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AGDI Working Paper

WP/20/013

Electricity Consumption, Urbanization and Economic Growth in Nigeria: New Insights from Combined Cointegration amidst Structural Breaks¹

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Electricity Consumption, Urbanization and Economic Growth in Nigeria: New Insights from Combined Cointegration amidst Structural Breaks

Solomon P. Nathaniel & Festus V. Bekun

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Abstract

The study explores the link between electricity consumption, urbanization and economic growth in Nigeria from 1971-2014. The bounds test and the Bayer and Hanck (2013) cointegration tests affirm cointegrating relationship. Electricity consumption increases economic growth in both time periods, while the impact of urbanization appears to inhibit growth. The fully modified OLS (FMOLS), dynamic OLS (DOLS) and the canonical cointegrating regression (CCR) confirm the robustness of the findings. The vector error correction model (VECM) Granger causality test supports the neutrality hypothesis in the short run and the feedback hypothesis among the variables in the long run. Therefore, policies to ensure efficient electricity supply, curb rapid urbanization and promote sustainable economic growth were suggested.

Keywords: Electricity Consumption; Urbanization; Economic Growth; ARDL; Nigeria.

1. Introduction

There are plethora of studies on growth and electricity consumption in the literature. The link between both have been clearly established as well. Both variables seem to be highly correlated (EIA, 2013). Electricity is the fulcrum of economic progress. It drives manufacturing, complements capital and labour and a shortage of it precipitate growth (Shahbaz, *et al.* 2017; Jaiyesimi *et al.* 2017; Pinson & Madsen 2014; Lin& Liu 2016) and hampers production (Khan*et al.* 2016; Shahbaz 2015; Costantini & Martini 2010; Abeberese 2017; Sarwar *et al.* 2017). Studies like (Allcott *et al.* 2016; Shahbaz 2015; Fisher-Vanden 2015; Wolfram *et al.* 2012; Baskaran *et al.* 2015; Aklin *et al.* 2016) have attributed shortage in electricity supply in developing countries to either poor infrastructures or low income level. Be that as it may, there are still no consensus on either the magnitude or direction of effect between both variables. Studies have attributed this to institutional factors, policies, time considered for the study, differences in the stages of development and variations in climate (see Payne 2010; Alola 2019a; Alola 2019b; Ozturk 2010). To a large extend, environmental and energy policies design depends on the understanding of this link (Costa-Campi*et al.*, 2018; Mezghani & Haddad 2017).

The importance of electricity is colossal both to the household and the business enterprise alike (Best& Burke 2018; Costa-Campi *et al.* 2018; Alola et al. 2019c; Atems & Hotaling 2018). Electricity is a factor of production (Stern *et al.* 2017a) and a driver of capital formation (Lechthaler, 2017). It has the capacity to mitigate air population emerging from the household (Lim *et al.*, 2012) and increase labour hour (Salmon and Tanguy, 2016). In spite of these importance, access to electricity still remain a huge problem. According to the World Bank (2017a), in developing countries, about one billion people did not have access to electricity in 2014. In the same year, about 40% of Nigerian went without electricity (Best& Burke, 2018). Many factors are responsible for the global increase in electricity demand.

Chief among them are urbanization, population explosion, economic growth, entrepreneurial consideration among others. Energy demand in the world is expected to double in 2050.¹

The federal government of Nigeria has discovered the importance, especially the backward and forward linkages of electricity in the economy. As a result, various forms of reforms have been introduced in the sector. Whether these reforms have impacted on economic growth is yet to be seen. Also, Nigeria is becoming more urbanized holding to rural poverty and little or no access to basic facilities in the rural areas. The big questions are; is urbanization one of the drivers of electricity consumption in Nigeria? What are the relative impact of urbanization and electricity consumption on growth? Is there a causal link among these variables? It is the urgent need to provide answers to the above questions that the motivation for this study arose. However, the author is not aware of any study that have tried to explore the causal link among these variables in Nigeria, which should be a potential candidate for such investigation. Rather, most studies merely concentrated on the link between electricity consumption and economic growth (see for instance, Essien 2011; Iyke 2015; Akpan & Akpan 2012). This study intends to fill this lacuna. The Bayer and Hanck (2012) combined cointegration test was used to examine the long-run relationship. The FMOLS of Phillips and Hansen (1990), DOLS and Canonical cointegration regression (CCR) were used as sensitivity check and to further scrutinized the findings in order to ensure robust estimates. The joint use of urbanization and electricity consumption in the model will give fresh insights to policy makers and the relevant authorities to come up with comprehensive and well-designed growth and energy policies amidst the impact of urbanization.

The other parts of the study are designed in the following format: Section 2 contains an overview on the electricity sector in Nigeria. Section 3 presents the empirical review of literature. Section 4shows the data source and methodology. Section 5 shows the results and discussion of findings. Section 6 concludes.

2. An Overview on the Electricity Sector in Nigeria

Nigeria is one of the countries that has found extremely difficult to provide adequate electricity for its timing population. Since independent in 1960, the sector has performed below par as about 80million Nigerians do not have access to any form of electricity in their homes, despite the various reforms in the sector (Okafor, 2018). In 2009, only about 47% of Nigerians had access to electricity (UNDP, 2009).

Nigeria started generating its electricity in 1896, and the Nigerian Electricity Supply Company (NESCO), introduced in 1929, was the pioneer utility company. After 22 years of operation, the Electric Corporation of Nigeria (ECN) succeeded NESCO in 1951. ECN acquired both the assets and functions of NESCO. In 1962, the Nigeria Dams Authority (NDA) became a partner to the ECN to assist in the development of hydropower. ECN and NDA later formed a merger in 1972 which led to the emergence of the National Electric Power Authority (NEPA). Probably due to inefficiency and little or no funding, NEPA was later privatized and subsequently called the Power Holding Company of Nigeria (PHCN). With the reform in the sector in 2005, the Nigerian Electricity Regulatory Commission (NERC) became the chief regulator of the sector with eleven distribution companies and 60% of the company's shares were now owned by private investors. The function of electricity transmission was however returned by the government. The sector was further reformed in 2013 but little or no progress was achieved in terms of electricity generation and distribution as the country could only generate about 3500MW which is a far cry from what is expected to meet the demand of about 180 million Nigerians. On December 18, 2017, the sector achieved a peak power generation of 5,222MW which was an all-time national high. This appears to be a tiny speck of good as this trend has hardly been sustained.

3. Literature Review

The most recent of studies on growth and energy has been carried out by Srichaikul *et al.* (2019) with a special consideration on the BRICS countries using Panel Quantile Bayesian regression approach. Findings showed that energy consumption exacts a positive impact on growth. Alola & Alola (2018) discovered feedback causality between economic growth and renewable energy consumption in sixteen Coastline Mediterranean Countries. Saint Akadiri et al. (2019) also discovered the same for EU-28 countries. Alola et al. (2019a) examined the impact of renewable energy, economic growth and migration on GHGs in the United Kingdom, Germany and France. From their findings, there is no causal link between economic growth and renewable energy consumption in these countries.

Bakirtas & Akpolat (2018) investigated the causal link between economic growth, urbanization and energy consumption in a panel of six new emerging-market countries from 1971 to 2014. The bivariate analysis revealed a unidirectional causality from economic growth to energy consumption on one hand, and from urbanization to economic growth and energy consumption on the other. Kumari & Sharma (2018) explored the causal link between GDP and electricity consumption from 1981–2013. Findings revealed that electricity consumption does not only drive economic growth, but also a key determinant of FDI inflow into the country. Elfaki *et al.* (2018) incorporated urban population and trade as control variables while trying to establish a link between growth and energy consumption in Sudan. Contrarily to what is obtained in extant literature, findings showed that energy consumption inhibits growth.

Bilgili *et al.* (2017) examined the link between urbanization and energy intensity for ten countries in Asian from 1990-2014. The impact of urbanization on energy intensity was negative and significant in both time periods. As opposed to previous findings, Osman *et al.*

(2016) confirmed the feedback hypothesis for GCC countries. Maksimović *et al.* (2017) disaggregated energy consumption to ascertain the influence of each of the component on growth in the EU member countries. Energy from renewable sources was found to impact more on growth. Before Bilgili *et al.* (2017), Belloumi & Alshehry (2016) had earlier examined a similar relationship in Saudi Arabia with ARDL, FMOLS, and DOLS. Urbanization added to energy intensity in both time periods. They concluded that sustainable development in Saudi Arabia could only be achieve by reducing energy inefficiency. By using a quarterly data that spans 2005Q1 to 2016Q3, Liu *et al.* (2018) discovered that economic growth causes electricity consumption in Beijing.The finding was consistent in both aggregate and sectoral level.

Shahbaz *et al.* (2017) tried to ascertain if urbanization drives energy consumption in Pakistan by using the STIRPAT model. Findings from the ARDL result suggests that urbanization is the major driver of energy consumption in Pakistan. Similarly, Sbia *et al.* (2017) discovered a U-shaped relationship between electricity consumption and urbanization. It was also the same for electricity consumption and economic growth in the UAE. Tatlı (2017)used the ARDL to predict factors contributing to electricity demand in Turkey. Findings reveal that urbanization and economic growth (proxy by income) negatively and significantly affect residential electricity consumption in both time periods. Lechthaler (2017) explored the impact of electricity consumption drives economic growth. However, a direct opposite relationship was found for high-income countries. While most studies focused on electricity demand, Atems & Hotaling (2018) were more concerned with electricity generation. As a result, they used a system GMM to estimate data for a panel of one hundred and four countries. Findings revealed that electricity generation drives economic growth among the countries used in the study. By introducing financial development as one of the control

variables, Bah & Azam (2017) unlike previous studies in South Africa, discovered no causality between electricity consumption and growth. They however called for investment in the energy sector to boost sustainable development. Iyke (2015) revisited the energy-growth debate for Nigeria with an attempt to ascertain the causal link between both variables. The findings were similar to that of Kumari & Sharma (2018) as causality flow from electricity consumption to economic. The study, however, ignored the influence of urbanization knowing that Nigeria is fast becoming urbanized since the turn of the 21th century owing the poverty in most of its rural areas.

Author(s)/year	Region/Country(s)	Methodology	Finding(s)
Baz et al. (2019)	Pakistan	NARDL	A symmetric causality exist
			Pakistan.
Fotourehchi (2017).	Forty two	Canning and	$EC \rightarrow G.$
	developing	Pedroni (2008)	
	countries	long-run	
Bayat <i>et al.</i> (2017)	BRICS	Emirmahmuto	$FC \rightarrow G$ in Russia
	Dities	ğlu and Kose	
		(2011)panel	
		causality test	
Karanfil and Li	160 countries	VAR	$EL \rightarrow G$. The nexus between
(2014)			both variables is sensitive to urbanization and income level
Hasanov <i>et al.</i> (2017)	10 Eurasian	VECM	$EC \rightarrow G$ in both time periods
	countries.	Granger	
		causality test	
Shiu& Lam (2004)	China	\checkmark	$EL \rightarrow G$. The study called for
			rural electrification.
Obradović&Lojanica	South Eastern	\checkmark	$EC \rightarrow G$ in the long run only.
(2017).	Europe		$FI \rightarrow G$ Government should
Dogan (2013)	Turkey	▼	invest massively in the energy
			sector.
Iyke (2015)	Nigeria	\checkmark	$EL \rightarrow G$. The unidirectional
			causality exist in both time
A 1 - 1 1	Sandi An 1		periods
Alsnenry and Belloumi (2015)	Saudi Arabia	↓	$EU \rightarrow U.$
Denouiiii (2013)			

Table1: Studies that supported energy-led growth hypothesis.

Odhiambo (2014)	4 lower and middle income countries	\checkmark	$EC \rightarrow G$ in Uruguay and Brazil.
Aslan <i>et al.</i> (2014)	USA	Wavelet analysis; Granger causality	$EL \rightarrow G.$
Al-mulali and Sab (2012)	Sub-Sahara Africa	Multivariate causality test	$EC \rightarrow G$. There is need to introduce energy saving projects in the region.
Narayan (2016)	135 countries	\checkmark	$EC \rightarrow G$ for lower middle income countries.
Fatai (2014)	18 Sub-Saharan Africa countries	\checkmark	$EC \rightarrow G$ in Southern and East Africa.

NOTE: \leftrightarrow and \rightarrow denote the bidirectional and unidirectional causalityrespectively. G, EC and EL represent economic growth, energyconsumption and electricity consumption respectively.

Table 2:	Studies	that supp	orted the	growth-led	energy of	consumption	hypothesis.
				0			

Author(s)/year	Region/Country(s)	Methodology	Finding(s)
Rahman&Velayutham	South Asia	FMOLS and	$G \rightarrow EC.$
(2020)		DOLS.	
Chen & Fang (2018)	210 prefecture	Panel Granger	$G \rightarrow EL.$
	cities in China	non-causality	
		test	
Kirikkaleli et al. (2018)	35 OECD	Dumitrescu-	$G \rightarrow EL$. Positive link exist
	countries	Hurlin	among internet, electricity
		causality tests	and economic growth.
Nyashaet al. (2018)	Ethiopia	VECM	$G \rightarrow EC$
		Granger	
		causality test	
Burakov&Freidin	Russia	\checkmark	$G \rightarrow EC$ only in the short
(2017)			run period.
Kyophilavong et al.	Lao PDR	\checkmark	$G \rightarrow EL$ only in the long
(2017)			run.
Salahuddin and Alam	Australia	\checkmark	$G \rightarrow EL$. Economic growth
(2015)			drives electricity
			consumption
Hwang &Yoo (2014).	Indonesia	\checkmark	$G \rightarrow EC. EKC$ exist.
Odhiambo (2014)	Brazil, Cote	\checkmark	$G \rightarrow EC$ exist in Cote
	d'Ivoire, Ghana,		d'Ivoire and Ghana.
	and Uruguay		
Stern and Enflo (2013)	Sweden	\checkmark	$G \rightarrow EL.$
Ouedraogo (2013)	ECOWAS	\checkmark	$G \rightarrow EC$ exist in the short
			run.
Iyke&Odhiambo(2014)	Ghana	\checkmark	$G \rightarrow EL$ in both time
			periods.
Wolde-Rufael (2009)	17 Africa	Multivariate	$G \rightarrow EC$ was true for eight
	countries	causality test	of the countries (Nigeria

inclusive).

Table 3: Studies that supported the feedback causality.

Author(s)/year	Region/Country(s)	Methodology	Finding(s)
Zafar et al. (2019)	Asia-Pacific	Continuously	$EC \leftrightarrow G.$
	Economic	Updated Fully	
	Cooperation	Modified	
	countries	Ordinary	
		Least Square	
Lin & Wang (2019)	China	Panel VAR	$EL \leftrightarrow G.$
Ben-Salha et al. (2018)	Iran, Venezuela,	Pooled Mean	$EC \leftrightarrow G.$
	USA, Canada,	Group.	
	Saudi Arabia,		
	Austrolio		
Hamdiat al. (2014)	Rebrain	VECM	FI 4 G
	Demain	Granger	
		causality	
Saad&Taleb (2018)	12 European	J	$EC \leftrightarrow G.$
	Union countries	•	
Akpan&Akpan (2012)	Nigeria	\checkmark	$EL \leftrightarrow G$. Findings did
			not support the EKC.
Solarin <i>et al.</i> (2016)	Angola	\checkmark	EL \leftrightarrow G. Urbanization
			also causes EL.
Sarwar <i>et al.</i> (2017)	210 countries	\checkmark	$EL \leftrightarrow G$. Developing
			countries are electricity
		-	dependent.
Boukhelkhal&Bengana	4 North-African	\checkmark	$EL \leftrightarrow G$ in Tunisia.
(2018) Marshari & Haddad (2017)	Countries		EL C in the short run
Mezghani& Haddad (2017)	Saudi Aradia	\checkmark	$EL \leftrightarrow G$ in the short run in Saudi Arabia
Tang and Tan (2013)	Malaysia	1	$FI \leftrightarrow G$ Technological
Tang and Tan (2013)	wiałaysia	V	innovation also drives
			electricity consumption
BazarchehShabestari(2018)	Sweden	1	$EC \leftrightarrow G$ No causality
		v	existed between both in
			the short run.
Rafindadi (2016)	Nigeria	\checkmark	EC \leftrightarrow G. Economic
	-		growth reduces energy
			consumption.
Ajlouni (2015)	Jordan	\checkmark	EC \leftrightarrow G. Growth
			depends on energy
			consumption.
Solarin& Shahbaz (2013)	Angola	\checkmark	$EL \leftrightarrow G$. Angola will
			witness growth if
			electricity supply
$\frac{1}{2}$	De et u cel		Increase.
Snandaz <i>et al</i> . (2011).	Portugai	√	\vdash \leftarrow \leftarrow \leftarrow exist for

			Portugal in the long run.
Aslan (2014).	Turkey	\checkmark	$EL \leftrightarrow G.$
Mohammadi&Parvaresh (2014)	14 oil-exporting countries	√	$EC \leftrightarrow G.$ Growth policies may have adverse effect on the environment.
Hasan <i>et al.</i> (2017)	Bangladesh	\checkmark	EL \leftrightarrow G. Electricity consumption impacts positively on GDP in the long run.
Bayar &Ozel (2014)	Emerging economies	Block Exogeneity Wald Test	$EL \leftrightarrow G$. Electricity drives growth.
Osman <i>et al.</i> (2016)	GCC countries	\checkmark	$EL \leftrightarrow G.$

4. Data and Methodology

The study made use of data spanning 1971 to 2014. The availability of data informed the time period. Data were derived from the World Development Indicators (2017). The variables used for the study include: electricity consumption (kWh per capita), urbanization (% of total) and real GDP per capita (proxy for economic growth).

4.1 Unit root test

As a precaution to avoid spurious regression, the unit root were first examined with the Augmented Dickey Fuller (1981) and the Phillip & Perron (1988) tests. To make up for the criticism levelled against both tests, in terms of their sensitivity to size, low power and inability to consider break(s) in the series, the variables were further subjected to the Zivot and Andrews (1992), (ZA, hereafter) test to account for structural break

4.2 Cointegration

This test would be achieved using the Bayer& Hanck (2013) combined cointegration test. This test encompasses other individual tests like the Banerjee *et al.*, (1998), Boswijk (1995), Johansen (1991) and Engle & Granger (1987). The Fisher equation is provided as:

$$EG - JOH = -2[\ln(\rho_{EG}) + (\rho_{JOH})]$$
(1)

$$EG - JOH - BO - BDM = -2[\ln((\rho_{EG}) + (\rho_{JOH}) + (\rho_{BO}) + (\rho_{BDM})]$$
(2)

 ρ_{BDM} , ρ_{BO} , ρ_{JOH} and ρ_{EG} are the test probability of individual cointegration tests.

4.3 Estimation Techniques

Apart from the Bayer& Hanck (2013) test, the ARDL bounds test to cointegration of Pesaran *et al.* (2001) was also used. In Eq.3, we state the model in its general form.

$$\Delta Y_t = \vartheta_0 + \sum_{i=1}^k \vartheta_1 \Delta y_{t-i} + \sum_{i=0}^k \omega_1 \Delta x_{t-i} + \tau_1 y_{t-1} + \tau_2 x_{t-1} + \mu_t$$
(3)

Where ϑ_1 and ω_1 are the short-run coefficients, τ_1 and τ_2 are long-run coefficients. The number of lags and the error term is respectively k and μ_t . The ARDL estimation technique has various advantages over other methods of estimation in that, it is suitable for small sample size, it can be applied regardless of the order of integration with the exception that the series is not integrated at I(2). Also, it can be used for the simultaneous computation of long-run and short-run results. As earlier mentioned, the FMOLS, DOLS and the CCR were used as sensitivity checks and to further scrutinize the findings in order to ensure robust estimates. Eq. (4) shows the FMOLS equation.

$$Y_{t} = \gamma_{0} + \gamma_{1}EC_{t} + \gamma_{2}URB_{t} + \sum_{i=q}^{q} \pi_{i}\Delta EC_{t-i} + \sum_{i=q}^{q} \pi_{i}\Delta URB_{t-i} + \mu_{t}$$

$$(4)$$

Where Y_t is the dependent variable, *EC* and *URB* are the symbols for electricity consumption and urbanization respectively. All variables are in their log-linear form (*ln*); since log-linear models produce efficient results and reduce sharpness in the series (Shahbaz *et al.*, 2013)

4.4 VECM Granger Causality test

This test was picked ahead of other tests because it has the capability to show the direction of causality in both time periods. The test equation, indeterminant form, is given as;

$$(1-L)\begin{bmatrix}Y_{t}\\EC_{t}\\URB_{t}\end{bmatrix} = \begin{bmatrix}\alpha_{1}\\\alpha_{2}\\\alpha_{3}\end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix}\alpha_{11i}\alpha_{12i}\alpha_{13i}\\\alpha_{21i}\alpha_{22i}\alpha_{23i}\\\alpha_{31i}\alpha_{32i}\alpha_{33i}\end{bmatrix} \times \begin{bmatrix}Y_{t-1}\\EC_{t-1}\\URB_{t-1}\end{bmatrix} + \begin{bmatrix}\lambda_{1}\\\lambda_{2}\\\lambda_{3}\end{bmatrix} ECT_{t-1} + \begin{bmatrix}\varepsilon_{t1}\\\varepsilon_{t2}\\\varepsilon_{t3}\end{bmatrix}$$
(5)

Where (1-L) is the difference operator, ECT_{t-1} represents lagged error term and ε_{it} remains the disturbance term. While the significance of the t-statistic for ECT_{t-1} indicate a long-run causal relationship, short-run causality is confirmed by the significance of F-statistics of the lagged variables.

5. Empirical Results and Discussion of Findings

The graphical representation of the series is required to provide necessary information about the series. See Figure 1 for plots of the series.







Sources: Author's compilation, 2019.

From the plots, urbanization exhibits an upward trend. Urbanization maintained a stable increase throughout the time period. Economic growth witnessed a sharp decline in 1980. However, economic growth has witnessed a stable increase from 2002 to 2014. Energy demand to be fluctuating throughout the time period.

A good understanding of the characteristics of time series data is germane for its analysis. From Table 4, the mean of the variables almost equal their median. Urbanization recorded the highest value of 46.98. Urbanization and growth are positively skewed, while electricity consumption is negatively skewed.

Variables <i>ln</i> URB <i>l</i>	ariables <i>ln</i> URB <i>ln</i> Y <i>ln</i> EC						
Mean	30.99	7.4034.407					
Median	30.937.3934.	467					
Skewness	0.1870.224-0	.724					
Kurtosis	1.8831.6573.	091					
Probability	0.2800.1590.	145					
<i>ln</i> URB	1						
lnY	(0.259)*	1					
lnEC	(0.384)**	(0.122)	1				

Table 4: Descriptive Statistic and Correlation Analysis

Note: ** and * show significance at 10% and 1% respectively. **Source:** Author's computation.

The kurtosis values show that none of the variable is mesokurtic. Electricity consumption is leptokurtic while growth and urbanization are platykurtic. Juxtapose with the Jarque-Bera statistic is the probability values which suggest that the variables are normally distributed. For unit root results, see Table 5.

Variables	ADF	PP	ZABreak date	;	
T-statistic	T-statisticT-s	tatisticTime break			
PANEL A					
AT levels					
EC	-0.980	-1.089	-4.139	1994	
URB	-1.006	-0.181	-3.874	1997	
Y	-0.372	-0.141	-3.126	1994	
PANEL B					
AT first difference					
EC	-8.837*	-9.250*	-5.541**	2002	
URB	-3.874*	-3.607*	-5.136**	1997	
Y	-5.535*	-5.710*	-7.151*	1988	

 Table 5: ADF and PP tests (without break) and ZA unit root test (with break)

* and ** show significance at 1% and 5% respectively.

Source: Authors computation.

The results from the various tests (ADF, PP and ZA) confirm I(1) for the variables. The

result of the Bayer& Hanck (2013) cointegration test and the ARDL bounds test results are

presented in Table 6.

Estimated modelsOptimal lag Break F-stat.Diagnostic tests Cointegration						
yearNormality ARC	CΗ					
Panel A: Bounds Test						
lnEC = f(lnURB, lnY)	1, 3, 0	2002	4.325*	0.328	0.564	\checkmark
lnURB =f(ln EC, ln Y)	2, 2, 2	1997	2.645	0.453	0.223	\checkmark
lnY = f(lnURB, lnEC)	2, 1, 2	1986	3.892**	0.154	0.453	Χ
Critical values bounds						
	Lower	Upper				
	Bound	Bound				
5% critical value	2.79	3.44				
10% critical value	2.54	3.12				
1% critical value	2.88	3.98				

Table 6: ARDL Bounds Test and Bayer-Hanck Test Results

Panel B: Bayer-Hanck Test

Estimate ModelsEG-JOH	EG-JOH-BO-B	DM Cointegration	
lnEC = f(lnURB, lnY)	13.435**	26.487**	Yes
lnURB =f(ln EC, ln Y)	14.645**	25.627**	Yes
lnY = f(lnURB, lnEC)	16.261**	24.281**	Yes
5% critical value	10.895	21.106	

* and ** indicate significance at 1% and 5% levels respectively. **Source:** Author's computation.

The Fisher statistic for EG-JOH and EG-JOH-BO-BDM are greater than the 5% critical values of 10.021 and 20.486 respectively. In this case, we can reject the null hypothesis and conclude that the variables (EC, URB and Y) are cointegrated. The ARDL bounds test further confirmed cointegration among the variables, except when urbanization is being used as a dependent variable. See Table 7 for the ARDL short and long-run results.

Dependent Variable: <i>ln(Y</i>	Dependent Variable: <i>ln(Y)</i>						
Short-run Coefficients							
Independent variables	Coefficient	Standard Error	t-Statistic				
Constant	2.3317	0.9128	2.5542				
$\Delta ln(Y(-1))$	0.0794	0.0658	1.2063				
$\Delta ln(EC)$	0.1612	0.0673	2.3943				
$\Delta ln(\text{URB})$	-2.3844	1.2223	-1.9507				
ECM _{t-1}	-0.0917	0.0254	-3.6018				
Adjusted R ²	0.5182						
Durbin-Watson	2.1087						
Long-run Coefficients							
Independent variables	Coefficient	Standard Error	t-Statistic				
<i>ln</i> (EC)	0.1565	0.0341	4.5894				
<i>ln</i> (EC(-1))	0.1612	0.0777	2.0746				
<i>ln</i> (URB)	-0.2188	0.0815	-2.6846				
Diagnostic tests	Probability						
	Values (χ^2)						
Ramsey RESET	0.2361						
Jarque-Bera	0.0743						
ARCH LM test	0.0623						
Breusch-Godfrey LM test	0.5544						

 Table 7: ARDL Short-run and Long-run Results

Source: Author's computation.

From the findings in Table 7, a 1% increase in electricity consumption amount to 0.16% increase in growth holding the influence of other variables constant. This finding is intuitive. It suggests that electricity drives growth in Nigeria, in the short run. Nigerians are not among the highest consumers of electricity in Africa, and the world by extension, due to limited supply resulting from little generation of electricity. This could be the reason while the growth in GDP has not been substantial over the years due to little or no attention accorded to

the sector. The lack of substantial growth could not be exclusively tied to electricity poverty in the country, there are array of several factors ranging from economic, social, political, religious amongst others. An improvement in electricity consumption has the potential to improve economic growth in the country. However, the same cannot be said for urbanization. Urbanization inhibits growth. It reduces growth by 2.38%. This is a practical revelation of what is obtainable in Nigeria. Few cities like Lagos, Port Harcourt, Kano and Kaduna are becoming increasingly urbanized as a result of a few or no social amenities in the rural areas (electricity inclusive). In the 60's and early 70s, agriculture was the mainstay of the Nigerian economy. Agricultural activities were mainly carried out in the rural areas. The rural areas suffered from inadequate facilities to improve both their yields and preservation of their products. As a result, migration to cities for livelihood was inevitable. These, to a large extend, impacted negatively on the countries growth.

The long run results are consistent with that of the short run in terms of the relationship between the independent variables and the dependent variable. Electricity consumption still exacts a positive impact on economic growth while the impact of urbanization is still negative. The intuition behind this, is that, most people living in the urban areas are unemployed and poor. They contribute very little or nothing to economic growth. This is in line with the Okun's Law which suggests an indirect relationship between economic growth and unemployment. Of little wonder the country became the poverty headquarters of the world in 2018 as reported by the World Poverty Clock with about 86.9million (accounting for about 50%) of its citizen living in extreme poverty. Hydropower has proven not to be sufficient, shifting attention to renewable sources, such as, biofuel, biogas, solar energy, tidal power, wave power, geothermal heat etc. will go a long way to ensure electricity available and by extension, sustain the country's growth. Another added advantage of renewable energy sources is that, they are low in emission and can promote environmental sustainability (Emir & Bekun, 2018).

The study also complied with most of the assumptions of the Ordinary Least Squares (OLS). The study is free from serial correlation, heteroskedasticity, residuals are normally distributed and the model has the right functional form. Impact does not imply causation, Table 8 reports the causality test, and the FMOLS, DOLS, and CCR results.

Dependent Variable: <i>ln(Y)</i>									
Panel A: FN	Panel A: FMOLS, DOLS, and CCR.								
Variables	FMO	LS	DO	LS		CCR			
Coefficient	t.Stat. C	oefficient	t.Stat.	(Coefficient	t.Stat.			
<i>ln</i> (URB _t)	-0.1161***	-2.9130	-0.1425	***	-3.3504	-0.1111***	-3.2114		
$ln(EC_t)$	0.5092***	5.0510	0.5984	***	4.8591	0.5254***	4.9767		
Panel B: VE	ECM Granger (Causality T	est						
$Dln(Y_{t-1})$	$Dln(EC_{t-1})$	Dln(U	RB _{t-1})		ECT _{t-1}				
$Dln(Y_t)$		0.23	373	0.0	005	-0.0617	7		
		(0.72	28)	(0.	657)	(-2.170))**		
$Dln(EC_t)$	0.1578			-0.	2321	-1.569	9		
	(1.932)			(1.	390)	(2.400)***		
Dln(URB _t)	1.1777	0.32	245			-4.0740	5		
	(0.361)	(0.6	57)			(3.584)***		

 Table 8: Sensitivity Check and VECM Granger Causality Test

Note: ****** and ******* indicate significance at 5% and 1% levels respectively. **Source:** Author's computation.

Table 8 affirm the neutrality hypothesis for the variables in the short run. The feedback hypothesis is affirmed in the long run. A bidirectional causality exist between economic growth and electricity consumption. The same direction of causality is found between urbanization and economic growth, similarly for electricity consumption and urbanization.

The message from these findings are clear; electricity conservation policies will cripple growth. This findingscomplements those of Hasan*et al.* (2017) for Bangladesh, Rafindadi (2016) and Akpan & Akpan (2012) for Nigeria, Solarin & Shahbaz (2013) for Angola, Aslan (2014) for Turkey, Hamdi *et al.* (2014) for Behrain, Mezghani & Haddad (2017) for Saudi Arabia, Tang & Tan (2013) for Malaysia and Shahbaz *et al.* (2011) for Portugal.

The FMOLS, DOLS and CCR were used to ascertain the robustness of the ARDL regression results. From the findings, all tests are in harmony. The tests strongly affirm the positive impact of electricity on economic growth, and the negative influence of urbanization on growth.

6. Conclusion and Policy Direction

This study explores the link among economic growth, electricity consumption, and urbanization in Nigeria. The ADF, PP and ZA unit root tests established stationarity of the variables after first difference. The ARDL bounds test and the Bayer and Hanck (2013) cointegration tests confirmed long run relationship among the variables. Findings revealed a positive impact of electricity consumption on economic growth, confirming the energy-growth nexus for Nigeria. This suggests that increasing electricity generation and distribution will improve production, which will in turn trigger growth. Renewable energy sources could be the game changer in this regard especially due to the ubiquitous campaign for clean energy (Alola & Yildirim 2019; Nathaniel & Iheonu 2019; Alola et al. 2019b; Alola et al. 2019c; Balsalobre-Lorente *et al.*, 2018; Bekun*et al.* 2019; Nathaniel et al. 2019; Nathaniel et al. 2020; Nathaniel & Bekun 2019). This is desirable in Nigeria where most of her youths are unemployed, with a desire to embrace entrepreneurship, but fail due to inadequate power supply. Electricity generation from renewable sources (like geothermal, solar, wind, hydropower, tide, etc.) will help to promote the quality of the environment. The government

can also investment in environmentally friendly technologies to curb emissions and enhance growth.

Urbanization arises from discrepancies in development factors such as infrastructural provisions, household income, basic amenities, etc. The negative impact of urbanization on economic growth should be a wake-up call for policymakers to enact relevant policies that will curtail rural-urban migration. The government can also engage in aggressive rural infrastructural development. This will serve as a motivation for rural dwellers to remain in the rural area and contribute meaningfully to economic growth without causing congestion and other urban anomalies. For growth to be sustainable, there must be a commitment to develop infrastructure and the environment (both economic and political) must be conducive for business to thrive.

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End notes

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APPENDICES

Tables

Table1: Studies that supported energy-led growth hypothesis.

Author(s)/year	Region/Country(s)	Methodology	Finding(s)
Baz et al. (2019)	Pakistan	NARDL	A symmetric causality exist
			between EC and G in
			Pakistan.
Fotourehchi (2017).	Forty two	Canning and	$EC \rightarrow G.$
	developing	Pedroni (2008)	
	countries	long-run	
		causality test	
Bayat <i>et al.</i> (2017)	BRICS	Emirmahmuto	$EC \rightarrow G$ in Russia
		ğlu and Kose	
		(2011)panel	
		causality test	
Karanfil and Li	160 countries	VAR	$EL \rightarrow G$. The nexus between
(2014)			both variables is sensitive to
			urbanization and income level.
Hasanov <i>et al.</i> (2017)	10 Eurasian	VECM	$EC \rightarrow G$ in both time periods.
	countries.	Granger	
		causality test	
Shiu& Lam (2004)	China	\checkmark	$EL \rightarrow G$. The study called for
			rural electrification.
Obradović&Lojanica	South Eastern	\checkmark	$EC \rightarrow G$ in the long run only.
(2017).	Europe		
Dogan (2015)	Turkey	\checkmark	$EL \rightarrow G$. Government should
			invest massively in the energy
			sector.
Iyke (2015)	Nigeria	\checkmark	$EL \rightarrow G$. The unidirectional
			causality exist in both time
			periods
Alshehry and	Saudi Arabia	\checkmark	$EC \rightarrow G.$
Belloumi (2015)			
Odhiambo (2014)	4 lower and	\checkmark	$EC \rightarrow G$ in Uruguay and
	middle income		Brazil.
	countries		
Aslan <i>et al</i> . (2014)	USA	Wavelet	$EL \rightarrow G.$
		analysis;	
		Granger	
		causality	
AI-mulali and Sab	Sub-Sahara Africa	Multivariate	$EC \rightarrow G$. There is need to
(2012)		causality test	introduce energy saving
	105		projects in the region.
Narayan (2016)	135 countries	$ \checkmark$	$EC \rightarrow G$ for lower middle
	10 01 01		income countries.
Fatai (2014)	18 Sub-Saharan	$ \checkmark$	$EC \rightarrow G$ in Southern and East
	Africa countries		Atrica.

NOTE: \leftrightarrow and \rightarrow denote the bidirectional and unidirectional causalityrespectively. G, EC and EL represent economic growth, energyconsumption and electricity consumption respectively.

Author(s)/year	Region/Country(s)	Methodology	Finding(s)
Rahman&Velayutham	South Asia	FMOLS and	$G \rightarrow EC.$
(2020)		DOLS.	
Chen & Fang (2018)	210 prefecture	Panel Granger	$G \rightarrow EL.$
	cities in China	non-causality	
		test	
Kirikkaleli et al. (2018)	35 OECD	Dumitrescu-	$G \rightarrow EL$. Positive link exist
	countries	Hurlin	among internet, electricity
		causality tests	and economic growth.
Nyasha <i>et al.</i> (2018)	Ethiopia	VECM	$G \rightarrow EC$
		Granger	
		causality test	
Burakov&Freidin	Russia	\checkmark	$G \rightarrow EC$ only in the short
(2017)			run period.
Kyophilavong et al.	Lao PDR	\checkmark	$G \rightarrow EL$ only in the long
(2017)			run.
Salahuddin and Alam	Australia	\checkmark	$G \rightarrow EL$. Economic growth
(2015)			drives electricity
			consumption
Hwang &Yoo (2014).	Indonesia	\checkmark	$G \rightarrow EC. EKC \text{ exist.}$
Odhiambo (2014)	Brazil, Cote	\checkmark	$G \rightarrow EC$ exist in Cote
	d'Ivoire, Ghana,		d'Ivoire and Ghana.
	and Uruguay		
Stern and Enflo (2013)	Sweden	\checkmark	$G \rightarrow EL.$
Ouedraogo (2013)	ECOWAS	\checkmark	$G \rightarrow EC$ exist in the short
-			run.
Iyke&Odhiambo(2014)	Ghana	\checkmark	$G \rightarrow EL$ in both time
			periods.
Wolde-Rufael (2009)	17 Africa	Multivariate	$G \rightarrow EC$ was true for eight
	countries	causality test	of the countries (Nigeria
		-	inclusive).

 Table 2: Studies that supported the growth-led energy consumption hypothesis.

Table 3: Studies	that supported	the feedback causality.
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Author(s)/year	Region/Country(s)	Methodology	Finding(s)
Zafar et al. (2019)	Asia-Pacific	Continuously	$EC \leftrightarrow G.$
	Economic	Updated Fully	
	Cooperation	Modified	
	countries	Ordinary	
		Least Square	
Lin & Wang (2019)	China	Panel VAR	$EL \leftrightarrow G.$
Ben-Salha et al. (2018)	Iran, Venezuela,	Pooled Mean	$EC \leftrightarrow G.$
	USA, Canada,	Group.	
	Saudi Arabia,		
	Brazil, China and		
$H_{\text{and}} \neq \pi L(2014)$	Australia.	VECM	FL () C
Hamdi <i>el al.</i> (2014)	Benrain	VECM	$EL \leftrightarrow G$
		Granger	
Sand&Talah (2018)	12 Europeen	Causanty	FC
Saada Taleo (2018)	Union countries	√	$EC \leftrightarrow O.$
Akpan&Akpan (2012)	Nigeria	1	$FI \leftrightarrow G$ Findings did
rikpuncerikpun (2012)	1 (igeria	v	not support the EKC
Solarin <i>et al.</i> (2016)	Angola	./	$EL \leftrightarrow G$ Urbanization
	1	v	also causes EL.
Sarwar <i>et al.</i> (2017)	210 countries	1	$EL \leftrightarrow G$. Developing
		•	countries are electricity
			dependent.
Boukhelkhal&Bengana	4 North-African	\checkmark	$EL \leftrightarrow G$ in Tunisia.
(2018)	countries		
Mezghani& Haddad (2017)	Saudi Arabia	\checkmark	$EL \leftrightarrow G$ in the short run
			in Saudi Arabia.
Tang and Tan (2013)	Malaysia	\checkmark	$EL \leftrightarrow G.$ Technological
			innovation also drives
			electricity consumption.
BazarchehShabestari(2018)	Sweden	\checkmark	EC \leftrightarrow G. No causality
			existed between both in
			the short run.
Rafindadi (2016)	Nigeria	\checkmark	$EC \leftrightarrow G.$ Economic
			growth reduces energy
A:1	T		consumption.
Ajlouni (2015)	Jordan	\checkmark	$EC \leftrightarrow G.$ Growth
			consumption
Solarin& Shabbaz (2013)	Angola		EI \leftrightarrow G Angola will
Solarina Shanbaz (2013)	Aligola	√	$EL \leftrightarrow O.$ Aligoid will witness growth if
			electricity supply
			increase.
Shahbaz <i>et al.</i> (2011)	Portugal	1	$EL \leftrightarrow G$ exist for
		•	Portugal in the long run.
Aslan (2014).	Turkey	1	$EL \leftrightarrow G.$
· · · · · · · · · · · · · · · · · · ·	.		

Mohammadi&Parvaresh	14 oil-exporting	\checkmark	EC \leftrightarrow G. Growth
(2014)	countries		policies may have
			adverse effect on the
			environment.
Hasan <i>et al.</i> (2017)	Bangladesh	\checkmark	EL \leftrightarrow G. Electricity
			consumption impacts
			positively on GDP in the
			long run.
Bayar &Ozel (2014)	Emerging	Block	$EL \leftrightarrow G.$ Electricity
	economies	Exogeneity	drives growth.
		Wald Test	
Osman <i>et al.</i> (2016)	GCC countries	\checkmark	$EL \leftrightarrow G.$

Table 4: Descriptive Statistic and Correlation Analysis

Variables <i>ln</i> URB <i>ln</i> Y <i>ln</i> EC							
Mean	30.99	7.4034.407					
Median	30.937.3934.467	30.937.3934.467					
Skewness	0.1870.224-0.724						
Kurtosis	1.8831.6573.091						
Probability	0.2800.1590.145						
lnURB	1						
lnY	(0.259)*	1					
lnEC	(0.384)**	(0.122)	1				

Note: ** and * show significance at 10% and 1% respectively. **Source:** Author's computation.

1994
1997
1994
2002
1997
1988
1 1 2(19

Table 5: ADF and PP tests (without break) and ZA unit root test (with break)

* and ** show significance at 1% and 5% respectively. Source: Authors computation.

Table 6: ARDL Bounds Test and Bayer-Hanck Test Results

Estimated modelsOptir yearNormality ARC	nal lag CH	Break F-	stat.Diagno	stic tests	Cointegratio	on
Panel A: Bounds Test						
lnEC = f(lnURB, lnY)	1, 3, 0	2002	4.325*	0.328	0.564	\checkmark
lnURB =f(ln EC, ln Y)	2, 2, 2	1997	2.645	0.453	0.223	\checkmark
lnY = f(lnURB, lnEC)	2, 1, 2	1986	3.892**	0.154	0.453	Χ
Crit	tical valu	es bounds				
	Lower	Upper				
	Bound	Bound				
5% critical value	2.79	3.44				
10% critical value	2.54	3.12				
1% critical value	2.88	3.98				

Panel B: Bayer-Hanck Test

Estimate ModelsEG-JOH	EG-JOH-BO-B	DM	Cointegration	
lnEC = f(lnURB, lnY)	13.435**	26.487*	*	Yes
lnURB =f(ln EC, ln Y)	14.645**	25.627*	*	Yes
lnY = f(lnURB, lnEC)	16.261**	24.281*	*	Yes
5% critical value	10.895	21.106		

* and ** indicate significance at 1% and 5% levels respectively. **Source:** Author's computation.

Coefficient												
Coefficient	0, 1 15		Short-run Coefficients									
	Standard Error	t-Statistic										
2.3317	0.9128	2.5542										
0.0794	0.0658	1.2063										
0.1612	0.0673	2.3943										
-2.3844	1.2223	-1.9507										
-0.0917	0.0254	-3.6018										
0.5182												
2.1087												
Coefficient	Standard Error	t-Statistic										
0.1565	0.0341	4.5894										
0.1612	0.0777	2.0746										
-0.2188	0.0815	-2.6846										
Probability												
Values (χ^2)												
0.2361												
0.0743												
0.0623												
0.5544												
0.0623												
	0.0794 0.1612 -2.3844 -0.0917 0.5182 2.1087 Coefficient 0.1565 0.1612 -0.2188 Probability Values (χ^2) 0.2361 0.0743 0.0623 0.5544	0.0794 0.0658 0.1612 0.0673 -2.3844 1.2223 -0.0917 0.0254 0.5182 2.1087 2.1087 2.1087 CoefficientStandard Error 0.1565 0.0341 0.1612 0.0777 -0.2188 0.0815 Probability 2.361 0.0743 0.0623 0.5544 0.0815	0.0794 0.0658 1.2063 0.1612 0.0673 2.3943 -2.3844 1.2223 -1.9507 -0.0917 0.0254 -3.6018 0.5182 2.1087 -2.1087 Coefficient Standard Error t-Statistic 0.1565 0.0341 4.5894 0.1612 0.0777 2.0746 -0.2188 0.0815 -2.6846 Probability $Values (\chi^2)$ 0.2361 0.0743 0.0623 0.5544									

Table 7: ARDL Short-run and Long-run Results

Source: Author's computation.

Dependent Variable: <i>ln(Y)</i>									
Panel A: FM	Panel A: FMOLS, DOLS, and CCR.								
Variables	FMC	DLS	DO	LS		CCR			
Coefficient	t.Stat. C	Coefficient	t.Stat.	(Coefficient	t.Stat.			
<i>ln</i> (URB _t)	-0.1161***	-2.9130	-0.1425	***	-3.3504	-0.1111***	-3.2114		
<i>ln</i> (EC _t)	0.5092***	5.0510	0.5984	***	4.8591	0.5254***	4.9767		
Panel B: VE	ECM Granger	Causality T	'est						
$Dln(Y_{t-1})$	$Dln(EC_{t-1})$	D <i>ln</i> (U	RB _{t-1})		ECT _{t-1}				
$Dln(Y_t)$		0.23	373	0.0	005	-0.0617	7		
		(0.72	28)	(0.	657)	(-2.170)**		
Dln(EC _t)	0.1578			-0.	2321	-1.569	9		
	(1.932)			(1.	390)	(2.400)***		
Dln(URB _t)	1.1777	0.32	245			-4.0746	6		
	(0.361)	(0.6	57)			(3.584)***		

Table 8: Sensitivity Check and VECM Granger Causality Test

Note: ****** and ******* indicate significance at 5% and 1% levels respectively. **Source:** Author's computation.