of causality between total energy consumption and GDP. Others reported unidirectional causality.

The major gaps identified in the literature review are first, the use of bivariate model. Secondly, to the knowledge of the researcher, none of the studies measured the relative strength of the causality tests beyond the sample period or give insights about the relative importance of each variable in the model. Thirdly there are

conflicting results from the previous studies. This study will fill the gap in the literature by complementing the previous studies; investigates the dynamic relationship between energy consumption and economic growth in Nigeria via a multivariate framework including three inputs: capital, labor, and energy in the model, and estimating the magnitude of influence exerted by the identified causal variables in the study using current data.
The remainder of this paper is organized as follows: the next section contains the literature review on the relationship between energy consumption and output and the profile of Nigeria's energy. Section three presents the methodology and section four presents and analyses the empirical results. The final section contains conclusions and policy recommendations of the paper.

II. LITERATURE REVIEW

Energy is capacity of matter to perform work as the result of its motion or its position in relation to forces acting on it. (Encarta, 2009). We use energy for everything we do, from making a jump to sending astronauts into space. The same concept according to Tejada-Bailly (1981) can be expressed as the amount of heat that must be transferred, exchanged or used up to effect a process or deliver a good to a particular point in the economic system.

Energy exists in various forms, including atomic, electrical, chemical, mechanical, nuclear, radiant and thermal. Although energy can be transferred from one form to another but it cannot be created or destroyed.
Energy can be extracted from a variety of resources that can be categorized as primary and secondary; commercial and non-commercial; conventional and nonconventional; renewable and non-renewable and traditional and non-traditional. The table below gives example of some energy sources and resources.

Table 1: Sources of energy

Nonrenewable energy sources	Renewable energy sources	Secondary energy sources
Oil and petroleum products	Hydropower	Electricity
- **Diesel fuel**	Biomass	
- **Propane**	- Phytomasseg wood peat	
- **Gasoline**	- Animal dung	
Natural gas	- Agricultural wastes	
Coal	- Charcoal	
Nuclear	- Agricultural crops	
- **Uranium**	Ethanol	
- **Deuterium**	Biodiesel	
- **Radium**	Wind	
- **Thorium**	Geothermal	
- **Tritium**	Solar	
	- Radiation	
	- Photovoltaics	
	- Photosynthesis	
	- Flat-Plates collectors	

Source: Tejada-Bailly (1981) and EIA (2012)

Profile of Nigeria's Energy

Nigeria is fortunate to have huge energy resources, which potentially give the country ample opportu¬nity to transform her economy and the lives of her citizens. Nigeria sits astride of over 35 billion barrels of oil, 187 trillion cubic feet of gas, 4 billion metric tons of coal and lignite, as well as huge reserves of tar sands, hydropower and solar radiation, among others (Adenikinju, 2008). For understandable reasons, Nigeria has not devoted equal attention to her abundant energy resources. Her efforts have been con-centrated on the development, exploitation and utilization of crude oil and gas for fiscal objectives.

- Oil

  Nigeria has an estimated 37.2 billion barrels of proven oil reserves as of the end of 2011. The majority of reserves are found along the country's Niger River Delta and offshore in the Bight of Benin, the Gulf of Guinea, and the Bight of Bonny. Current exploration activities are mostly focused in the deep and ultra-deep offshore with some activities in the Chad basin, located in the northeast of the country. The government hopes to increase proven oil reserves to 40 billion barrels in the next few years.Nigeria has four refineries with a total installed capacity of 445,000 barrels per day. However, capacity utilization is low. Consequently, annual consumption of petroleum products, which according to government figures stood at 34 million litres per day, is not fully met by internal production and has to be supplemented by imports.

- Natural Gas
  Nigeria's proven natural gas reserves, estimated at about 187 trillion standard cubic feet, are known to be substantially larger than its oil resources in energy terms. Gas discoveries in Nigeria are incidental to oil exploration and production activities. As at 2001, over 50% of the gas produced (mainly associated gas) was flared.
  In view of the increasing domestic oil consumption, an economically optimal strategy to replace oil with gas and gas derivatives will enhance the availability of more oil for export. This will also promote the conservation of the oil reserves. Apart from the economic advantage, fuel substitution from oil to gas is more environmentally friendly because gas is a cleaner fuel than oil.
  Given the current reserves and rate of exploitation, the expected life-span of Nigerian crude oil is about 44 years, based on about 2mb/d production, while that for natural gas is about 88 years, based on the 2001 production rate of 1850 bscf. It is therefore, strategically important to undertake major investments in the gas sector in order to prepare adequately for gas as a substitute for oil both for domestic needs and foreign exchange earnings.
- Coal
  Recent technical and economic studies have identified coal energy as a cost effective solution for power generation; it comes at a cost that is about 20% that of fuel oil and with the cost of crude oil heading towards US$100 per barrel, the gap will continue to widen. Furthermore, with over two billion tons reserves in Nigeria, coal is an abundant domestic resource that can support the mining and energy industries and provide numerous jobs with potentially high multiplier effects on the local economy. Current technologies allows for clean burning of coal, which takes care of its negative environmental impact; indeed over 50% of the US electrical power supply is from coal resources. Nwasike (undated)
  Nigerian coal can be utilized for power generation, steam production, in cement production and for brick making; as a heat source and reducing agent for steel production; as a domestic fuel; and as feedstock for the production of chemicals, liquid fuels, gaseous fuels, batteries, carbon electrodes etc. These potentials of coal need to be effectively harnessed into the country's energy delivery system and export commodity mix through the development of a vibrant coal industry.
  Coal is an alternative energy medium that could be used with oil and gas to give the nation the desired mix that will ensure a reliable, affordable and environmentally friendly energy medium.
- Electricity
  Commercial electricity is generated mainly from hydropower, steam plants and gas turbines in Nigeria. Table 2 shows the profile of the Nigerian electricity industry infrastructure.

Table 2: Profile of the Electricity Industry Infrastructure

Generation	Pre – 1999	Post – 1999
Thermal	4058 MW	5010 MW
Hydro	1,900 MW	1,900 MW
Installed capacity	5,996 MW	6,910 MW
Available Capacity	1,500 MW	4,451 MW
Transmission		
- 330kv line	4,800 km	4,889.2 km
- 132kv lines	6,100 km	6,284.06 km
Transformer capacity		
- 330/132KV	5,618 MVA	6,098 MVA
- 132/33KV	6,230 MVA	7,805 MVA
Distribution		
- 33kv lines	37,173 km	48,409.62 km
- 11kv lines	29,055 km	32,581.49 km
- 415v lines	70,799 km	126,032.79 km
Transformer capacity	8,342.56 MVA	12,219 MVA

Source: Maigida (2008) in Adeola, (2008)

A key point that emerges from the table is that there has been very marginal improvement in electricity infrastructure over the years. Between 1985 and 2000, electricity generation capacity grew by a mere 10 per cent in Nigeria compared to 332 per cent in Vietnam, 142 per cent in Iran, 237 per cent in Indonesia, 243 per cent in Malaysia and 205 per cent in South Korea (Maigida, 2008). Electricity generation capacity is also far below comparator countries. Nigeria, with a population of over 150 million people, has an installed generation capacity of 6000MW compared to UAE 4740MW to a population of 4 million or South Africa that has 46000MW to 44million people.

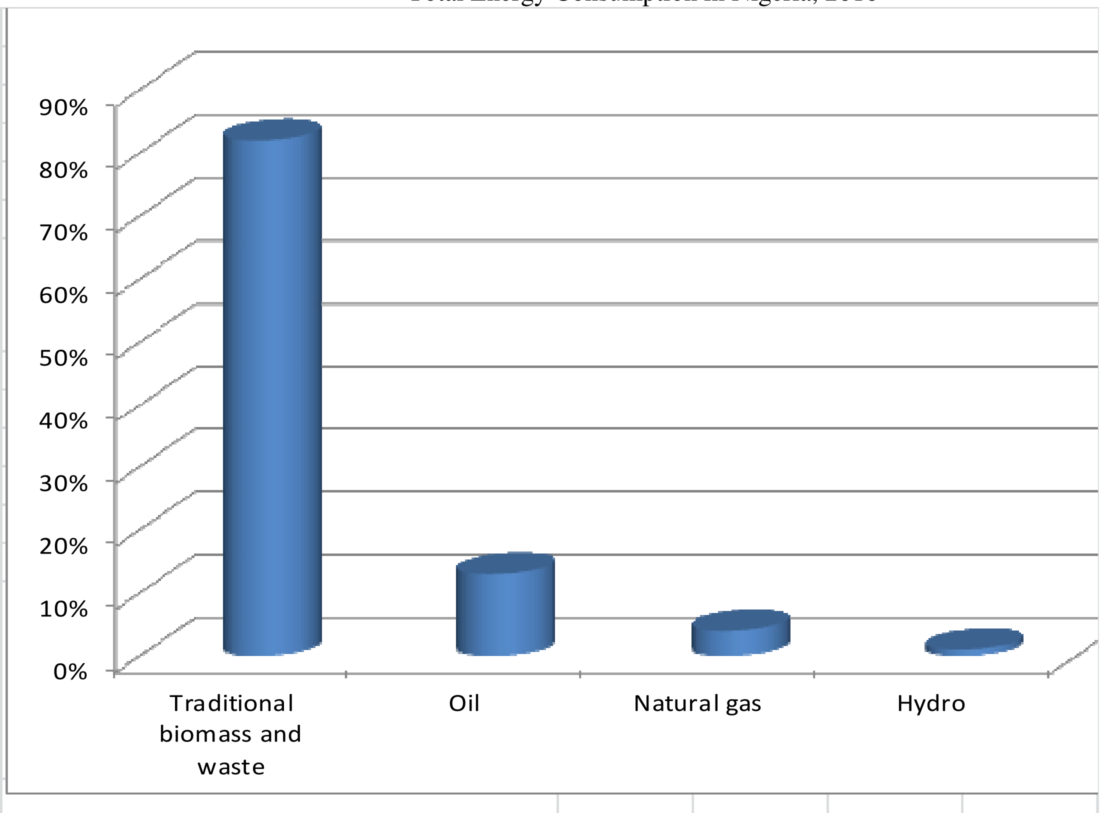
- **Biomass**

Organic, non-fossil material of biological origin is called biomass. The biomass resources of Nigeria can be identified as wood, forage grasses and shrubs, animal wastes and wastes arising from forestry, agricultural, municipal and industrial activities, as well as aquatic biomass. The biomass energy resources of the nation have been estimated to be significant.

Plant biomass can be used as fuel in thermal power plants or converted to produce solid briquettes, which can then be utilized as fuel for small-scale industries. Biogas digesters of various designs are capable of sustaining household, industrial and institutional energy needs. It has indeed been shown that the remaining biomass material after digestion is a better fertilizer than the original waste. The intensive application of this will reduce the existing heavy reliance on chemical fertilizers.

The abundant energy available from biomass can be meaningfully introduced into the nation's energy mix through the development of a comprehensive programme. The programme should encompass fully supported research, development, demonstration and manpower training components.

Total Energy Consumption in Nigeria, 2010



Source: US EIA, (2012)

Empirical Literature

There is a consensus in the literature that the maiden investigation into the energy consumption and economic growth relationship was the seminal work of Kraft and Kraft (1979). This study covered an annual data for the USA for the period 1947 to 1974 which supported the unidirectional causality running from GNP to energy consumption. Since then, economists developed interest in this area with a multitude studies in form of country-specific and multi-country; bivariate and multivariate; those using aggregate energy consumption data and disaggregate; and studies for low income and middle income countries using different methodologies and reporting mixed results.

The single country studies includes Cheng (1999) and Paul and Bhattacharya (2004), for India; Aqeel and Butt (2001) for Pakistan; Soytas Sari and Ozdemir (2001), Hondroyiannis et al (2002) and Tsani (2010) for Greece; Altinay and Karagol (2004), Lise and Montfort (2007), So¨zen and Arkakliogu (2007) ErdalErdal and Essengun (2008) for Turkey; Chima and Freed (2005) and Yildirim et al (2012) for USA; Odhiambo (2008) for Tanzania; Belloumi (2009) for Tunusia; Hou (2009), Shuyun and Donghua (2011), Wang et al (2011), Wang, Wang and Wang (2011), Ying Bing and Lang (2011), Zhang et al (2011) Sfeir (2012) and Zhang and Xu (2012) for China; Wolde-Rufael (2010) for South Africa; Adebola (2011) for Bostwana; Mogazzino (2011) for Italy;

Sami (2011) for Japan; Wondimaghegn (2011) for Ethiopia; Alam et al (2012) for Bangladesh; Dagher and Yacoubian (2012) for Lebanon; Shahiduzzaman and Alam (2012) for Australia; WessehJr and Zoumara (2012) for Liberia; Abaidoo (undated) for Ghana and Amirat and Bouri (undated) for Algeria.

On the other hand, the multi-country studies are, among others, Chontanawat et al (2006) for 30 OECD and 78 non OECD countries, Huang (2007) for 82 countries from 1971 to 2002, Mahadevan and Asafu-Adjaye (2007) for developed and developing countries from 1971 to 2002, Mehrara (2007) for oil exporting countries 1971 – 2002, Akinlo (2008) for 11 sub-Saharan African countries from 1980 to 2003, Chiou-wei et al (2008) for Asian newly industrialized countries and US covering the period 1954 to 2006, Apergis and Payne (2009) for Central America from 1980 to 2004, Nguyen-Van (2009) for 158 countries and territories for the period 1980 - 2004, Apergis and Payne (2010) for 9 South American countries 1980 - 2004, Balcilar et al (2010) for G-7 Counties from 1960 to 2006, Belke et al for 25 OECD countries for the period 1981 to 2007, Esso (2010) in 7 African countries for the period 1970 – 2007, Ozturk et al (2010) for low and middle income countries from 1971 to 2005, Chang Fabiola and Carballo (2011) for Latin America and Carribean for the period 1971 to 2005, Eggoh et al (2011) for 21 African countries from 1971 – 2005, Hasanov and Telatar (2011) across 178 countries in the world, sadorky (2011) for South America from 1980 – 2007, Arouri et al (2012) for Middle East and North African countries for the period 1981 – 2005, Aslan et al (2012) for G-7 countries from 1980 to 2009, Nadia (2012) for ECOWAS from 1980 to 2008, Pirlogea and Cicea (2012) for EU covering the period 1990 to 2010, and Yildirim and Aslan (2012) for 17 highly developed OECD countries.

Growth hypothesis or unidirectional causality running from energy consumption to GDP using Granger causality test in the presence of cointegration among the variables with the use of vector error correction model (VECM) had empirical supports in Alam et al (2012) for Bangladesh data on GDP per capita energy consumption, electricity consumption and Carbon Dioxide (CO_2)emission for the period 1972 to 2006; Bellomi 2009 for Tunisia from 1971 to 2004 and Soytas et al (2001) in a bivariate framework; and Wang et al (2011) for china in a multivariate framework. Supporting this hypothesis using ARDL bound test to cointegration and unrestricted error correction (UREC) are Adebola (2011) for Bostwana from 1980 to 2008 and Wolde-Rufael and Menyah (2010) from 1965 to 2006 all in a multivariate framework. Also in the same framework isAmirat and Bouri (undated) using causality and variance decomposition. Yildirim et al (2012) supported the hypothesis using bootstrap corrected causality test on US data for the period 1980 to 2009.

Conservation hypothesis i.e. unidirectional causality running from GDP to energy consumption in a multivariate framework is documented in Lise and Montfort (2007) for Turkish economy data for the period 1970 to 2003 and Zhang and Xu (2012) for china from 1995 to 2008 using causality test in the presence of cointegration with VECM. Also Aqeel and Butt (2010) for Pakistan using Hsiao’s version of granger causality and Wondimaghehn(2011) for Ethiopia using Granger causality, variance decomposition and generalized impulse response function in a multivariate framework.

Bidirectional or feedback hypothesis was reported in Paul and Bhattacharya (2004) for india for the period 1950 to 1996 in a multivariate framework using standard Granger causality test and Johansen multivariate cointegration; Chima and Freed (2005) for USA using Handerson and Quant’s (1980) macroeconomic model; Erdal et al (2008) for Turkish economy data for the period 1970 to 2006 using pairwise Granger causality test; Hou (2009) for china from 1953 to 2006 using Hsiao’s Granger causality and ECM but Shuyun and Donghua (2011) used multivariate approach and panel cointegration and VECM for the same economy for the period 1985 to 2007. Recent evidences are found in Dagher and Yacoubian (2012) for Lebanon from 1980 to 2009 in a bivariate framework using Hsiao’s causality and VEC based Granger causality test; Shahiduzzaman and Alam (2012) for Ausralia from 1960 to 2009 applying Granger causality test in the presence of cointegration with VECM and WessehJr and Zoumara for Liberia from 1980 to 2008 using bootstrapped causality test.

Evidence of neutrality hypothesis (i.e. no causality) are found among others in Altinay and Karagol (2004) for Turkey from 1950 to 2000 applying Hsiao’s version of Granger causality in a bivariate framework and Sfeir (2012) for China for the period 1981 to 2008 using Granger causality.

In the case of Nigeria, the empirical investigation to date comprises of different methodology (in bivariate and multivariate framework), time period and choice of variables. Ebohon (1996) reported bidirectional causality between energy consumption and economic growth for Nigeria and Tanzania. Adeniran (2008) on the other hand using aggregate and disaggregate energy consumption data for Nigeria from 1980 to 2006, applying Hsiao’s Granger causality and ECM reported unidirectional causality running from GDP to coal consumption to electricity consumption and no causality between oil, gas and GDP. But for aggregate energy consumption data, total energy consumption Granger causes GDP without feedback.

However, Omotor (2008) used disaggregate time series data for Nigeria’s energy consumption from 1970 to 2005 and applying cointegration and Hsiao’s version of Granger causality supported the feedback hypothesis thus vindicating Ebohon (1996). Odularu and Okonkwo (2009) set a new pace by including additional variables capital and labor together with the disaggregate energy consumption variables. The empirical evidence suggests that crude oil, electricity and coal consumption are positively related to economic growth.

Recent findings in Aliero and Ibrahim (2012) indicates absence of causality between total energy consumption and GDP using aggregate energy consumption data. From the disaggregate energy consumption data for the period 1970 to 2009, the study shows evidence of causality running from coal, petrol and electricity consumption to GDP and a causality both ways between gas consumption and GDP. Applying newly developed ARDL bound approach to cointegration using unrestricted error correction model (UECM) on disaggregated energy consumption data for Nigeria from 1980 to 2010, Dantama et al (2012) reported a long run cointegrating relationship of petrol, coal and electricity consumption with real GDP. Coal consumption coefficient, although negative, but statistically insignificant while both petroleum and electricity consumption have positive and are statistically significant on economic growth.

An observation from the literature reveals that in most of the studies bivariate models were used but in recent times there is growing number of studies using multivariate model. Variables such as labour, capital, carbondioxide and exports are used in the multivariate model in addition to energy consumption and GDP. Results from the studies support all the hypotheses (growth, conservation, neutrality and the feedback hypothesis). These conflicting results, according to Ozturk (2010) may arise due to the different time periods of the studies, countries' characteristics, variables and the different econometric methodologies used. In the country specific studies, the common methodologies used are the Granger (1969) and Sims (1972); the Johansen and Juselius (1990) cointegration and error correction model including the recently developed ARDL bound approach and the Hsiao's (1981) technique. In the multicountry studies, panel cointegration and error correction mechanism are the widely used.

III. METHODOLOGY

The annual time series data on Nigerian economy from 1980 to 2011 will be used for this research work.The data sources for this study include World Bank (World Development indicators) 2012 and the Central Bank of Nigeria (CBN) statistical Bulletins. The complete data series are reported in Appendix 8.

The Model

The theoretical model for this study is the conventional neo-classical one-sector aggregate production model drawn from the mainstream theory of growth. According to Shahiduzzaman and Alam (2012) a more comprehensive methodology that avoids the ad hoc selection of additional variables can be found in the production function approach proposed by Stern (1993, 2000), which models GDP as a function of energy, capital and labor inputs. The inclusion of capital and labor in such a cointegration model helps to avoid any spurious correlations between energy and output and illustrates the marginal effect of energy use on output by keeping other factors of production constant.

In the same vein, numerous recent studies have tried to incorporate energy as an additional factor to labor and capital in this neo-classical one-sector aggregate production model (see among others, Odularo and Okonkwo 2009, Adebola, 2011, Wang et al 2011, Shahiduzzaman and Alam 2012, Amirat and Bouri, undated). It is against this background this work will investigate the causal linkage between energy consumption and economic growth for Nigeria where capital, labor and energy are treated as separate factors of production.

The model is specified as:

$$\mathrm{RGDP_t = f(CAP_t, LAB_t, TEC_t)} \ldots\ldots\ldots\ldots\ldots\ldots..\text{equation (1)}$$

where: RGDP is aggregate output or real GDP
CAP is the capital stock
LAB is the level of employment
TEC is the total energy consumption in aggregate level and
the subscript t denotes the time period

In this study the cointegration and vector error correction methodology will be used. In addition, generalised impulse response rooted in Wondimaghegn (2011) and forecast error variance decomposition in Amirat op cit will be applied. The estimation procedures are as follows:

Unit Root Test

Since the use of the VECM requires the series to be cointegrated with the same order, it is essential to first test the series for stationarity. A series is said to be nonstationary, if it has a non-constant mean, variance and autocovariance over time. If a nonstationary series has to be differenced d times to become stationary, then it is said to be integrated of order d: i.e. I(d). This first step is essential because the causality tests are very sensitive to the stationarity of the series (Stock and Watson, 1989) in Bellomi (2009), and the majority of macroeconomic series are nonstationary (Nelson and Plosser, 1982). Therefore, the augmented Dickey and Fuller (ADF) and the Phillips and Perron (PP) tests will be performed to test whether the data are difference stationary or trend stationary.

Cointegration Test

Once we found that the variables are non-stationary at their level and are in the same order of the integration i. e., integrated of order one or more, the Johansen and Juselius (1990) cointegration test can be applied. According to Koop (2005), if cointegration is present, then not only do we avoid the spurious regression problem, but we also have important economic information (e.g. that an equilibrium relationship exists or that two series are trending together). The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship among the variables.

The presence of a cointegrating relation forms the basis of the VEC specification. To illustrate the VAR-based cointegration tests using the methodology developed in Johansen (1991, 1995a), we consider a VAR of order p:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + Bx_t + \epsilon_t \dots\dots\dots\dots\dots\dots .\text{eqn } (7)$$

wherey_t is a k-vector of non-stationary $I(1)$ variables, x_t is a d-vector of deterministic variables, and ϵ_t is a vector of innovations. We may rewrite this VAR as: $\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \epsilon_t \dots\dots .\text{eqn } (8)$

Where $\Pi = \sum_{i=1}^{p} A_i - I, \quad \Gamma_i = -\sum_{j=i+1}^{p} A_j$

Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank $r < k$, then there exist $k \times r$ matrices $\propto$ and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is $I(0)$. $r$is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector.The cointegration rank in this study will be carried out using maximum eigenvalue and trace statistics.

Vector Error Correction (VEC)

Cointegration implies that causality exists among the series, but it does not indicate the direction of the causal relationship. In this step, vector error correction model (VECM) will be employed to detect the direction of the causality. This is based on the stationarity properties of the time series as they mostly found to be nonstationary. The dynamic Granger causality can be captured from the vector error correction model derived from the long-run cointegrating relationship.

Granger Representation Theorem, says that if Y and X are cointegrated, then the relationship between them can be expressed as an ECM.

Following Soytas and Sari (2011), Juselius procedure which is based on the on the maximum likelihood methodology has superior properties than the Engle-Granger two-step procedure. Also the VECM can be written as:

$$\Delta X_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-p} + e_t \dots\dots\dots\dots\dots\dots\dots\dots\dots . (9)$$

Where X is a $(n \times 1)$ vector of variables, μ is a $(n \times 1)$ vector of constant terms, $e_t$is a vector of random error terms that follows a usual Gaussian white noise process with zero mean and constant variance.The rank of the matrix Γ, the matrix determining the long-run relationships between variables, is equal to the number of independent cointegrating vectors denoted by r. If r = 0, then the elements of X are nonstationary, and (4) is a usual VAR in first differences. Instead, if the rank (Γ) is n and r = n, then the elements of X are stationary. Γ Xt − pis error-correction factor, if r = 1. For other cases, 1 < r < n, there are multiple cointegrating vectors. The number of distinct cointegrating vectors can be obtained by checking the significance of characteristic roots of Γ. The cointegration rank in this study will be carried out using maximum eigenvalue and likelihood ratio.

Variance Decomposition Analysis

The causality test presented above indicates only Granger causality within the sample period and does not allow us to gauge the relative strength of the Granger causality tests among the series beyond the sample period (Payne, 2002 in Wolde-Rufael 2010). Thus, to complement the above discussion, we apply the generalized impulse response approach proposed by Pesaran and Shin (1998) that does not require orthogonalization of shocks and is invariant to the ordering of the variables in the VAR. The impulse response function outlines the effect of a one-time shock to one endogenous variable on the other variables in the VAR model. Variance decompositions will also be investigated as the analysis gives insight about the relative importance of each variable in the VAR.

IV. EMPIRICAL RESULTS

The result is computed using Eviews 7 and is presented in the following section

Unit Root Test

ADF and PP tests were conducted to determine the stationarity properties of the series. Table 3 reports the result.

Table 3: Unit root test result

Variables		RGDP	CAP	LAB	TEC
ADF	At Level	0.483288	1.647062	2.139065	-3.139465
	At First Diff.	-7.159166*	3.574753***	-7.231631*	-5.310203*
PP	At Level	-0.178463	2.723401	1.347228	-3.103114
	At First Diff.	-10.76205*	-4.398951*	-6.017624*	-7.671296*

Source: regression output using E-views7
*, ** and*** indicates significance at 1 percent, 5 percent and 10 percent level
The results shows that all the variables (RGDP, CAP, LAB and TEC) were found integrated at the first difference i.e. I(1).Result of the tests at level indicates that all the variables contain unit roots.

Cointegration Test
Since we found that the variables are non-stationary at their level and are in the same order of the integration,we proceed with testing their long-run relationship using Johansen and Juselius (1990) method.The trace test (λ_{trace}) and maximum eigenvalue (λ_{max}) test results are presented in Table 4.
Table 4: CointegrationTest result

Hypothesized NO. of CE(s)	Trace Statistic	1% Critical Value	Max-Eigen Statistic	1%Critical Value
None	123.8348*	54.46	82.57922*	32.24
At most 1	41.25555*	35.65	35.58328*	25.52
At most 2	5.672278	20.04	5.629451	18.63
At most 3	0.042827	6.65	0.042827	6.65

Source:Extract from estimation output using E-views7
* denotes rejection of the hypothesis at the 0.01 level

The result shows the existence of two cointegrationg equations based on the trace statistics and the maximum eigenvaluestatistics at 1 percent level of significance. The Ostewald- Lenum critical values were used for the decision rule. Cointegration indicates a long-run relationship between the variables. In effect, this finding suggests that energy consumption may contain important information regarding economic growth.

Causality Test
The unit root and Johansen cointegration test results favored the use of VECM instead of the unrestricted VAR. Also the cointegration relation implies granger causality. We therefore use the VECM to detect the direction of the causality. The results of block exogeneitywald test are reported in Table5.
Table 5: VEC Granger Causality Wald Test Result

Dep. variable: D(RGDP)			
Excluded	Chi-sq	df	Prob.
D(TEC)	4.719128	3	0.1936
D(CAP)	4.909080	3	0.1786
D(LAB)	8.052583	3	0.0449
Dep. variable: D(TEC)			
Excluded	Chi-sq	df	Prob.
D((RGDP)	1.881509	3	0.5974
D(CAP)	5.480349	3	0.1398
D(LAB)	3.962212	3	0.2656
Dep. variable: D(CAP)			
Excluded	Chi-sq	df	Prob.
D((RGDP)	15.48705*	3	0.0014
D(TEC)	7.261055**	3	0.0640
D(LAB)	4.258404	3	0.2349
Dep. variable: D(LAB)			
Excluded	Chi-sq	df	Prob.
D(RGDP)	17.19938*	3	0.0006
D(TEC)	402.1915*	3	0.0000
D(CAP)	2.804574	3	0.4227

*Source:*estimation output using E-views7. .
*and** denotes rejection of the hypothesis at the 0.01 and 0. 05 level

The output displays x^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables. In the table where RGDP is taken as dependent variable, the null hypothesis is that energy consumption does not Granger cause growth and the alternative hypothesis says energy consumption Granger cause economic growth. Considering the "p-value" for TEC of 0.1936, we lack sufficient evidence to reject the null hypothesis. On the other hand where TEC is dependent variable, the null hypothesis is economic growth does not Granger cause energy consumption. The "p-value" for RGDP of 0.5974 suggests that we fail to reject the null hypothesis. The result in both cases strongly supports the neutrality hypothesis.
In order to have robust results we compare the wald test results with that of Pairwise Granger causality. The estimated F-statistics of the Pairwise Granger Causality test results are reported in the table below.

Table 6: Pairwise Granger Causality test Result

Null Hypothesis:	Obs	F-Statistic	Prob.
LAB does not Granger Cause GDP		1.07291	0.3095
GDP does not Granger Cause LAB	30	8.40512	0.0073
CAP does not Granger Cause GDP		0.28047	0.6007
GDP does not Granger Cause CAP	30	6.72298	0.0152
TEC does not Granger Cause GDP	31	0.82550	0.3713
GDP does not Granger Cause TEC		2.8E-05	0.9958
CAP does not Granger Cause LAB	30	47.6170	2.E-07
LAB does not Granger Cause CAP		0.32423	0.5738
TEC does not Granger Cause LAB	30	2.64992	0.1152
LAB does not Granger Cause TEC		0.00781	0.9302
TEC does not Granger Cause CAP	30	3.07561	0.0908
CAP does not Granger Cause TEC		0.02075	0.8865

Source: Estimation output using E-views7

The two causality test results (the VEC Wald test and the Pairwise Granger causality test) are consistent with each other.We have no substantial evidence to reject the null hypothesis of no causality between energy consumption and the real GDP. In essence, energy consumption does not Granger cause economic growth and economic growth does not Granger cause energy consumption.Both evidences vindicate the famous neutrality hypothesis. The findings are in line with Altinay and Karagol (2004) for Turkey, Sfeir (2012) for China for the period 1981 to 2008 using Granger causality, Yoo and Kwak (2010) for Peru and the recent findings in Aliero and Ibrahim (2012) using Nigeria's data from 1970 to 2009. It contradicts the findings in Alamet'al (2012), Wondimaghen (2011), Hou (2009), Omotor (2008), Aqeel and Butt (2001), among others.

Impulse Response Function

The impulse response function examines the response of the dependent variable in the VAR to shocks in the error terms. (Asteriou and Stephen, 2007). It thus traces the effect of a shock emanating from an endogenous variable to other variables through the dynamic structure of the VECM.The response of RGDP,TEC, CAP and LAB to itself and to other variables in the Cholesky ordering RGDP, CAP, LAB and TEC after 12 years is presented in Appendix.

Variance DecompositionAnalysis

While impulse response functions trace the effects of a shock to one endogenous variable on the other variables in the VAR, the variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR. As we are more concerned by the role of energy consumption to economic growth as compared to other two inputs of labour and capital, we only report the variance decomposition of RGDP and TEC in the Cholesky orderingRGDP, CAP, LAB and TEC. Table 9 reports the result. (See Appendix 6 for more results).

Table 9 : Variance Decomposition Analysis

Variance Decomposition of RGDP:				
Period	RGDP	CAP	LAB	TEC
After 4 years	79.43816	4.137390	13.10310	3.321350
After 8 years	67.85440	13.71627	15.42155	3.007779
After 12 years	66.25764	17.53757	13.96106	2.243725

Variance Decomposition of TEC:				
	RGDP	CAP	LAB	TEC
After 4 years	52.05286	8.798003	21.02304	18.12609
After 8 years	46.22750	12.68978	25.15966	15.92305
After 12 years	42.81947	16.07328	25.21684	15.89041

Source: Extract from estimation output using E-views7

The variance decomposition of RGDP shows that in Nigeria labouris the mostimportant factor contributing to GDP compared to other factors of capital and energy consumption. While RGDP contributes 79 percent to itself, labour capital and energy consumption contributes 13 percent, 4 percent and 3 percent respectively in the short term. The importance of energy consumption will diminish in the long term but never die out. However, capital will take over the lead in the long run with 18 percent contribution while labour will increase slightly to 4 percent.

The variance decomposition of TEC shows the growing importance of capital of 9 percent in the short-run to 16 in the long-run. That of labour is projected to be 21 percent and 25 percent in the short-run and long-run respectively. RGDP however, is the most important contributing factor to energy consumption despite the absence of causality between the two variables. RGDP's contribution of 52 percent in the short-run will decline after 8 years but will remain significant throughout the periods of analysis.

The results further shows that RGDP accounts for 62 percent of its variance in the long-run, TEC accounts for only 16 percent of the variance in the period.

V. CONCLUSION AND RECOMMENDATIONS

The paperhas presented the empirical analysis of dynamic relationship between energy consumption and economic growth using a multivariate framework by including labour and capital in the causality analysis on Nigeria's time series data from 1980 to 2011.The unit root test conducted on the variables shows that all the series are stationary in the first difference, and integrated of order I(1). This enables us determined the cointegration relationship among the variables based on the trace and maximum eigenvalue statistics of Johansen and Juselius (1990) method. This long run relationship was established at 1 percent level of significance. The direction of causality between energy consumption and economic growth in Nigeria was investigated using pairwise Granger causality and Wald test and the two methods confirmed the absence of causality. In spite of the absence of causality between the two variables the impulse response function and the results of the variance decomposition shows how important RGDP is in affecting energy consumption beyond the sample period.

The empirical result of absence of causality between energy consumption and economic growth suggests that the country can pursue an expansive or conservative energy policy without undermining its economic growth. Results of the variance decomposition showing labour and capital as the most important factors in output growth, implies that in order to sustain high economic growth in the long-run, the country needs to increase the efficiency of its workforce and expand its saving capacity to generate more capital.

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