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Electricity consumption, urbanization, and economic growth in Nigeria: New insights from combined cointegration amidst structural breaks

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The study explores the link between electricity consumption, urbanization, and economic growth in Nigeria from 1971 to 2014. The bounds test and the Bayer and Hanck (*Journal of Time Series Analysis*, 2013, *34*(1), 83–95) 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, dynamic OLS, and the canonical cointegrating regression confirm the robustness of the findings. The vector error correction model 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.

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 labor and a shortage of it precipitate growth (Jaiyesimi, Osinubi, & Amaghionyeodiwe, 2017; Lin & Liu, 2016; Pinson & Madsen, 2014; Shahbaz, Chaudhary, & Ozturk, 2017) and hampers production (Abeberese, 2017; Costantini & Martini, 2010; Khan et al., 2016; Sarwar, Chen, & Waheed, 2017; Shahbaz, 2015). Studies like (Aklin, Cheng, Urpelainen, Ganesan, & Jain, 2016; Allcott, Collard-Wexler, & O'Connell, 2016; Baskaran, Min, & Uppal, 2015; Fisher-Vanden, Mansur, & Wang, 2015; Shahbaz, 2015; Wolfram, Shelef, & Gertler, 2012) 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 Alola, 2019a, 2019b; Ozturk, 2010; Payne, 2010). To a large extend, environmental and energy policies design depend on the understanding of this link (Costa-Campi, García-Quevedo, & Trujillo-Baute, 2018; Mezghani & Haddad, 2017).

The importance of electricity is colossal both to the household and the business enterprise alike (Alola, Yalçiner, & Alola, 2019; Atems & Hotaling, 2018; Best & Burke, 2018; Costa-Campi et al., 2018). Electricity is a factor of production (Stern, Burke, & Bruns, 2017) 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 labor hour (Salmon & Tanguy, 2016). In spite of these importance, access to electricity still remain a huge problem. According to the World Bank (2017), 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.

The federal government of Nigeria have 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, Akpan & Akpan, 2012; Essien, 2011; Iyke, 2015). This study intends to fill this lacuna. The Bayer and Hanck (2013) combine cointegration test was used to examine the long-run relationship. The fully modified OLS (FMOLS) of Phillips and Hansen (1990), dynamic OLS (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 4 shows 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 80 million 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 et al., 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 11 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 3,500 MW 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 5,222 MW 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, Yamaka, and Sriboonchitta (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 and Alola (2018) discovered a feedback causality between economic growth and renewable energy consumption in 16 Coastline Mediterranean Countries. Saint Akadiri, Alola, Akadiri, and Alola (2019) also discovered the same for EU-28 countries. Alola, Yalçiner, Alola, and Saint Akadiri (2019) 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 and 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 and Sharma (2018) explored the causal link between GDP and electricity consumption from 1981 to 2013. Findings revealed that electricity consumption does not only drive economic growth, but also a key determinant of FDI inflow into the country. Elfaki, Poernomo, Anwar, and Ahmad (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, Koçak, Bulut, and Kuloğlu (2017) examined the link between urbanization and energy intensity for 10 countries in Asian from 1990 to 2014. The impact of urbanization on energy intensity was negative and significant in both time periods. As opposed to previous findings, Osman, Gachino, and Hoque (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) and Belloumi and 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, Sarwar, Chen, and Malik (2017) tried to ascertain if urbanization drives energy consumption in Pakistan by using the STIRPAT model. Findings from the ARDL result suggest that urbanization is the major driver of energy consumption in Pakistan. Similarly, Sbia, Shahbaz, and Ozturk (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 on economic growth for various countries. For middle-income countries, energy consumption drives economic growth. However, a direct opposite relationship was found for high-income countries. While most studies focused on electricity demand, Atems and Hotaling (2018) were more concerned with electricity generation. As a result, they used a system GMM to estimate data for a panel of 104 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 and 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 and 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 21st century owing the poverty in most of its rural areas (Tables 1–3).

TABLE 1 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 developing countries	Canning and Pedroni (2008) long-run causality test	EC → G
Bayat, Tas, and Tasar (2017)	BRICS	Emirmahmutoğlu and Kose (2011) panel causality test	EC → G in Russia
Karanfil and Li (2015)	160 Countries	VAR	EL → G. The nexus between both variables is sensitive to urbanization and income level
Hasanov, Bulut, and Suleymanov (2017)	10 Eurasian countries	VECM Granger causality test	EC → G in both time periods
Shiu and Lam (2004)	China	✓	EL → G. The study called for rural electrification
Obradović and Lojanica (2017)	South Eastern Europe	✓	EC → G in the long run only
Dogan (2015)	Turkey	✓	EL → G. Government should invest massively in the energy sector
Iyke (2015)	Nigeria	✓	EL → G. The unidirectional causality exist in both time periods
Alshehry and Belloumi (2015)	Saudi Arabia	✓	EC → G
Odhiambo (2014)	Four lower and middle income countries	✓	EC → G in Uruguay and Brazil
Aslan, Apergis, and Yildirim (2014)	USA	Wavelet analysis; Granger causality	EL → G
Al-mulali and Sab (2012)	Sub-Sahara Africa	Multivariate causality test	EC → G. There is need to introduce energy saving projects in the region
Narayan (2016)	135 Countries	✓	EC → G for lower middle income countries
Fatai (2014)	18 Sub-Saharan Africa countries	✓	EC → G in Southern and East Africa

Note: ↔ and → denote the bidirectional and unidirectional causality, respectively. G, EC, and EL represent economic growth, energy consumption, and electricity consumption, respectively.
Abbreviation: VECM, vector error correction model.

TABLE 2 Studies that supported the growth-led energy consumption hypothesis

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

Abbreviation: VECM, vector error correction model.

4 | DATA AND METHODOLOGY

The study made use of data spanning 1971–2014. 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 was first examined with the Augmented Dickey and Fuller (1981) and the Phillips and Perron (1988) tests. To make up for the criticism leveled 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 and Hanck (2013) combined cointegration test. This test encompasses other individual tests like the Banerjee, Dolado, and Mestre (1998), Boswijk (1995), Johansen (1991), and Engle and Granger (1987). The Fisher equation is provided as:

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

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

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 and Hanck (2013) test, the ARDL bounds test to cointegration of Pesaran, Shin, and Smith (2001) was also used. In Equation (3), we state the model in its general form.

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

where $\vartheta_1$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

TABLE 3 Studies that supported the feedback causality

Author(s)/year	Region/country(s)	Methodology	Finding(s)
Zafar, Shahbaz, Hou, and Sinha (2019)	Asia-Pacific Economic Cooperation countries	Continuously updated fully modified ordinary least square	EC ↔ G
Lin and Wang (2019)	China	Panel VAR	EL ↔ G
Ben-Salha, Dachraoui, and Sebri (2018)	Iran, Venezuela, USA, Canada, Saudi Arabia, Brazil, China, and Australia	Pooled mean group	EC ↔ G
Hamdi, Sbia, and Shahbaz (2014)	Behrain	VECM Granger causality	EL ↔ G
Saad and Taleb (2018)	12 European Union countries	✓	EC ↔ G
Akpan and Akpan (2012)	Nigeria	✓	EL ↔ G. Findings did not support the EKC
Solarin, Shahbaz, and Shahzad (2016)	Angola	✓	EL ↔ G. Urbanization also causes EL
Sarwar et al. (2017)	210 Countries	✓	EL ↔ G. Developing countries are electricity dependent
Boukhelkhal and Bengana (2018)	Four North-African countries	✓	EL ↔ G in Tunisia
Mezghani and Haddad (2017)	Saudi Arabia	✓	EL ↔ G in the short run in Saudi Arabia
Tang and Tan (2013)	Malaysia	✓	EL ↔ G. Technological innovation also drives electricity consumption
Bazarcheh Shabestari (2018)	Sweden	✓	EC ↔ G. No causality existed between both in the short run
Rafindadi (2016)	Nigeria	✓	EC ↔ G. Economic growth reduces energy consumption
Ajlouni (2015)	Jordan	✓	EC ↔ G. Growth depends on energy consumption
Solarin & Shahbaz, Hye, Tiwari, and Leitao (2013)	Angola	✓	EL ↔ G. Angola will witness growth if electricity supply increase
Shahbaz, Tang, and Shabbir (2011)	Portugal	✓	EL ↔ G exist for Portugal in the long run
Aslan (2014)	Turkey	✓	EL ↔ G
Mohammadi and Parvaresh (2014)	14 Oil-exporting countries	✓	EC ↔ G. Growth policies may have adverse effect on the environment
Hasan, Zaman, Sikder, and Wadud (2017)	Bangladesh	✓	EL ↔ G. Electricity consumption impacts positively on GDP in the long run
Bayar and Özel (2014)	Emerging economies	Block exogeneity wald test	EL ↔ G. Electricity drives growth
Osman et al. (2016)	GCC countries	✓	EL ↔ G

Abbreviation: VECM, vector error correction model.

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. Equation (4) shows the FMOLS equation.

$$Y_t = \gamma_0 + \gamma_1 EC_t + \gamma_2 URB_t + \sum_{i=q}^{q} \pi_i \Delta EC_{t-i} + \sum_{i=q}^{q} \pi_i \Delta URB_{t-i} + \mu_t \quad (4)$$

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 | Vector error correction model 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, in determinant form, is given as;

$$(1-L)\begin{bmatrix} Y_t \\ EC_t \\ URB_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix} \alpha_{11i}\alpha_{12i}\alpha_{13i} \\ \alpha_{21i}\alpha_{22i}\alpha_{23i} \\ \alpha_{31i}\alpha_{32i}\alpha_{33i} \end{bmatrix} \times \begin{bmatrix} Y_{t-1} \\ EC_{t-1} \\ URB_{t-1} \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \varepsilon_{t1} \\ \varepsilon_{t2} \\ \varepsilon_{t3} \end{bmatrix} \quad (5)$$

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.

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.

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.

TABLE 4 Descriptive statistic and correlation analysis

Variables	*ln*URB	*ln*Y	*ln*EC
Mean	30.99	7.403	4.407
Median	30.93	7.393	4.467
Skewness	0.187	0.224	−0.724
Kurtosis	1.883	1.657	3.091
Probability	0.280	0.159	0.145
*ln*URB	1		
*ln*Y	(0.259)*	1	
*ln*EC	(0.384)**	(0.122)	1

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

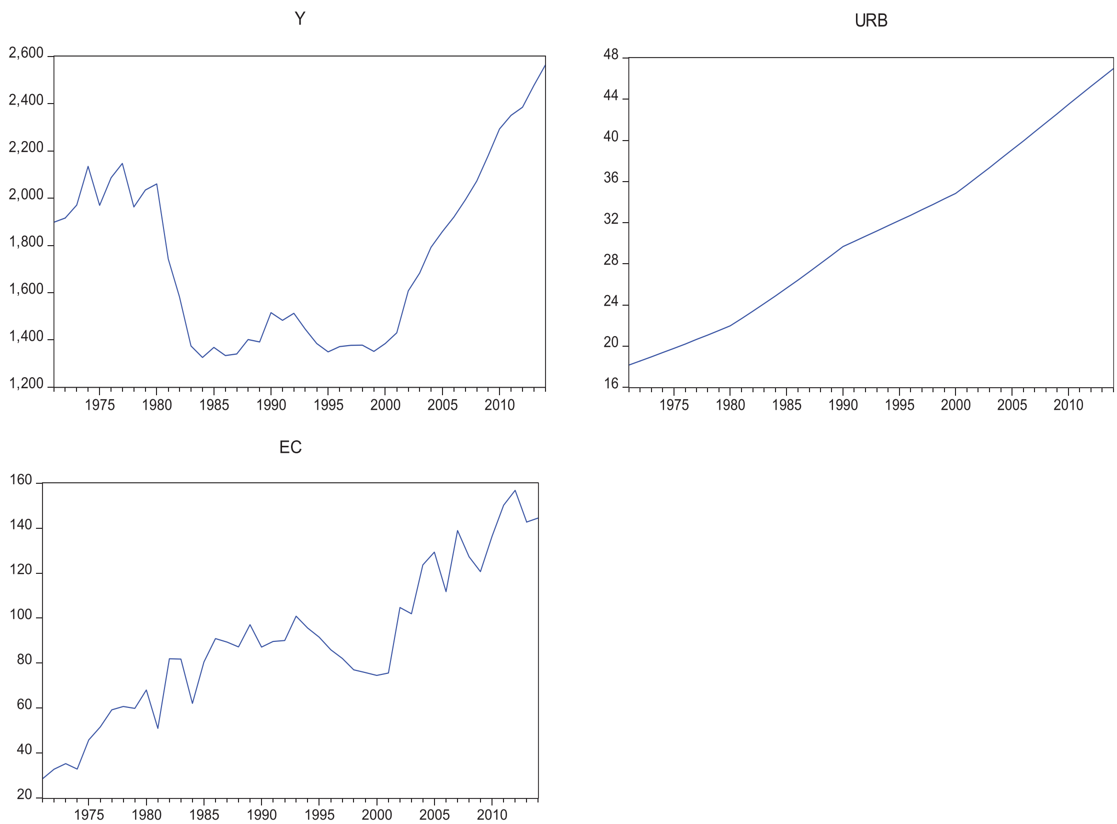

FIGURE 1 Plots of the series. *Sources*: Author's compilation, 2019

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

Variables	ADF T-statistic	PP T-statistic	ZA T-statistic	Break date Time 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

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

TABLE 6 ARDL bounds test and Bayer–Hanck test results

Estimated models	Optimal lag	Break year	F-stat.	Diagnostic tests Normality	ARCH	Cointegration
Panel A: Bounds test						
*ln*EC = f(*ln*URB, *ln*Y)	1, 3, 0	2002	4.325*	0.328	0.564	✓
*ln*URB = f(*ln*EC, *ln*Y)	2, 2, 2	1997	2.645	0.453	0.223	✓
*ln*Y = f(*ln*URB, *ln*EC)	2, 1, 2	1986	3.892**	0.154	0.453	X
	Critical values bounds					
	Lower bound	Upper bound				
5% Critical value	2.79	3.44				
10% Critical value	2.54	3.12				
1% Critical value	2.88	3.98				
Estimate models	**EG-JOH**		**EG-JOH-BO-BDM**		**Cointegration**	
Panel B: Bayer-Hanck test						
*ln*EC = f(*ln*URB, *ln*Y)	13.435**		26.487**		Yes	
*ln*URB = f(*ln*EC, *ln*Y)	14.645**		25.627**		Yes	
*ln*Y = f(*ln*URB, *ln*EC)	16.261**		24.281**		Yes	
5% critical value	10.895		21.106			

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

The results from the various tests (ADF, PP, and ZA) confirm *I* (1) for the variables. The result of the Bayer and Hanck (2013) cointegration test and the ARDL bounds test results are presented in Table 6.

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.

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 among 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 60s 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.

TABLE 7 ARDL short-run and long-run results

Dependent variable: *ln(Y)* *Short-run coefficients* Independent variables	Coefficient	Standard error	*t*-Statistic
Constant	2.3317	0.9128	2.5542
Δln(Y(−1))	0.0794	0.0658	1.2063
Δln(EC)	0.1612	0.0673	2.3943
Δln(URB)	−2.3844	1.2223	−1.9507
ECM_{t-1}	−0.0917	0.0254	−3.6018
Adjusted R^2	.5182		
Durbin–Watson	2.1087		
Long-run coefficients **Independent variables**	**Coefficient**	**Standard error**	***t*-Statistic**
ln(EC)	0.1565	0.0341	4.5894
ln(EC(−1))	0.1612	0.0777	2.0746
ln(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		

Source: Author's computation.

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 86.9 million (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, and so on 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.

TABLE 8 Sensitivity check and VECM Granger causality test

Dependent variable: *ln(Y)* *Panel A: FMOLS, DOLS, and CCR*	FMOLS		DOLS		CCR	
Variables	**Coefficient**	**t.Stat.**	**Coefficient**	**t.Stat.**	**Coefficient**	**t.Stat.**
ln(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: VECM Granger causality test	D*ln*(Y_{t-1})	D*ln*(EC_{t-1})	D*ln*(URB_{t-1})	ECT_{t-1}
D*ln*(Y_t)	–	0.2373	0.0005	−0.0617
		(0.728)	(0.657)	(−2.170)**
D*ln*(EC_t)	0.1578	–	−0.2321	−1.5699
	(1.932)		(1.390)	(2.400)***
D*ln*(URB_t)	1.1777	0.3245	–	−4.0746
	(0.361)	(0.657)		(3.584)***

Note: ** and *** indicate significance at 5 and 1% levels, respectively.
Source: Author's computation.
Abbreviations: CCR, canonical cointegrating regression; DOLS, dynamic OLS; FMOLS, fully modified OLS; VECM, vector error correction model.

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 findings complements those of Hasan et al. (2017) for Bangladesh, Rafindadi (2016) and Akpan and Akpan (2012) for Nigeria, Solarin and Shahbaz (2013) for Angola, Aslan (2014) for Turkey, Hamdi et al. (2014) for Behrain, Mezghani and Haddad (2017) for Saudi Arabia, Tang and 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, Alola, & Saint Akadiri, 2019; Alola, Yalçiner, & Alola, 2019; Alola & Yildirim, 2019; Balsalobre-Lorente, Shahbaz, Roubaud, & Farhani, 2018; Bekun, Emir, & Sarkodie, 2019; Nathaniel, 2019; Nathaniel et al., 2019; Nathaniel & Iheonu, 2019). Renewable energy could be a solution to the country's energy poverty (Nathaniel, Anyanwu, & Shah, 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, and so on. 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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