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STRUCTURAL BREAKS, ELECTRICITY GENERATION AND ECONOMIC GROWTH IN NIGERIA

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ABSTRACT

Instability and low electricity generation in Nigeria has continued to raise concerns. The power sector reforms aimed at enhancing increased and stable electricity generation over the decades have not been economic growth oriented. Among other factors, obsolete and poor infrastructural equipment as well as inadequate investment has continued to impede the optimal impact of the power sector. This paper used full sample VAR and structural breaks approach-rolling impulse response(RIR) model-to obtain evidence for changes in the impact of electricity generation on Nigerian economic growth based on quarterly data from 1970 to 2016. Findings revealed that electricity generation does not Granger-cause real GDP growth rate and gross fixed capital formation, while a short-run relationship exist for labour force. No strong dynamic relationship exists between electricity generation and real GDP growth over the lag period. Lastly, result from RIR technique also showed that real GDP growth rate does not respond to impulses from electricity generation over the years, but for weak impact in the early 1980s.

Contribution/Originality: This study contributes to the existing literature by examining the relationship between electricity production and economic growth in Nigeria using a recent innovative structural break approach (Rolling impulse response). The approach was used to capture the variations in economic growth that arises from structural changes relating to electricity generation overtime.

1. INTRODUCTION

Steady and abundant electricity supply is a vital input in consumption and production activities, explaining its importance in general economic growth. Structural as well as policy changes have been identified globally as factors accounting for reduced growth instability. Therefore, this relationship is likely to be subject to variation as a result of changes in the economy's structure like changes in energy policy or economic development regime, reforms in energy regulation, or institutional developments (Lee and Chang, 2005). Considering the fact that electricity policies are formulated on the background of ensuring stable relationship between electricity generation and economic growths, this paper empirically test this hypothesis while also testing the direction of relationship between electricity generation and economic growth in Nigeria.

Nigeria has adopted various economic reform model to ensure an encompassing development over the decades. Right from the periods of National plans of the 1970s to the Rolling plans of the 1980, post-Structural Adjustment period, and to the recent period, a sizable number of energy policies with particular interest on increased electricity generation have been formulated. Notable, is the 1988 power sector reform and the electricity sector reform Act drafted in 2005. The later reform gave birth to the unbundling of the power sector, in 2013, which has hitherto remained under state control. A unique feature of all the reforms was to address the problem of unstable generation and the acute power shortage arising from dilapidated structures, obsolete equipment among others. However, frequent instability in the quantity of electricity generated has remained unabated, serving as a bane to general economic activity. At nominal the generating capacity of electricity stands at about 12,500MW, but supply has always remained below half (Iwayemi, 2016). In 2007, and 2016, net electricity generated was 3527.1 megawatts and 2638.1 megawatts (International Electricity Agency, 2018). This situation explains Nigeria's biggest gap in electricity demand and supply in the world. In contrast, South Africa with a population of less than 60 million people generates about 28,852.4 megawatts while Brazil, an emerging economy like Nigeria, generates about 68,366.3 megawatts for its 201 million population in 2016 (IEA, 2018).

Several empirical studies in Nigeria are permeated with electricity consumption-economic growth nexus based on the relationship of trend and not structural breaks. Akinlo (2009) adopted co-integration and co-feature analysis to investigate the causality relationship between energy consumption and economic growth for Nigeria during the period 1980 to 2006. The empirical results show that real gross domestic product and electricity consumption are cointegrated and there is only unidirectional Granger causality running from electricity consumption to real GDP. Ogundipe and Apata (2013) examined the relationship between electricity consumption and economic growth in Nigeria using the Johansen and Juselius Co-integration technique for the period 1980 to 2008. Findings from the study indicate the existence of co-integrating relationship among the variables in the model with the indicator of electricity consumption impacting significantly on growth. There is evidence of bi-directional causal relationship between electricity consumption and economic growth. Also, Iyke (2015) examines the dynamic causal linkages between electricity consumption and economic growth in Nigeria within a trivariate VECM, for the period 1971-2011. The results show that there is a distinct causal flow from electricity consumption to economic growth both in the short run and in the long run.

Examining the relationship based on electricity production is of great importance since consumption can only be derived from stable and abundant electricity generation. Second, trend relationship is not adequate to capture cyclical components (Akinlo, 2009). Hence, it is paramount to consider variations in economic growth arising from structural changes relating to electricity generation over the decades. To investigate this relationship, a full sample approach, Vector Autoregressive method and a recent innovative approach (Rolling impulse response-RIR) that accounts for variation across different sample windows were adopted (Blanchard and Gali, 2007).[1] Unlike the conventional structural breaks techniques, the RIR method has the ability to describe variations over a sample period without necessarily imposing discrete break over full-sample observation.

Therefore, the main objective of the paper is to fill this gap in the literature. As such, the paper departs from the extant literature by considering the possibility of economic variation, measured by real growth of Gross Domestic Product (GDP); as a result of changes in electricity reforms in Nigeria. The remaining part of the paper is divided into four sections. Section two describes the situation of the Nigerian electricity generation and economic growth. Section three details the adopted theoretical framework and methodology. Section four is based on the empirical analysis and results, while the last section concludes the study.

2. NIGERIAN ELECTRICITY GENERATION AND ECONOMIC GROWTH

Electricity generation in Nigeria dates back to 1896 when it was first produced in Lagos (National Electric Power Authority (NEPA), 2004). Electricity generation in Nigeria is derived from hydro, thermal and fossil fuels

[1] The full sample VAR approach was employed to compare results with RIR approach.

with major generation through hydro and gas thermal plants sources Figure 1. Following the introduction of the Electric Power Sector Reform Act in 2005, National Electric Power Authority (NEPA) was transformed into a holding Company (PHCN) which was subsequently unbundled into 18 companies; including 6 generators, 11 distributors and one transmission company.

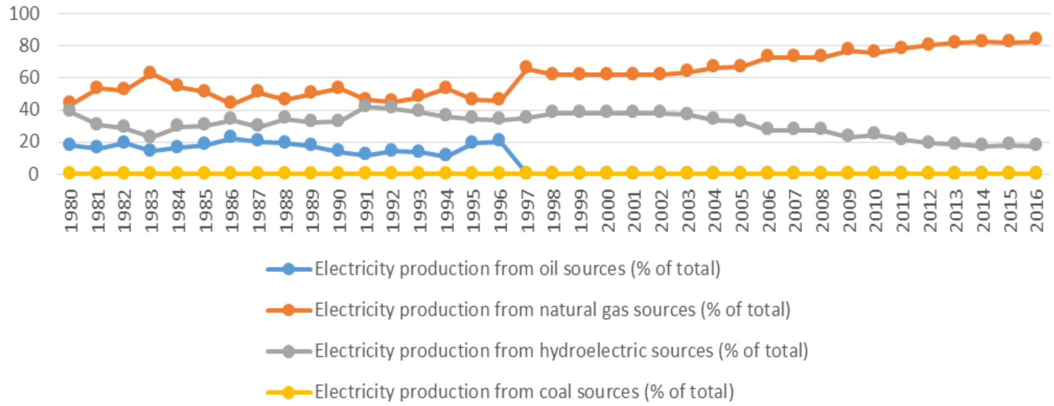

Figure-1. Composition of electricity generation by sources (1980 to 2016).
Source: World Bank World Development Indicator (WDI) (2018) and IEA (2018).

In spite the various reforms put in place to enhance optimal performance of the electricity sector, total generation has remained below yearly installed capacity. Growing from a modest installed capacity of 1979MW in 1980 to peak at 6628MW in 2016 Figure 2, the total electricity generated for the same period stood at 783.9MW and 2425.1 megawatts Figure 3. These scenarios indicate the slow rate of development in the power sector. In the same vein, the relationship between quantity generated electricity was almost the same in the 1980s, with larger gap in subsequent periods. Specifically there were seemingly unrelated associated between the total electricity generated and economic growth Figure 3. This is not too surprising considering the fact that low electricity generation over the years impacted negatively on general economic activities to the extent that about 90 percent of industrial customers and a significant number of residential and other non-residential customers provide their own power at a huge cost to themselves and to the Nigerian economy (Ogagavwodia *et al.*, 2014).

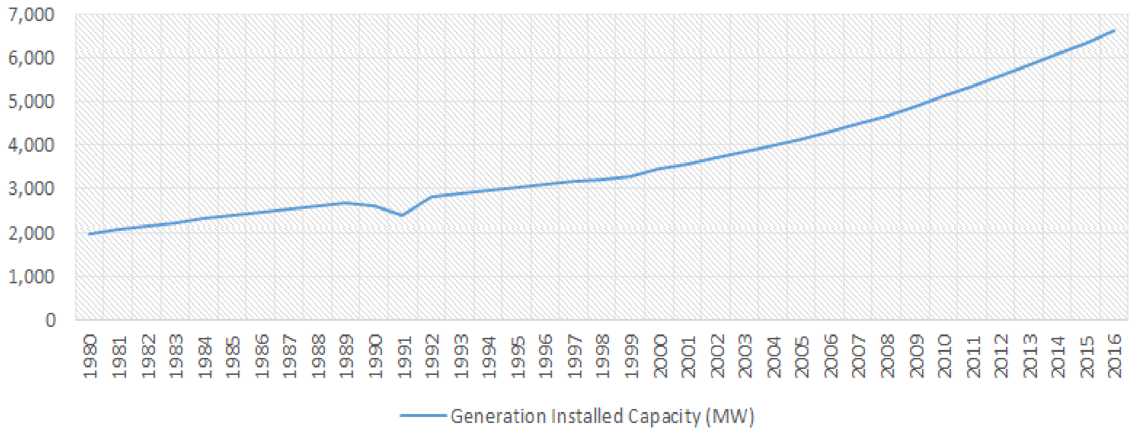

Figure-2. Total installed electricity generation capacity.
Source: https://www.indexmundi.com/nigeria/energy_profile.html.

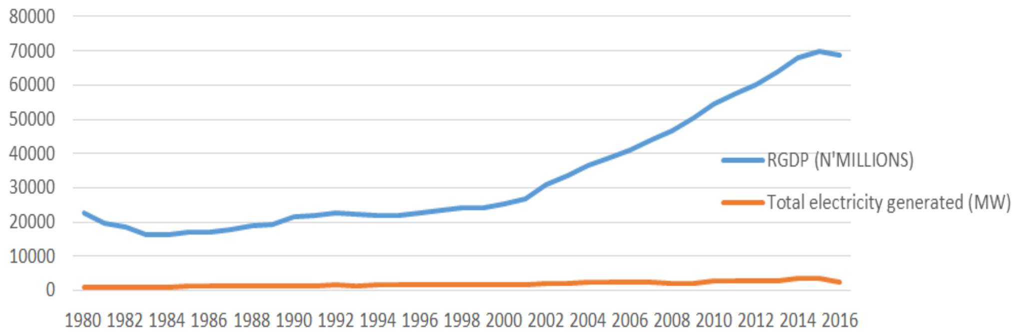

Figure-3. Total electricity generation and real GDP (1980 to 2016).

Source: 1. IEA, 2. CBN (Various issues) 35.

3. DATA AND METHODOLOGY

3.1. Data

Nigeria is chosen in this study because it is one of the largest energy resource endowed country in the world. The country has a 5475.2 billion cu.m. gas reserve and crude oil reserves of about 37 billion barrels (Electricity Installed Capacity, 2018). Beyond oil and gas resources, Nigeria is equally rich in renewable energy sources like small hydro (3,500 megawatts potential), solar energy (4.0kWh/m2/day-6.5kWh/m2/day) and biomass (18.5 million of which 6.8 million is biogas). All these combined have not impacted on the contribution of the country's power sector on economic growth. For instance, the electricity sector contributed about 0.41 percent to GDP in 2018. To improve the performance of the power sector various reform were initiated be the Nigeria, one of which brought about the 2013 power sector privatization. Although studies have investigated the energy-economic growth nexus in Nigeria (Akinlo, 2009; Iyke, 2015) the production effect of electricity on economic growth has not been given the required attention. Investigating the electricity generation-economic growth nexus will provide insight into the effectiveness of government policies in power sector and how it impacts on economic growth over the policy regime. Hence, this study carry out a detail analysis between electricity generation and economic growth across different sample period.

Data were sourced from Central Bank statistical Bulletin (various issues), IEA statistics, and World Bank Development Indicators for the empirical analysis. The variables employed are: real GDP growth, electricity generation, real gross fixed capital formation (in constant Nigerian currency) as proxy for capital, and labour force for labour. Since the estimation approach (RIR) required the use of large sample size, some of the variables in annual series were transformed to quarterly frequency and the dataset was obtain from $1970Q_1$ to $2016Q_4$. To this effect, a quadratic match-sum method was employed to transform the series to quarterly series. All variables were used in their natural log form.

3.2. Methodology

In providing the theoretical framework for the relationship between electricity generation and growth, the production function based on growth theory is adopted. Within this framework the impact of electricity on (aggregate) output is usually modelled in two ways: firstly, directly when electricity services enter production as an additional input and secondly, indirectly when they raise total factor productivity by reducing transaction and other costs, thus allowing for more efficient use of conventional productive inputs (Straub, 2008). Hence, a standard functional model showing a relationship between electricity generation and economic growth is specified below:

$$Y_t = Af(L_t, K_t) \qquad (1)$$

Where Y_t is output indicator, A total factor productivity or efficiency parameter, Lt is labour, Kt is capital. Following (Ogagavwodia *et al.*, 2014) electricity indicator is assumed to impact on output through factor productivity. Total factor productivity is further assumed a function of electricity indicator (Xt). Thus:

$$A_t = f(X_t L_t, K_t) \quad (2)$$

Equating Equations 1 and 2 and substituting for A_t gives:

$$Y_t = f(L_t, K_t, X_t) \quad (3)$$

An empirical testable model was then developed from Equation 3:

$$GDPgr_t = \alpha + \beta_1 LF_t + \beta_2 GFCFt + \beta_3 ELECTgt + \varepsilon_t \quad (4)$$

In Equation 4 above, $GDPgr_t$ denotes output indicator and this is measured by real GDP growth rate (Edquist and Henrekson, 2006) LF_t is labour force population, $GFCF_t$ is gross fixed capital formation used to measured capital, and $ELECTg_t$ stands for electricity indicator which is measured by quantity of electricity generation.

It is theoretically expected that labour force, gross fixed capital formation and electricity generation will directly impact on economic growth.

Dealing with time series data implies testing for the order of integration of the two series using the Augmented Dickey Fuller (ADF) and Philip-Perons (PP) unit root test. If the variables are stationary at levels I (0) or mixture of I(0) and I(1) we proceed to test for the short-run relationship of the model using Granger-causality test (Naka and Tufte, 1997). The short-run relationship between the electricity generation and economic growth was performed in two steps. First, I use Vector autoregressive (VAR) model to show dynamic relationship between electricity generation and the selected variables. Second, I test for the possibility of structural break exploring the dynamic rolling impulse response (RIR) model which is specified to empirically analyse Equation 5. The RIR function is a bivariate model within the VAR framework; it shows the dynamic interaction between the quantity of electricity generation and economic growth across different sample periods. The RIR estimable model is specified as:

$$GDPgr_t = \delta + \sum_{j=1}^{k} \theta_j GDPgr_{t-j} + \sum_{j=0}^{k} ELECTg_{t-j} + \varepsilon_t \quad (5)$$

In Equation 5 GDP growth rate is specified as a function of its lagged value and current and lagged value of quantity of electricity generation.

The RIR approach is based on change in the response pattern of a surface contour as shown by the estimates of output growth rate and quantity of electricity generation relationship. Instability/ structural break in output growth rate-electricity generation is determined by the nature of the surface contour, a flat surface contour indicates stability, while a spiky contour indicates otherwise.

4. EMPIRICAL ANALYSIS AND RESULTS

The time series properties of the series are presented in Table 1 and Table 2. Table 1 shows the stationarity analysis of the variables using the Augmented Dickey Fuller (ADF) and Phillips-Peron (PP) Unit Root Test Statistics. The result revealed that most variables in the model are stationary at their levels, while only one is not (GFCF), implying that the series are mixture of I(0) and I(1). The null hypothesis of unit root cannot be rejected for all the variables in the model specified in the previous section. Consequently, the dynamic relationship between electricity generation and GDP growth rate can be determine within a VAR framework (Turhan *et al.*, 2012). Thus, the unrestricted VAR model was used since the series are a mixture of I (0) and I(1) (Farzanegan and Markwardt, 2009) as cited in Iwayemi and Fowowe (2011a). As such, we ascertain a short-run statistical association among the variables using Granger causality test based on the block Exogeneity Wald test approach.

Table-1. Unit root test result.

Augmented dickey fuller (ADF)			Phillips-perron (PP)		
Series	**Intercept**	**Trend and intercept**	**Series**	**Intercept**	**Trend and intercept**
ELECTg	-2.429	-2.510	ELECTg	-3.697**	-2.890
RGDPgr	-2.414	-3.118	RGDPgr	-6.947*	-7.123*
LF	-0.677	-5.931*	LF	-0.316	-1.399
GFCF	-0.533	-2.491	GFCF	-0.500	-2.586

Note: *** ** * indicates significance level at 1%, 5%, and 10%.

The result for Granger causality test in Table 2 indicates no short-run relationship between electricity, real GDP growth rate and gross fixed capital formation. Suggesting that electricity generation does not account for economic growth in Nigeria. This is not too surprising given the fact Nigeria's electricity generation remains one of the lowest in the world, thus, its non-impact on general economic activities. The finding is also consistent with other literature (Yoo and Kim, 2006). However, there is causality between electricity generation and labour force.

Table-2. Granger causality test result.

Null hypothesis: Electricity generation granger cause:		
Variable	**Chi-sq**	**Prob.**
GDPgr	1.94	0.38
LF	33.07	0.00*
GFCF	2.30	0.31

Note: The Granger causality tests are based on VAR Granger causality/ Block Exogeneity Wald Test. *** ** * indicates significance level at 1%, 5%, and 10%.

The dynamic response of the selected variables to electricity generation is presented in Figure 4 based on full sample VAR approach. Central to this study is the relationship between electricity generation and economic growth rate. The response of real GDP growth rate, though negative, tends towards zero both in the short and long lag, confirming insignificant impact of electricity generation on real growth rate in Nigeria. Until the 4th-quarter period, labour force did not respond significantly to electricity generation. While the response of fixed capital formation also remained insignificantly negative to impulses from electricity generation throughout the lag period. The findings are not too different from the results obtained from Granger causality test.

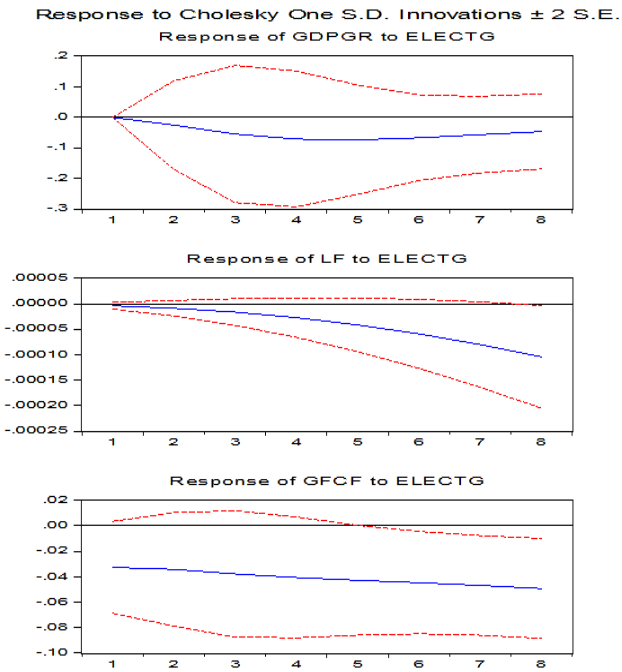

Figure-4. Dynamic response of real GDP growth rate, labour force and gross fixed capital formation to electricity generation.

The sub-sample analysis based on rolling impulse response (RIR) captured differences across 40-quarters window (10-years) each, with the first window centred in 1980q1. Variation in the sample periods comes inform of spikes on the surface contour. Similarly, the result in Figure 5 further indicates a minute impact of electricity generation on real GDP growth in the early period of the 1980s, no impact was recorded in the subsequent periods. Hence, given the various electricity reform strategy over the decades, instability in electricity generation has weak impact on Nigerian economic growth. It is worthy of note that findings from the sub-sample approach are not too different from the full sample VAR results.

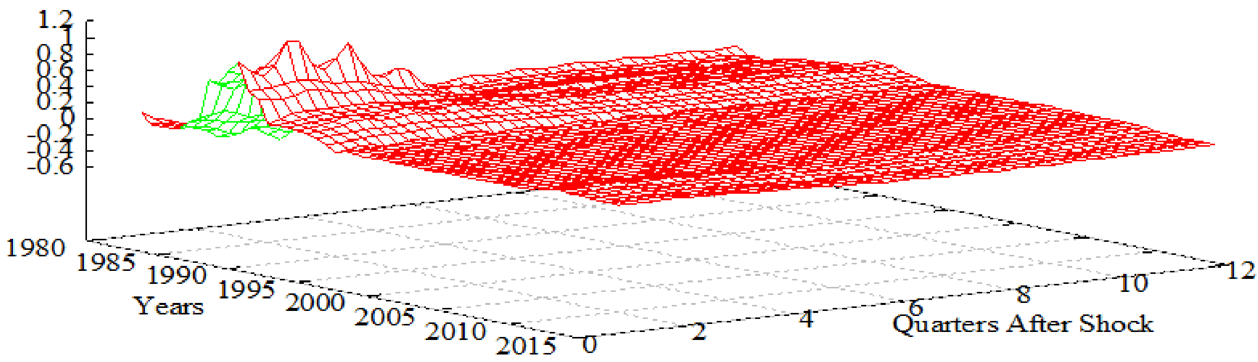

Figure-5. Response of real gross domestic product growth rate.

5. CONCLUSION

Instability and low electricity generation in Nigeria has continued to raise concerns. As such various energy reforms has been put in place to enhance optimal performance of the electricity sector given its role in economic growth and development. This paper used full sample VAR and structural breaks approach-rolling impulse response model-to obtain evidence for changes in the impact of electricity generation on the Nigerian economy across sub-sample periods. Findings revealed that electricity generation does not Granger-cause real GDP growth and gross fixed capital formation, while a short-run relationship exist for labour force. No strong dynamic relationship exists between electricity generation and real GDP growth over the lag period. Lastly, result from RIR technique indicates that real GDP growth rate does not respond to impulses from electricity generation over the years, but for weak impact in the early 1980s.

The implication of the findings is that power sector reforms aimed at enhancing increase and stable electricity generation over the decades have not been economic growth oriented. Most of these reforms must have been a mere paper work poorly strategized and implemented. Among other factors, obsolete and poor infrastructural equipment as well as inadequate investment has continued to impede the optimal impact of the power sector. It therefore suggests that unstable and inadequate electricity generation is a bane to economic growth. Hence, Nigeria requires large-scale investment to be injected in the electricity sector and needs to take another electricity supply action (renewable electricity generation-mixed) to bridge its present and future demand–supply gap. Although the power sector is partially liberalized, effort should also be made at completing various abandoned power projects in the country, which in a way will facilitate steady increase in electricity generation.

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