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REVISITING ELECTRICITY-ECONOMIC GROWTH NEXUS IN SUB-SAHARA AFRICA: PERSPECTIVES FROM NIGERIA AND SOUTH AFRICA

Iyabo OLANRELE[1]

[1]*Research Fellow Economics and Business Policy Department Nigerian Institute of Social and Economic Research (NISER) PMB 5, UI Ojoo Road, Ibadan, Oyo State, Nigeria*
Email: adeyemiyabo@yahoo.com

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ABSTRACT

This study considered the effect of electricity consumption on Nigeria and South Africa's economic growth using Linear Autoregressive Distributed Lag (ARDL) Model. Aside from the size of the two economies and the strategic position they hold in Africa, Nigeria, unlike South Africa, in 2013 reformed its power sector to accommodate private participation for improved performance. In spite of this, the empirical results show that electricity consumption has no significant effect on Nigeria's economic growth both in the short and long-run. Contrarily, there was significant short-run electricity consumption effect on economic growth in South Africa. The effect persisted till the long-run though at an insignificant rate. The implication of the findings is that power sector reforms, especially in 2013, has not brought about the desired economic impact in Nigeria. As such, it is pertinent to revisit and correct the anomalies in the recent power sector privatization for economic growth. Evidently, electricity consumption engenders growth in South Africa, even with recent data, but more investment is required in the power sector to sustain long-run effect on the economy.

Contribution/Originality: This study contributes to the existing literature by considering the short run and long-run effects, as against the causal link, of electricity-economic growth nexus. Also, extending data to recent period is apt, as this has an implication for capturing possible dynamics from the changing structure of the economies.

1. INTRODUCTION

Abundant and reliable energy supply has been a vital input in consumption and production possibilities in modern economies. Its availability also serves as a conduit for capital inflows, which equally impact economic growth and development (Olanrele and Adenikinju, 2018). While universal access has remained one of the focal points in the Sustainable Development Goals (SDG)- goal No. 7, however, access to modern energy in Africa has remained below the level required to engender meaningful impact. This deficit is massive as about 62.5% population in the sub- Sahara is without electricity access (World Economic Forum, 2018). In the region, the population without access is projected around 619million by 2030 (IEA, 2016 cited by Morrissey (2017)). Beyond this, the rate of electrification in the region averaged 42 percent in 2016 (World Bank, 2017). The high rate of poverty remained an issue engendering low access, and also concerns on tariff rates, energy investment, institutional bottlenecks, complementarity between modern and traditional fuel. In Nigeria, a significant proportion of about 40.3 percent of the population is without access to electricity in 2016, this more than doubled South Africa's 15.8 percent (WB, 2017). Although disparity abounds between rural and urban access.

In the sub-Sahara region, Nigeria and South Africa are classified as the largest economy. As at 2014, based on real Gross Domestic Product (GDP), the size of the Nigerian economy stood at $ 452.2 billion, growing at 6.3 percent. In the same period, South Africa's real GDP was about $ 413 billion, with an annual growth rate of about 1.7 percent (WB, 2017). The Nigerian economy is low energy intensive, as is growth and development narrative are basically hinged on its oil export, neglecting vital input of the power sector. The country's electricity generation has remained abysmally low, at an average value of 4000MW, for its huge population of over 180 million, with about 82 percent from gas sources and 18 percent from hydro. The dominance of gas generation is explained by the country's huge natural gas deposit of about 5475.2billion cu.m (Organization of Petroleum Exporting Countries, 2017). Unlike Nigeria, South Africa's growth and development narratives are driven by its high energy intensity. Electricity generation in the country averaged 25,000MW and is sourced from coal (90 percent), nuclear (6 percent), renewable (1.4 percent), while sources like oil and hydro constitute less than 1 percent each (WB, 2017).

Despite the huge energy resource endowment, Nigeria, in particular, has not done well in tapping electricity generation potentials required for meaningful economic activities. Notably, with the recent unbundling of Nigeria's power sector, energy margin has grossly remained inadequate for the country's growing population. Having scaled up total generation installed capacity from the 7000MW to little above 12000MW, supply and demand margin remained high. Prior to 2013 unbundling of the electricity industry, available generation was about 2888.3MW but marginally increased to 3587.4MW in 2015. This was grossly below the projected 15,730MW required in 2015 (Sambo, 2008). Aside from the inadequacy of supply, high transmission and distribution losses are other concerns affecting supply balance, as well as, acute power shortages. Another dimension in recent times has to do with lack of utilities in the distribution chain, needed to match the existing available generation, a situation that led to a stranded generation of about 2000MW in 2017. According to WB (2017) the monthly average number of power outages in 2014 in firms is around 33 (thirty-three). These situations explain Nigeria's low electricity consumption per capita (144KWh), to South Africa's (4229KWh). Although South Africa's power sector has done fairly well for its less than 60 million people, the sector grapples with decreasing reserve margin in the electricity sector (Bah and Azam, 2017). Growing demand has not been matched with equal supply due to new required investment on generating facilities as existing facilities are deteriorating (Trollip *et al.*, 2014). Coal being the dominant source of electricity poses a serious environmental concern on the economy, as most of the coal-fired power plants are not environmentally compliant, and some of them past or close to their end-of-life (Yelland, 2018).

A plethora of studies exists in this regard, for instance, the estimation result by Akinlo (2009) show that real gross domestic product and electricity consumption are cointegrated and there is only a unidirectional Granger causality running from electricity consumption to real GDP in Nigeria. A unidirectional causality was equally reported in Menyah and Wolde-Rufael (2010) as energy consumption is found to Granger cause economic growth and from energy consumption to pollutant emission. In more recent time, a study on Nigeria (Iyke, 2015) found evidence of a causal relationship, with a causality flowing from electricity consumption to growth in the short and long run, supporting the electricity-led growth hypothesis. Contrarily, in Odhiambo (2009) a short-run bidirectional relationship between electricity and economic growth in South Africa was established. Still, in South Africa, Bah and Azam (2017) found no evidence of causality between electricity and economic growth, vis-versa. Hence, the neutrality hypothesis holds in this case.

Using threshold cointegration and causality relationship between energy use and growth, Esso (2010) investigates the long-run and the causality relationship between energy consumption and economic growth for Sub-Saharan African countries during the period of 1970–2007. Evidence abounds that energy consumption is cointegrated with economic growth in Cameroon, Cote d'Ivoire, Ghana, Nigeria, and South Africa. Also, the test suggests that economic growth has a significant positive long-run impact on energy consumption in these countries before 1988 and this effect becomes negative after 1988 in Ghana and South Africa. The causality tests suggest bidirectional causality between energy consumption and real GDP in Cote d'Ivoire and unidirectional causality running from real GDP to energy usage in the case of Congo and Ghana. Using a nonparametric approach, Lin and Wesseh (2014) re-examined energy consumption and economic growth in South Africa, with data spanning 1971 to 2010. Findings revealed evidence of long-run unidirectional Granger causality from energy consumption and economic growth. A feedback effect of electricity consumption-economic growth nexus was established in Angola by Solarin *et al.* (2016) using data from 1970-2012. Results from vector autoregressive error correction model revealed that electricity consumption boost economic growth but urbanization impairs it. The causality test also shows a feedback relationship between electricity consumption and economic growth, exports, and imports.

Although some studies investigated the electricity-economic growth relationship using electricity generation indicator. For instance, Zeshan (2013) assess the relationship between electricity generation and economic growth in Pakistan. In the same vein, Yoo and Kim (2006) established a unidirectional causality running from economic growth to electricity generation without any feedback effect. At a disaggregated level, Marques and Nunes (2016) examined electricity generation mix and economic growth in France. Their findings indicate that nuclear energy has been a huge driver of economic growth, while renewables exert a negative effect on economic growth. Investigating this relationship using an indicator like the electricity generation may not reveal much in a country with huge transmission and distribution losses. The average electric power transmission and distribution losses (% of output) for Nigeria in the period 2004 to 2014 was about 16 percent. At this rate, it behoves that the amount of electricity consumed counts more for economic growth.

As shown above and other relevant literature, in terms of methodology, most studies have relied on examining the causal link between electricity consumption and growth, with little attention on the short-run and long-run effect of electricity on economic growth. Repeatedly, some studies have established the relationship inherent in electricity-economic growth nexus, with results reinforcing each other's findings even with different sample periods (Akinlo, 2009; Menyah and Wolde-Rufael, 2010; Iyke, 2015). This study departs from this trend by investigating the short and long-run effect of electricity consumption on economic growth. And since a concrete analysis is a prerequisite for better policy implications, it would be important to have the knowledge of both short and long run scenarios in the model, thus the used of Autoregressive Distributed Lag Model (ARDL).

Reinvesting the electricity-economic growth nexus base on country comparison is apt in the current context, as this will avail the opportunity of drawing pathways for increasing electricity access required for making more growth. Aside from the size of the two economies and the strategic position they hold in Africa, Nigeria, unlike South Africa, in 2013 unbundled its power sector, to accommodate private participation; investigating the impact of the reform on economic growth will provide great information for policy formulation. On the other hand, the South Africa electricity industry is vertically integrated, under the state control. To this end, does electricity consumption engenders economic growth, what is the short and long-run effects of electricity consumption on economic growth in Nigeria and South Africa. Empirical understanding of this and other issues will form the crux of this paper. A time-series econometric technique based on linear Autoregressive Distributed Lag (ARDL), using annual data from 1980 to 2016 will be employed. The ARDL does not involve pre-testing the variables. It is equally possible that different variables in the ARDL model have different optimal lags, and suitable for a small size (Duasa, 2007).

2. STYLIS FACTS

Electricity generation in Nigeria dates back to 1896, when electricity was first generated in Lagos, various types of reforms were put in place period after. Prominent are the 1988 power sector policy, the Electricity sector reform Act drafted in 2005 that culminated into 2013 unbundling of the power sector, and the Power Sector Recovery Programme initiated in 2017. Prior to 2013, the Nigerian power sector was solely under the state control, while the existing arrangement allows for private control of the generation and distribution chain, the transmission chain still under state monopoly. A peculiar emphasis that ran across the Nigerian power sector reforms was to address the problem of acute power shortages that have impeded meaningful economic activities in the real sector of the economy.

In a bit to make the Nigerian power sector efficient and effective, the defunct National Electric Power Authority (NEPA) which has hitherto remained under the state control was restructured to allow for private sector participation. Although this process was initiated in 2004, under the nomenclature of Power Holding Company of Nigeria (PHCN), the privatisation process was completed in 2013. Under the new structure, the sector was unbundled into six (6) generation companies (GECOs), one (1) transmission company, and 11 (eleven) distribution companies (DISCOs). The Nigerian transmission company till date remains under the state control, hence, it is ring-fenced. This is so due to the centralized grid system adopted in the country, and the huge fund requirement that cannot be left at the mercy of private investors. To enhance optimal performance, the Nigerian Electricity Regulatory Commission (NERC) was set up in 2005 as a fall-out in a new structure. As part of the power sector reform, the Nigeria Bulk Electricity Trading (NBET) Plc came into being in 2010 as a manager and administrator of electricity pool that brokers between the generating and distributing companies.

Despite the increasing size (real GDP and economic growth rate) of the economy as notice between 1980 to 1989 and 2010 to 2016, key sectors like the manufacturing contributed less than 10 percent to real GDP (Table 2.1). Considering the role of electricity in the production process, however, electric consumption was low, possibly explaining the overwhelming cost of production as indicated by the high rate of inflation, hence low share of the manufacturing sector in GDP. The growing size of the population has equally not been adequately matched by electricity generation given the low level of electricity consumption per capita in the country.

Growing from a modest installed capacity of 804.7MW in 1970 to peak at 12000MW in 2017, the total electricity generated has not exceeded 7000MW. As depicted in Figure 2.1, electricity generation, from 1980, was dominated by gas power generation followed by hydro plants generation. Generation from oil power plants has not grown beyond 20 percent from 1980 to 1996. Generation from gas power plants became dominant, absorbing the share of oil generation since 1997. From 45 percent in 1996, gas plant generation has increased beyond 60 percent from 1997 to date. The discovery of natural gas in commercial quantity accounted for this development. However, generation from coal was below 1 percent from 1983 to 1992 that it existed, while the output from hydro declined from about 39 percent in 1980 to 19 percent in 2015. The subsequent decline in hydropower generation, despite the available natural resources, is accounted for by weak infrastructure, low water level engendered by seasonal variation and inadequate investment.

Table-2.1. Overview of the Nigerian Economy, 1980 to 2016

Indicator	1980-1989	1990-1999	2000-2009	2010-2016
Share of Real Manufac. GDP (%)	5%	5%	5%	6%
Real GDP (US$, Billions)	178.8	207.1	366.5	635.2
GDP Growth Rate	-1.4	2.6	8.9	4.2
Inflation Rate	20.9	30.6	12.2	11.5
GDP per capita constant (US$)	1452	1291	1747	2454
Electricity Consumption (MW)	753.3	1063.5	1759.9	2899.45
Electric power consumption (KWh per capita)	78.9	87.5	110.8	146.1
Population (Million)	83	107	138	172

Source: Author's computation with data from World Development Indicators, 2017

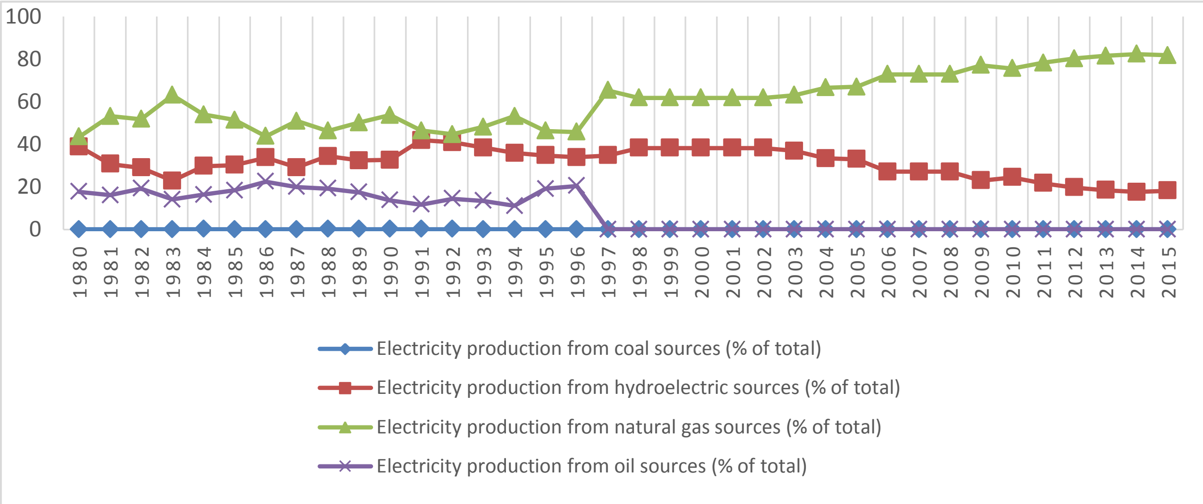

Figure-2.1. Composition of the Nigerian Electricity Generation by Source, 1980 to 2015

Source: Author Depiction with data from World Development Indicators, 2017

Since inception, South Africa's power sector has remained under the State control, hence a vertically integrated model. The ESKOM, which is the state utility, is majorly responsible for generation, transmission, and distribution. Most of the existing privately power producers were gradually consolidated and absorbed into the vertically integrated state utility. In a way to enhance accountability and transparency, the governance of ESKOM was overhauled and new commercial principles were embedded into the operation utility (Eberhard *et al.*, 2017).

As shown in Table 2.2, the narrative on the performance of some selected macroeconomic indices is entirely different in South Africa, which has grown by leaps and bounds in its power sector. Manufacturing GDP was more than 10 percent in the period 1980 to 2016. This is not a surprise considering a more favourable macroeconomic environment. Obvious of the fact that the country's electricity supply is one of the best, thus, the reducing cost of production that could have dampened the performance in the real sector of the economy. As electricity generation remained high, its consumption per capita becomes positive.

Current generation capacity in South Africa is about 49,000MW. The country's electricity mix is comprising of nuclear, hydro, coal and oil. Of these sources, coal generation was dominant contributing as much as 94.4 percent from 1980 to 2016. Other sources, however, contributed less than 10 percent, although the nuclear source has an average of about 5.3 percent, with others having less than 1 percent each. The huge coal potential explained its dominant role. Unlike Nigeria, South Africa has made some effort in its renewable energies since 1990 with an average of about 0.7 percent from 1990 to 2016.

On the environmental front, an endowment of natural gas, which is a clean energy, is a plus in Nigeria's power generation mix. Although a leading giant in electricity generation, coal utilization has been a challenge in South Africa's power sector, considering the environmental hazard that comes with its usage.

Table-2.2. Overview of South Africa's Economy, 1980 to 2016

Indicator	1980-1989	1990-1999	2000-2009	2010-2016
Manufacturing GDP (%)	16	14	14	13
Real GDP (US$ Billion)	206.3	233.5	317.9	402.3
GDP Growth Rate	2.2	1.4	3.6	2.0
Inflation Rate	15.8	10.9	7.8	6.0
Electricity consumption total (MW)	14713.2	20187.6	24956.1	26455.5
Electricity consumption kw per capita	3854.3	4249.8	4509.9	4376.8
Population	33	41	48	54

Source: Author's computation with data from World Development Indicators

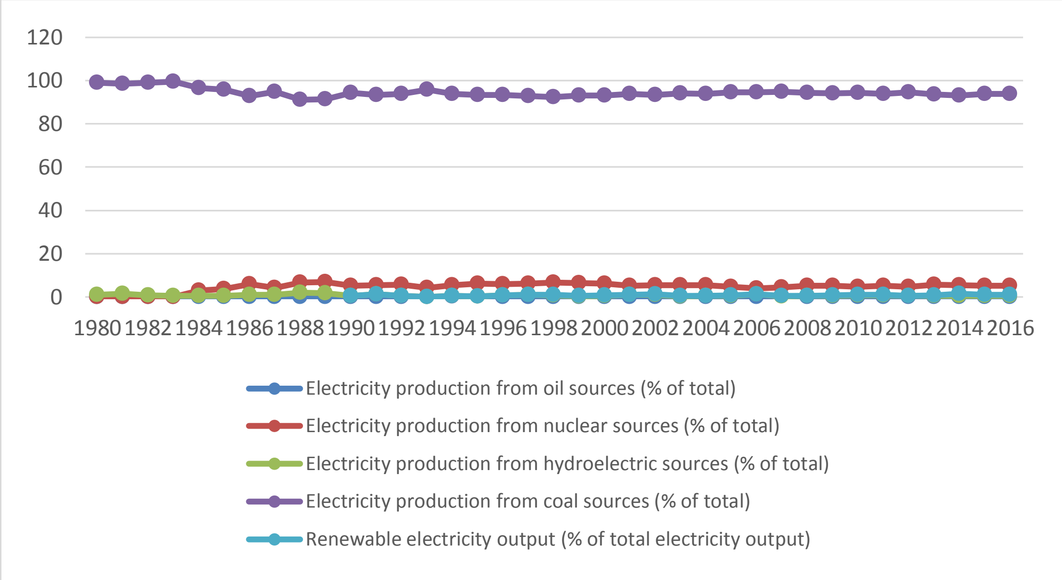

Figure-2.2. Composition of South Africa's Electricity Generation by Source, 1980-2016
Source: Author with data from World Development Indicators, 2017

3. DATA AND METHODOGOY

3.1. Data

Annual secondary data spanning 1980 to 2016 was used in this analysis, with data from WB (2017) and the International Energy Agency (IEA) (2018). The selected economies happened to be the largest economies in sub-Sahara and Africa as a whole. Key reforms, especially in Nigeria, in the power sector happened in the selected period. Lastly, the adopted econometric technique is time series, which requires small or a substantial number of observations. Below is a brief description of the dataset used.

Economic Growth is proxy by real gross domestic product (Rgdp) expressed in US$ and is in 2010 constant prices. The electricity consumption is measured in Megawatts (MW). Labour is proxy by the population of 15 to 64 years since this group represents the active labour force. Lastly, capital is represented by gross fixed capital formation. The natural logarithm form of the selected variables was employed for the analysis.

3.2. Methodology

Based on the energy led-growth hypothesis established in extant literature (Akinlo, 2009; Menyah and Wolde-Rufael, 2010; Iyke, 2015) the aggregate production function was adopted. The production function is traditionally seen as a function of capital and labour. The implicit form of this function is given in equation (4.1)

$$Y_t = Af(L_t, K_t) \quad (4.1)$$

Where Yt is the output indicator, A_t total factor productivity or efficiency parameter, Lt is labour, Kt is capital and t is the time period. However, energy plays an important role in economic growth, as such, production is seen as a function of capital, labour, and energy (Ghosh, 2009; Stern, 2010; Ogagavwodia, 2014). Total factor productivity is further assumed a function of energy indicator (Xt). Thus:

$$A_t = f(X_t L_t, K_t) \quad (4.2)$$

Substituting equation (4.2) into (4.1) for A_t gives:

$$Y_t = f(L_t, K_t, X_t) \quad (4.3)$$

All parameter definition remains the same, except for X_t, which is an energy indicator

The explicit form of the model from equation (4.3) is specified as:

$$RGDP_t = \alpha + \beta_1 LF_t + \beta_2 GFCFt + \beta_3 ELECTct + \varepsilon_t \quad (4.4)$$

$RGDP_t$ denotes output indicator and it is measured by real GDP (Edquist and Henrekson, 2006) LF_t is labour force proxy by population workforce of 15-64 years, $GFCF_t$ is gross fixed capital formation used to measured capital, and *ELECTc* stands for energy indicator which is measured by the quantity of electricity consumed. It is theoretically expected that labour force, gross fixed capital formation, and electricity consumption will directly impact on economic growth.

The analysis was quantitative nature. Specifically, the electricity consumption and economic growth relationship were analysed using an econometric technique describe in equations 4.5 to 4.6. A concrete analysis is a prerequisite for better policy implications, it would be important to have the knowledge of both the short-run and the long-run scenarios in the model. Specifically, the Autoregressive Distributed Lag (ARDL) model was used to examine the short and long run relationship of the model. To analyse the ARDL model, the long-run cointegration test must be established. When cointegration is established, the conditional ARDL (*p*, *q1*, *q2*, *q3*), the long-run model for R*GDPt* will be estimated as follows:

$$lnRGDP_t = \beta_0 + \sum_{i=1}^{p} \beta_1 lnRGDP_{t-1} + \sum_{i=0}^{q1} \beta_2 lnLF_{t-1} + \sum_{i=0}^{q2} \beta_3 lnGFCF_{t-1} + \sum_{i=0}^{q3} \beta_4 lnELECTc_{t-1} + \mu_t \quad (4.5)$$

The parameters in equations (4.5) remain the same. Estimating the ARDL model entails the selection of appropriate lag length for the models, hence, the Schwarz and Akaike criteria were used since they provide the least lag length. Having established the long-run relationship, the short-run relationship was obtained through the Error Correction Model (ECM) estimates. The ECM helps to reconcile the short-run and long-run behaviours of an economic variable. The ECM representation of the series is specified as follows:

$$\Delta lnRGDP_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta lnRGDP_{t-1} + \sum_{i=0}^{q1} \beta_{2j} \Delta lnLF_{t-1} + \sum_{i=0}^{q2} \beta_{3k} \Delta lnGFCF_{t-1} + \sum_{i=0}^{q3} \beta_{4m} \Delta lnELECTc_{t-1} + \partial ECM_{t-1} + \mu_t \quad (4.6)$$

where ∂ is the speed of adjustment parameter and ECM is the error correction term. It is expected that the coefficient ∂ be negative and statistically significant for the existence of a short-run relationship.

The analysis commenced with a check on the time series properties of the model-unit root test and descriptive statistics. This was to enhance reliable inferences for policy decisions.

4. EMPIRICAL RESULTS

4.1. Unit Root Result

The time series properties of the analysis are presented in Table 4.1. This is done using Augmented Dickey-Fuller (ADF) and Philips Perron (PP). Considering that the variables are mixture of I (0) and I (1), the assumption for ARDL bound test holds (Pesaran *et al.*, 2001; Ouattara, 2004) as such, we proceed to other estimation within the ARDL technique.

Table-4.1. Unit Root Test Result

Variable	ADF Test				PP Test			
	Nigeria							
	Levels		**1st Difference**		**Levels**		**1st Difference**	
	Constant	Constant and Trend	Constant	Constant and Trend	Constant	Constant and Trend	Constant	Constant and Trend
rGDP	0.89***	-3.01***	-4.99	-5.09	0.59***	-3.01***	-4.98	-5.09
$Elect_c$	-0.66***	-3.21**	-8.88	-8.76	-0.33***	-3.34**	-8.81	-8.69
Pop_{1564}	-0.73***	-2.18***	-6.59	-6.53	1.13***	-2.97***	-2.66**	-2.32***
Gfgf	-1.02***	-2.64***	-2.34***	-2.26***	-1.02***	-2.64***	-4.50	-5.14
Variable	**ADF Test**				**PP Test**			
	South Africa							
	Levels		1st Difference		Levels		1st Difference	
	Constant	Constant and Trend	Constant	Constant and Trend	Constant	Constant and Trend	Constant	Constant and Trend
rGDP	0.77	-2.49***	-4.35	-4.61	0.69	-1.62***	-4.42	-4.67
$Elect_c$	-2.99*	-2.06***	-4.96	-5.44	-4.06	-2.04***	-4.94	-6.18
Pop_{1564}	-2.23***	-1.99***	-0.69	-2.16***	-4.21	0.17	-0.58***	-1.93***
Gfgf	-0.47***	-2.97***	-3.33*	-3.56	0.14	-1.84***	-3.28*	-3.37**

Source: Author's computation using output from Eviews 9

4.2. Bound Test

Cointegration relationship is determined by comparing the computed F-Statistic, which captures the statistical significance of the model with the lower and upper bound critical values provided by Narayan (2005). The null hypothesis suggests that all slope coefficients are equal to zero, where the F-Statistic falls within the upper and lower bound critical values. Table 4.2 shows that the F-Statistics of 11.2 and 4.7 fall outside the bound, beyond the upper significance limits both at 10% and 5%. Therefore, we reject the null hypothesis and conclude for cointegration relationship.

Table-4.2. Bound Test for Cointegration

Nigeria				
F-Statistics	**90% Lower**	**90% Upper**	**95% Lower**	**95% Upper**
11.2	2.72	3.77	3.32	4.35
South Africa				
F-Statistics	**90% Lower**	**90% Upper**	**95% Lower**	**95% Upper**
4.7	2.72	3.77	3.23	4.35

Source: Author's computation using output from Eviews 9

Having established the existence of long-run cointegrating relationships in the estimated economic growth model, ARDL specifications were estimated for the following model specification (3, 3, 2, 4) and (3, 1, 1, 1) based on the assumption of linear trend. The maximum lag length of 4 was selected for both dependent and independent variables for Nigeria and 3 for South Africa's long and short-run models.

4.3. Estimation Results

The economic growth of Nigeria and South Africa is premised upon the dynamics of variables such as energy (electricity consumption), capital (gross fixed capital formation), and labour (population of 15 to 64 years). As such, the long-run and short-run estimated models are presented below.

Nigeria

Table 4.3 shows that electricity, that is the variable of interest has a negative and significant long-run impact on real output (rgdp). An increase in megawatt electricity consumed will engender output decrease by 0.4 percent. Although the quantum of impact is less than 1 percent, the result does not conform to expectation. The negative relationship confirms the findings of similar studies such as Wolde-Rufael (2006). A percent increase in labour (pop1564) and capital (gfcf) will increase rgdp by 0.7 percent and 0.2 percent respectively. These results are statistically significant at 1 percent and equally conformed to theoretical expectation.

The short-run estimation based on the Error correction model (ECM) in Table 4.4 indicates that at 1.7%, the model will speedily adjust itself to its long-run equilibrium. The short-run effect of electricity consumption (Electc) remained the same as the long-run impact, but statistically insignificant. The result shows that despite the fact that electricity consumption has caused output growth, as also established by Akinlo (2009) its effect remained insignificant even with recent data. This outcome is possible because of the inadequate investment in the country's electricity sector, a situation that has to impede meaningful economic activities. At 0.8 percent, *rgdp* in the past period caused a significant increase in itself. In the same vein, at 0.2 percent, capital (gfcf) will increase rgdp, this is statistically significant. Labour (pop1564) has a negative effect on *rgdp*, the coefficient turned out significant.

The test for serial correlation was conducted based on LM test, with the null hypothesis that the residuals are serially uncorrelated. The F-Statistic *p*-value of 0.5083 indicates the acceptance of this null. Therefore, we conclude that the residuals are serially uncorrelated. Similarly, the heteroscedasticity test implied that the residuals of the model estimated are purely white noise given that the test statistics are not statistically significant. The stability condition of the error correction model was tested based on Cumulative Sum of Recursive Residuals (CUSUM) and Plot of Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ). Figures 4.1 and 4.2 show that both plots fall within the critical bands, hence, Nigeria's *rgdp* short-run model is structurally stable.

Table-4.3. Estimated Long-run Coefficients Result

Dependent Variable: *lnrgdp*
Selected Model: ((3, 3, 2, 4)
Criterion: Akaike Information Criterion

	Coefficient	Standard Error	T-test	Prob.
LnElectc	-0.436950***	0.046670	-9.362498	0.0000
lnPop1564	0.705121***	0.072267	9.757127	0.0000
LnGfcf	0.184613***	0.040373	4.572697	0.0001
C	6.126422**	2.162288	2.833305	0.0094

Note: ***, **, and * denote statistical significance at 1%, 5% and 10%

Table-4.4. Error Correction Representation of the Selected ARDL Model

Dependent Variable: *lnrgdp*
Selected Model: ((3, 3, 2, 4)
Criterion: Akaike Information Criterion

	Coefficient	Standard Error	T-test	Prob.
Δ*lnrGDP(-1)*	0.775442***	0.159282	4.868357	0.0001
Δ□*nElec*□*c*	0.102830	0.077808	1.321587	0.2038
Δ*lnPop1564*	-22.302730**	7.176759	-3.107633	0.0064
Δ*lnGfcf*	0.161002**	0.051820	3.106934	0.0064
ECM (-1)	-1.696090***	0.272622	-6.221401	0.0000
ECM= RGDP - (0.4370*ELECT + 0.2045*GFCF + 0.7051*POP1564 + 6.2567□6.2567□)				

Note: ***, **, and * denote statistical significance at 1%, 5% and 10%

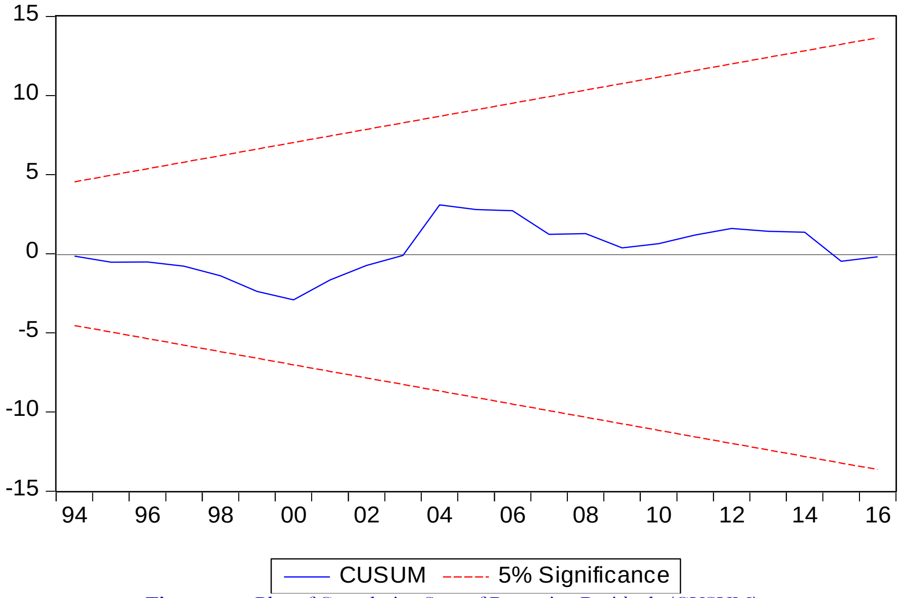

Figure-4.1. Plot of Cumulative Sum of Recursive Residuals (CUSUM)

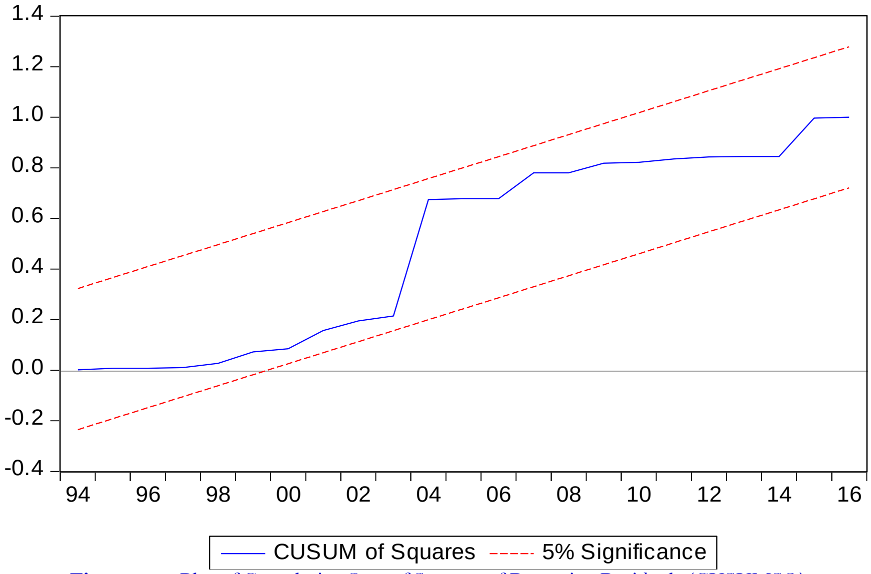

Figure-4.2. Plot of Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ)

South Africa

In the long, electricity consumption decreases *rGDP* in South Africa by about 0.4 percent, the result is statistically insignificant (Table 4.5). The coefficient for labour (pop1564) and capital (gfcf) are as expected in the long run, increase in labour (pop1564) and capital (gfcf) increase output by 0.09 percent each, these results were statistically significant, and the later corroborates evidence from Menyah and Wolde-Rufael (2010). The short-run model was able to adjust the long-run model to its equilibrium at 0.1 percent (Table 4.6). Electricity consumption caused rGDP increase by about 0.2 percent. This is statistically significant at 5 percent. Hence huge investment in South Africa's power sector has paid upon the economy, this reaffirms that the country is indeed capital intensive. Capital (gfcf) also impacted on rGDP in the short-run. However, rGDP in the past period and labour coefficients are negatively signed, implying that an increase in the two brings about a decrease in rGDP, the results are significant at 5 percent and 1 percent respectively.

Table-4.5. Estimated Long-run Coefficients Result

Dependent Variable: *lnElectc*
Selected Model: (3, 1, 1, 1)
Criterion: Akaike Information Criterion

	Coefficient	Standard Error	T-test	Prob.
LnElectc	0.472480	0.590242	0.800486	0.4313
LnPop1564	0.090431	0.593139	0.152461	0.8801
LnGfcf	0.090048	0.181850	0.495179	0.6250
C	18.659907**	6.509220	2.866689	0.0085

Note. ***, **, and * denote statistical significance at 1%, 5% and 10%

Table-4.6. Error Correction Representation of the Selected ARDL Model

Dependent Variable: *lnRGDP*
Selected Model: (3, 1, 1, 1)
Criterion: Akaike Information Criterion

	Coefficient	Standard Error	T-test	Prob.
Δ*lnrGDP(-1)*	-0.308898**	0.139955	-2.207117	0.0371
Δ*lnElectc*	0.179474**	0.068869	2.605998	0.0155
Δ*lnPop1564*	-3.390541***	0.818114	-4.144338	0.0004
Δ*lnGfcf*	0.187115***	0.039281	4.763534	0.0001
ECM (-1)	-0.127528	0.068498	-1.861787	0.0749
ECM= RGDP - (0.4725*ELECT + 0.0904*POP1564 + 0.0900*GFCF +18.6599)				

Note. ***, **, and * denote statistical significance at 1%, 5% and 10%

The diagnostic test based on test of serial correlation, shows the absence of serial correlation as the null hypothesis cannot be accepted based on the p-value of 0.6279. The stability condition of the error correction model presented in Figures 4.3 and 4.4 show that, the South Africa's output short-run model is structurally stable.

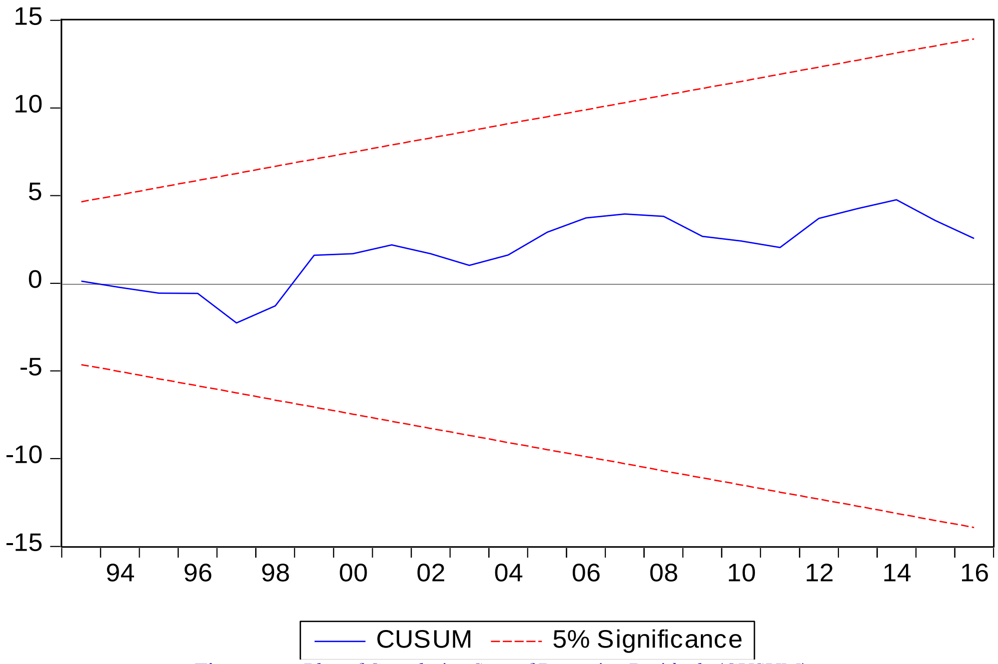

Figure-4.3. Plot of Cumulative Sum of Recursive Residuals (CUSUM)

Source: Graph obtained from Eviews 9

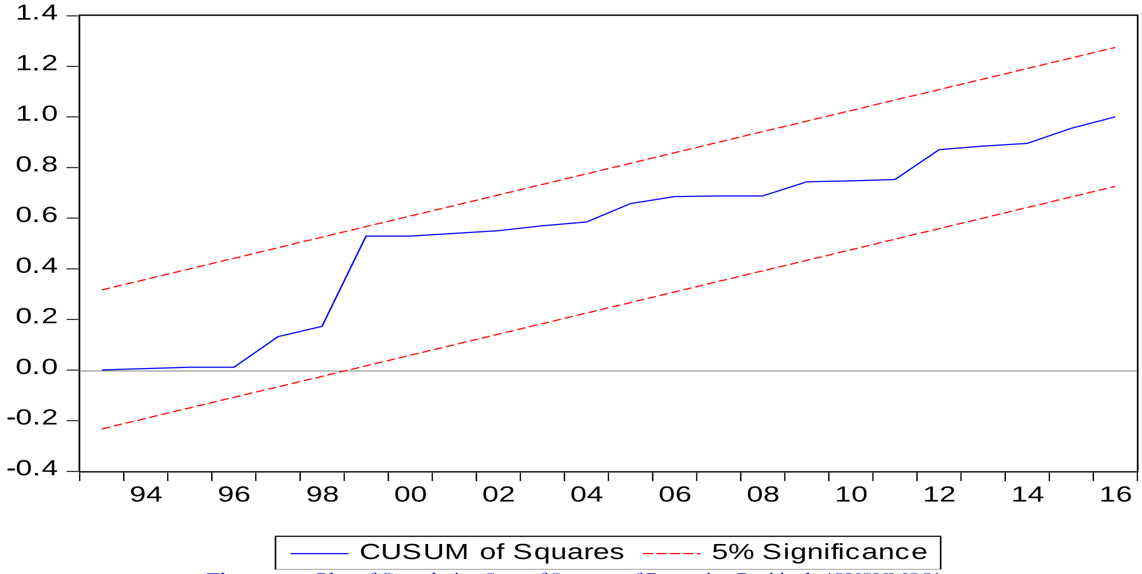

Figure-4.4. Plot of Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ)

Source: Graph Obtained from Eviews 9

5. POLICY IMPLICATIONS

In Nigeria, the short-run effect of electricity on the economy although positive at less than 1 percent, but insignificant. This situation is so considering the number of megawatts of electricity produced during the review period. The long-run effect worsens with electricity consumption decreasing output. Although there is evidence of electricity engendering economic growth in Nigeria, at the present rate of consumption its effects remain inconsequential on aggregate economic activities. Second, the use of recent date, considering 2013 unbundling of the power sector, has not improved the performance of the sector, hence the economy. Thus, it is imperative to do more in the power sector.

Specifically, the Federal Government of Nigeria should undertake a thorough, impartial and transparent investigation, to ensure that government/public resources are no longer used to subsidize private entities under the present structure. This will facilitate better performance of the sector. Presently, the existing distribution companies (DISCOS), despite having feeders with over 4000MW, operating feeders are just but about 450MW, thus explaining their inability in meeting the required demand for economic growth. The recent effort at ensuring stable gas supply through the passage of the natural gas master plan is welcoming, however, there is need to expedite speedy implementation of the plan, so as to enhance the regular and stable supply of gas to gas-thermal plants which constitute over 80 percent of the total existing electricity thermal plants. Like South Africa, more generation can be harnessed from the off-grid solution, like solar and wind, so as to widen the country's electricity generation base and supply security.

Evidently, electricity consumption in South Africa is more growth-oriented, considering the huge investment that has gone into the sector, thus transmitting into more generation and consumption. Unlike Nigeria, the sector remains mainly under the state control. It impacts significantly on the economy in the short-run, however, the long-run effect, though positive, but insignificant. This implies that investment in the sector has reached its steady state, hence becoming insignificant on the economy. Thus, government should create an enabling environment for investment in new infrastructure to replace aging infrastructure among the on-grid utilities. It is high time the South African government shifts ground by allowing private sector participation, although with state regulation, especially in the production of the more needed clean electricity sources like gas. Also, the recently launched off-grid initiative, being subsidized by the government up to 80 percent and 100 percent for the indigent (RECP, 2018) through government annual spending of US$400 should be sustained and pursued rigorously to engender more generation from the off-grid technologies for both short and long-run economic impact.

6. CONCLUSION

In conclusion, low access to electricity has remained a source of concern in sub-Sahara Africa. As such the electric-economic growth nexus was examined in two African largest economies. Nigerian case was pertinent in this case considering the recent privatization reform in the country's power sector, while South Africa under the state control has persisted as a major electricity supplier in Africa, hence, its role as an energy-intensive economy. Using ARDL with annual data from 1980 to 2016, our empirical results show that electricity consumption has no significant effect on the Nigerian economy both in the short and long-run. Contrarily, there was significant short-run electricity consumption effect on economic growth in South Africa. The effect persisted till the long-run though at an insignificant rate. The implication of the findings is that power sector reforms, especially in 2013, has not brought about the desired economic impact in Nigeria. As such, it is pertinent to revisit and correct the anomalies in the recent power sector privatization for economic growth. Evidently, electricity consumption engenders growth in South Africa, even with recent data, but more investment is required in the power sector to sustain long-run effect on the economy.

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