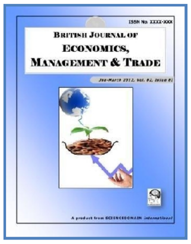

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Empirical Analysis of the Causal Relationship Between Electricity Consumption and Economic Growth in Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author YA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors OJ and WS contributed in the literatures and policy recommendations of the study. All authors read and approved the final manuscript.

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ABSTRACT

This paper investigates the relationship between electricity consumption and real GDP growth in Nigeria during a period of thirty six years (1970-2005). The paper adopts Vector Auto Regressive (VAR) and Error Correction Model (ECM) to test the causality between real GDP and electricity consumption. The order of integration of the two variables was determined using Augmented Dickey Fuller (ADF) test which was followed by co-integration and causality test. The result shows that there is unidirectional causality from real GDP to electricity consumption without a feedback effect. This could be attributed to the low level of electricity consumption, engendered by low level of electricity generation, which is too small to cause economic growth. There is need for government to diversify the energy mix to include all the untapped potentials of renewable power options such as small hydro, wind, solar and biomass among others in all the states and local constituencies. Energy wastages should be curtailed through proper efficiency measures and different pricing system. It is also suggested that government should make policies which will create an enabling environment for the private sector to generate electricity from renewable sources in terms of fiscal incentives such as tax rebate, subsidies and low import duties for the imported equipment among others. Furthermore, there is a need to review the 2003 National Energy Policy so as to come up with a sound, robust and technological

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energy policy that will be able to solve the challenges of the electricity sector. Political commitment through investment in energy infrastructures and capacity building of the citizens in renewable energy technologies are critical towards the improvement of electricity generation, which could then cause electricity consumption to have a significant impact on economic growth in Nigeria.

Keywords: Electricity consumption; causality; renewable energy; technology; government.

1. INTRODUCTION

The energy sector remains very critical towards the development of all other sectors of the economy. There are various energy and environmental challenges facing the entire globe ranging from carbon emission, flood risk, and melting glacier among others. Some countries such as China and India still use coal in large quantities as their major source of energy. This may be as a result of its abundance or cheapness in these locations. Conversely, most of the developed nations are exploring diverse ways of reducing carbon emissions from this energy source. This is due to its catastrophic effects on the global environment as it has been established that energy related CO_2 accounts for almost two-third (2/3) of the total green house gas emission. According to World Energy Outlook [1], approximately 1.5 billion people which represent 22% of the world's population mostly in rural South Asia and Sub-Saharan Africa do not have access to electricity. This trend may continue as 1.3 billion people are projected to still lack access to electricity by the year 2030 despite the widespread of advanced technology. This has made some developing nations engage in policies that could improve their electricity generation to improve their national productivity regardless of the sources.

Many authors have studied not only the correlation and relationship between electricity consumption and economic growth but also the direction of causality between the two variables. The purpose of establishing the causal direction is an important phenomenon in making policy recommendation for the government. This will assist the government in formulating future electricity policies such as investing more in the electricity sector when electricity consumption causes economic growth, or engaging in electricity conservation program when economic growth causes electricity consumption. The causality can be unidirectional or bidirectional. However, no causality can also exist between the two variables. Unidirectional causality can run from electricity consumption to economic growth and vice versa. If causality runs from electricity consumption to economic growth, it means that reduction in electricity consumption in such a country could lead to fall in the economic growth while if it runs from economic growth to electricity consumption, it implies that policies for reducing electricity consumption may be adopted and implemented with little or no adverse effects on economic growth [2,3]. Bidirectional causality shows that increase/decrease in one of them lead to increase/decrease in the other which means that they complement each other. Conversely, no causality between the two variables implies that government can adopt the policy of either increasing or decreasing the electricity consumption and/or economic growth without any negative effect on the other.

Nigerian government has a vision to be among the top 20 economies by the year 2020 and energy sector has been highlighted among the critical areas towards this development. While some Nigerians believed that there is no need for conservation policy as there is low electricity generation in the country, others opined that there are wastages in the household electricity consumption, hence, the need to increase the energy efficiency in various homes and industries without affecting the generating capacity and productivity of the nation. This paper therefore seeks to investigate the causality between electricity consumption and economic growth in Nigeria for the purpose of making sound policy recommendations to the government so as to harness the country's STI capacity and capability building in the power sector towards achieving the national transformation agenda. The remainder of this paper is organised as follows: Section 2 is an overview of electricity situation in Nigeria while related past literature is reviewed in Section 3. Section 4 presents the methodology and data analysis while policy recommendations and conclusion are presented in Section 5.

2. OVERVIEW OF THE NIGERIAN ELECTRICITY SECTOR

There is no doubt that electricity is essential to the socio-economic and technological development of any nation. The history of electricity in Nigeria dates back to 1896 when two generating sets were installed to produce electricity in Lagos, fifteen years after its introduction in England [4]. In the 1950s, the demand for electricity was below its supply and the industry was able to meet the country's need at that period. However, the demand for electricity gradually increased and later outstripped supply as industrialisation set in [5]. Though electricity production has existed for more than a century in Nigeria, yet its development has been very slow. Electricity Corporation of Nigeria (ECN) was established in 1950 to be responsible for electricity supply and development in Nigeria. Niger Dams Authority (NDA) was also established by an act of parliament in 1962. This Authority was responsible for the construction and maintenance of dams and other works on the River Niger and other hydro generating plants. Electricity produced by the NDA was sold to ECN for distribution and sales at utility voltages [6]. In 1972, Nigerian Electric Power Authority (NEPA) was established by the Government by merging ECN and NDA. NEPA has since operated as a government-controlled monopoly responsible for power generation, transmission, and generation. Subsequent to the introduction of the Electric Power Sector Reform Act in 2005, NEPA transformed into the Power Holding Company of Nigeria (PHCN) which was later unbundled into 18 companies, including 6 generators, 11 distributors and 1 transmission company. These companies are responsible to carry out the functions relating to the generation, transmission, trading, distribution and bulk supply as well as resale of electricity [7]. The reform has been able to introduce a new set of players such as the Independent Power Producers (IPPs) and Nigeria Electricity Liability Management Company (NELMCO). The power sector is now regulated by the National Electricity Regulatory Commission (NERC) under the Federal Ministry of Power.

Despite the huge endowment of petroleum resources with estimated reserves of 35 billion barrels and 187 trillion cubic feet of crude oil and natural gas respectively, Nigeria is presently characterized by incessant power shortages and poor power quality. The gap between the electricity demand and supply continues to get wider year on year as industrialisation and population increase. This may be a very good sign for economic growth if the government is able to improve the electricity supply in the country. Approximately 40% of Nigerians have access to electricity [8], with only about 30% of their demands being met. Also, recurrent outages of power supply has forced about 90% of those in the industrial sector and a significant number of household residential customers to provide their own power through different forms of generating sets at a huge cost to themselves and to the Nigerian economy. As at 2010, the estimated total installed capacity of the combined hydro and thermal power stations was 8,000 MW, whereas the power generation capacity available was approximately 4,000MW from both PHCN and IPPs out of which only about 1500 MW was readily available to generate electricity [9]. The source of electricity production in Nigeria over the last 50 years varied from gas-fired, oil-fired, hydroelectric power stations to coal-fired, with hydroelectric power system and gas-fired system taking precedence. According to Sambo [4], large hydroelectric power stations accounted for about 31.30% of grid electricity generation as at 2005 while natural gas power stations accounted for 68.30%. There are three hydro and seven thermal generating stations in Nigeria as at 2011.These have not been operating at full capacity and hence not sufficient to meet the electricity need of the country. Nigeria is said to be blessed with abundant solar and wind energies, which are yet to be fully tapped in generating electricity. This may be due to the failure of past governments to encourage private sectors to utilise science, technology and innovation (STI) in producing electricity from other sources such as wind, solar and coal. Currently, it is estimated that the demand for electricity is above 10,000MW and it is expected to grow in the future. Electricity consumption in Nigeria is among the lowest in the world which is estimated to about 125 Kwh per capita. Fig. 1 below shows the electricity consumption per capita in the Sub-Sahara African (SSA) countries.

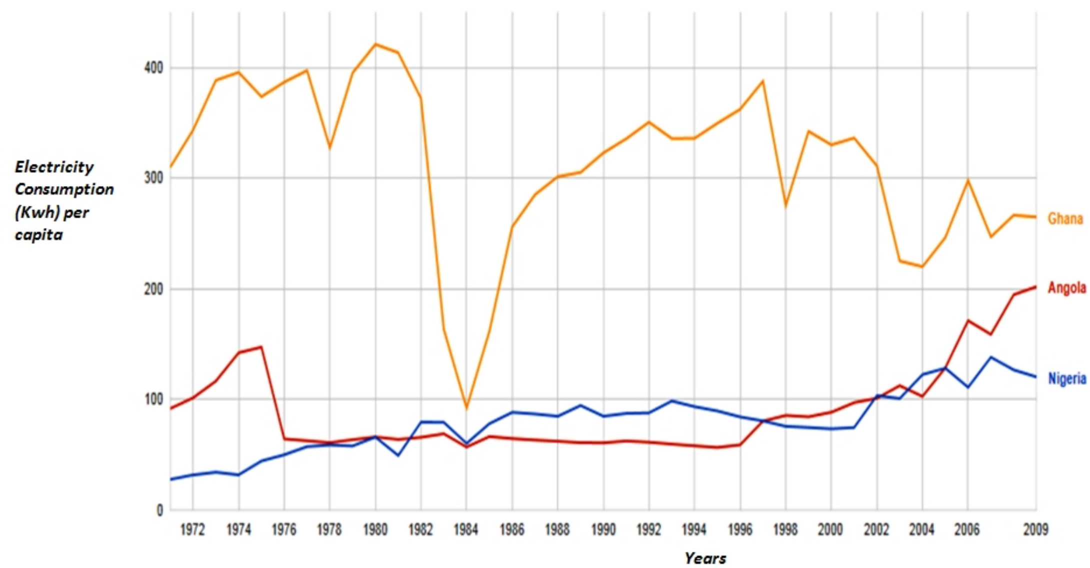

Fig. 1. Electricity Consumption (in Kwh) per capita in selected Sub-Sahara African countries

Source: World Bank Data Bank

Fig. 1 shows that Nigeria has the lowest electricity consumption per capita among the three SSA countries considered. As at 2009, while the electricity consumption per capita of Nigeria was 120.51 Kwh, and that of Ghana and Angola were 265.11Kwh and 202.15Kwh, respectively. Also, Fig. 2 shows the electricity consumption per capita of the BRICS countries vis-a-vis that of Nigeria.

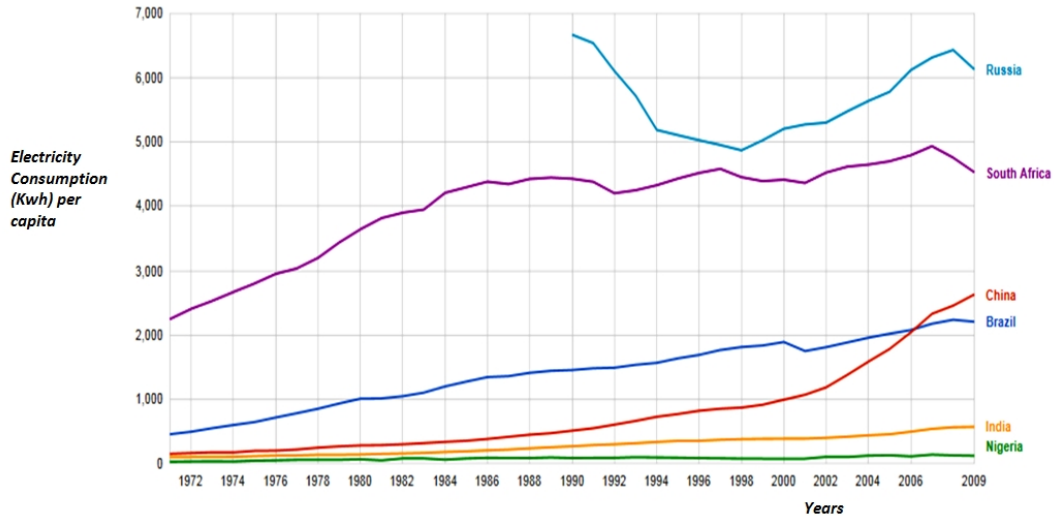

Fig. 2. Electricity Consumption (in Kwh) per capita among the BRICS countries
Source: World Bank Data Bank

Fig. 2 above shows that the level of electricity consumption in each of the BRICS countries (Brazil, Russia, India, China and South Africa) is higher than that of Nigeria. Despite the fact that China and India have the highest population in the world, the electricity consumption per capita in each of them is 2,631.4Kwh and 570.93Kwh respectively as at 2009. Russia has the highest consumption level at 6,132.98 per capita among the BRICS, followed by South Africa, which had 4,532.02Kwh per capita in 2009. This implies that the level of electricity consumption in Nigeria is very low compared with that of the top economies in the world. Thus, Nigeria's electricity sector is facing various challenges which affect the supply and demand of electricity.

The challenges facing the power industry in Nigeria are numerous ranging from generation to distribution of electricity. Ibitoye and Adenikinju [10] stated that ageing power plants, poor maintenance and dearth of funds are some of the factors that could be responsible for the sub-optimal operation in the power sector. Odularu and Okonkwo [11] argued that inefficiency, inadequacy and poor maintenance of facilities to boost electricity supply have also been a major cause of the increasing gap between demand and supply of electricity in Nigeria. Thus, the challenges of the power sector in Nigeria cut across economical, social, political, environmental and technical. The Presidential Task Force on Power Project (PTFP) estimated the sector needs on a yearly basis at least =N=520 billion in Nigeria's currency (equivalent to US$3.5billion) to increase generating capacity from approximately 4000MW to 13000MW by 2013. The transmission network is also facing serious challenges as the network is overloaded with a wheeling capacity less than 4,000 MW. Thus, there are significant line voltage and power losses as high as 25% (compared with 3% in the US and 0.5% in Japan), in the transmission systems due to the large average distances between 300 and 500km over which electrical energy is distributed [12]. The Nigerian government is currently committed to improving the performance of the power sector by providing an enabling environment for private investors. This includes an upward revision of the power tariff within the multi-year tariff order (MYTO) to a cost reflective upper limit on end user tariffs. Recently, a number of potential private investors have been selected through a competitive bidding process for all the successor companies so as to ensure proper privatisation of the unbundled entities.

3. LITERATURE REVIEW

This section reviews the literature on the causal relationship between electricity consumption and economic growth across the globe. It is important to note that there is a lack of consensus from various studies that electricity consumption caused economic growth or vice versa. This may be due to the different methodology adopted by various authors and the scope of the data.

The work of Kraft and Kraft [13] was among the earliest studies in this area. They used annual data of gross national product and energy consumption of the United States between the year 1947 and 1974. It was found that there was a strong unidirectional causality running from gross national product to energy consumption. Hence, they concluded that the level of economic activities may influence energy consumption, but the level of gross energy consumption has no causal influence on economic activities. Virtually the same set of data with just an additional five years between 1947 and 1979 for the United States was used by Yu and Hwang [14] and they found that no causality exists between energy consumption and gross national product over the sample period. Aqeel and Butt [15] ran cointegration analysis on energy and economic growth in Pakistan. The study found that increase in electricity consumption in developing countries like Pakistan leads to economic growth rather than the other way round. Altinay and Karagol [16] investigated causal relationship between electricity consumption and economic growth in Turkey for the period between 1950 and 2000. The Granger causality test conducted showed strong evidence of unidirectional causal relationship running from electricity consumption to GDP growth. Yang [17] found bidirectional causality between electricity consumption and economic growth in Taiwan. Gurgul and Lach [18] using quarterly data of Poland from year 2000 to 2009 found a feedback between total electricity consumption and GDP as well as between total electricity consumption and employment. Also, Yoo [19] investigated both short and long run causal relationship between electricity consumption and economic growth in the Korean Republic. He made use of cointegration and error correction procedures and found out that there exists bidirectional causal relationship between electricity consumption and economic growth in the Korean economy. This implies that growth in electricity consumption directly promotes economic growth through expansion in energy-dependent economic activities and sustained economic growth in the process also stimulates electricity consumption. Shiu and Lam [20] showed that real GDP and electricity consumption in China are cointegrated and also found unidirectional Granger causality running from electricity consumption to real GDP growth. Also, [21] used cointegration and error correction model to examine the causal relationship between electricity consumption and economic growth of China between the period 1953 and 2003. Their study showed that real GDP and electricity consumption in China are cointegrated, and unidirectional causality ran from electricity consumption to real GDP growth. Lean and Smyth [22] examined the causal relationship between economic growth, electricity generation, exports and prices in Malaysia using multivariate model. One of the major findings of the paper was that there was unidirectional Granger causality running from economic growth to electricity generation which implies that electricity conservation policies designed to reduce the wastage of electricity can be implemented without having an adverse effect on the economic growth of Malaysia. Also, [23] employed annual data from 1971 to 2006 taking into consideration output, electricity consumption, exports, labour and capital in a multivariate model for Malaysia. They include other relevant variables like labour and capital because most of the bivariate frameworks are likely to be biased due to the omission of relevant variables from the study. Their study found bidirectional causality running between aggregate output and electricity consumption. Hence, they recommended that Malaysia should adopt the dual strategy of increasing investment in electricity infrastructure and stepping up electricity conservation policies to lessen the unnecessary wastage of electricity. Moreover, the result is similar to that of [24] who also found a bidirectional relationship between electricity consumption and economic growth in Pakistan.

Chen, Kuo and Chen [25] estimated the relationships between GDP and electricity consumption in 10 newly industrializing and developing Asian countries using both single data sets and panel data procedures. The empirical results from single data sets indicate that the causality directions in the 10 Asian countries are mixed while there is a unidirectional short-run causality running from economic growth to electricity consumption and a bi-directional long-run causality between electricity consumption and economic growth if the panel data procedure is implemented. They therefore concluded that electricity conservation policies through both rationalizing the electricity supply efficiency improvement to avoid the wastage of electricity and managing demand side to reduce the electricity consumption without affecting the end-user benefits could be initiated without adverse effect on economic growth in most of the countries studied. Also, Wolde-Rufael [26] tested long-run causal relationship between electricity consumption per capita and real gross domestic product (GDP) per capita for 17 African countries for the period 1971 to 2001. The study employed cointegration and Granger causality test. The results showed that there exists a long-run relationship between electricity consumption per capita and real GDP per capita among 9 of the countries studied and Granger causality for 12 countries out of the 17 studied. Unidirectional causality running from real GDP per capita growth to electricity consumption per capita was found for 6 countries and the reverse for 3 of the countries. Thus, despite the evidence of long-run relationship between economic growth and electric energy consumption, direction of causality could vary significantly.

Kouakou [27] investigated the relationship between the growth of economic activities and electricity consumption in Cote d'Ivoire using data from 1971 to 2008. GDP per capita and industry value added were used to measure economic activities. The empirical results, through cointegration and an error correction model, indicated that there is a relationship between economic growth and electricity consumption and there is a bidirectional relationship running from electricity consumption to economic growth and from economic growth to electricity use in the short run while the long run estimates show that there is a unidirectional causality running from electricity consumption to economic growth. Consequently, a shortfall in the supply of power will certainly impair economic activities in the country. Yuan et al. [28] applied the cointegration theory to examine the causal relationship between electricity consumption and real GDP for China during 1978–2004 and the estimation results indicate that real GDP and electricity consumption for China are cointegrated and there is only unidirectional Granger causality running from electricity consumption to real GDP but not vice versa.

Akinlo [29] showed that real GDP and electricity consumption in Nigeria are co-integrated using the data between 1980 and 2006 and there is only unidirectional Granger causality running from electricity consumption to GDP. Ighodaro [30] also established that causality ran from electricity consumption to economic growth as well as from gas utilization to economic growth while it ran from economic growth to domestic crude oil production. Emeka [3], however, using annual data covering the period 1978 to 2008 estimated that real GDP and electricity consumption for Nigeria are co-integrated and there is unidirectional Granger causality running from real GDP to electricity consumption with no feedback effect.

4. METHODOLOGY AND DATA ANALYSIS

This Section presents the methodology and analysis of the causality between electricity consumption and GDP growth.

4.1 Methodology

This paper adopted Vector Auto regressive (VAR) and Error Correction Model to test the causality between real GDP and electricity consumption in Nigeria. The order of integration of the two variables was determined using Augmented Dickey Fuller (ADF) test. This is followed by co-integration, and then causality test. These tests are explained below.

4.1.1 Stationary test, cointegration and granger causality test

A stationary time series refers to the series with a constant mean, constant variance, and constant autocovariances for each given lag (Brooks, 2008). The use of non-stationary data usually leads to spurious regressions. Thus, there is need to conduct a unit root test to determine the order of integration of the variables using the Augmented Dickey Fuller test [31]. The Augmented Dickey Fuller regression

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + U_t$$

Where:

$\Delta Y_t = Y_t - Y_{t-1}$ is the difference of series Y_t

α0, γ, βi, are parameters to be estimated and Ut is a stochastic error term. The null hypothesis of non stationarity (Presence of unit root) is accepted if γ = 0, while the null hypothesis of non stationarity is rejected if γ <0. This implies that if H0 cannot be rejected, then the series has a unit root but if otherwise, then the series does not have a unit root. When time series data contain unit root, it is necessary to remove the unit root by differencing the data by *d* times in order to make them stationary i.e I*(d)*. When both series are integrated of the same order, then the presence of cointegration could be examined. Though many time series data are non-stationary but move together over time which means that the two series are bound by some relationship in the long run. Thus, a linear combination of two or more non-stationary series which have the same order of integration may be stationary [32], and when such a stationary linear combination subsists, the series are considered to be cointegrated and long-run equilibrium relationships exist. However, if there were no cointegration, there would be no long-run relationship binding the series together, so that the series could wander apart without bound [33]. Since all linear combinations of the series would be non-stationary and hence would not have a constant mean that would be returned to.

Granger causality test has been widely used in related literatures to determine the direction of causality between one variable and another. The Granger [34] test states that, if past values of a variable Y significantly contribute to forecast the value of another variable X, then Y is said to Granger cause X and vice versa, but if the past values of both variables significantly contribute to forecast each other, then it results to bi-directional causality. This can be shown in the equations below.

$$Y_t = \gamma_0 + \sum_{z=1}^{p} \gamma_z Y_{t-z} + \sum_{i=1}^{q} \lambda_i X_{t-i} + \mu_t \qquad \text{Eq.... 1}$$

$$X_t = \varphi_0 + \sum_{z=1}^{p} \delta_z X_{t-z} + \sum_{i=1}^{q} \psi_i Y_{t-i} + \varepsilon_t \qquad \text{Eq.... 2}$$

From the two equations above, Y_t and X_t represent the two main variables in the equations, $\gamma 0$ and φ_0 are the intercepts, μ_t and ε_t are respective error terms, t denotes time period, while z and i are the number of lags. The null hypothesis is $\lambda_i = \psi_i = 0$ for all i's versus the alternative hypothesis that $\lambda_i \neq 0$ and $\psi_i \neq 0$. If the coefficient λ_i is statistically significant but ψi is not then X causes Y, whereas if ψ_i is statistically significant but λ_i is not then Y causes X. But if both coefficients are significant then causality runs both ways [34,30]. Applying the error correction framework, one may determine the direction of causation between observed variables while providing estimates on both long run and short run pattern. Co-integration provides information about the long run relation among the variables while Granger causality tests provide information on short run dynamics. This can be captured via ECM as stated below:

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_t + \beta_2 (y_{t-1} - \gamma x_{t-1}) + u_t \qquad \text{Eq.... 3}$$

According to Brooks [33], $\boldsymbol{y}_{t-1} - \gamma \boldsymbol{x}_{t-1}$ in the equation above is known as the error correction term. If $\boldsymbol{y}_t$ and $\boldsymbol{x}_t$ are both I(1) and cointegrate, then all elements at RHS of the equation 3 are stationary i.e I(0). ***y*** is purported to change between t −1 and t as a result of changes in the values of the explanatory variable(s), ***x***, between t − 1 and t, and also in part to correct for any disequilibrium that existed during the previous period. The error correction term in eq. 3 appears with a lag. It would be implausible for the term to appear without any lag. γ defines the long-run relationship between ***x*** and ***y***, while β1 describes the short-run relationship between changes in ***x*** and changes in ***y***. Broadly, β2 describes the speed of adjustment back to equilibrium, and measures the proportion of last period's equilibrium error that is corrected for and its value is expected to be negative ($\beta 2 < 0$).

4.2 Data Analysis

The annual data used in this study are sourced from the Central Bank of Nigeria statistical bulletin from 1970 to 2005. The real GDP and electricity consumption are expressed in terms of =N= millions (Nigeria currency in millions) and Megawatts per hour respectively. Meanwhile, they are both further expressed in terms of natural logarithms where real GDP is LRGDP and electricity consumption is LELEC. The choice of the starting period was constrained by the availability of data on electricity consumption. All the tests in this paper are conducted with EViews 7. Table 1 below shows the result of the unit root test of both real GDP and electricity consumption in logarithmic form.

Table 1. Unit Root tests of real GDP and electricity Consumption

Unit root tests of real GDP and electricity consumption						
ADF test						
Variables	**Level**			**First Difference**		
	t-stat.	p-value	Remark	t-stat.	p-value	Remark
LRGDP	-2.173	0.2192	Contains unit root	-5.4511	0.0001	No unit root
LELEC	-1.878	0.3381	Contains unit root	-8.2998	0.0000	No unit root
Test Critical Values						
1% level	-3.6394					
5% level	-2.9511					
10% level	-2.6143					

Table 1 displays the results of the ADF tests on the level of integration of the two series and it shows that each of the series was not stationary at level since p-values of ADF test calculated for the two series are larger than 0.10. This indicates that the series of all the variables are non-stationary at 10% level of significance and thus any causal inferences from the two series in levels are invalid. However, after differencing it once, the series become stationary, and the null hypothesis of non-stationary is rejected. This implies that the variables are individually integrated of order one or I(1). Having ascertained the stationary position of the variables and the integration of the two series to be of the same order, this study forged ahead to examine the existence of co-integration between the variables. Table 2 below shows the result of the co-integration using the Engle-Grangler test.

Table 2. Cointegration test between real GDP and electricity consumption

Cointegration Test - Engle-Granger		
Null hypothesis: Series are not Cointegrated		
Specification: LRGDP LELEC C		
	Value	**P-value**
Engle-Granger tau-statistic	-4.1217	0.0129
Engle-Granger z-statistic	-23.9801	0.0066
*MacKinnon (1996) p-values		

From Table 2, the result shows that the null hypothesis, which states that the series are not co-integrated, is rejected given the p-value at 10% level of significance. The results in Table 2 and appendix 2 indicate that the integrated variables have inherent comovement tendency over the long run. Electricity consumption and real GDP are therefore co-integrated and this implies that there is a long-run relationship between electricity consumption and real GDP for Nigeria. Though the result shows that the variables are cointegrated, the direction of causality was not shown. Thus, Granger causality test was conducted through VAR/ Exogeneity Wald test in order to determine the direction of causality as displayed in Table 3.

Table 3. Granger Causality test between real GDP and electricity consumption

VAR Granger Causality/Block Exogeneity Wald Tests		
Variables	**Chi-sq**	**p-values**
DLRGDP does not Granger cause DLELEC	19.45241	0.0001
DLELEC does not Granger cause DLRGDP	3.682984	0.1586

The result shows that the null hypothesis that real GDP does not Granger cause electricity consumption is rejected but the null hypothesis that electricity consumption does not Granger cause real GDP cannot be rejected. Contrary to a priori, the result implies that there is unidirectional causality from real GDP to electricity consumption without a feedback effect. This is similar to the result obtained by Kraft and Kraft [13] for USA; Wolde-Rufael [26] for Nigeria; Abaidoo [35] for Ghana, among others. This means that the past values of economic growth is useful to forecast the value of electricity consumption in Nigeria, whereas the past values of electricity consumption are not useful in forecasting the value of economic growth. This might be as a result of the low level of electricity consumption in Nigeria which makes it insignificant in Granger causing economic growth. The available electricity generating capacity of approximately 4,000 MW is too low to cater for a population of almost 160 million. The low level of electricity generation leads to the low level of electricity consumption of about 120Kwh. There is need for government to diversify the energy mix to include all the renewable power options such as small hydro, wind, solar and bio mass among others. Nigeria has huge untapped potentials of renewable energies. Small hydro plants can be developed in the entire 36 states of the country as well as every local government in each state to generate electricity for their local dwellers since there is a large number of dams and rivers within the country. Government, through an agency like NASENI, can provide solar Photo Voltaic to generate electricity especially for the rural dwellers and also create an enabling environment for privately owned firms to operate. Government's support through funding, capacity building and fiscal incentives remain the key driver for renewable energies [1]. Thus, steady investment in energy infrastructures and capacity building of the citizens in renewable energy technologies are critical towards the improvement of electricity generation and consumption in Nigeria. It is believed that once the level of electricity generation and consumption improve drastically, then electricity consumption will be significant enough to cause GDP growth.

ECM model corroborates the long run causality between the electricity consumption and economic growth as the coefficient of the error correction term (ECT) is found to be significant in the real GDP equation which indicates that given any deviation in the ECT, both variables in the ECM would interact in a dynamic fashion to restore long-run equilibrium (see Appendix 4).The value of the ECT is -0.015 in the model suggesting that a deviation from the long run equilibrium level of the GDP in one year is corrected by about 1.5% the next year.

5. CONCLUSION AND POLICY RECOMMENDATION

This paper has investigated the relationship between the economic growth and electricity consumption in Nigeria using data from 1970 to 2005. Time series data were presented and analysed through ADF, co-integration, VAR and an error correction model. The study found that the series are Non stationary at levels and the unit roots of the series were removed by differencing the series through the ADF test. The empirical results indicate that there is a long run relationship between economic growth and electricity consumption, and the results established the existence of Granger causality running from economic growth to electricity consumption without any feedback effect which is similar to few of the results obtained by some authors in the past.

This study provides some recommendations which could assist the government in policy formulation and implementation. The causality from economic growth to electricity consumption shows that the level of electricity consumption in Nigeria in the past was infinitesimal that it couldn't cause economic growth. Thus, the present growth in the Nigerian economy does not exclusively rely on the level of electricity consumption. So, conservation policy through efficient and proper management of new energy technologies in all sectors of the economy might not affect economic growth. This means that continuous growth of the economic activities in the country will invariably improve the level of electricity consumption. On the other hand, though government is in the right direction of deregulating the electricity market so as to allow private sectors to run it in a competitive manner, there is need for the government to also invest in R&D and capacity building in the area of renewable energy technologies. The competition in the electricity sector is expected to stimulate economic growth in the long run. The Nigerian government needs to also be committed to investing in the renewable energy technologies in harnessing STI to generate electricity from renewable sources such as wind, solar, and biomass among others. It is also recommended that the government should provide policies which will create an enabling environment for the private sector to generate electricity from renewable sources. These policies might be in terms of fiscal incentives such as tax rebate, subsidies, and lower import duties for the imported equipment among others. This will reduce the extent of carbon emissions and energy poverty. Furthermore, there is a need to review the 2003 National Energy Policy even though most of the actions in that policy are yet to be implemented. A sound, robust, technological and implementable energy policy that will be able to solve the challenges of the electricity sector should be formulated and implemented in order to make the sector to start having more impact on the economy.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Appendix 1: Unit root test of real GDP and electricity consumption in Nigeria

Null Hypothesis: LELEC has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.878303	0.3381
Test critical values:	1% level	-3.639407	
	5% level	-2.951125	
	10% level	-2.614300	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LELEC)
Method: Least Squares
Date: 09/19/12 Time: 15:45
Sample (adjusted): 1972 2005
Included observations: 34 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LELEC(-1)	-0.088115	0.046912	-1.878303	0.0698
D(LELEC(-1))	-0.366478	0.157347	-2.329105	0.0265
C	0.671368	0.308171	2.178559	0.0371

R-squared	0.218033	Mean dependent var	0.068715
Adjusted R-squared	0.167584	S.D. dependent var	0.173090
S.E. of regression	0.157922	Akaike info criterion	-0.769337
Sum squared resid	0.773118	Schwarz criterion	-0.634658
Log likelihood	16.07872	Hannan-Quinn criter.	-0.723407
F-statistic	4.321814	Durbin-Watson stat	2.070551
Prob(F-statistic)	0.022101		

Null Hypothesis: D(LELEC) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.299800	0.0000
Test critical values:	1% level	-3.639407	
	5% level	-2.951125	
	10% level	-2.614300	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LELEC,2)
Method: Least Squares
Date: 09/19/12 Time: 15:47
Sample (adjusted): 1972 2005
Included observations: 34 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LELEC(-1))	-1.355644	0.163335	-8.299800	0.0000
C	0.095189	0.030648	3.105897	0.0040

R-squared	0.682812	Mean dependent var	-0.005726
Adjusted R-squared	0.672900	S.D. dependent var	0.286822
S.E. of regression	0.164041	Akaike info criterion	-0.720376
Sum squared resid	0.861104	Schwarz criterion	-0.630590
Log likelihood	14.24639	Hannan-Quinn criter.	-0.689756
F-statistic	68.88668	Durbin-Watson stat	2.049155
Prob(F-statistic)	0.000000		

Null Hypothesis: LRGDP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.173115	0.2192
Test critical values:	1% level	-3.632900	
	5% level	-2.948404	
	10% level	-2.612874	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LRGDP)
Method: Least Squares
Date: 09/19/12 Time: 15:48
Sample (adjusted): 1971 2005
Included observations: 35 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LRGDP(-1)	-0.086317	0.039720	-2.173115	0.0371
C	1.140335	0.464093	2.457123	0.0194

R-squared	0.125189	Mean dependent var	0.139765
Adjusted R-squared	0.098679	S.D. dependent var	0.362606
S.E. of regression	0.344251	Akaike info criterion	0.760553
Sum squared resid	3.910785	Schwarz criterion	0.849430
Log likelihood	-11.30968	Hannan-Quinn criter.	0.791233
F-statistic	4.722429	Durbin-Watson stat	2.020882
Prob(F-statistic)	0.037051		

Null Hypothesis: D(LRGDP) has a unit root

Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.451138	0.0001
Test critical values:	1% level	-3.639407	
	5% level	-2.951125	
	10% level	-2.614300	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LRGDP,2)
Method: Least Squares
Date: 09/19/12 Time: 15:49
Sample (adjusted): 1972 2005
Included observations: 34 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LRGDP(-1))	-0.963557	0.176763	-5.451138	0.0000
C	0.135428	0.068796	1.968555	0.0577

R-squared	0.481487	Mean dependent var	-0.001417
Adjusted R-squared	0.465283	S.D. dependent var	0.510751
S.E. of regression	0.373483	Akaike info criterion	0.925135
Sum squared resid	4.463668	Schwarz criterion	1.014920
Log likelihood	-13.72729	Hannan-Quinn criter.	0.955754
F-statistic	29.71491	Durbin-Watson stat	1.989213

Appendix 2: Cointegration test between real GDP and electricity consumption

Dependent Variable: LRGDP
Method: Fully Modified Least Squares (FMOLS)
Date: 09/19/12 Time: 15:52
Sample (adjusted): 1971 2005
Included observations: 35 after adjustments
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LELEC	2.235314	0.187405	11.92769	0.0000
C	-2.882748	1.234122	-2.335869	0.0257

R-squared	0.855086	Mean dependent var	11.73161
Adjusted R-squared	0.850695	S.D. dependent var	1.399769
S.E. of regression	0.540871	Sum squared resid	9.653885
Durbin-Watson stat	1.372577	Long-run variance	0.433030

Cointegration Test - Engle-Granger
Date: 09/19/12 Time: 15:54
Equation: EQ01_COINT
Specification: LRGDP LELEC C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated
Automatic lag specification (lag=0 based on Schwarz Info Criterion, maxlag=8)

	Value	Prob.*
Engle-Granger tau-statistic	-4.121731	0.0129
Engle-Granger z-statistic	-23.98014	0.0066

*MacKinnon (1996) p-values.

Intermediate Results:	
Rho - 1	-0.685147
Rho S.E.	0.166228
Residual variance	0.252357
Long-run residual variance	0.252357
Number of lags	0
Number of observations	35
Number of stochastic trends**	2

**Number of stochastic trends in asymptotic distribution.

Engle-Granger Test Equation:
Dependent Variable: D(RESID)
Method: Least Squares
Date: 09/19/12 Time: 15:54
Sample (adjusted): 1971 2005
Included observations: 35 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.685147	0.166228	-4.121731	0.0002

R-squared	0.332639	Mean dependent var	-0.017347
Adjusted R-squared	0.332639	S.D. dependent var	0.614932
S.E. of regression	0.502351	Akaike info criterion	1.489121
Sum squared resid	8.580131	Schwarz criterion	1.533560
Log likelihood	-25.05962	Hannan-Quinn criter.	1.504461
Durbin-Watson stat	1.994999		

Appendix 3: Granger causality test

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 10/05/12 Time: 13:21
Sample: 1970 2005
Included observations: 33

Dependent variable: DLELEC

Excluded	Chi-sq	df	Prob.
DLRGDP	19.45241	2	0.0001
All	19.45241	2	0.0001

Dependent variable: DLRGDP

Excluded	Chi-sq	df	Prob.
DLELEC	3.682984	2	0.1586
All	3.682984	2	0.1586

Appendix 4: ECM model

Dependent Variable: DLRGDP
Method: Least Squares
Date: 09/19/12 Time: 16:04
Sample (adjusted): 1973 2005
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLRGDP(-1)	0.611128	0.201822	3.028060	0.0052
DLRGDP(-2)	-0.126799	0.300889	-0.421415	0.6767
DLELEC(-1)	0.341624	0.684456	0.499118	0.6216
DLELEC(-2)	-0.250972	0.352063	-0.712861	0.4818
RESID01(-1)	-0.481205	0.185232	-2.597852	0.0148

R-squared	0.251677	Mean dependent var	0.143746
Adjusted R-squared	0.144774	S.D. dependent var	0.373268
S.E. of regression	0.345192	Akaike info criterion	0.849296
Sum squared resid	3.336411	Schwarz criterion	1.076039
Log likelihood	-9.013377	Hannan-Quinn criter.	0.925588
Durbin-Watson stat	1.900405		

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