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Electricity Generation and Economic Growth in Nigeria: Is there any Link?

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Abstract
This study examined the relationship between electricity generation and economic growth in Nigeria during the period 1986-2019 and employed the co-integration test, autoregressive distributed lag, Granger causality test techniques. The co-integration test result revealed a long-run relationship between explanatory variables. The study found that electricity plays an important role in propelling economic growth in Nigeria. Likewise, the result from the causality test indicates that, a bi-directional causal relationship between total electricity consumption and economic growth in the long run exist. The study recommends that policymakers need to improve the power sector to harness the potential of electricity in growing the economy.
Keywords: Granger Causality; Economic Growth; Electricity; Energy Generation; Productivity

1.0 Introduction

Nigeria is Africa's energy giant. It is the continent's most prolific oil-producing country, which, together with Libya, accounts for two- thirds of Africa's crude oil reserves. It ranks second to fourth Algeria in natural gas. Most of Africa's bitumen and lignite reserves are found in Nigeria. In its mix of conventional energy reserves, Nigeria is simply unmatched by any other country on the African continent. It is not surprising; therefore, that energy export is the mainstay of the Nigerian economy (George & Oseni, 2012).

Primary energy resources dominate the nation's industrial raw materials endowment. Electricity energy production in Nigeria over the last 40 years varied from gas-fired, oil-fired, hydroelectric power stations to coal-fired with the hydroelectric power system and gas-fired system taking precedence (Oyedepo, 2012). This is predicated by the fact that the primary fuel sources (coal, oil, water, gas) for these power stations are readily available. Nigeria's coal reserves are large and estimated at 2 billion metric tonnes of which 650 million tonnes are proven reserves. About 95% of Nigeria's coal production has been consumed locally; mainly for railway transportation, electricity production and industrial heating in cement production (Emovon, Kareem & Adeyeri, 2011).

The Nigeria has the biggest gap in the world between electricity demand and supply, providing its population of over 190 million with less than 4000 megawatts of electricity (Okafor, 2008). In contrast, South Africa with a population of over 55 million people generates more than 40,000 megawatts while Brazil, a developing economy like Nigeria, generates over 100,000 megawatts for its 201 million citizens. Indeed, the gap in the power sector has far-reaching implications for improving the business climate, sustaining economic growth and the social wellbeing of Nigerians (Joy, 2017).

Furthermore, about 45 per cent of the population has access to electricity, with only about 30 per cent of the demand for power being met. The power consumption (KW) in USA, Japan, South Africa, China, India and Nigeria were 3,913; 934; 212; 5,523; 973 and 24 respectively, these roughly correlate with the GDP per capita of the countries in 2016 (World Bank , 2017). Nigeria's energy resources, particularly oil, are exported to other countries while its economy suffers from severe shortfalls of the very same product. This is evidenced by the limited and most times the erratic supply of electricity and shortage of most petroleum products (Joy, 2017).

On economic growth, the GDP per capita of Nigeria expanded by 132% between independence in 1960 and 1969 and rose to peak growth of 283% between 1970 and 1979 (Uzor, 2020). The severity of this led to the restructuring of the economy in 1986. In the period 1988-1997 which constitutes the period of structural economic adjustment and liberalization, the GDP responded to economic adjustment policies and grew at a positive rate of 4%. In 2006, the real GDP growth rate was 7%. The economy when measured by the real GDP grew by 7.87% in 2010 the (World Bank, 2017).

The examination of the literature shows that majority of the studies carried out to observe the relationship between power generation and economic growth focus on either testing the role of energy in stimulating economic growth or examining the direction of causality between these two variables. Although the positive role of energy infrastructure on economic growth has become well known, there are some reservations about the results from these studies methodologically.

Some authors have used a panel data approach and multivariate models (Khobai, Mugano & Le Roux, 2017). It should be noted that most of these studies produced varied results and there is no agreement on the existence and direction of causality between energy consumption and economic growth. This paper is aimed at determining the relationship between power generation and economic growth. To also find out if different sources of energy have varying impact on economic growth. This paper contains introduction, literature review, methodology, results, analyses, conclusion and recommendations

2.0 Literature Review

The study has it theoretical underpinning from the Solow growth model which explained that output grows because of increases in inputs as well as the productivity increases, as a result of improved technology and a highly skilled labour force. Output growth can be characterized as economic growth while electricity generation or supply is a form of improved technology that can increase productivity and therefore have an effect on the economic growth or output growth according to the Solow Growth Model.

Sarker and Alam (2010) employed a Granger-causality test on the nexus between economic growth and electricity generation using Bangladesh data covering the period 1973-2006. Their study revealed that only a unidirectional causal relationship existed between electricity generation and economic growth in Bangladesh between the periods 1973-2006**.**

Lean and Smyth (2010) found out that there is unidirectional Granger causality running from economic growth to electricity generation in Malaysia from 1970-2008 after employing the cointegration test and granger causality test in their paper "Multivariate Granger causality between electricity generation, exports, prices and GDP in Malaysia".

Altintas and Kum (2013) in their study Multivariate Granger Causality between Electricity Generation, Exports, Prices and Economic Growth in Turkey concluded that long-run equilibrium relationship and long-term causality are found between economic growth and electricity generation, and in the short run there are bi-directional causalities between economic growth-and electricity generation in Turkey between the periods 1970 to 2010**.**

Ogundipe and Apata (2013) examined the link 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 time frame of 1980-2008. The study utilized the Vector Error Correction Modeling and the Pairwise Granger Causality test in order to empirically determine the error correction adjustment and direction of causality between electricity consumption and economic growth in Nigeria. Findings revealed the existence of a unique co-integrating relationship among the variables in the model with the indicator of electricity consumption impacting significantly on growth; alongside bi-directional causal relationship between electricity consumption and economic growth. The study recommended amongst others the need to strengthen the effectiveness of energy generating agencies by ensuring periodic replacement of worn-out equipment in order to drastically curtail transmission power losses.

Ohwofasa, Obeh and Erakpoweri (2015) examined the impact of electricity Supply on economic growth in Nigeria. Variables examined included per capita income (a proxy for economic growth) and electricity consumption in Nigeria. The study employed an error correction model and results show that there was no long run relationship between per capita income and the explanatory variables. Findings revealed that in the short run while electricity consumption, government expenditure and investment exert positive impact on per capita income, the relationship between the later and export is negative. Finally the ECM observed the usual negative slope with very high speed of adjustment. The study recommended among other things that corruption prevalent in the power sector must be checked in order to ensure stability in electricity supply and hence increased per capital income.

Khodeir (2016) conducted an empirical study seeking to find the relationship between the generation of electricity from renewable resources and unemployment in the Egyptian economy. The research covered a time frame of 1989-2013. The study utilized the Autoregressive Distributed Lag (ARDL) approach in order to identify the effects in the short and long run during the period. Findings revealed that a long long-run positive relationship between variables under consideration. This is due to the fact that renewable energy projects in their establishment stages focus on capital intensity more than labour intensity, but with time both direct and indirect employment effects start to emerge. The study recommends amongst other that improved generation of electricity from renewable resources will help improved implement generation in Egypt.

Atems and Hotaling (2018) indicated that there is a strong positive and statistically significant relationship between renewable and non-renewable electricity generation, and growth for a panel of 174 countries over the period 1980–2012. While Yoon and Kim (2006) found out that there is a uni-directional causality running from economic growth to electricity generation without any feedback effect in Indonesia from 1971 to 2002 in their paper "Electricity generation and economic growth in Indonesia"

Oyeleke and Akinlo (2019) research on the effect of Energy generation and economic growth in Nigeria indicated the existence of co-integration among the variables. They found that gas energy is crucial to the development of economic growth in the long run. However, in the short run, hydropower contributed to the development of the economy of Nigeria for the period 1980–2017. In another study, Ogbonna, Idenyi and Nick (2016) analyse power generation capacity and economic growth in Nigeria. The study applied a Causality Approach. The findings from the study revealed a stable long-run relationship but no causality between power generation capacity and economic growth in Nigeria within the period 1980-2015.

Nkalo and Agwu (2019) examine the impact of electricity supply on economic growth in Nigeria between the periods 1938 to 2017. The study shows that for every 1% increase in electricity supply, the economy is expected to grow by 3.94 percent. Similarly, Clue (2020) investigates the impact of power generation on economic growth in Nigeria from 1980-2017. The result of the study shows that power generation did not significantly contribute to economic growth in Nigeria.

George-Anokwuru and Ekpenyong (2020) examined electricity and economic growth in Nigeria. The study covered 1971-2018. The research utilized regression analyses and adopted Error Correction Method (ECM) as analytical technique. With the dependent variable as GDP, and explanatory variables are electricity consumption, electricity generation, and electricity transmission and distribution losses. The study found a positive relationship between electricity consumption and economic growth. Electricity generation also had a negative link with economic growth, while electricity distribution and losses have a negative association with economic growth in Nigeria during the period reviewed. The study recommends amongst others that government should ensure that energy generated in the country stays in the country and that electricity generation should be backed up with optimal production and utilization and budgetary allocation into research and development in this sector so that innovation can be improved.

Solomon and Festus (2020) evaluated the link between electricity consumption, urbanization, and economic growth in Nigeria. The research utilized data from 1971 to 2014. The analytical methods adopted included, bounds test and the Bayer and co-integration tests to test co-integrating relationship. Findings revealed that Electricity consumption increases economic growth in both time periods, while the impact of urbanization appears to inhibit growth. The fully modified OLS, dynamic OLS, and the canonical co-integrating regression again validated the robustness of the findings. The vector error correction model Granger causality test served as support for the neutrality hypothesis in the short run and the feedback hypothesis among the variables in the long run. The study recommended amongst other that policies to ensure efficient electricity supply, curb rapid urbanization, and promote sustainable economic growth should be encouraged

3.0 Methodology

From the Solow Model, a Cobb-Douglas production function with constant returns to scale:

$$Y = AK^{\alpha} L^{\beta} \qquad (1)$$

Equantion (1) was adopted following the work of (Ogundipe & Apata, 2013). Y is the total production (output), L is the labour input, K is capital input and A is the total factor productivity. α and β are the output elasticities of capital and labour, respectively.

The model in the econometric form (where electricity generation is total factor productivity and economic growth is total output) would then be

$$GDP = \beta_0 KAP^{\beta_1} LAB^{\beta_2} ELEC^{\beta_3} \quad (2)$$

Where GDP represents Gross Domestic Product growth rate, $ELEC$ is the electricity consumption (Kilowatt per hour), LAB is total labour force, is the stock of capital. The a priori expectation is such that β_1, β_2, $\beta_3 > 0$, because the variables are expected to have a significant positive impact on Economic Growth. The explicit form of the model stated in a log linearized form is as follows:

$$LOGGDP_t = \beta_0 + \beta_1 LOGKAP_t + \beta_2 LOGLAB_t + \beta_3 LOGELEC_t + e_t \quad (3)$$

The Ordinary Least Squares method was used to carry out the multiple regression analysis. It was utilized because it is the best linear unbiased estimator, and is simple to understand. Other tests such as Descriptive analysis, Unit Root Test for Stationarity, Co-integration Test, Autoregressive Distributed Lag Model (ARDL) and the Granger-causality Test were carried out. The data is drawn from the World Development indicators of the World Bank. The data selected are GDP growth in annual percentage (GDP%) for the dependent variable, gross fixed capital formation, labour force and electricity use as the independent variables, as provided in the World Development Indicators of the World bank. Data gathered are limited to a period of 30 years (1986 – 2019). Hence, the reliability of the estimates shall depend on the accounts of the data gathered through this source.

4.0 Results and Analysis

4.1 Descriptive Analysis

The various statistics of the variables in the study were descriptively analyzed, using the statistical tool known as the Econometric-Views (E-VIEWS) statistical software. The variables analyzed are GDP growth in annual percentage (GDP%), Gross Capital Formation (KAP), Total Labour Force (LAB) and Electric Power Consumption in kWh per capita (ELEC). Altogether, this study covered a sample of 34 years, the period 1986-2019. Table 1 shows the descriptive statistics in the summary of all the variables used in the course of the study. All the mean values of all the variables were found to be positive. This means that all the variables used have recorded an increasing trend throughout the period (1986 – 2019). This further implies that while Nigeria’s GDP has sustained an average increase over the years, the gross capital formation, the labour force, as well as the electric power supply have also maintained a steady increase.

Table 1: Descriptive Statistics

	GDP (%)	KAP	LAB	ELEC
Mean	5.776835	28.99598	17.52071	4.654120
Median	4.887387	28.65951	17.51562	4.619091
Maximum	33.73578	30.03980	17.83666	5.048922
Minimum	-0.617851	28.33366	17.21754	4.305837
Std. Dev.	6.677702	0.569196	0.184833	0.241505
Skewness	3.039470	0.701078	0.058712	0.092378
Kurtosis	13.52351	1.860769	1.899517	1.649717
Jarque-Bera	153.8519	3.399887	1.275886	1.934792

Probability	0.000000	0.182694	0.528378	0.380072
Sum	144.4209	724.8996	438.0177	116.3530
Sum Sq. Dev.	1070.201	7.775606	0.819917	1.399787
Observations	25	25	25	25

Source: Author's Computation using E-Views, Version 9.0

The maximum and minimum values indicate the highest points and lowest points of the variables throughout the study period. The maximum value for GDP growth during the period under study was 33.74% in the year 2004. The lowest GDP growth rate during this period was -0.62% in the year 1991, where Nigeria recorded negative growth for the first time. The Gross Capital Formation was at its peak in the year 2014 at US$ 11120.4 billion as a result of rising domestic investment, while the lowest value was US$ 14390.7 billion in the year 1988.

The level of volatility, which was measured by the standard deviation, indicated that electricity (at 31.23) was not static, tending to fluctuate. The skewness explained that both labour and electricity were negatively skewed, while the kurtosis indicated that only the GDP growth rate was leptokurtic (>3), meaning that it produced outliers, which is attributed to the instability of the Nigerian economy. Also, the high Jarque-Bera statistics for all the variables mean that the null hypothesis has been rejected at the 5% level of significance. In other words, the data does not come from a normal distribution.

4.2 Unit Root Test for Stationarity

Table 2: Augmented dickey fuller unit root test

Variables	**ADF**	**Critical value (1%)**	**Critical value (5%)**	**Critical value (10%)**	**Order**
GDP %	-8.010829	-4.323979	-3.580623	-3.225334	I (0)
LnKAP	-6.029189	-4.356068	-3.595026	-3.233456	I (1)
LnLAB	-5.533971	-4.416345	-3.622033	3.248592	I (1)
LnELEC	-6.128503	-4.356068	-3.595026	-3.233456	I (1)

Source: Author's Computation using E-Views, Version 9.0

The Augmented Dickey-Fuller (ADF) unit root test was deployed to examine the stationarity of the time series and test the null hypothesis of the unit root. It is expected that the series does not contain the unit root to find the relationship among the variables in the long run. A variable is stationary if the ADF statistic is greater than the 1% or 5% critical value. The test was carried out at level, first difference and second difference using 1%, 5% and 10% Mackinnon Critical value. The result of the ADF unit root test carried out is presented in Table 2. The ADF test reveals that only the GDP growth rate is stationary at level, while both Capital formation and Electric Power supply are stationary at first difference. Labour force, on the other hand, obtained stationarity on second differencing. This necessitates the Co-integration test to find the long-run co-integrating relationship among the variables.

4.3 Co-integration Test

Table 3: Co-integration test using ARDL bounds test

F-Stat	I(0) Bound at 5%	I(1) Bound at 5%
4.704831	3.23	4.35

Source: Author's Computation using E-Views, Version 9.0

As the variables were found to be stationary at level, first and second differences, the long-run relationship would be tested among the variables using the Pearson Bound test procedure. The result obtained shows that the F−Statistic is greater than both the I(0) bound and the I(1) bound. Since the decision rule for co-integration is that the F-stat should be greater than both the I(0) and I(1) bounds, that implies that there is a long-run relationship existing among the variables. The result obtained is shown in Table 3.

4.4 Autoregressive Distributed Lag Model (ARDL)

Table 4: Autoregressive distributed lag model estimates

Variables	Coefficient	T-statistic
C	42.02307	0.267355
LOGKAP	-13.09079	-2.768726
LOGLAB	12.02981	0.936982
LOGELEC	28.44027	2.965864
R-squared 0.385335 F-statistic 4.704831 Adjusted R^2 0.262402 Prob (F-statistic) 0.037362 Durbin-Watson stat 2.049010		

Source: Author's Computation using E-Views, Version 9.0

To determine the long-run equation of the model, the ARDL regression result obtained is presented in Table 4. From the long-run equation in Table 4, the coefficients of labour force and electricity are found to be positive, while the coefficient of capital formation is negative. This typifies that both labour and electricity have a positive relationship with the growth of GDP, while capital formation has a negative relationship with GDP growth. Capital formation is shown to have a negative relationship with GDP growth with a coefficient of 13.14460, signifying that for everyone increase in Gross Capital Formation, the GDP growth will fall by the value of 13.15. This signifies a negative significant fall. The result is in line with the work of (Ogundipe & Apata, 2013). Contrary to this work although, the work of Ohwofasa, Obeh and Erakpoweri (2015) which revealed that electric power generation do not have any significant impact on the growth of the Nigerian economy in the short run.

Labour force, on the other hand, has a positive relationship with GDP growth with a coefficient of 12.12248. This means that if the total labour force in the country increases by the value of 1, the level of GDP growth will increase by approximately 12.12. This is a positive relationship between Labour force and the GDP growth, however insignificant at 5% level of probability. The findings of this work are in line with the works of Ogundipe and Apata, (2013) which identified a positive relationship between Labour force and the GDP growth. Contrary to this work although, the work of Ohwofasa, Obeh and

Erakpoweri (2015) found electric power generation not to have any significant impact on the growth of the Nigerian economy in the short run.

Electric Power Supply has a positive relationship with GDP growth with a coefficient of 28.71402. For every increase in the megawatts produced in Nigeria, Economic Growth would be affected positively by approximately 28.71%. There is, therefore, a significant positive relationship between the electric power supply and economic growth. The result of this work correlated with the work of George-Anokwuru and Ekpenyong (2020) which found a positive relationship between electricity consumption and economic growth. Electricity generation also had a negative link with economic growth, while electricity distribution and losses have a negative association with economic growth in Nigeria during the period studied. The R^2 reads 0.497611, indicating that 49.76% of the total variations in the gross domestic product growth is explained by the variations in the independent variables. The F-statistic 4.704831 at 1% prob (0.008276) shows that there is a linear relationship between the dependent variable – GDP growth and all the independent variables put together. The Durbin Watson value of 1.98 indicates that there is no autocorrelation associated with the regression result. The figure is close to 2, meaning that the independent variables are truly independent, even in the long run.

Comparing the apriori expectations with the actual results, it was found that not all the variables conformed to the apriori expectations. It was apriori expected that Capital formation, labour force and electricity would all have positive relationships with the GDP, as the apriori expectation was that β_1, β_2, $\beta_3 > 0$. It was however discovered that from the actual results, only Labour force and electricity conformed to the apriori expectations. Capital formation proved to be negatively related to the growth of the gross domestic product.

4.5 Granger Causality Test

Table 5: Granger-causality test result

Null Hypothesis:	Obs	F-Statistic	Prob.
ELEC does not Granger Cause GDP GROWTH	26	3.41182	0.05040
GDP GROWTH does not Granger Cause ELEC		4.64951	0.02015

Source: Author's Computation using E-Views, Version 9.0

The causality test using the pairwise approach was carried out to measure the causal relationship between electric power supply and GDP growth. The result of the causality test shows with F-statistic at 3.41182 and probability of 0.05040, that electric power supply granger-caused GDP growth during the observed period. Table 5 indicates that the F-statistic was 4.64951 and probability of 0.02015. The result shows that GDP growth granger-caused electric power supply during the same period, typifying a bi-directional relationship between the electric power supply and the GDP growth, implies that during the period under review, the level of electric power supply increased simultaneously with the economic growth in Nigeria.

5.0 Conclusion and Recommendations

The study concludes that increased electricity generation and supply is a strong determinant of economic growth in Nigeria and should, therefore, be given more relevance by exploiting the opportunities in the power sector to foster economic growth. Arguably, the most popular impediment to the attainment of Nigeria's vision to become one of the 20 developed economies in 2020 is the electric power supply. This is because of the direct bearing it has on other economic indicators like gross capital formation, unemployment rate and low capacity utilization in the manufacturing/industrial sector. The study recommended that policy reforms should gear towards fully deregulating the electric power sub-sector of the economy to allow for private sector participation in the generation, transmission and distribution of electricity. Similarly, improvement in the performance of electricity supply should be vigorously pursued. This is because it would ultimately affect GDP when those who depend on more expensive alternatives (petrol and diesel generators) would now depend on the public electric power supply.

According to the bi-directional causality result, as an increase in electric power supply boosts economic growth, policies to expand electric power generation should also be improved. This would continually boost electric power generation, which would also increase economic growth. Other electric energy sources should also be fully exploited for the supply of electric energy. Finally, there is great need to strengthen the effectiveness of electric power generating agencies by ensuring periodic replacement of worn-out equipment and necessary tools to drastically reduce power losses.

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