The Causal Relationship between Renewable and Non-Renewable Energy Consumption and Economic Growth: The Case Study of Nigeria

By

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Abstract

This paper investigates the causal link between renewable and non-renewable energy sources and economic growth in Nigeria. A quarterly time series data was employed from the period of 1971-2013. Real GDP was used as a dependent variable and energy as an independent variable. The Augmented Dicky Fuller (ADF) and Philip Perron (PP) test provided different results in the order of integration among the variables providing strong justification for the bounds testing approach to conintegration. The Granger causality test produced mixed results between renewable energy consumption and economic growth, non-renewable energy consumption and economic growth in Nigeria.

The result suggested that causality runs from renewable energy to real GDP but not the other way round, and supports a long run causality running from Real GDP to Non-renewable energy. The results of ordinary least squares test show positive relation between Real GDP and energy sources in Nigeria. The elasticities values show that a unit change in renewable and non-renewable energy increases economic growth by 19.0% and 8%, respectively. This implies that the government should pay more attention to comprehensive research on energy policies (renewable energy sources) as a long term plan that aim at reducing the use of fossil fuel energy for the sake of environmental quality knowing that the all-embracing use of conventional energy sources can no longer be sustained.

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Despite the importance of energy consumption to economic growth, empirical findings have been mixed on the causal relationship between energy and growth. From theoretical and empirical literature, evidence on the direction of causality between energy consumption and economic growth has remained inconclusive. While some researchers have found a unidirectional causality running from economic growth to energy consumption (Ozturk et al. 2010a; Lee and Chang, 2007 and Odhiambo, 2009), others have found bidirectional relationship between energy consumption and growth (Ramakrishna, and Rena, 2013), and (Tsani, 2010).Yet others found no real effect of energy consumption on economic growth (Ozturk et al. 2010b).

Although, conventional energy consumption based on oil, coal, and natural gas has proven to be highly effective drivers of economic progress, it has also been viewed to have negative impact on the environment (Newman et al., 1996). Recent economic researches focused on policies against global warming and are concerned with mitigation policies. While, a large number of studies have focused on mitigation policies such as cap & trade and carbon tax, to combat global warming in the case of US and some other developed countries, some other studies have focused on the use of Renewable Energy Technologies (RETs) as solution to global warming (Greiner et al., 2014).

However, the literature for transiting to renewable energy is not yet clear and proven particularly for countries that are huge exporters of conventional energy sources. Renewable energy sources have been said not only to be economically costly but also that it could generates huge domestic resistance among the poor. Hence it is said to be highly debatable that the process of transition can of itself generate the growth that most countries are seeking for, particularly for developing countries, as conventional growth may provide a more rapid route out of poverty (Tarp and Thurlow, 2013, Huberty et al., 2011, Dercon, 2012 and Scott, 2013). Nonetheless, the extent to which renewable energy can impact economic growth is not adequately exploited, especially in Sub-Saharan Africa where there are huge developmental gaps and substantial poverty.

Nigeria is one of such Sub-Saharan African countries with the same challenges. The country energy supply is still dominated by non-renewable energy sources (petroleum, natural gas and coal), (CBN, 2009). Although energy is viewed to be the main drive for economic growth, the contribution of energy to GDP has declined over the years from 15.50% to

13.70% in 2013 (ECN, 2013) due to the decrease in crude oil production, this could hamper economic growth if strategic policies are not put in place. However, with vast potentials of energy, it can be adequately supplied if adequate policies are set up. The benefits of increased energy consumption would lead to the generation of more income, thereby, boosting economic activities and economic growth.

Moreover, the paucity of researches on renewable and non renewable energy consumption – growth nexus in Nigeria constitutes an important gap that needs to be filled. Hence, to investigate the causal relationship between consumption of renewable and non-renewable energy and economic growth in Nigeria based on the null hypothesis of a weak causality between energy consumption and economic growth. Thus, the study expects to extend our knowledge in two main areas: it (1) expands our understanding of the causal links between renewable and non-renewable energy consumption and economic growth in Nigeria, and (2) creates the climate for effective policies on inclusive energy consumption and economic growth in the country

The reminder of this paper is structured as follows. Section two presents a brief literature review while section three focuses on the discussion of the stylized facts of energy consumption and economic growth in Nigeria. Methodology and interpretation of regression results are presented in section 4. Section 5 contains conclusion and policy implications.

2.0 Literature Review

The motivation behind the renewed interest of researchers probing the direction of causality between energy consumption and economic growth resulted from the important policy implications from theoretical and empirical standpoints. Hence, considerable literatures exist on the causality on energy-growth nexus and have been largely explored from different competing views which can be divided into: (1) growth hypothesis, (2) feedback hypothesis (3) conservative hypothesis and (4) neutrality hypothesis.

The first view states that energy consumption plays a crucial role in economic growth. This is known as the *growth hypothesis* which is advanced by ecological economists, who argued that all the other inputs (technological improvement, capital and labour) could not substitute for the important role that energy plays in the production process (Stern, 1993). This therefore implies that a country's economic growth depends largely on energy consumption, so that any decrease in energy consumption may bring about a reduction in economic growth. Hence, energy is a limiting factor to economic growth, so that any shocks to energy supply will have a negative impact on economic growth (Ozturk, 2010a).

The *feedback hypothesis* asserts the existence of a bidirectional causal relationship between energy consumption and economic growth. This theory reflects the interdependence between energy consumption and growth, implying that energy consumption and economic growth are jointly determined and affected at the same time. Although bi-directional causality implies that energy conservation policy harms economic growth in aggregated level, energy policy should be carefully regulated, since one-sided policy selection is harmful for economic growth (Yildirim and Aslan, 2012).

Another view on the causality relationship between growth and energy is the *neutrality hypothesis.* This view according to the neoclassical economists argued that energy does not influence economic growth (Stern and Cleveland, 2004). In other words, both energy consumption and economic growth are neutral with respect to each other, meaning that capital and labour are the primary factors of production while energy is seen as intermediate input of production which is used up in the entire production process (Tsani, 2010) and (Alam et.al., 2012). This theory thus postulates that there is no causality between energy consumption and economic growth.

Finally, the fourth view states the unidirectional causality that runs from economic growth to energy consumption, this is known as the *conservation hypothesis*. This theory postulates that a country's economic growth is highly associated with energy consumption because energy as any other production factor may be the limiting factor to economic growth (Alam et.al., 2012). In this regard the policy of conserving energy consumption, such as the reduction in greenhouse gas emissions efficiency improvement measures, and demand management policies, designed to reduce energy consumption and waste may have little or no adverse effect on economic growth. Therefore, this theory is supported if an increase in real GDP causes an increase in energy consumption. In the case of an energy dependent economy, energy conservation policies that could be implemented to reduce emissions may not have influence on economic growth

Empirical literature on the causality between energy consumption and economic growth are not without controversies. The review of studies is grouped into five views such as conservation hypothesis, growth hypothesis, neutrality hypothesis, feedback hypothesis and mixed hypothesis.

Kraft and Kraft (1978) in a seminar paper conducted the Granger Causality test to investigate the relationship between energy and growth. The study provided reason that supported the conservative hypothesis of a unidirectional relationship that runs from gross domestic product (GDP) to energy consumption for the USA over the 1947-74 periods. Also, (Ewing et al. 2007) applied the autoregressive distributive lag (ARDL) approach to test the long run relationship between the variables using monthly data over the period of 2001–2005. He found results that supported the existence of conservative hypothesis. Furthermore, (Cheng et.al., 2009) researched the linkages between renewable energy consumption and economic growth using a panel data for 30 OECD countries under different economic growth regimes. Results also, confirm with the conservative hypothesis implying a causal relationship running from economic growth to renewable energy consumption.

Apergis and Payne, (2009) examined the relationship between energy consumption and economic growth for six Central American countries over the period 1980–2004 within a multivariate framework. The results showed the presence of both short and long run causality from energy consumption to economic growth which supports the growth hypothesis. Similarly, (Odhiambo, 2009a) investigated the causal relationship between energy consumption and economic growth in Tanzania. The bound test found the existence of a stable long-run relationship between each of the proxies of energy consumption and economic growth. Also, the results of the causality test showed that there is a unidirectional causal flow from total energy consumption to economic growth. Furthermore, Payne (2010b) examined causal relationship between the biogas energy consumption and real output over the period of 1949-2007 in the US economy. The result confirmed the growth hypothesis implying that growth depends on energy consumption. Other studies are (Odhiambo, 2009b) and (Wandji, 2013)

Payne (2009) investigated the nature of causal relationship between renewable energy consumption, non-renewable energy consumption and real output in the case of United States. The results revealed the case of no causality between the variables and, therefore, supported the existence of neutrality hypothesis. Similarly, (Halicioglu, 2009) studied the relationship between energy consumption and income and found evidence that support the neutrality hypothesis theory of no causal relationship between energy consumption and economics growth in Turkey. Payne (2010) also provided comprehensive surveys on the literature of causal relationship between energy consumption, electricity consumption and economic growth, the result infer that there is no clear consensus whether particular countries or group of countries are energy dependent or energy neutral

Mahadevan and Asafu-Adjaye (2007) found that there exist bidirectional causality between economic growth and energy consumption in the developed countries in both the short and long run, but for the developing countries, energy consumption was found to stimulate growth only in the short run. Also, (Apergis and Payne, 2010a and 2010b) conducted a study to investigate the causal relationship between renewable energy consumption and economic growth for a panel of thirteen OECD countries. Result revealed the feedback hypothesis of bidirectional causality between renewable energy consumption and economic growth both in the long and short run. Other studies with similar findings are (Apergis and Payne, 2011), (Apergis and Payne, 2012), (Wang et.al., 2012), (Shahbaz et.al., 2012), ((Mallick, 2009), and (Ramakrishna and Rena, 2013)

Akinlo (2008) examined the causal relationship between energy consumption and economic growth for eleven countries in sub-Saharan Africa. He found mixed results for the various countries studied. The Granger causality test based on vector error correction model (VECM) showed that bi-directional relationship exists between energy consumption and economic growth for Gambia, Ghana and Senegal. However, Granger causality test showed that economic growth Granger causes energy consumption in Sudan and Zimbabwe, while the neutrality hypothesis was confirmed in respect of Cameroon and Cote D'Ivoire, Nigeria, Kenya and Togo. Similarly, Bowden and Payne (2010) investigated the causality between renewable energy consumption, non-renewable energy consumption and real output. Their results was mixed as it revealed the situation of no causal relationship between commercial and industrial renewable energy consumption and real output.

3.0 STYLIZED FACT ABOUT ENERGY AND ECONOMIC GROWTH IN NIGERIA

This section provides a brief overview on the stylized facts of energy and economic growth by highlighting the key areas on how energy influences growth for the period of study.

Nigeria is the largest oil producer in the continent and also among the world's top five exporters of liquefied natural gas (LNG) (EIA, 2013). However, despite the large volumes of oil produced, the country's political instability and supply disruption have to a large extent hampered the production of oil, while lack of infrastructure to monetize the production of natural gas that is been flared has restricted the energy sector.

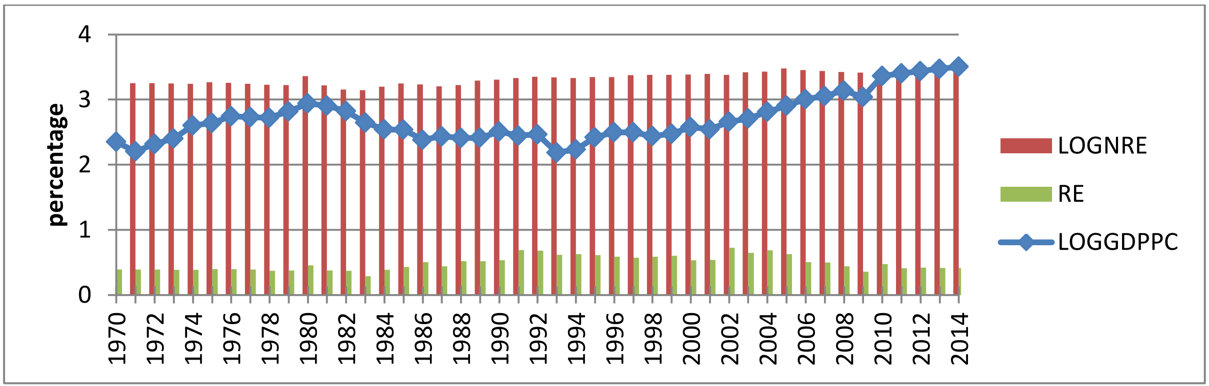
Although, the country is abundantly endowed with both conventional and renewable energy resources [crude oil =37.2 billion barrels, natural gas = 187 Tscf, tar sand = 31 billion barrels, coal = 2.7 billion tones, hydro = 11,250MW, solar = 6.5kWh/m^2/day, wind = 2-4m/s at 10m height and biomass (animal waste = 61 million tones/yr, and crop residue = 83 million tones/yr)]. It is solely dependent on oil to meet its development expenditure with oil revenue accounting for about 98.7% of exports and 76.5% of total government revenues (ECN, 2013**).** According to Energy Information Administration (EIA)estimates, total primary energy consumption was about 4.3 quadrillion British thermal unit (Btu) in the year 2011 with traditional biomass and waste (typically consisting of wood, charcoal, manure, and crop residues) accounting for 83%. This high share represents the use of biomass that was mainly used to meet off-grid heating and cooking needs, mainly in rural areas (EIA, 2013).

Prior to the discovering of oil in the late 1960s, the Nigerian economy's major power source was coal in the 1950s, which accounted for about 70% of the country's total power consumption. After the discovering of oil, Nigerian became a member of the Organization of the Petroleum Exporting Countries (OPEC) in 1971, thereafter the economy become solely dependent on crude oil reserves with very little focus on other energy sources (ECN, 2013). Therefore, Nigeria's energy consumption mix is currently dominated by oil (53%), natural gas (39%) and hydroelectricity (7%). Accordingly, coal, nuclear and other renewable are currently not part of Nigeria's energy consumption mix, with the exception of biomass often used to meet rural heating and cooking needs (CBN, 2009).

Moreover, oil and natural gas resources are also said to be the mainstay of the country's economy. With Energy serving as the pillar of wealth creation as evident from being the centre of operations and engine of growth for all sectors of the economy (Onakoya et.al., 2013). At the current energy crisis due to declining oil prices, increasing demand for energy, Nigerian economy is facing challenges which pose a risk to economic growth, resulting from improper use of its natural resource endowment, particularly fossil energy. Robinson, Torvik and Verdier (2006) describe this situation as a "resource curse – a paradox of poverty amidst plenty resources".

Consequently, although GDP grew by 6.6% in 2012, it was said to have decreased compared to 7.4% in the previous year. The development was attributed, largely, to the growth in the contribution of the non-oil sector. Real non-oil GDP grew at 8.7 per cent and accounted for 88.3 per cent of total GDP in the review quarter. Real oil GDP, comprising crude petroleum and natural gas, grew by 0.3 per cent and accounted for 11.7 per cent of GDP, in contrast to the decline of 0.5 per cent recorded in the preceding quarter of 2013. The Growth in 2012 GDP was mainly attributed to the constructive effects of the various measures and initiatives put in place by the government and the CBN to boost in real sector output (CBN, 2013).

Figure 1: Trend of GDPPC, Non-renewable and Renewable energy in Nigeria



The figure above shows the trend between GDP growth rate, Renewable and non-renewable energies. In the period of 1960s-1970s, the economy witnessed a truncated growth as GDP recorded about 3.1 per cent growth annually, but in the in the early 1970s after the discovering of oil, GDP grew positively by 6.2 per cent annually (Ekpo and Umoh, 2015). However, in the 1980s, GDP had negative growth rates which constituted the period of structural adjustment, while in the early 1990s, GDP responded to economic adjustment and grew positively as is seen from the figure above. This increase is supported by the sharp increases in the production of non-renewable energy, as renewable energy production remains minimal and stable as portrayed by the figure.

Given the importance of energy and the crucial role it plays to enhance economic growth, the inability to meet this need in the country is potentially an impeding factor to economic and social development. Therefore, concerns on the increased energy demand resulting from the volatility of oil prices and the dwindling or depletion of fossil energy coupled with the consequences of carbon emissions has renewed the interest in renewable energy sources as a means to diversify the country's energy consumption mix in achieving economic growth.

4.0 Methodology and Interpretation of Results

4.1 Theoretical Framework

The theoretical framework is based on the work of (Toman and Jemelkova, 2002). They utilized a Cobb-Douglas production function to investigate the relationship between energy consumption and economic growth and incorporated other input of the factors of production. Shahbaz et.al. (2012) also, utilized a log-linear functional form of Cobb–Douglas production function. It is to be noted that the omission of other variables in the function could bias the direction of causality between energy and economic growth.

According to (Toman and Jemelkova, 2002), "If higher-quality energy is more costly to provide (in particular, requires more capital expenditure) but offers higher overall factor productivity, then society can make a trade-off between the two energy forms that favors more advanced but more productive energy forms as development progresses". According to this theory, there exist several ways through which increased availability of energy could boost productivity and thereby enhance the effective supply of physical and human capital services.

For the advanced economy, this could mean increase energy availability leading to the use of more modern machines that can bring about expansion in effective capital-labour ratio as well as increase in productivity. However, this could mean the lowering of households opportunity cost of education, so that when the reduce need of raw labour input is accompanied by an increase in labour input to human capital provision this can then lead to increasing returns from the provision of energy services (Toman and Jemelkova, 2002).

In relating this theory of higher quality of energy to increased productivity, (Shahbazet.al., 2012) decomposed energy consumption into renewable and non-renewable energy consumption in order to investigate the individual impact of the energy sources on domestic production as well as on economic growth. However, they noted that the issue of the component of energy that impacts growth more is debatable particularly in developing countries as to which type of energy source should be invested in or what energy mix should be utilized for sustainable economic growth.

4.2 Model Specification

Based on the specific objective of this study, the study adopts a log-linear functional form of Cobb–Douglas production function to explore the causal link between energy consumption and economic growth. The model is specified as follows:

$$\ln RGDP_t = \alpha_0 + \alpha_1 \ln RE_t + \alpha_2 \ln NRE_t + \alpha_3 \ln K_t + \alpha_4 \ln L_t + \alpha_5 \ln Con + \varepsilon_t \qquad (1)$$

Where: *Con* is vector of any other control variable(s) such as financial development measured by bank credit to private sector, and institution variables (Rule of law, Regulatory Quality, Government Effectiveness, Political Stability, Voice and Accountability and contrite Corruption). RGDP stands for Real GDP, RE denotes Renewable energy sources (Hydropower, Geothermal, Solar, and Nuclear, among others), NRE denotes Non-renewable energy i.e fossil fuel energy consumption (Coal, Petroleum and Natural gas), while K represent the physical capital and is represented by Gross Fixed Capital Formation and L is human capital measured by secondary school enrolment.

The long-run relationship between energy and economic growth is established within an Autoregressive Distributed Lag (ARDL)-bounds testing approach, popularised in Pesaran et al. (2001).The ARDL approach is based on the following validations. First, the decision on the order of integration of the series does not matter as the ARDL does not impose a restrictive assumption that all the variables under study must be integrated of the same order unlike other conventional cointegration techniques. Secondly, while other cointegration techniques are sensitive to the sample size, the ARDL approach is more suitable and appropriate for a small sample. Also, appropriate modification of the order of ARDL technique can correct and provide unbiased estimates of the long-run model and valid t-statistics even when some of the regressors are endogenous.

The ARDL representation of (1) below indicates that economic growth tends to be influenced and explained by its past values, the past values of all the explanatory variables as well as the change in the past values of all the variables in the model.

$$\Delta \ln RGDP_t = \alpha_0 + \alpha_1 ln RGDP_{t-1} + \alpha_2\, ln RE_{t-1} + \alpha_3\, ln NRE_{t-1} + \alpha_4\, ln L_{t-1} + \alpha_5\, ln K_{t-1} + \alpha_6\, ln Con_{t-1} + \sum_{t=i}^{n} \emptyset_1 \Delta ln RGDP_{t-i} + \sum_{t=i}^{n} \Delta\emptyset_2 ln RE_{t-i} + \sum_{t=i}^{n} \Delta\emptyset_3 ln NRE_{t-i} + \sum_{t=i}^{n} \Delta\emptyset_4 \ln L_{t-i} + \sum_{t=i}^{n} \Delta\emptyset_5 ln K_{t-i} + \sum_{t=i}^{n} \Delta\emptyset_5 ln Con_{t-i} + ECT_{t-1} + \varepsilon_t \quad (2)$$

α_0 is a constant term, $\alpha_1$to α_6 are long run coefficients and $\emptyset_1$ to $\emptyset_6$ stand for the short run coefficients. Where Δ is the lag operator, and all other variables are as defined above. The ECT is the error correction term, derived from residuals generated from the original function (1). It shows the adjustment process of short-to long run equilibrium relationship between economic growth, energy utilization and other specified independent variables in Nigeria. As is standard, the coefficient of the ECM term is expected to be negative and also statistically significant for there to be short run adjustment to long run equilibrium. The error term, ε_t, is expected to be well behaved in the usual sense of being serially independent. The model adopts the general to specific approach such that only variables with the best econometric properties are presented and discussed.

4.3 Data Source

The study employed single-country data due to some of the advantages associated with using cross-country data. Unlike cross-country data, single-country data is able to cater for country specific effects of energy consumption on economic growth and vice versa. According to (Odhiambo, 2009), cross-country data may fail to explicitly address the potential biases induced by the existence of cross-country heterogeneity, which may lead to inconsistent and misleading estimates, single country data keeps consistency in measurement of variables.

Also, the study utilizes quarterly time series data that was sourced from World Development Indicators (WDI),World Bank and Nigerian Bureau of Statistics from the period of 1980Q1to 2013Q4. The choice of period was guided by the availability of data.

4.4 Estimation techniques and empirical analysis

4.5.1 Stationary test

Part of conditions for the bounds testing approach to cointegration is the test for unit root. A series is referred to as stationary if it's mean, variance and auto covariance (at various lags) remain the same regardless of the point they are measured. That is, they are time invariant (Gujarati, 2004). For the purpose of the study, test for stationarity in all the variables is done with two popular tests, namely; the Augmented Dickey-Fuller (ADF) test, and the Phillip Perron (PP) test, the result for which are presented in tables1a &b. The bounds testing approach to conintegration requires variables to be stationary at level or at most first difference, giving it an advantage over other methods, such Johansen and Juselius (1999) that requires all variables to be stationary at first difference.

Table 1a: AUGMENTED DICKEY-FULLER UNIT ROOT TEST

	Constant				Drift & Trend			
Variable	Level	Prob.	First diff	Prob.	Level	Prob.	First diff	Prob.
RGDP	2.20	1.00	-1.21	0.67	-0.76	0.97	-3.42	0.05
NRE	-2.59	0.10	-11.49	0.00	-2.98	0.14	-11.47	0.00
RE	-1.84	0.36	-11.49	0.00	-1.74	0.73	-11.48	0.00
K	-1.43	0.57	-11.52	0.00	-3.00	0.14	-11.48	0.00
L	0.09	0.96	-11.55	0.00	-1.18	0.91	-11.98	0.00
INST	-2.76	0.07	-5.39	0.00	-2.74	0.22	-5.38	0.00
CPS	-1.08	0.72	-11.51	0.00	-1.97	0.61	-11.51	0.00

Table 1b: PHILIP PERRON UNIT ROOT Test

	Constant				Drift& Trend			
Variable	Level	Prob.	First diff	Prob.	level	Prob.	First diff	Prob.
RGDP	4.29	1.00	-12.87	0.00	-0.73	0.97	-16.49	0.00
NRE	-2.59	0.10	-11.49	0.00	-2.98	0.14	-11.47	0.00
RE	-1.79	0.38	-11.61	0.00	-1.67	0.76	-11.69	0.00
K	-1.29	0.63	-12.15	0.00	-3.04	0.12	-12.09	0.00
L	-0.11	0.94	-11.62	0.00	-1.16	0.91	-11.98	0.00
INST	-3.02	0.04	-11.60	0.00	-3.00	0.14	-11.56	0.00
CPS	-1.10	0.71	-11.51	0.00	-1.99	0.60	-11.51	0.00

The results of the stationarity tests reported in tables 1a and b rejected the nulls of unit root at second difference. Furthermore, all but one variable-institution- appears to be stationary at the first difference in both the ADF and PP test when tested. It will appear too that the null of unit root is rejected only when the variable is tested with drift and trend in the ADF test for real GDP but that PP test strongly rejected the null of unit root for the variable at first difference with constant, as well as constant with drift. The differences in order of integration among the variables as well as the fact that different test results produced different results for the unit root test apparently provides strong justification for the bounds testing approach to conintegration.

4.5.2 Conintegration analysis (Bounds Testing Approach)

To determine conintegration relationship between growth and energy utilization in Nigeria, the unrestricted error correction model (2) is estimated with constant and trend, and out of 65536 models evaluated, an ARDL (4, 0, 1, 0, 1, 0, 0, 1) is chosen from the top twenty models because it minimizes the Akaike Information Criteria for the lag length selection as shown in Figure 1. Following that, a general to specific estimation procedure was adopted for estimating the unrestricted error correction model (2) above such that only the model with best economic and statistical properties is presented and discussed. Table 2 contains results from the parsimonious model relating economic growth and energy consumption in Nigeria. The proxy for economic growth, real GDP, is found to respond positively to its first lag. Also, renewable and non-renewable energy both have positive coefficients though the coefficient of non-renewable energy utilization is not statistically significant. Other control variables namely, labour, capital as well as credit to the private sector also produced the expected signs and their coefficients are statistically significant. However, our proxy for institution produces counter intuitive evidence in the model.

Table 2: Unrestricted ECM model

Dependent Variable: LNRGDP				
Variable	**Coef**	**SE**	**t-Stat**	**Prob.**
LNRGDP(-1)	0.54	0.08	6.99	0.00
LNRGDP(-2)	-0.02	0.08	-0.22	0.83
LNRGDP(-3)	-0.02	0.08	-0.22	0.83
LNRGDP(-4)	0.32	0.07	4.40	0.00
LNRE	0.03	0.02	2.08	0.04
LNNRE	0.04	0.04	1.03	0.31
LNNRE(-1)	0.06	0.04	1.42	0.16
LNK	0.14	0.05	3.04	0.00
LNL	0.08	0.01	6.61	0.00
LNL(-1)	-0.05	0.01	-4.17	0.00
LNINST	-0.04	0.02	-1.95	0.05
LNCPS	0.08	0.02	3.19	0.00
C	0.88	0.29	3.03	0.00
@TREND	0.00	0.00	4.55	0.00

LM Test=4.001[0.209], Heteroscedasticity F-Stat 3.71(0.00), Probability values for the LM and test for homoscedasticity are in bracket.

The model however contains some good econometric properties in terms of being stable, given the recursive estimates with the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMsQ) plots, which both lie within the 5 per cent level of significance. Also, the errors are serial independent with LM test statistic of 4.0 with a probability value of 0.20 per cent, leading to accepting the null of serial independence of errors. Similarly, the errors are homoscedastic with an F-statistic of 3.7 and its associated probability which rejected the null of heteroscedasticity. Other diagnostics including the residual plot Figure 3, which confirms the reliability of the model for analysis.

Test for long run co-integration among the specified variables enables for identification of the both the short and long relationship is possible under the bounds testing procedure. The error correction term, derived from the level form estimate of equation (2) indicates the speed of adjustment of short to long run equilibrium relation of output and energy consumption in Nigeria. The bounds testing require a test of the joint significance of the variables in the model or an F- (Wald test) under the null hypothesis that all variables in the model are jointly insignificant. Consequently, a statistically significant F-statistic is compared with the upper bounds of the critical values provided in Pasaran et.al (2001) for establishing long run relationship among stationary variables in the model. Thus, an F-statistic of 5.2 as shown in table 3 is sufficient for the strong rejection of the null of no long run relationship between real output and the specified determinants in Nigeria as this exceeds even the 1% critical value for the upper bounds test critical values.

Table 3: ARDL Bounds Test

Test Statistic	Value	K
F-statistic	5.290983	7
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.22	3.17
5%	2.5	3.5
2.50%	2.76	3.81
1%	3.07	4.23

Table 4: ARDL Cointegrating And Long Run Form.
Dependent Variable: LNRGDP

Long Run Coefficients		Short-run coefficients	
Variable	Coef	Variable	Coef
LNRE	0.19** (2.34)	D(LNRGDP(-2))	-0.29*** (-4.38)
LNNRE	0.08 (0.61)	D(LNRGDP(-3))	-0.31*** (-4.58)
LNK	0.82** (2.82)	D(LNRE)	0.05** (-2.12)
LNL	0.16*** (5.75)	D(LNNRE)	0.06* (-1.55)
LNINST	0.23* (1.92)	D(LNK)	0.23*** (3.28)
LNCPS	0.46** (2.81)	D(LNL)	0.08*** (7.39)
C	0.82*** (6.81)	D(LNINST)	0.02 (-0.40)
ECM(-1)	-0.16*** (-6.72)	D(LNCPS)	0.14*** (3.31)
		@TREND	0.01*** (10.07)

Note: *, **, and * indicates significance at 10%, 5% and 1% level. The values in brackets are the SE.**

Given the long run conintegration among the variables, table 4 report results for the short and long form equation for real output and its specified determinants in Nigeria. An inspection of table 4 suggests a positive response of real output to both renewable and non-renewable energy consumption in the country. However, the coefficient of non-renewable energy resources is not statistically significant both in the short and in the long run. Similarly, real out is positively sensitive to labour and capital in the short run as well as in the long run as expected. While the proxy for institution produced counter intuitive evidence in the short run but has long run positive impact on growth in the long run. A positive and statistically significant association of private sector credit with real economic growth exists in the long run.

The error correction term has the appropriate sign and statistical properties. Evidences suggest that nearly 16 per cent of any disequilibrium between real output and it determinants is corrected within one period (one quarter). Table 4b presenting long run elasticities estimates between output and its explanatory variables. Evidences suggest that a 1 per cent change in the utilization of renewable energy would raise economic growth by 19 per cent. However, though non-renewable energy has the expected positive sign, there is insufficient statistical evidence to reject its null hypothesis of non-significance in the long run. Similarly, the growth of real output is significantly sensitive to capital, labor, institutions and claims on the private sector in the long run.

4.5.3 VAR Granger Causality/block exogeneity Wald Test

Theoretically, the procedure for conintegration described above are only able to show whether the variables are cointegrated and a long-run association exist among the variables. However, to know the direction of causality, the two most common method employed for Granger causality tests, are VAR and VECM when the variables are cointegrated Mehrara (2007).

Table 5 presents granger causality test results from a VAR model. Generally the results support the unidirectional hypothesis between renewable energy consumption and economic growth, non-renewable energy consumption and economic growth, and between labour and economic growth, in Nigeria for the long run. Given the probability values presented, it does appear that causality runs from renewable energy and labour to real GDP but not the other way round. Also, the results indicate that there is a long run causality running from Real GDP to Non-renewable energy. The results also suggests that causality runs from capital input, and all the variables jointly to renewable energy. Similarly, non-renewable energy does not granger cause real GDP but that it is caused by renewable energy, labour variable and institutions and indeed all the variables in the model. There is however no enough evidence to reject the null hypothesis of no causality between RGDP and all other control variables in the model.

Table 5: VAR Granger Causality/Block Exogeneity Wald Tests

	Dependent Variables							
Explanatory variables	D(LNRGDP)	D(LNRE)	D(LNNRE)	D(LNK)	D(LNL)	D(LNINST)	D(LNCPS)	D(IMPORT)
D(LNRGDP)		0.54	0.01	0.95	0.17	1.00	1.00	0.87
D(LNRE)	0.06		0.00	1.00	1.00	1.00	0.84	0.93
D(LNNRE)	0.83	0.83		1.00	0.98	0.90	0.85	0.98
D(LNK)	0.57	0.00	0.98		0.91	0.99	0.98	0.97
D(LNL)	0.03	0.93	0.00	1.00		0.98	0.06	0.79
D(LNINST)	0.35	0.13	0.00	1.00	0.97		0.93	1.00
D(LNCPS)	0.58	0.12	0.91	1.00	0.99	0.91		1.00
D(IMPORT)	0.76	0.01	0.99	1.00	0.95	0.95	1.00	
All	**0.78**	**0.02**	**0.00**	**1.00**	**0.30**	**1.00**	**0.95**	**1.00**

P. values are reported

Note: The Null hypothesis is that the independent variables individually or jointly cannot granger cause RGDP while the Alternative hypothesis is that the independent variables individually and jointly granger cause RGDP. The rejection or acceptance of the Null hypothesis is based on probability values. So that if probability value is more than 5%, the Null hypothesis cannot be rejected.

5.0 Policy Implications and Conclusion

The paper evaluated the causal relationship between renewable and non-renewable energy consumption and economic growth in Nigeria, using quarterly time series data from 1980-2013 and employed Bound Testing approach and Granger causality test based on Vector Auto regressive model VAR.

The ARDL estimates demonstrated that renewable and non-renewable energy consumption and institutional variables have cointegration with Real GDP, as the coefficients portray positive relationship in long-run. The elasticities values show that a unit change in renewable and non-renewable energy increases economic growth by 19.0% and 8%, respectively. For a country whose mainstay is fossil energy, and listed among the countries in Sub-Sahara Africa that have the lowest levels of energy efficiency (Akinlo, 2008), this discovering is important in identifying the forms of renewable energies in which the country is well endowed. This implies that the government should pay more attention to comprehensive research on energy policies (renewable energy sources) as a long term plan that aim at reducing the use of fossil fuel energy for the sake of environmental quality knowing that the all-embracing use of conventional energy sources can no longer be sustained. Furthermore, since the use of renewable energy sources produce less carbon emissions as to the use of fossil fuel, the current study can be improved upon in future by investigating the different sources of renewable energy as a means for diversifying the country’s energy consumption mix for optimal energy efficiency in the country.

The VAR results indicates the existence of a unidirectional causality running from renewable energy and labour to RGDP, supporting the growth hypothesis which implies the importance of renewable energy to economic growth. Similarly, the result also show that NRE is granger caused by RGDP, portraying a unidirectional hypothesis that supports the conservative hypothesis. This implies that energy consumption is determined by economic growth in Nigeria and that it is possible to implement energy conservation polices with little or no effect on economic growth particularly policies geared towards the reduction of Green house gas emissions.

Furthermore, the elasticity results as shown in table 4b indicate that a 1% change in the utilization of the explanatory variables (capital, labour, Institutions and CPS), will bring about a change in economic growth by 82%, 16%, 23% and 46% respectively. Hence, it is clear that economic growth is sensitive to changes in capital, labour, CPS and the institutions. Therefore, the Government should realize its impact on the economy and identify macro-economic policies together with increase investment in physical capita, research and development particularly in human capital and vital improvement in the structure and functioning systems of governance for a more stable economic growth.

Finally, the result of this study may be biased due to circumstances surrounding data collection and availability of data. As energy data in the country are not readily available particularly the renewable energy data. Also, the use and measures of estimated variables in the model with the sources of renewable energy and non-renewable energy. It is also important to note that reasons highlighted above are only suggestive and further studies can be done by employing other methods such as multivariate models for total energy use.

REFERENCE

Akinlo, A.E., (2008), "Energy consumption and economic growth: evidence from 11 Sub-Sahara African countries". Energy Economics 30, 2391–2400 and economic growth in Europe" Energy, 35, (5412-5420)

Alam, M.A., Begum, I.A., Buysse, J. & Huylenbroeck, G.V. (2012). Energy consumption, carbon emissions and economic growth nexus in Bangladesh: Cointegration and dynamic causality analysis. Energy Policy, 45 (2012), 217–225.

Apergis, N. and Payne, J.E., (2009), "CO_2 Emissions, Energy Usage, and Output in Central America" Energy Policy 37, 3282–3286

Apergis, N. and Payne, J.E., (2010a), "Coal Consumption and Economic Growth: Evidence from A Panel of OECD Countries". Energy Policy 38, 1353–1359.

Apergis, N. and Payne, J.E., (2010b), "Energy consumption and economic growth in Central America: Evidence from a panel cointegration and error correction model" Energy Policy, 38, 650–655

Apergis, N. and Payne, J.E., (2011), "The Renewable Energy Consumption–Growth Nexus in Central America" Applied Energy 88, 343–347.

Apergis, N. and Payne, J.E., (2012) "Renewable and Non-Renewable Energy Consumption Growth Nexus: Evidence from A Panel Error Correction Model. Energy Economics"

Bowden, N. and Payne, J.E., (2010), "Sectoral Analysis of the Causal Relationship between Renewable and Non-Renewable Energy Consumption and Real Output in the US. Energy

CBN, (2013), "The Central Bank of Nigeria Report of the Vision 2020 National Technical Working Group on Energy Sector" Published by the Central Bank of Nigeria

Chen W. (2007) "Economic Growth and the Environment in China An Empirical Test of the Environmental Kuznets Curve Using Provincial Panel Data" Xiamen University, Department of Economics China.

Dercon S., (2012) "Is Green Growth Good for the Poor" World Bank Policy Research Working Paper 6231

ECN (2013), "Achieving Renewable Energy Potential in Africa" Energy Commission of Nigeria, Abuja

EIA, (2013), Energy Information Administration, (2013) "International Energy Annual", Energy Information Administration, Washington, DC

Ekpo, H. and Umoh O. 1. (2014) Overview of economic growth and development in Nigeria. In H, Ekpo and O.J. Umoh (Eds) Escaping poverty in Nigeria: A perspective on strategic agendafor Africa. Nigeria: Millennium Text Publishers Limited.

Ewing, B. T., Sari, R.,Soyta, U. (2007).'Disaggregate energy consumption and industrial output in the United States', Energy Policy 35, 1274–128.

Greiner A., Gruene L. and Semmler W., (2014) " Economic Growth and the Transition from Non-renewable to Renewable Energy" Environment and Development Economics, Cambridge University Press (CUP), p.34

Halicioglu, F., (2009). "An Econometric Study of CO2 emissions, Energy Consumption, Income and Foreign Trade in Turkey Energy Policy", 37: 1156-1164

Hamit-Haggar M., (2012) "Greenhouse gas emissions, energy consumption and economic growth: A panel cointegration analysis from Canadian industrial sector perspective" Energy Economics, 34, (358–364)

Huberty M., Gao H., Mandell J., Zysman J., (2011) "shaping the Green Growth Economy" The Berkeley Roundtable on the International Economy

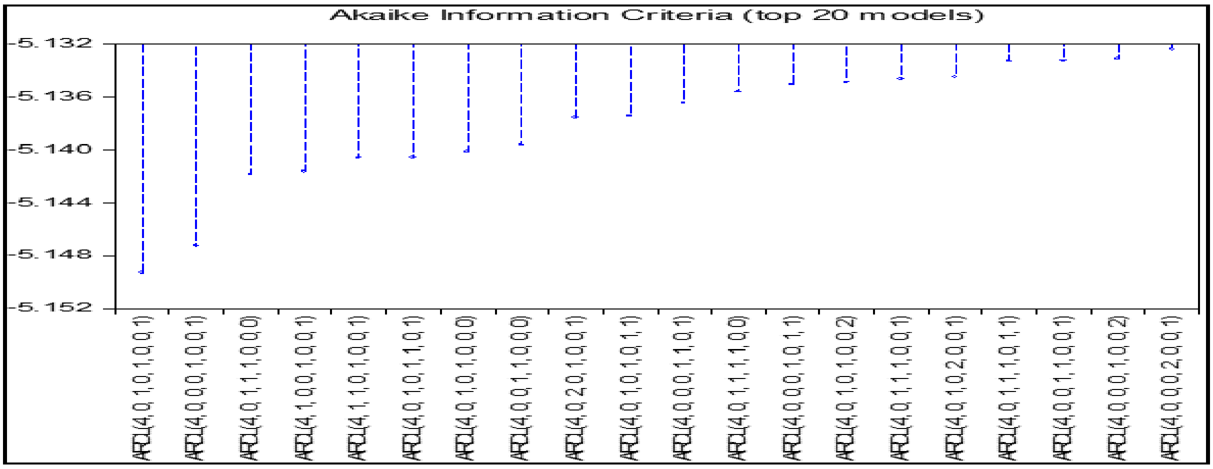
Kraft, J., Kraft, A., (1978) "On the relationship between energy and GNP" Journal of Energy Development 3, 401–403

Lee C. and Chang C., (2007) "The impact of energy consumption on economic growth: Evidence from linear and nonlinear models in Taiwan" Energy, 32, (2282–2294)
Mahadevan, R. and Asafu-Adjaye J., (2007) "Energy consumption, economic growth and prices: A Reassessment Using Panel VECM for Developed and Developing Countries" Energy Policy, 35, (2481–2490)
Mallick H. (2004), "Examining the Linkage Between Energy Consumption And Economic Growth In India" The Journal of Developing Areas, No. 1, Vol. 43
Menyah K. and Wolde-Rufael Y., (2010) "Energy Consumption, Pollutant Emissions and Economic Growth in South Africa" Energy Economics, 32, (1374–1382)
Newman PW, Baum S, Bhatia K, Brown SK, Cameron S, Foran B, et al. Human Settlements in Australian State of the Environment. Melbourne: CSIRO Publishing; 1996 [Ch. 3].
Odhiambo N.M., (2009a) "Electricity consumption and economic growth in South Africa: A Trivariate causality test" Energy Economics, 31, (635-640)
Odhiambo N.M., (2009b) "Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach" Energy Policy, 37, (617–622)
Onakoya A.B., Onakoya A.O., Salami O.A, and Odedairo B.O., (2013) "Energy Consumption and Nigeria Economic Growth: An Empirical Analysis" European Scientific Journal, Vol. 9, No. 4, pg 1857-7881
Ozturk, I., (2010), "A literature survey on energy–growth nexus". Energy Policy 38, 340–349.
Ozturk, I., Aslan, A., Kalyoncu, H., (2010a), Energy Consumption and Economic Growth Relationship: Evidence from Panel Data for Low and Middle Income Countries. Energy Policy, 38, 4422–4428.
Payne J.E., (2009) "On the dynamics of energy consumption and output in the US" Applied Energy, 86, (575–577)
Payne, J., (2010) A survey of the electricity consumption-growth literature. Applied Energy 87,3723-3731.
Pesaran, M., Shin, Y., Smith, R., (2001). "Bounds Testing Approaches to the Analysis of Level Relationships" Journal of Applied Econometrics 16, 289–326
Ramakrishna, G. and Rena R., (2013) "An empirical analysis of energy consumption and economic growth in India: are they causally related?" Studia Oeconomica, 58(2): 22-40
Resnick D., Tarp F. And Thurlow J., (2012) "The Political Economy of Green Growth: Cases from Southern Africa" Public Admin. Dev.32, 215–228
Scott A. et.al., (2013) "Research and Evidence on Green Growth" Oversee Development Institutes for Evidence on Demand, Climate and Environmental Infrastructure on Livelihood.
Shahbaz M. and Zeshan M. and Afza T., (2012) "Is Energy Consumption Effective to Spur Economic Growth in Pakistan? New Evidence from Bounds Test to Level Relationships and Granger Causality Tests" Economic Modelling 29, (2310–2319)
Stern, D. I. (1993), "Energy Use and Economic Growth in the USA, A multivariate approach" Energy Economics, 15, 137–150
Toman M. and Jemelkova B. (2003), "Energy and Economic Development: An Assessment of the State of Knowledge" Resource Paper, Resource for the Future
Tsani, S.Z., (2010) "Energy consumption and economic growth: a causality analysis for Greece" Energy Economics 32 (3), 582–590
Wandji Y.F., (2013) "Energy Consumption and Economic Growth: Evidence from Cameroon" Energy Policy 61, 1295-1304

Wang et.al., (2011), "Energy consumption and Economic Growth in China: A Multivariate Causality Test", Energy Policy 39, 4399-4406

Yildirim E., and Aslan A., (2012) "Energy consumption and economic growth nexus for 17 highly developed OECD countries: Further evidence based on bootstrap-corrected causality tests" Energy Policy, 51, (985–993)

Figure 1: Model Selection



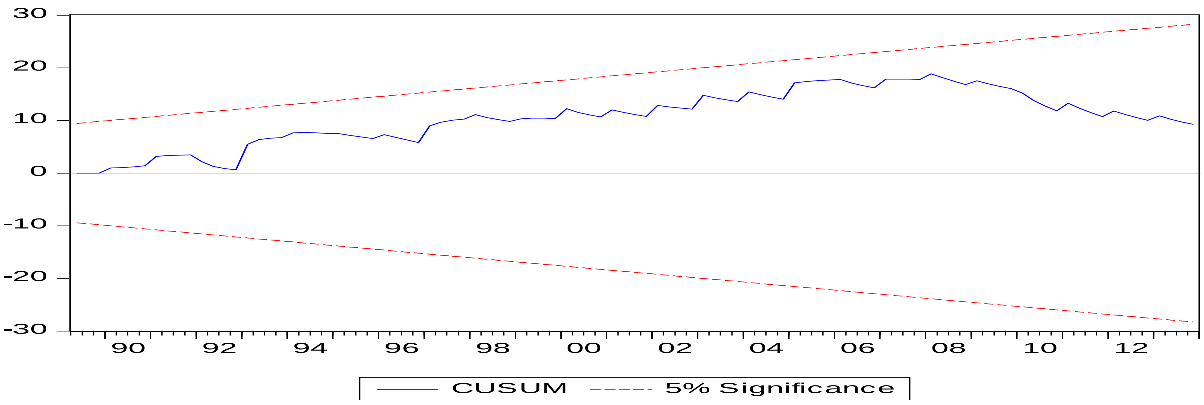


Figure 2a: Stability test: CUSUM

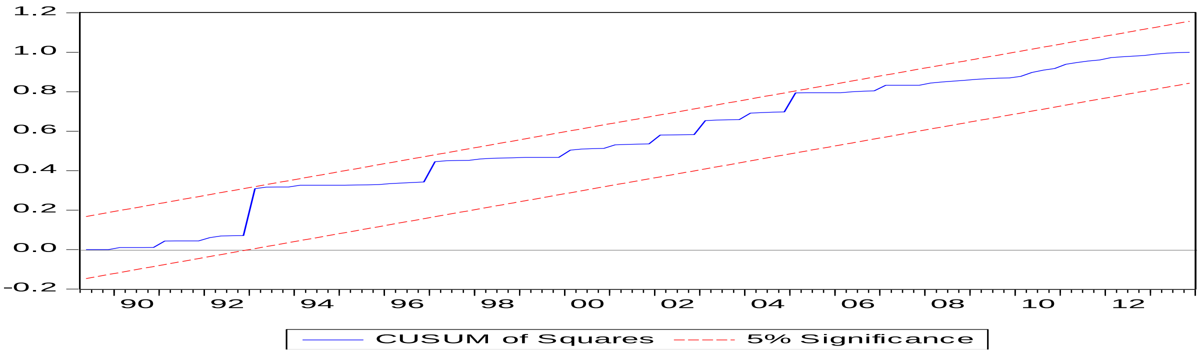


Figure 2b: CUSUMsQ

Figure 3: Plot of actual and fitted residuals model for real output