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The Causality BetweenElectricity Consumption and Economic growth for Nigeria: A Time Varying Framework

Abdulwahab Hassan Yusuf,[1]OnisanwaIdowu Daniel,[2]Kanadi Charles[3]

[1,2& 3]*Department of Economics and Development studies, Federal University of Kashere, Gombe, Nigeria*

Abstract

The relationship between electricity consumption and economic growth is vital to an understanding of the dynamics of economic growth and development. A perspective in the literature suggest that there is apositive association between electricity consumption and economic growth, implying that the economy cannot grow at a rate much higher than the rate of increase in the electricity supply. This study employs the state of the art econometric approach to investigate whether the relationship is time varying. The results of non-linear unit root test suggest that real GDP is stationary at levels, while electricity consumption is integrated of order (1) as such cointegration test is not valid when a time series is stationary. Further, whether energy variable has unit root has implications for the correct modelling of energy and economic growth. The results of the Granger causality test using F statistics finds evidence supporting the neutrality hypothesis, implying an absence of causality. In this case, fluctuations in economic growth will not be transmitted back to electricity consumption. The absence of causality further points us to the fact that a reduction in electricity consumption through energy conservation policies will not impact economic growth.

Keywords: Electricity, Consumption, Economic Growth
JEL Codes:E20, E21

Introduction

The relationship between electricity consumption and economic activity has been generously investigated in the literature because the growth rate of electricity consumption has important implications for economic activities and public policy.Outcomes from several studies give the impression that there is a positive association between electricity consumption and economic growth, implying that the economy cannot grow at a rate much higher than the rate of increase in the electricity supply. This relationship: whether electricity consumption drives real GDP is essential for electricity conservation policies (Olaniyan, McLellan, Ogata, & Tezuka, 2018). The broad acknowledgement of the union between electricity and the production and consumption of goods and services prompted the prominence of energy outcome in the sustainable Development Goals (SDGs). In fact Goal 7 entails ensuring universal access to affordable electricity by 2030, which calls for investment in clean energy sources like wind, thermal and solar. Infrastructural development and technological advancement are necessary tools in the provision of clean energy in all less developed countries that can result in growth and aid the environment. This paper,therefore, re-investigates the relationship between electricity use and economic activity covering the period of 1970-2014. This would better make us understand the perspective in the literature that suggest that when the economy is expanding, the electricity sector is driven to supply more energy to meet the demand and also when the economy slows down, the electricity sector will be under pressure to reduce its supply in response to less demand.Althoughthe mechanisms that drive the relationship are full of controversies. However,so long as we do not understand these controversies we do not have a clear idea of the actual relationship.For instance, high consumption of electricity usually boosts power producers income and is seen as a medium of advancing economic growth of a country. At the same time electricity generation using fossil fuels may add to pollution and other environmental woes.Therefore, allocating resourcesto electricity production is an important issue in many resource constraint countries. In order to improve our understanding, this study utilizes Error Correction Model (ECM) and causality approach so as to identify the special causal relationship between electricity use and economic activity since 1970.

The outline of the paper is structured as follows: Section 2 presents the contextual setting; Section 3 presents a brief review of related literature; section 4 presents the methodological framework; Section 5 presents the results of the bi-variate model; finally, section 6 consist of further discussion and the overall concluding remarks, respectively.

Contextual Setting

This section documents electricity consumption and economic growth trends in Nigeria. Nigeria is the largest economy in sub-Saharan Africa, but adequate, reliable electrical service which is important for economic growth has been elusive.Besides inadequate supply which is linked to the poor performance of the electricity supply, transmission line constraint has also been responsible for the poor electricity consumption in Nigeria.Recently the nations power plants experienced a reduced output by about 3,118 megawatt as a result of transmission line constraint and low demand by electricity distribution companies.

Demand for electricity has been on the increase but available generation from the national grid averages 3,8578.28 MW/h (Central Bank of Nigeria, 2017). A significant part of the rising demand is met by onsite generating sets which are primarily fueled by petrol and diesel.

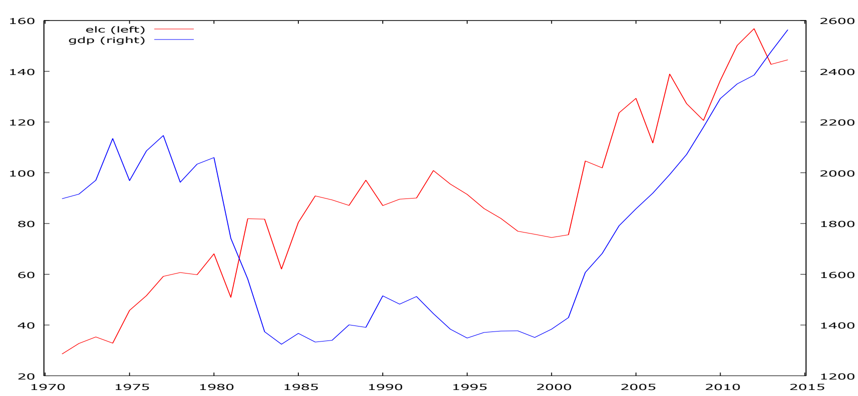


Figure 1, highlights important trend. First it shows that electricity consumption grew 13.7 per cent from 1972-1977 at a time when the economy grew by just 2 per cent. Meanwhile from 1990-1995, electricity consumption seemed to grow in lockstep with the GDP, both recording negative growth rate of -0.73 per cent and -0.40 percent.However from 2002 to 2007, the GDP grew 5.74 per cent as electricity consumption jumped 12 per cent. From that year, it seems then, that GDP growth correlated with electricity consumption.

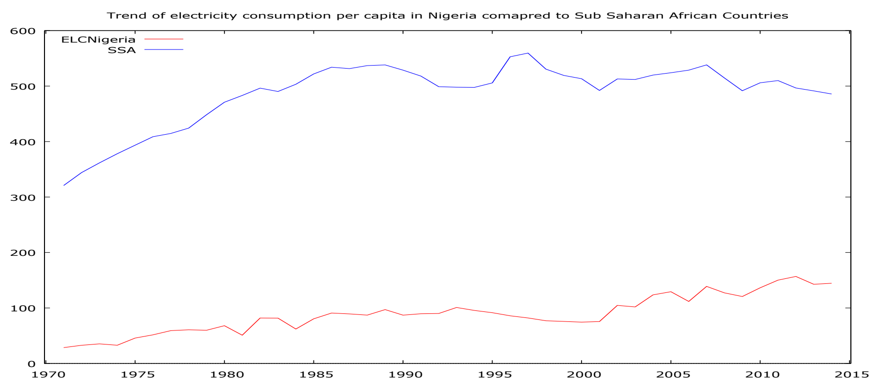


Figure 2, highlights important trends. First, Nigeria is electricity poor in comparative perspective despite her vast natural resources. Second, the national average has been significantly below the average for the group of Sub Saharan African countries. This trend is disturbing because the economy cannot grow at a rate much higher than the rate of increase in the electricity supply (Hirsh & Koomey, 2015). As a result of poor electricity services, Nigeria is the largest African importer of diesel generators, and back-up diesel generation cost households and business almost $22 billion per year in fuel cost alone (WEO, 2017). This practical problem leads us yet to another important issue which is the environmental woes that may arise from construction of conventional generating plants to meet rising demand of electricity. Additionally, the nation generates the bulk of its electricity from gas-fired power plants which contributes to rising level of Green House Gases. Emissions have profound impact on health and climate. Additionally,most gensets contribute to noise pollution which further reduces the quality of life of users and non-users.

Literature Review

The literature on electricity and growth nexus has attempted to find an answer as to whether electricity consumption drives growth or growth drives electricity consumption. Although one cannot dispute the claim that electricity use has brought about expanded business activity and will likely continue to do so in the future. A reflection upon the history of this relationship demonstrates that it has been more variable than people have assumed (Hirsh & Koomey, 2015). From this perspective, there are four lines of arguments with respect to the causal relationship between energy consumption and economic growth. For a detailed review of the 4 hypotheses see Apergis and Payne (2011). The hypotheses on the causal relationship between consumption of energy and economic growth are; Energy-led-Economic Growth hypothesis, Economic Growth-led-Energy theory, Energy-led-Economic Growth-led-Energy hypothesis, as well as the Growth-Energy Neutrality theory.

The Energy-led-Economic Growth hypothesis postulates a unidirectional causation from energy consumption to the growth of the economy. This means a poor or inadequate supply of energy can dampen economic growth. The Economic Growth-led-Energy theory states that the growth of an economy leads to rising demand for electricity and not the other way round. This tends to suggest adverse energy condition will not constraint economic growth. The Energy-led-Economic Growth-led-Energy hypothesis implies a feedback relationship, where energy consumption and economic growth are importantly causing each other. Finally, the neutrality hypothesis assumes absence of causal relation between energy consumption and economic growth.

Several empirical evidence abounds on the relationship between energy and economic growth. However, the reviewed literatures on the causal relationship between electricity consumption and economic growth, showed varied and inconsistent empirical information in relation to electricity consumption and economic growth nexus.

Based on the four hypotheses advanced, there are four empirical evidences on the causal relationship between electricity consumption and economic growth.
First, is the empirical evidence on the electricity-led-growth hypothesis.For instance,Dantama, Abdullahi, and Inuwa (2012) investigate the effect of energy demand on economic growth in Nigeria using autoregressive distributed lag (ARDL) approach to cointegration analysis. The study reported a long-run relationship between economic growth and different measures of energy. Specifically, the study found that coal does not exert a positive influence on economic growth, while the consumption of electricity and petroleum positively impact the economy. However, the combination of three sources of energy tend to undermine the economic influence of electricity consumption.

Akinlo (2009)examines the causal relation between the amount of electricity consumed and real gross domestic product in Nigeria and found a unidirectional causation from electricity use to economic growth. The study further decomposed the trend and the oscillating integral of the real gross domestic product and electricity consumption with the use of Hodrick-Prescott (HP) filter. The findings reveal a long-term relationship between the trend and periodic parts of the two series, this tends to suggest interlink between Granger causality and the periodic function. Meanwhile, the weakness of the study lies in the usage of small sample size and omitted variable bias that may arise from bivariate analysis. In another related study, Akomolafe and Danladi (2014) investigate the direction of causality between electricity use and economic growth and found a unidirectional causality from electricity use to economic growth. The study opined that the supply of electricity is adequate enough to cause investment growth, thereby fueling economic growth. Similarly, Odularu and Okonkwo (2009) result reveals that electricity exerts a positive influence on economic growth in Nigeria. In line with this, Solarin (2011)suggests that past values of electricity consumption have the ability to predict the present level of economic growth in Botswana.

These studies seem to suggest that an increase in the supply of electricity through cutting inefficiency and more investment by firm and government in the generation of electricity as well as rising usage will catalyze the growth of the economy.

On the contrary, empirical evidence on cointegration relation between economic growth and electricity consumption and a one way causation from economic growth and electricity consumption abounds. For instance,Akinwale, Jesuleye, and Siyanbola (2013)investigate the causal relationship between gross domestic product (GDP) and electricity consumption in Nigeria using vector autoregressive and error correction model approach, and found a unidirectional causation from GDP to consumption of electricity. The study attributed the relationship to poor electricity supply which resulted in inadequate demand for electricity that is not significant enough to propel economic growth. Also, Adom (2011) using Toda and Yomamoto Granger causality found a unidirectional causality running from economic growth to electricity usage in Ghana. In addition, Wolde-Rufael (2006)found evidence of cointegration between economic growth and electricity consumption and failed to reject the growth-led-energy (electricity) hypothesis in some African countries. Similarly, Apergis and Payne (2011)showed that past values of economic growth have a predictive capability in determining current values of electricity consumption in some low-income countries.

Meanwhile, Al-mulali, Fereidouni, and Lee (2014)found a feedback causality between the consumption of electricity and economic growth in a study on selected Latin American countries. Similarly, Bélaïd and Abderrahmani (2013)reported a bidirectional causality between economic growth and electricity consumption for Algeria in the short-run and long-run. These study support the notion that there is a relation between electricity usage and growth of economy, hence, electricity influences the growth of gross domestic product, and a significant measure of economic growth causes a reasonable consumption of electricity and vice versa. Apergis and Payne (2011)panel results, further suggests a bidirectional causal relationship between electricity consumption and economic growth in some countries with high per capital income. In the case of Burkina Faso, Ouedraogo (2013)investigated the relation between electricity consumption and growth of the economy. The study found a bidirectional relationship between the use of electricity among households and economic growth, thereby suggesting that electricity is an important factor in growing the economy of Burkina Faso.

Finally, few studies, such asAcaravci and Ozturk (2010); (Ozturk & Acaravci, 2011)found neither short run relationship nor long run relation between electricity consumption and economic growth in some North Africa and Middle East countries. Similarly, Yoo, &Kwa (2010) found no evidence of causal relationship between economic growth and electricity consumption in Peru.

This inconsistency can be ascribed to a number of determinants that include time horizon, the method of estimation, measure of variables, and econometric approaches as well as prevailing economic conditions(Smyth & Narayan, 2015).

The study discovers that existing studies based on Nigeria data with the exception of Akinlo (2009)studied the relationship of the trend, not the cyclical components. Meanwhile, the causation among the cyclical parts of the variables in question is germane, given that it correlates with fluctuation in output.Therefore, this study extends the frontier of knowledge on the causal relationship between electricity consumption and economic growth along several dimensions. First, the study employ both linear and non linear unit root test, so as to properly identify unitroot properties of the series. Second, the sign and magnitude of the coefficients will be analyzed in relation to the various hypotheses related to the causal relationship between real GDP growth and electricity consumption. Third, like the studies by (Menyah & Wolde-Rufael, 2010; Wolde-Rufael, 2014), TY causality techniques are used that do not require pre testing for the cointegration properties of the system. The TY procedure avoids the potential bias associated with the unit root and cointegration technique (Menyah & Wolde-Rufael, 2010).

Methodology

Analytical Framework

To gauge the nature and direction of causality, a first step is to identify the appropriate analytical framework, but the energy- GDP causality literature in most cases are exploratory in nature, not having any solid theoretical underpinning (Beaudreau, 2010). One approach (e.g., Bernstein & Madlener, 2015; Best & Burke, 2018) is the conventional augmented production function. The underlying economic framework in this study derives from a functional relationship between output and electricity consumption.Specifically, the study adopts a special class of distributed lag models known as error correction model to investigate the Granger causality between real GDP and electricity consumption for Nigeria.

The Error Correction Model is outlined as follows. It is hypothesized that there is a long run relationship between real GDP and electricity consumption. In the short-run however, there may be disequilibrium. With the error correction mechanism, the disequilibrium in one period is corrected in the next period.To ensure the error correction process reconcile short-run and long-run behavior, it should be negative and range between zero and one in absolute term (Gross, 2012; Ramnathan, 2002).

Suppose the long-run relationship between real GDP growth denoted as (Y) and electricity consumption (X) is of the form

$$Y_t = KX_t \text{ ---------------------- } 1$$

Where K is a fixed constant, taking log of both sides of equation (1), yields

$$y_t = k_t + x_t \text{ ---------------------- } 2$$

Because $y_{t-1} = k + x_{t-1}$ we have;

$$\Delta y_t = \Delta x_t \text{ ---------------------- } 3$$

Where Δ denotes the change in a variable from period $t-1$ to t. A general short-run model with lagged adjustment is of the following form:

$$y_t = \beta_0 + \beta_1 x_1 + \beta_2 x_{t-1} + \alpha_1 y_{t-1} + u_t \text{ ---------- } 4$$

Equation 4 is the structure of the ECM. It relates the change in real GDP to the change in electricity consumption plus the gap between the two variables in the previous period. The general specification of the error correction model is as follows:

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_1 + \gamma_1 x_{t-1} + \gamma_2 y_{t-1} + u_t \text{ ---------- } 5$$

if the variables are found not to be cointegrated, then equation (5) reduces to a VAR model in differences which is used to investigate the short-run interactions.

$$\vec{Y} = \vec{\alpha} + \Theta_1 \vec{Y}_{t-1} + \vec{\varepsilon}_t \text{ -------------- } 6$$

Where $\vec{Y} = (Y_{t,} X_t)'$ is a column vector, Θ_1 is a $2X2$ matrix, $\vec{\varepsilon}_t$ is a 2 dimensional vector of white noise terms with covariance matrix $\sum$. This is basically an extension of the AR model.

Data

This study used the annual time series data of the Nigeria economy from 1971-2014. The data was obtained from World Bank Development Indicators. All variables are converted to natural logs prior to analysis.The bivariate framework includes real GDP in billions of constant 2010 US dollars, and electric power consumption (ELC) defined in kilowatt hours.

Estimation Technique and Results

As a robustness check, it is important to test the data on stationarity. For this purposes, this study employs Augmented Dickey Fuller (ADF), and Kwiatkowski-Phillips-Schimdt-Shin (KPSS) tests. The results suggest that both series are nonsationary, the results from ADF and KPSS tests are given in Table 1.

Table 1 Results of ADF and KPSS test

	ADF		KPSS	
	Level	1st difference	Level	1st difference
ELC	-0.71	-6.450**	1.03	0.155*
GDP	-0.07	-4.375**	0.32**	0.08**

Notes:

a .ELC stands for Electricity consumption, GDP for gross domestic product

b. Critical values for the ADF test at 5% level without trend and with trend are -2.93 and -3.51 respectively

c. Critical values for the KPSS LM statistics at 1% and 5% are 0.212 and 0.149

The null hypothesis of ADF is that a series is $I(1)$, while the null of KPSS is that a series is $I(0)$.In the case of electricity consumption, since the LM test statistics value (1.03) is larger than the critical value at level 5% (0.46), we reject the null hypothesis of stationarity. Thus, the time series is non stationary. Meanwhile in the case of real GPD, the LM test statistics value (0.32) is not larger than critical at 5% (0.46), we fail to reject the null hypothesis of stationarity. Thus GDP is stationary. Similarly, the ADF results from Table 1, are largely consistent with previous studies, but we suspect an increasing role of industry in the domestic economy following various reforms adopted in the economy since the SAP era. Therefore, we test for structural break in electricity consumption and real GDP using the Zivot and Andrews (1992) test. The Zivot and Andrews (ZA henceforth) is an extension of the Dickey-Fuller type test. An important advantage of the ZA test is that it does not require knowledge of the break point. The ZA test require estimating the following equations respectively;

$$y_t = \mu^B + \beta^B t + \gamma^B DT_t^*(\lambda) + \alpha^B y_{t-1} + \sum_{j=1}^{k} c_j{}^B \Delta y_{t-1} + \varepsilon_t \text{-----------} 7$$

$$y_t = \mu^C + \theta^C DU_t(\lambda) + \beta^C t + \gamma^C DT_t^*(\gamma) + a^C y_{t-1} + \sum_{j=1}^{k} c_j{}^C \Delta y_{t-1} + \varepsilon_t \text{-----------} 8$$

Where following Zivot and Andrews (1992) notation, we use superscript B and C to indicate the two alternative test hypotheses, and λ is the fraction indicating break point position, $DU_t(\lambda)$ =1 if $t > T\lambda, 0$ otherwise; $DT_t^*(\gamma) = t - T\lambda$ if $t > T\lambda, 0$ otherwise y is the series being tested.

Table 2 Results of Zivot and Andrews Test for Unit Root Subject to Structural Break

Variable	Breakpoint	Statistics	Critical value at 1%	Critical value at 5%
	Case 1: Break in Slope only			
ELC	2001	-3.59	-4.80	-4.42
GDP	1996	-3.16	-4.80	-4.42
	Case 2: Break in Slope and intercept			
ELC	1996	-4.85	-5.57	-5.08
GDP	1993	-3.11	-5.57	-5.08

Note: The null hypotheis of Zivot and Andrews test is that the original series is nonstationary with unit root; the alternative hypothesis is that the original sereis is stationary around a broken trend line

The results of the ZA test are shown in Table 2 indicating no significant break point. First, for the case of a break in slope, the test statistics on electricity consumption turns out to be -3,59. This value is larger than the critical value of 1% and 5% significance level, suggesting that there is no significant break point in electricity consumption. This results suggest that electricity consumption is nonstationary at levels.The test statistics for GDP turns out to be -3.16, greater than the critical value of 1% and 5% level. This therefore suggest that there is no significant break point in GDP, and that we cannot reject the null hypothesis that GDP is nonstationary with a unit root.

Second, for the case of a break in both the slope and intercept, both electricity consumption and GDP are found to be unit root process without any significant break point.

Cointegration test can only be carried out on nonstationaryseries,we therefore apply the ECM approach to investigate the cointegrating relationship. The results of the cointegration(available upon request) suggest that both series are not cointgerated, Therefore, we depart from the analysis of long-run relationship, and instead examine the short-run causality only. To do this, we specifically transform all the variables into their respective growth rates to achieve stationarity and study their short-run interactions in a model of ordinary VAR as against ECM model by estimating equation 6.

Granger non Causality Results

Based on the structurally identified VAR, the FEVD results are obtained and presented in table 4 covering a 10 year forecast horizon. For each variable, the results is shown by one of the two panels in table 4. For each panel in the table, there are 6 rows showing the variance decomposition of that variable from time period 1 to 10 years ahead. The first panel shows how the variations of GDP depend on itself and on electricity consumption. At first period, 98% of GDP growth is due to itself while electricity consumption explains a little as 1.35%. This suggest that electricity plays a disproportionate role in growth of GDP. The contribution of electricity consumption is very limited, no more than 1.8% over the 10 year horizon.

The second panel of table 4 shows how electricity consumption variation is explained by itself and growth of GDP. Beginning at period 1, consistent with the causality results suggested by the F statistics analysis, presented in table 3, Electricity consumption is exogenous, explaining 99% of its own variation. Over the 10 year horizon, the contribution of GDP to electricity consumption is as low as 4.6%.

Table 3 Granger non-Causality test(F Statistics)

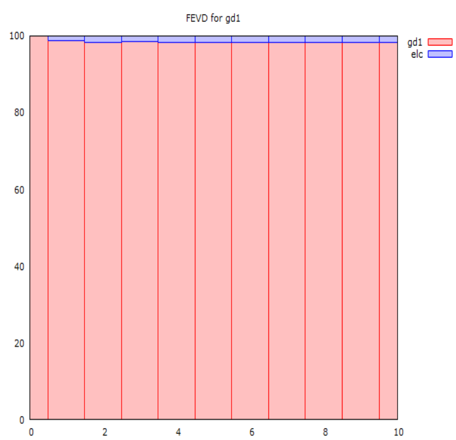
Dependent variable	GDP	ELC
All lags of GDP	-	0.0016[0.9681]
All lags of ELC	0.6744[0.4165]	-

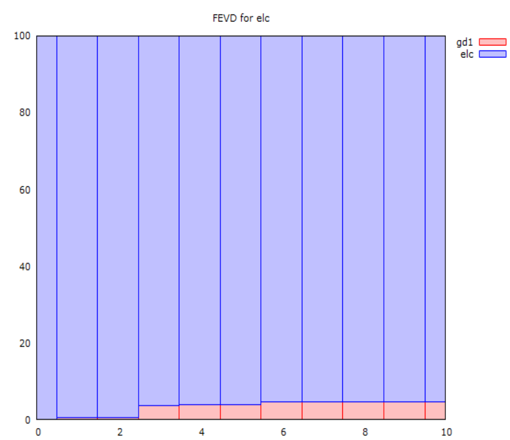
Figures in parenthesis are p-values

Table 4: Forecast Error Variance Decomposition Result

Panel A{GDP}			Panel B (ELC)		
Period	GDP	ELC	Period	GDP	ELC
1	1	0	1	0.1	99.8
2	98.6	1.65	2	0.52	99.4
3	98.3	1.7	3	0.53	99.4
4	98.4	1.6	4	3.7	96
5	98.27	0.17	5	0.38	96.1
10	98.2	1.81	10	4.7	95.3

In summary, the FEVD results of the first two panels of the table demonstrate, there is no causality in the short-run, because each variable explains a greater portion of its own variance over the 10-year horizon. Failing to find Granger causality in either direction implies that electricity consumption is regarded as a small component of growth of GDPThis therefore suggest that electricity conservation policies will not have effect on economic growth which is consistent with the neutrality hypothesis. The results further show the relative exogeniety of electricity consumption over GDP. This result differs from the branch of literature that suggest either a unidirectional or bidirectional relationship between electricity consumption and economic growth, see for instant (Akinlo, 2009; Squalli, 2007; Wolde-Rufael, 2006).





Conclusion

Although electricity is a vital factor in the growth prospects it plays a disproportionate role in the production process of different economies. It has features such as aggregation, substitution, the representation and dynamics,and trends.This is indeed the case for Nigeria. Nigeria in particular is rich in both renewable and non renewable energy sources but yet the Nigerian economy finds herself in a situation where she is over dependent on fossil sources and at same time experiences one of the lowest electric power consumption per capita in the world.

This study explores the causal relationship between electricity consumption and economic growth using the Structural VAR approach. First, the unit root results provides mixed evidence regarding stationarity properties of both variables, this has implications on for the correct modeling of energy and economic growth Second,ECMcointegration test indicate that there does not exist long run equilibrium relationship between real GDP and electricity consumption. This observation, leads this study focus on short-run dynamics instead of long-run dynamics which is prevalent in most studies.

Finally, the estimation of Granger non causality tests using the SVAR approach revealed the absence of causality between electricity consumption and economic growth. It follows that, in terms of policy implications, electricity conservation policies that reduce electricity consumption will not retard economic growth.In general, theresults from the multivariate approaches suggests that the role of electricity has disproportionate impact, hence of little importance in so far as growth is concerned. This finding is consistent with early literature that finds a disproportionate role of electricity in growth (Toman & Jemelkova, 2003) and this study supports this view.

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