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Analysis of Electricity Consumption and Economic Growth in Nigeria: An Ardl Approach

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Abstract: *This paper examines the relationship between electricity consumption and economic growth in Nigeria using the Autoregressive Distributed Lagged (ARDL) approach. The paper used quarterly time series data for economic growth and some selected variables electricity consumption, electricity supply, electricity loss and inflation rates. The results indicate positive and significant influence of electricity consumption on economic growth in both the short run and long run. However, there is other variables except inflation rates show insignificant contribution to economic growth in the long run. The result of the causality test also supports the electricity-led growth hypothesis in Nigeria. The findings suggest that increase in electricity consumption will contributes to economic growth in the country. It is recommended that electricity consumption should be considered when forecasting and making economic growth policies.*

Keywords: *Electricity consumption, Economic growth, ARDL bounds test, Nigeria*

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I. Introduction

Electricity consumption is one of the key drivers to growth and development of all economies. It serves as an important input that can enhance the productive activities in almost all sectors of the economy. However, the recent energy crises, increase in prices of crude oil, climate change, and the ever-growing emission of carbon into the atmosphere have led to a great debate on the relationship between electricity consumption and economic growth (Iyke, 2015). Some previous research provide evidence in support of the electricity led-growth hypothesis (see, Orhewere, 2013; Akonlafe and Danladi, 2013; Iyke, 2014), the neutrality hypothesis (see, Mustapha and Fagge, 2015 and Mohammed et al 2014) while other studies supported the feedback hypothesis between electricity consumption and economic growth (see, Bashier, 2016; Alpher, et al, 2014; Ogundupe, 2013).

There is a wide gap between electricity supply and its consumption in Nigeria. For many years, the power sector has been facing enormous challenges regarding its generation, distribution and consumption. These problems has weakened the industrialization process, and significantly undermined the effort to achieve sustained economic growth, increased competitiveness of domestic industries at both regional and global markets, and employment generation in the country (Iwayemi, 2008). Apart from the inability of the country to generate the required amount of electricity for its ever-growing population, there is a large quantity that is lost between the generation units and the final units of consumption. Akomolafe and Danladi (2014) shows that less than 40% of the population has access to electricity and the power sector suffers from high energy losses (30-35%) which caused a low collection rate of money owed to the power supplier. As a result, a lot of our domestic industries have now been shutdown and many are unable to operate at their optimum capacity. These constraints also posed other fundamental infrastructures deaths in the country. World Bank (1991) reported that the inability to meet the domestic and industrial needs for electricity has affected the growth potentials of Nigeria. Several measures and policies have been set to boost the electricity sector. In 2012, the Nigerian National Electric Power Authority (NEPA) was privatized in order to improve electricity supply and strengthen the sector performance. Iyke (2015) reported that the demand for electricity in Nigeria was projected to increase from 5,746 megawatts in 2005 to nearly 297,900 megawatts by the end of 2030. So the power sector has to increase the supply of electricity by approximately 11,686 megawatts each year to match this projection.

This paper reinvestigates the relationship between electricity consumption and economic growth in Nigeria. This paper contributes to the literature in the following ways: First, majority of the previous studies examined the relationship between electricity consumption and economic growth in Nigeria using the Johansen cointegration and VAR approaches. In this paper we applied the ARDL bound test cointegration approach to provide evidence on this relationship. Second, we include other important variables in our analysis such as

electricity supply and electricity loss which to our knowledge there is little or no information on the relationship between these variables and economic growth in Nigeria.

The remainder of this paper is organized as follows. Section 2 discusses the literature related to the study. Section 3 discusses the methodology for the study. Section 4 describes the data and their statistical characteristics. Section 5 presents the empirical results and discussion. And Section 6 concludes and offers recommendations.

II. Literature Review

A large body of literature has examined the relationship between electricity consumption and economic growth. Studies for Nigeria include the work of Orhewere (2013) who investigated the relationship between electricity consumption and economic growth in Nigeria using the Johansen cointegration over the period 1970-2005. They found long run cointegration relationship among the variables and a unidirectional causality running from total electricity consumption to GDP both in the short and long-run. The study suggests that large supply of electricity can ensure a higher level of economic growth in the country. Ogundipe (2013) examined the relationship between electricity consumption and economic growth in Nigeria using the Johansen and Juselius Co-integration technique based on the Cobb-Douglas growth model covering the period 1980-2008. He found that the variables are cointegrated in the long run. The result also shows evidence of bi-directional causal relationship between electricity consumption and economic growth. He recommends periodic replacement of worn-out equipment in order to drastically curtail transmission power losses and strengthen the effectiveness of energy generating agencies. Iyke (2014) reexamined the dynamic linkage between electricity consumption and economic growth relationship in Nigeria using a trivariate VECM over the period 1971-2011. Including inflation rate in the analysis, the results supports both linear and nonlinear cointegration relationship between the variables. The results also show a unidirectional causality running from electricity consumption to economic growth in both the short run and in the long run which supports the electricity-led growth hypothesis. He recommends the appropriate monetary policies that would moderate inflation in order to enhance economic growth in the country. Akomolafe and Danladi (2014) investigated the relationship between electricity consumption and economic growth in Nigeria using a multivariate system over the period covering 1990-2011. The Johansen cointegration test shows a long run relationship between electricity consumption and economic growth. The result of the Granger causality test shows unidirectional causality from electricity consumption to real gross domestic product. There is also unidirectional causality from capital formation to real gross domestic product. The study suggests capital formation's contribution to the economy is relatively determined by the adequate electricity in Nigeria. Mustapha and Fagge (2015) using VAR model approach re-examine the relationship between energy consumption and economic growth in Nigeria's data from 1980 to 2011. By including the variables labour and capital in their analysis, they found that there is no causality relationship between energy consumption and economic growth. Their results of the impulse response and variance decomposition analysis shows that capital and labour are more important in affecting output growth compared to energy consumption.

In other countries, Alper et al. (2014) using quarterly data investigated the dynamic causal relationship between energy consumption and economic growth in the U.S by employing the wavelet transformation. They found bi-directional causal effect between the variables, and in the short-term energy consumption is influenced by economic growth. Bashier (2016) using the Autoregressive Distributed Lag (ARDL) model found the existence of a long run equilibrium relationship between electricity consumption and economic growth in Jordan. The results also indicated a long-run bidirectional causality relationship between the variables while in the short run, there is evidence of bidirectional weak and strong causality between electricity consumptions per capita and economic growth. Bildiricit (2013) investigates the relationship between electricity consumption and economic growth in eleven African countries using Autoregressive Distributed Lag (ARDL) bounds testing approach and vector error-correction models (VECM). The ARDL results show cointegration between electricity consumption and economic growth in ten of the eleven countries. However, there is mixed results of causality relationship between electricity consumption and economic growth among the countries. Fuinhas and Marques (2012) examined the nexus between primary energy consumption and growth in Portugal, Italy, Greece, Spain and Turkey using the ARDL bounds test approach. They found bidirectional causality between energy and growth in both the long-run and short-run. They suggest that energy conservation policy will reduce GDP growth, while a saving phenomenon should be observed. Mohd et al. (2014) using Cointegration approach and the pairwise Granger causality examined the causal relationship between energy consumption and economic growth in Malaysia. They found existence of long run relationship among the variables but no causal relationship between electricity consumption and economic growth. In sum, majority of the previous literature provide evidence of the long run relationship between electricity consumption and economic. However, there is mixed conclusion regarding the causality relationship among the variables in Nigeria and other countries.

III. Methodology

3.1 Cointegration Test

We employ the Pesaran and Shin (1999) Autoregressive Distributed Lagged (ARDL) bound testing cointegration approach to examine the relationship between economic growth and electricity consumption in Nigeria. The ARDL overcomes the shortcomings of the alternative methods because it allows data to be handled in a flexible way, the technique is robust for finite samples, even in the presence of phenomena of shocks and regime shifts and useful when the integration of variables is of different order (see, Fuinhas and Marques, 2012) .The ARDL model specification of the long run relationship between the variables can be written as follows:

$$\Delta GDP_t = \beta_0 + \sum_{t=1}^{k} \beta_1 \Delta GDP_{t-i} + \sum_{i=1}^{k} \beta_2 \Delta EC_{t-i} + \sum_{i=1}^{k} \beta_3 \Delta ES_{t-i} + \sum_{i=1}^{k} \beta_4 \Delta EL_{t-i} + \sum_{i=1}^{k} \beta_5 \Delta INF_{t-i} + \alpha_1 GDP_{t-i} + \alpha_2 EC_{t-i} + \alpha_3 ES_{t-i} + \alpha_4 EL_{t-i} + \alpha_5 INF_{t-i} + \varepsilon_t \quad (1)$$

where, real gross domestic product is (RGDP), electricity consumption (EC), electricity supply (ES), electricity loss (EL) and inflation rates (INF). The parameters β_0 and ε_t are constant and error term. First, the optimal lag length was selected based on the Schwartz information criterion (SIC). The equation (1) tests the null hypothesis $H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$, there is no cointegration relationship between the variables against the alternative hypothesis $H_0 : \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0$ using the bounds testing procedure based on the joint F-statistic or Wald statistic tests. Secondly, when the null hypothesis of the no cointegration is rejected given by the F-statistic with values higher than the upper and lower bound, we estimate the conditional ARDL long run model. Lastly, the short-run relationship can be established by estimating the model with an error correction model (ECM):

$$\Delta GDP_t = \beta_0 + \sum_{t=1}^{k} \beta_1 \Delta GDP_{t-i} + \sum_{i=1}^{k} \beta_2 \Delta EC_{t-i} + \sum_{i=1}^{k} \beta_3 \Delta ES_{t-i} + \sum_{i=1}^{k} \beta_4 \Delta EL_{t-i} + \sum_{i=1}^{k} \beta_5 \Delta INF_{t-i} + \delta ECM_{t-1} + \varepsilon_t \quad (2)$$

where, ε_t represent the residual and δ is the coefficient for the error correction model which measure the speed of adjustment. If δ is negative and significant, then the variables in the model converge quickly to the long-run equilibrium position.

3.2 Granger Causality Test

The Granger causality test was used to determine whether the variables electricity consumption, electricity supply, electricity loss and inflation rates can improve the forecast performance of economic growth or vice-verca. The model can be specified as,

$$GDP_t = \alpha_1 + \sum_{i=1}^{n} \beta_i EC_{t-1} + \sum_{j=1}^{m} \gamma_j GDP_{t-j} + e_{1t} \quad (3)$$

$$EC_t = \alpha_2 + \sum_{i=1}^{n} \theta_i GDP_{t-1} + \sum_{j=1}^{m} \delta_j EC_{t-j} + e_{2t} \quad (4)$$

When the lagged values of EC_t are significant in explaining GDP_t, EC_t Granger-cause GDP_t and vice-versa. When lagged EC_t and GDP_t are significant in each other's equation, there is bidirectional causality, while the insignificants of the variables in explaining each other implies no causality between them (they are independent). The standard joint F- test is used to examine the Granger causality in a VAR system (see Brooks, 2008; Asteriou and Hall, 2007). We also estimate the relationship between economic growth and the other variables electricity supply, electricity loss and inflation rates using the specification in equation (3) and (4), respectively.

IV. Data and its properties

The paper employs quarterly time series data for Nigeria's real gross domestic product (RGDP), electricity consumption (EC), electricity supply (ES), electricity loss (from the time of its generation to the transmissions) (EL) and inflation rates covering the period 1990-2016. The variables real gross domestic product (RGDP) was used as proxy for economic growth. Data for the gross domestic product and inflation rates

were obtained from Central Bank of Nigeria (CBN) statistical bulletins (2017) while other variables were sourced from Nigerian Energy Commission (NEC). The electricity power consumption is (Kwh per capita), electricity supply is (GWh) and electricity loss is (% of output). The choice of the study period was based on the availability of data.

Table 1. Summary Statistics for the Selected Variables

	LRGDP	LEC	LES	LEL	INF
Mean	10.39082	4.666366	9.906395	3.188268	18.88649
Maximum	11.14221	5.048922	10.55216	3.780487	72.83550
Std. Dev.	0.451654	0.241135	0.281850	0.592355	17.82783
Skewness	0.312946	0.021766	0.376804	-0.909543	1.862533
Kurtosis	1.558099	1.598698	2.141281	2.499095	5.185469
Jarque-Bera	10.70688	8.517351	5.656398	15.42657	80.82703
Prob	(0.0047)	(0.0141)	(0.0591)	(0.0004)	(0.000)
ADF	-2.2603	-2.07091	-2.0679	-2.3822	-2.5065
Observations	104	104	104	104	104

Note: All the variables are in natural logarithmic form except inflation rates, Figures in bracket are probabilities which indicate that all the variables are not normally distributed. The ADF test t-statistics reported are in levels with trend and constant in the equation. * denotes significant at 5% level.

Table 1 reports the descriptive statistics for the natural logarithms of the variables in Nigeria. The mean is higher than the standard deviation in all the series, implying that the average value of the series is higher than its spread from the mean. The Jarque-Bera test indicates that the null hypothesis cannot be rejected at the 5% significant level in each of the times series variable except for real GDP. The Augmented Dickey Fuller (ADF) test results indicate that all the variables except real GDP contain a unit root at the 5% significant level, implying that they are I (I) process. However, they are all stationary in their first difference except real GDP. Since the variables have mixed order of integration, we applied the ARDL bound test to investigate the relationship between energy consumption and economic growth.

V. Empirical Results and Discussions

5.1 Results of the ARDL Cointegration test

Table 2 presents the results of the ARDL bound test to cointegration of equation 1. The test results indicate that F-statistics has a value of 27.95 which is higher than upper and lower bound at 1% significant level. This result indicates rejection of the null hypothesis of no cointegration between economic growth and the selected variables electricity consumption, electricity supply electricity loss and inflation rates. This implies that all the variables move together and therefore cannot diverge from each other independently in the longrun. The findings is consistent with Orhewere (2013), Iyke (2014) and Akomolafe and Danladi (2014) who found long run relationship between economic growth and electricity consumption in Nigeria. This result is confirmed by the negative and significant sign of the cointegration coefficient in table 3.

Table 2. Bounds Testing for Cointegration

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	27.95167	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.37	3.2
5%	2.79	3.67
2.5%	3.15	4.08
1%	3.65	4.66

Decision rule: reject the null hypothesis if the F-value is higher than the upper and lower bound

Table 3 reports the results of the long run and short run elasticities. The results indicate that in the long run, the coefficient for electricity consumption is positive and statistically significant at 5% level. The result shows that 1 units increase in energy consumption will increase economic growth by 0.54 % in Nigeria. Inflation rate is negative and significant; implying that increase in electricity price will reduce electricity consumption and its contribution to economic growth. However, the lower value of the coefficient 0.0018% indicates smaller impact of inflation on electricity consumption over the study period. The coefficients for electricity loss and electricity supply are statistically insignificant which suggests that increase in electricity supply and its losses would have no impact on economic growth in the long run. The implication of this result is that increase electricity supply would have no impact on the economy unless there is increase in its consumption in the long run.

The short-run elasticity estimates is also reported in Table 3. The result indicates that all the variables except electricity loss are statistically significant at 5% level which suggests that they contribute significantly to economic growth in Nigeria. The coefficient for electricity consumption is positive and significant, implying that it has a positive impact on economic growth. This result suggests that 1 unit increase in electricity consumption will lead to increase in economic growth by 0.15 % in the short run. In contrast to the long run analysis, the coefficient of electricity supply show positive and significant relationship with economic growth. This result show that 1 unit increase in electricity supply will contribute to economic growth by 0.23 %t in the short run.

Table 3. Results of the short run and long run relationship

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LES)	0.231411	0.061914	3.737641	0.0003
D(LEL)	-0.019362	0.014039	-1.379183	0.1711
D(LEC)	0.148997	0.052641	2.830438	0.0057
D(INF)	-0.000722	0.000347	-2.080575	0.0402
C	1.387428	0.331057	4.190901	0.0001
CointEq(-1)	-0.179012	0.042998	-4.163269	0.0001

Cointeq = LRGDP - (-0.0168*LES -0.0555*LEL + 0.5447*LEC -0.0018*INF + 0.0102*@TREND)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LES	-0.016845	0.216126	-0.077940	0.9380
LEL	-0.055513	0.051584	-1.076173	0.2846
LEC	0.544667	0.160515	3.393247	0.0010
INF	-0.001801	0.000770	-2.338896	0.0214
@TREND	0.010239	0.001824	5.614013	0.0000

Similar to the long run, the result indicates that inflation rates is significant but has a negligible influence on economic growth. Lastly, the coefficient of ECM term is negative and statistically significant at 1% showing the speed of adjustment of the variables to the long run equilibrium position. The results indicate that about 0.17% of the divergence between economic growth and electricity consumption, and other selected variables converges in the long run.

5.1 Results of the Granger Causality Test

Table 4 present the estimated results of the Granger causality test between economic growth and the selected variables. The results reject the null hypothesis of electricity consumption does not Granger causes economic growth, however, the null hypothesis of economic growth does not Granger causes electricity

consumption cannot be rejected at the 5% significant level. This implies that there is a unidirectional causality running from electricity consumption to economic growth consistent with Akomolafe and Danladi (2014) and Iyke (2014) supporting the electricity-led growth hypothesis in Nigeria. However, the findings contrast the work of Mustapha and Fagge (2015) who found no causality relationship between electricity consumption and economic growth. The implication of the findings is that increase in electricity consumption will boost economic activities which can lead to economic growth in the country.

Table 4. Results of Granger-causality test

Null Hypothesis:	F-Statistic	Prob.
LEC does not Granger Cause LRGDP	2.90649	0.0259
LRGDP does not Granger Cause LEC	2.90587	0.0749
LES does not Granger Cause LRGDP	1.09605	0.3634
LRGDP does not Granger Cause LES	2.17926	0.0775
LEL does not Granger Cause LRGDP	0.24890	0.9096
LRGDP does not Granger Cause LEL	1.65131	0.1682
INF does not Granger Cause LRGDP	0.71452	0.5841
LRGDP does not Granger Cause INF	0.55230	0.6978

For the other selected variables, the results indicate that we cannot reject the null hypothesis of economic growth does not granger cause electricity supply, electricity loss and inflation rates at the 5% significant level and vice-versa. The results imply that there is no causality relationship between economic growth and these variables. This suggests that there are other macroeconomics factors such as oil export, tax revenue, exchange rates etc that have stronger impact on economic growth in Nigeria.

VI. Conclusion

This paper investigates the relationship between electricity consumption and economic growth in Nigeria using the ARDL cointegration test. The study used quarterly time series data for electricity consumption, economic growth and other selected variables over the period 1990 to 2016. The findings provide strong evidence of positive relationship between electricity consumption and economic growth in both the short run and long run. The result also shows that inflation rates have small impact on economic growth while electricity losses and electricity supply show insignificant contribution to economic growth in long run. The results of the Granger causality test show unidirectional causality from electricity to economic growth supporting the electricity-led growth hypothesis in Nigeria. Other variables show no causality relationship with economic growth in both directions.

The implication of these findings is that electricity consumption has a positive impact on promoting economic growth and therefore making electricity accessible to the greater number of the population would enhance economic activities and expands total output in Nigeria. Secondly, the significance of electricity consumption suggests that it should be considered as an important factor in policy making and forecasting growth in the country. Thirdly, the policies of boosting electricity consumption should consider its prices because inflation rate have negative impact in reducing economic growth. Lastly, there is need for strong policies and strategies that would improve electricity supply and reduce losses because these are important factors in boosting economic growth especially in the long run.

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