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Trivariate modelling of the nexus between electricity consumption, urbanization and economic growth in Nigeria: Fresh insights from Maki cointegration and causality tests

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Trivariate Modelling of the Nexus between Electricity Consumption, Urbanization and Economic Growth in Nigeria: Fresh Insights from Maki Cointegration and Causality Tests [1]

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Research Department

Trivariate Modelling of the Nexus between Electricity Consumption, Urbanization and Economic Growth in Nigeria: Fresh Insights from Maki Cointegration and Causality Tests

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Abstract

In this era of intensive electricity utilization for economic development, the role of urbanization remains inconclusive, especially in developing economies. Here, this study examined the electricity consumption and economic growth nexus in a trivariate framework by incorporating urbanization as an additional variable. Using the recent novel Maki cointegration test, Ng-Perron, Zivot-Andrews, and Kwiatkowski unit root tests along with FMOLS, DOLS and the CCR estimation methods, we relied on an annual frequency data from 1971-2014. Results from FMOLS, DOLS and the CCR regression confirm the electricity consumption-driven economic growth. This is desirable as Nigeria is heavily dependent on energy (electricity) consumption. A unidirectional causality from urbanization to electricity consumption and economic growth was found but the long-run empirical findings revealed urbanization impedes growth — a situation that has policy implications. The study highlights that though urbanization is a good predictor of Nigeria's economic growth, however, the adjustment of the energy portfolio to meet the growing urban demand will curtail the adverse and far-reaching impact of urbanization on the economy.

JEL classification*:* O41, C32, Q43.

Keywords: Economic growth; Electricity consumption; Maki Cointegration; Dynamic Causality; Urbanization

1. Introduction

The goal of every economy, be it developed, emerging or developing economies is to achieve sustainable development. Global growth necessitated the economies to require more energy for the operations of different economic sectors, this is in line with its functions as the driver of most economic activities. Electricity consumption is considered one of the necessities in daily life as a result of its relationship between energy and human development that comprises health, population, agricultural productivity, education, industrial production, the living standard of different nations in the world (Asumadu-Sarkodie& Owusu, 2017). Electricity is a basic source of energy and its accessibility promotes both residential and domestic needs which has a positive correlation with factor inputswhile enhancing a country's export (Narayan and Smyth, 2009), reducing poverty and eventually enhancing the overall standard of living (Poveda and Martinez, 2011). Research reveals that the growth of a given economy is negatively influenced by the level of energy consumption, then diverse arguments are needed to justify such at any point in time (Ozturk 2010). Therefore, it is essential for growing economies to cut the level of energy consumed through the technological innovation of applying energy conservative and management techniques. Developing countries can also reduce the level of emissions by shifting attention to renewable energy sources such as solar energy, wind energy, etc. which are environmentally friendly and enhance *'green'* growth (Bekun *et al.,* 2019).

One of the goals of the United Nations Sustainable Development Goals (SDGs) by the year 2030 is to have access to clean and modern energy (Owusu *et al.*, 2016). Particularly, the economic growth of developing nations heavily depends on electricity consumption. Hence, a decline in electricity supply leads to a reduction inindustrial sector output. Electricity consumption is an important element of economic growth and it is linked to capital and labour (Costantini and Martini, 2010). Several studies have revealed the different impact of electricity consumption on economic growth (Tang *et al.,* 2016; Streimikiene and Kasperowicz, 2016; Mutascu, 2016a, 2016b; Narayan and Prasad, 2008; Shahbaz and Lean, 2012; Abosedra *et al.*, 2009; Ahmed and Azam, 2016; Yuan *et al.*, 2007; Iyke, 2015).

Just like many sub-Sahara African countries, Nigeria has found it difficult to meet the energy demands of its ever-increasing population. Various government reforms to salvage the situation in the energy sector have yielded little or no impact. The sector keeps falling behind expectation, for example,in 2009, only less than half of the country's population had access to electricity (Legros et al., 2009). As of 2018, about 80million Nigerians still lack access to electricity supply in their homes (Okafor, 2018). Even after more than 5years of privatizing the energy sector, the story still remainsunchanged. The

investors who acquired the six generating companies and the 11 distribution companies still grapple with the same problems (water management, low load demand by distribution companies, gas shortfall, electricity theft, inadequate supply, huge metering gap, limited distribution networks, etc.) that has bedeviled the sector over the years. The installed generation capacity is12,910.40MW, with the available capacity, transmission wheeling capacity, and the peak generation ever attained at 7,652.60MW, 8,100MW, and 5,375MW, respectively. Due to the challenges of the energy sector, peak generation of 5,375MW has hardly been sustained. After the privatization of the sector on November 1, 2013, the power grid has suffered over 100 collapses both partial and total (Femi, 2019). Nigeria is blessed with lots of natural resources especially renewable energy sources which whenexploitedwould surmount the energy woes. However, the country is yet to fully harness these renewables (wind, solar, geothermal, tide, hydropower, etc.) to solve its energy problems.

Given the backdrop, the current study focuses on Nigeria, like any other developing countryneeds sustainable growth. For growth to be sustainable, energy demand must be met,however, Nigeria's energy sector remains incapable to meet energy demand amidst increasing urban population. Demographic factors, such as urbanization, can deteriorate the environment and impede growth. There is a dire need to examine the increase in energy demand and urbanization on the country's economic growth which will serve as a benchmarkin achieving the objectives of the SDGs. There are lots of studies on the energy-growth nexus for Nigeria, but these studies fail to examine the role of urbanization on growth knowing the upward surge in the country's urbanization rate holding to discrepancies in developmental factors like, inter alia, basic amenities, household income, and infrastructural provision in rural areas. In time-series data, economic episodes offer structural break dates (Nathaniel & Bekun, 2019) which can influence the unit root, cointegration, and causality tests. Previous studies in Nigeria ignored the influence of structural breakswhile Rafindadi (2016) considered a single break, but the current study considers up to five structural breaks in the series.

The remaining sections are as follows: section twocompiles related literature on the proposed theme; section three highlights the methodological constructions and model specification used in the study. Section four discusses the empirical findings while section five provides a brief summary ofthe study and makes policy recommendations in relation to the research outcomes.

2. Literature Review

The current theoretical and empirical underpinnings of the linkage between electricity consumption and economic growth is well established. This is not unconnected with the essential role energy consumption plays in the global and country-specific economic development. Literature on electricity consumption-growth nexus is categorized into four components namely; studies that hypothesized energy consumption promotes economic growth (Damette and Seghir, 2013; Salahuddin et al. 2015; Dogan 2015; Shahbaz et al. 2017); studies that claim economic productivity spur energy consumption, also known as conservative hypotheses (Yoo and Kwak, 2010; Apergis and Payne, 2011; Baranzini *et al.*, 2013; Akadiri and Akadiri, 2018). The third category is known as feedback hypothesis, whichreveals the presence of a bidirectional causal nexus between energy consumption and economic growth (Lee *et al.,* 2008; Nazlioglu *et al.* 2013; Tang & Tan, 2013; Belaid and Abderrahmani, 2013; Osman *et al.*, 2016).The fourth category (Soytas & Sari, 2006; Halicioglu, 2009; Ameyaw *et al. 2016*) refers to the neutrality hypothesiswhich reveals no causal link between energy consumption and economic growth.

Despite the different studies, no agreement has been reached on the causality between electricity consumption and economic growth. Findings from advanced economies used energy as a measure of energy usage (see for example; Fatai *et al.*, 2002; Hondroyiannis *et al.*, 2002; Stern, 2000; Glasure, 2002; Ho & Siu, 2007; Payne, 2009). Similarly, studies from developing countries that applied electricity use to represent energy consumption found different outcomes of electricity causality. Several regional studies were conducted with the view of assessing the relationship between electricity consumption and economic growth(Athanasios, and Dagoumas 2013; Belaid and Abderrahmani 2013; Nindi and Odhiambo. 2014; Rafindadi and Ozturk 2017a; Zhang et al. 2017 and Wang et al. 2017). Recent findings in the electricity-growth nexus like Balcilar et al. (2018) affirm the presence of bidirectional causality between electricity andgrowth based on Maki cointegration analysis. Bakirtas and Akpolat (2018) assert a unidirectional causal relationship running from economic growth to energy consumption. A study in Malawi revealed that a shock in electricity consumption is found to cause a permanent rise in economic development (Jumbe, 2004). On the contrary, studies in 17 African countries showed that electricity supply is entirely not a nostrum for economic improvements in Africa

but a catalyst for improving lives and wellbeing (Wolde-Rufael, 2006; Odhiambo, 2009). Electricity consumption was found to trigger more economic productivity (GDP) in the Zimbabwe Samu et al. 2019). Electricity consumption was found to enhanceNigeria's economic growth, however, the short-run causality revealed a unidirectional in nature, running from electricity consumption to economic growth (Bekun and Agboola, 2019).In a study that explored the causality between electricity consumption, economic growth, and environmental factors in North Africa, economic growth was found tostimulate the upsurge in electricity demand (Boukhelkhal & Bengana, 2018). However, an increase in electricity demand and economic growth drive CO_2 emissions in the region. The authors further noted that achieving sustainable development will be difficult if countries in the region do not invest adequately in clean energy sources. In a similar study carried out in sub-Sahara Africa, the findings validated the notionthat electricity consumption increases economic growth, while electricity quality declines growth(Chakamera & Alagidede, 2018). The studyfurther revealed that emissions emanating from electricity stock hamper economic growth whereas the deterioration of electricity quality will have the same impact exacted by emissions emanating from electricity stock on growth. Surprisingly, unlike previous findings for African countries, a studyon the electricity-growth nexus for Sudan while controlling for urbanization reported that energy consumption does not stimulate growth but rather inhibits economic growth (Elfaki*et al.* 2018). While Bah & Azam (2017) found no direction of causality between electricity consumption and economic growth in South Africa, Iyke (2015) reported the exact opposite for Nigeria. The findings (Iyke, 2015) suggested a unidirectional causality from electricity consumption to economic growth. Solarin *et al.* (2016) revisited the electricity-economic growth nexus for Angola while controlling for import, export, and urbanization from 1971-2012. The result showed that urbanization impairs growth, while electricity consumption spurs economic productivity. A feedback causality was found between economic growth and electricity consumption in Angola. Rafindadi (2016) investigated the link between energy consumption, economic growth and CO_2 emissions in Nigeria from 1971-2011 while controlling for trade and financial development. Findings revealed that economic growth drives CO_2 emissions, but lowers energy demand. On the other hand, trade increases energy demand and improves environmental quality by reducing CO_2 emissions. Thus, a massive investment in the financial sector is essential because of its ripple effect on the energy sector of the country.Table 1 presents selected literature on electricity consumption and economic growth. Thus, given the trajectory of the literature. Previous studies have failed to account for the covariate (like Urbanization in the electricity-led growth literature) explored in this study. On

this premise, the current study revisits the theme with a new perspective and offer new insights into related literature.

Table 1. Compilation of selected literature on electricity consumption and economic growth

Author(s)	Year	Methodology	Findings
Yoo and Kwak	2010	Hsiao causality Test	EG → ELC in Ecuador, Columbia Argentina, Chile, and Brazil. Conversely, GDP ↔ ELC for Venezuela, while a neutral effect is confirmed in Peru.
Apergis and Payne	2011	Panel error correction model	EG ↔ ELC for upper-middle-income and high-income countries is proven.
Ozturk and Acaravci	2011	Panel cointegration method	EG and ELC have a long-run relationship.
Das, *et al.*	2012	System-GMM	ELC triggers EG.
Solarin and Shahbaz	2013	ARDL	EG ↔ Urbanization exists for Angola.
Nazlioglu *et al.*	2013	ARDL	EG ↔ ELC. The evidence of non-linearity is however found between the series.
Belaid and Abderrahmani	2013	Zivot–Andrews test; Gregory–Hansen cointegration test	EG ↔ ELC exists in both time periods.
Willie	2014	Granger causality test	EG → ELC in Zimbabwe.
Wolde-Rufael	2014	Panel bootstrap cointegration approach	For the case of Belarus and Bulgaria, ELC drives EG. EG → ELC in the Czech Republic, Latvia, and Lithuania. Although, EG ↔ ELC is found for Ukraine and Russian.
Hamdi *et al.*	2014	ARDL	ELC, FDI and capital impact EG

			positively.
Aslan	2014	ARDL	ELC drives EG in Turkey. EG ↔ ELC also exists.
Karanfil and Li	2015	ARDL	The link between ELG and EG is sensitive to regional differences, level of incomes and degree of urbanization as well as supply risk factors.
Abdoli and Dastan	2015	FMOLS	Trade and ELC impact EG positively. EG ↔ ELC is also established.
Salahuddin *et al.*	2015	Panel data analysis	ELC → EG in GCC member countries over the study period.
Kayikci and Bildirici	2015	ARDL	The causality between EG and ELC is conditioned upon the level of natural resources of the sampled countries.
Dogan	2015	VECM Granger causality	ELC → EG. Higher investment in the power sector is sacrosanct.
Belloumi and Alshehry	2016	ARDL, FMOLS, DOLS and Toda-Yamamoto causality	Urbanization → EG and energy. They resolved that sustainable development in Saudi Arabia is determined by reducing energy inefficiency.
Osman *et al.*	2016	Pool Mean Group technique among others.	Capitalization and electricity consumption promote GDP. EG ↔ ELC is established. Capitalization → EG, and EG → capitalization.
Ameyaw *et al.*	2016	Vector Error Correction Model	Energy is not a determinant factor in the growth of the Ghanaian economy.
Shahbaz *et al.*	2017	Panel cointegration	Variables have long-run relationships.

			Moreover, EG ↔ ELC. Also, oil prices ↔ GDP is found to be valid.
Wang *et al.*	2017	Alternate to the bootstrap Granger causality	The finding reflects a significant positive impact of ELC on EG. In the short run, GDP → ELC.
Bilgili *et al.*	2017	Panel causality test	Urbanization reduces energy intensity.
Shahbaz *et al.*	2017	ARDL	The ARDL result suggests that urbanization drives ELC in Pakistan. Also, urbanization → ELC.
Shahbaz *et al.*	2017	Non-Linear ARDL	The causality result reveals that ELC → EG in the Portuguese economy.
Tatlı	2017	ARDL	The findings reveal that urbanization and economic growth negatively and significantly affect residential electricity consumption.
Mezghani and Ben Haddad	2017	Time-Varying Parameters Vector Autoregressive Model	Electricity consumption is considered a determinant factor of carbon dioxide emissions in Saudi Arabia.
Kahouli	2018	Seemingly unrelated regression.	ELC → R&D stocks, however, R&D → CO_2 emissions also exist.
Bakirtas and Akpolat	2018	Panel causality test	The bivariate analysis revealed EG → energy consumption, and from urbanization → EG and energy consumption. The trivariate analysis, however, suggests that urbanization → EG and energy consumption.
Kumari & Sharma	2018	Granger causality	ELC → EG in India.
Balsalobre-Lorente *et al.*	2018	Panel least squares model	Renewable electricity consumption enhances the quality of the environment in 5 European Union nations.
Elfaki*et al.*	2018	ARDL	Energy consumption inhibits growth

			in Sudan.
Chen & Fang	2018	Panel Granger non-causality test	ELC → EG in all cities considered.
Akadiri and Akadiri	2018	Panel Granger causality test	EG → ELC in Middle Eastern countries.
Kahouli	2018	GMM, 3SLS, and SUR techniques	Electricity consumption promotes economic growth in Mediterranean countries.
Akadiri et al.	2019	ARDL and Toda-Yamamoto for Granger causality.	EG → ELC.
Balcilar et al.	2019	Maki cointegration test and Toda-Yamamoto causality test	Maki cointegration test validates long-run associations among the variables. Furthermore, EG ↔ ELC. Also, there is unidirectional causality ELC → CO2.
Bekun and Agboola	2019	Maki cointegration test, DOLS, and FMOLS techniques	The main finding documented that electricity-induced growth in Nigeria. Also, in the short run ELC → EG.
Samu *et al.*	2019	Maki cointegration and DOLS.	ELC → EG in Zimbabwe.

Note: ↔ and → denote the bidirectional and unidirectional causality respectively. ELC, EG, and CO2 represent electricity consumption, economic growth, and carbon dioxide emissions respectively.

3. Methodological Construction

3.1 Model Specification

This study explored the electricity-growth nexus in the fastest urbanized country in Africa (Nigeria). In the quest to investigate this theme, and the direction of causality, our study built on the existing literature (Shahbaz and Lean, 2012; Shahbaz *et al.*,2013). The econometric model used for the empirical analysis is specified as:

$$Y_t = f(EC_t, URB_t) \quad (1)$$

where Y_t represents real income level in per capita term, EC_t denotes electricity consumption per capita while URB_t is urbanization. Data range from 1971 to 2014 for the case of Nigeria. All data were retrieved from the WDI (2017). Urbanization induces structural changes in an economy, therefore, its impact on energy consumption cannot be ignored (Solarin and Shahbaz, 2013). As argued by Alam *et al.,* (2007), urbanization is a core factor in the development process. Urbanization creates a cluster of the population thatis involved in different economic activities. In turn, economic activities raise the demand for electricity.

3.2 Unit Root Test

The Zivot and Andrew (1992) unit root test (ZA, hereafter) was applied to account for a structural break in the variables. The three different strands of the test are shown in Eq.2., Eq.3., and Eq.4. which suggests a break in the intercept, trend, intercept and trend respectively.

$$\Delta z_t = \vartheta_1 + \vartheta_2 t + \xi z_{t-1} + \psi DU_t + \sum_{i=0}^{r} \omega_i \Delta z_{t-i} + \varepsilon_t \quad (2)$$

$$\Delta z_t = \vartheta_1 + \vartheta_2 t + \xi z_{t-1} + \delta DT_t + \sum_{i=0}^{r} \omega_i \Delta z_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta z_t = \vartheta_1 + \vartheta_2 t + \xi z_{t-1} + \psi DU_t + \phi DT_t + \sum_{i=0}^{r} \omega_i \Delta z_{t-i} + \varepsilon_t \quad (4)$$

Where T_b is the possible breakpoint, r is the upper limit of the lag length of the explanatory variables. Also, $DU_t = 1 \; and \; DT_t$ will be equivalent to $t - T_b$ if $t > T_b$ and it will be 0 if otherwise.

3.3 Cointegration Test

Traditional cointegration testslike Engle and Granger (1987), Johansen (1991), Banerjee *et al.* (1998) and Boswijk (1995) break down when there are structural breaks in the series. Hence,leading toerroneous estimates of the relationship among variables— especially the long-run equilibrium relationship. The

reverse is the case for tests like Carrion- i- Silvestre and Sansó (2006), Gregory and Hansen (1996), Hatemi-j (2008), ZA (1992) and Westerlund and Edgerton (2007) which account for one or two structural breaks in the series. However, relying on a single structural break can create a similar problem like those encountered in using the conventional standard cointegration tests. This study used the Maki (2012) cointegration test which considers up to five structural breaks in the series. As a prerequisite for adopting this test, the selected variables are expected to be nonstationary but integrated at I(1). There are four alternative models proposed by the test shown in Eq. 4-7, expressed as:

Model I: Break in intercept and without trend

$$x_t = \mu + \sum_{i=1}^{r} \mu_i D_{i,t} + \xi' z_t + u_t \tag{4}$$

Model II: Break in intercept and coefficients and without trend

$$x_t = \mu + \sum_{i=1}^{r} \mu_i D_{i,t} + \xi' z_t + \sum_{i=1}^{r} \xi_i' z_t D_{i,t} + u_t \tag{5}$$

Model III: Break only in intercept and coefficients, but the model has a trend

$$x_t = \mu + \sum_{i=1}^{r} \mu_i D_{i,t} + \delta t + \xi' z_t + \sum_{i=1}^{r} \xi_i' z_t D_{i,t} + u_t \tag{6}$$

Model IV: Break in intercept, coefficients, and trend

$$x_t = \mu + \sum_{i=1}^{r} \mu_i D_{i,t} + \delta t + \sum_{i=1}^{r} \delta_i t D_{i,t} + \xi' z_t + \sum_{i=1}^{r} \xi_i' z_t D_{i,t} + u_t \tag{7}$$

D_i is the dummy variable while T_b and r remain as explained above.

3.4 Estimation of Long-Run Coefficients

In the case of cointegrated variables, the need to estimate the long-run coefficients for the various variables used in the study isrelevant. For this purpose, the fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS) and the Canonical cointegration regression (CCR) were used. The FMOLS model is shown in Equation 8:

$$Y_t = \beta_0 + \beta_1 EC_t + \beta_2 URB_t + \sum_{i=-q}^{q} \delta_i \Delta EC_{t-i} + \sum_{i=-q}^{q} \delta_i \Delta URB_{t-i} + \varpi D_i + \mu_t \quad (8)$$

Where q is the lag order to be determined by using the Schwarz Information Criterion (SIC) and t is the time trend. D_i denotes the dummy variables of the breaking years from Maki (2012) cointegration test results. Hence, it will be possible to investigate whether these breaking years show a statistically significant effect in the long-run model. The FMOLS has the advantage of correcting for autoregression and endogeneity problems, as well as error emerging from sample bias (Narayan and Narayan, 2005).

3.5 Granger Causality Test

Since impactassessment is different from causation, this study adopted the Toda-Yamamoto (1995) causality test to ascertain the direction of causality. The test was preferred on the grounds that it allows for tests of augmented Granger causality, hence,providing long-run information (see, Karimo and Ogbonna, 2017). It can be carried out irrespective of the cointegration characteristics of models and the integration of the series (Gokmenoglu and Taspinar, 2018). The test recommends the modified Wald stat (MWALD). This will involve estimating VAR (*k*+*dmax*). Where *dmax* stands for a maximum order of integration, k is the optimal lag order. We apply a trivariate VAR (k+ dmax) model which comprised of economic growth, electricity consumption, and urbanization. The model is expressed as:

$$\ln Y_t = \varphi_0 + \sum_{k=1}^{n} \varphi_{1k} \ln Y_{t-k} + \sum_{r=m+1}^{d_{\max}} \varphi_{2r} \ln Y_{t-r} + \sum_{k=1}^{n} \beta_{1k} \ln EC_{t-k} + \sum_{r=m+1}^{d_{\max}} \beta_{2r} \ln EC_{t-r} + \sum_{k=1}^{n} \xi_{1k} \ln URB_{t-k} + \sum_{r=m+1}^{d_{\max}} \xi_{2r} \ln URB_{t-r} + \varepsilon_{1t} \quad (9)$$

$$\ln EC_t = \beta_0 + \sum_{k=1}^{n} \beta_{1k} \ln EC_{t-k} + \sum_{r=m+1}^{d_{\max}} \beta_{2r} \ln EC_{2,t-r} + \sum_{k=1}^{n} \varphi_{1k} \ln Y_{t-k} + \sum_{r=m+1}^{d_{\max}} \varphi_{2r} \ln Y_{t-r} + \sum_{k=1}^{n} \xi_{1k} \ln URB_{t-k} + \sum_{r=m+1}^{d_{\max}} \xi_{2r} \ln URB_{t-r} + \varepsilon_{2t} \quad (10)$$

$$\ln URB_t = \xi_0 + \sum_{k=1}^{n} \xi_{1k} \ln URB_{t-k} + \sum_{r=m+1}^{d_{\max}} \xi_{2r} \ln URB_{t-r} + \sum_{k=1}^{n} \delta_{1k} \ln RGDP_{t-k} + \sum_{r=m+1}^{d_{\max}} \delta_{2r} \ln RGDP_{t-r} + \sum_{k=1}^{n} \beta_{1k} \ln EC_{t-k} + \sum_{r=m+1}^{d_{\max}} \beta_{2r} \ln EC_{t-r} + \varepsilon_{3t} \quad (11)$$

Where Y, EC and URB are all expressed in section 3.1, ε_{1t}, ε_{2t} and ε_{3t} represent stochastic terms for fitted models and k denotes the optimal lag order (See Appendix A). By using the standard Chi-square statistics, Wald tests are employed to the first n-coefficient matrices.

4. Results and Discussion

The summary statistics of the study show that all the interest variables observe are positively skewed except for electricity consumption (See Table 2). The kurtosis statistic exhibits light tails as such, all series are normally distributed given the failure to reject the Jarque-Bera probability. Also observed among the series is a significant departure from their means. The Pearson correlation matrix analysis presented in Table 3 shows a positive association between growth and urbanization, which is not surprising for a heavily industrialized and growing economy like Nigeria. Similarly, we observe that urbanization and electricity consumption are positively and statistically related. However, correlation analysis is not enough to validate our position. Thus, this study proceeds with an econometrics procedure to investigate these outcomes.

Table 2: Summary Statistics of the variables for Nigeria

	Y	*EC*	*URB*
Observations	44	44	44
Mean	7.403	4.407	30.999
Median	7.393	4.467	30.930
Maximum	7.849	5.055	46.982
Minimum	7.048	3.352	18.151
Std. Dev.	0.239	0.424	8.643
Skewness	0.224	-0.724	0.187
Kurtosis	1.657	3.091	1.883
Jarque-Bera	3.676	3.864	2.544
Probability	0.159	0.145	0.280
Sum	325.733	193.921	1363.934
Sum Sq. Dev.	2.455	7.738	3212.529

Table 3: Pearson correlation estimates

	Y	*EC*	*URB*
Y	1.000		
T- statistic	-----		
P- value	-----		
EC	0.122	1.000	
T- statistic	0.799	-----	
P- value	0.429	-----	
URB	0.259	0.884	1.000
T- statistic	1.735	12.260	-----
P-value	0.090***	0.000*	-----

Note: *Correlation is statistically significant at *** 10% and* 1%, respectively.*

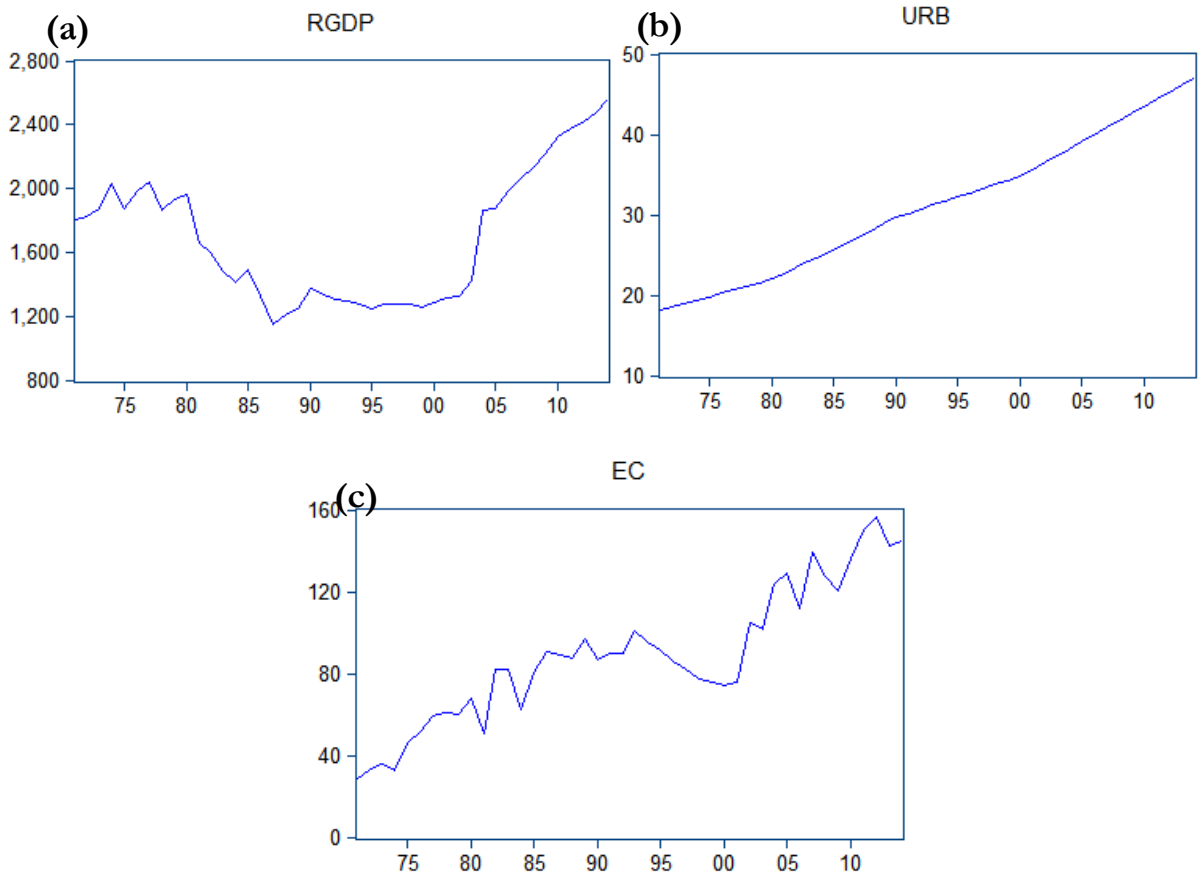


Figure 1: Visual plot of study variables (a) real income level (b) Urbanization (c) energy consumption

Here, we observed the series trend plot over the considered period, which shows an upward trend among all series with possible structural breaks. Over the years, gross domestic product trends upward, though with the obvious business cycle and a sharp decline in the 1985 and 1986, which resonates with the period of Structural Adjustment Program (SAP) era in Nigeria — where the government sort for financial help from the Bretton Wood institutions. As such, Nigeria was required to liberalize its economy, which translated into a major structural change in the macroeconomy and a sharp decline as obverted in the visual plot. In addition, the urbanization series exhibits a perpetual upward trend indicating the continuous increase in the urban population in Nigeria while electricity consumption displays many fluctuations especially in the 1980 and early 2000 that reflect the period of privatization of Nigeria's energy sector. As such, our econometric modeling accounts for such breakswhich arenecessary to avoid misleading statistical inferences. The current study employed both ZA and Ng-Perron that accounts for a possible single structural break and stationarity test of Kwiatkowski *et al.*, (1992). All the tests in Table 4 are in consensus that all series are I(1). However, the ZA unit root test reveals significant break dates that resonate with Nigeria's economic and political happenings,like that of the pre and post-structural adjustment era (1984-86) characterized by major economic changes in the macroeconomy and the political episodes in the 90s.

Table 4: Unit Root Tests

	Ng-Perron				KPSS	Zivot-Andrews
Variables	**MZa**	**MZt**	**MSB**	**MPT**	n_τ	ZA_τ
Y	-0.852	-0.438	0.514	55.964	0.235*	-3.126 (0) [1994]
Δ*Y*	-20.830*	-3.227	0.155	4.375	0.108	-7.151* (0) [1988]
EC	-8.949	-2.093	0.233	10.264	0.745*	-4.139 (0) [1994]
Δ*EC*	-18.587*	-3.048	0.164	4.906	0.093	-5.541** (3) [2002]
URB	-31.394*	-3.832	0.122	3.628	0.840*	-3.874 (1) [1997]
Δ*URB*	-6.774	-1.837	0.271	13.454	0.075	-5.136** (0) [1991]

Note: *** indicates a 5 percent statistical significance level while * denotes 1 statistical. Significance level. ( ) represents the optimum lag length. All tests were conducted with the model of both intercept and trend orientation.*

Table 5: Maki (2012) Cointegration Test

Number of Breaks Points		Test Statistics [Critical Values]	Break Points
$m \leq 5$			
	Model 0	-5.418 [-5.760]	1979,1982,1991,1994,1997
	Model 1	-6.498 [-5.993]**	1979,1984,1989,1991,2003
	Model 2	-7.887 [-7.288]**	1984,1987,1991,1999,2003
	Model 3	-6.605 [-8.129]**	1984,1989,1995,2003,2010

Note: *[ ] shows critical values at 5 percent significance level. **indicates significance at 5percent.*

The need for a cointegration test under the structural break model is pertinent in order to avoid the spurious analysis given the superior merits of the recently developed Maki (2012)[2]cointegration test that accounts for five breaks dates in a cointegration model. Table 5 reports the cointegration test of the study. Table 5 shows the cointegration relationship between the variables over the considered period. This implies that there some sort of co-movement among these series in the long-run, as convergence is observed.

Table 6: FMOLS-DOLS-CCR Long-run coefficient estimates

Dependent variable	*Y*					
	FMOLS		DOLS		CCR	
Series name	Coefficient	t-stat.	Coefficient	t-stat.	Coefficient	t-stat.
EC	0.161**	2.222	0.585**	4.221	0.182**	2.163
URB	-4.860*	11.842	-4.645*	-11.313	-5.031*	-12.871
D1984	-0.064	0.568	-1.743**	-6.594	-0.252***	-1.816
D1989	-0.263**	-3.090	-2.050**	-3.708	-0.300**	-2.278
D1995	-0.011	0.926	-0.211	-2.028	-0.021	-00.137
D2003	-0.120	-1.057	-0.258	-1.749	-0.192	-1.321
D2010	0.039	0.336	-0.772**	-3.775	0.103	0.526
constant	-66.798*	-10.647	-64.771*	-10.901	-69.397*	-11.615
trend	-0.121	-10.980	-0.114**	-10.015	-0.126*	-12.067

[2]For lack of space we reported only Model 5 results. Other model results are available upon request. However, the other model results are in harmony with Model 5. There is traces cointegration among the variables under review.

***Note:**, ** and *** indicate significance at 1 ,5 and 10 percent, respectively.*

To determine the long-run coefficient among the variables under review is crucial. This study adopted the FMOLS, DOLS, and CCR as tools to investigate the magnitude of the cointegration relationship among the three variables. All cointegration regression tests (FMOLS, DOLS, and CCR) are in harmony in terms of statistical significance and sign orientation and the CUSUM tests show the stability of the estimated model (Appendix B). We observe from Table 6 that an increase in electricity consumption spurs economic growth. This is necessary as Nigeria is heavily dependent on electricity. This corroborates the studies of Bekun and Agboola, 2019; Solarin and Bello, 2011; Shahbaz *et al.*, 2013. On the other hand, our study reveals that urbanization inhibits growth. The plausible logic for these outcomes lies in the fact that the country is driven by the primary sectoras such, most people in the urban areasare also poor. This implies that most of the persons in the cities in Nigeria are not gainfully contributing to national output (GDP), this could be a possible reason for the inverse relationship observed in this study. These results are in line withthe finding of a study conducted in Angola (Shahbaz *et al.*, 2013). The study conducted in South Africa (Bekun *et al.* 2018) further gives credence to the energy induced growth hypothesis while controlling for the contribution of capital and labour.

Table 7: The Toda-Yamamoto Granger Causality Analysis

Hypothesis	Chi-square	P-value	Conclusion
EC≠>Y	1.571	0.210	No causality relationship
URB≠>Y	3.517***	0.060	Causality relationship
Y≠>EC	0.082	0.775	No causality relationship
URB ≠>EC	5.410**	0.020	Causality relationship
Y≠>URB	0.019	0.901	No causality relationship
EC≠>URB	0.702	0.402	No causality relationship

***Notes: (1)** The symbol "≠>" represents no causality between the selected variables and ** indicates 0.05 statistical significance level. (2) Optimum lag length is selected as 1 by using SIC(See Appendix A).*

Given that regression does not necessarily depict causality, the need to conduct the Toda-Yamamoto Granger causality was essential. Table 7 shows a one-way causality relationship between urbanization and economic growth. This implies that urbanization is a good predictor for economic growth in Nigeria,an empirical result consistent with Nathaniel (2019).In a similar fashion, unidirectional causalityruns fromurbanization to electricity consumption. This is expected given the interconnectedness of the nation, the role of globalization as countries are open to each other, thus there will be a rise in global demand for energy (electricity) consumption, and Nigeria is not an exception.This aligns with the findings of Akinlo (2008), Matthew *et al.* (2015), Iyke (2015) and Ogundipe *et al.* (2016) for the case of Nigeria. However, there is no Granger causal relationship between electricity consumption and economic growth. In another way, electricity consumption and economic growth variables are not good predictors for each other.This finding contrasts withthe finding of Bekun and Agboola (2019) for Nigeria in the 1971-2014 period. The reason for this difference may come from model specification and data selection. However, empirical results reported in Matthew*et al.* (2015) show a non-causal relationship from electricity consumption to economic growth for Nigeria.

5. Conclusion and Policy Implication

This study explored the perceived relationship and causality among three variables (economic growth, urbanization, and electricity consumption) in Nigeria from 1971–2014. The Maki's (2012) cointegration test in the presence of multiple structural breaks was used to ascertain the long-run relationship in the model. The results revealed the presence of a long-run relationship among the variables amidst several significant structural breaks. All long-run regression results of FMOLS, DOLS, and CCR confirmed urbanization exerts a negative and inelastic statistically significant relationship on economic growth over the sampled period. We observed that electricity consumption drives economic growth. These findings confirmed the electricity (energy) induced growth hypothesis for Nigeria. The findings serve as a clarion call for the government and policymakers to initiate policies that will curtail rapid urban growth in various cities in the country. One of such policies will be to provide the needed infrastructures and other basic needs in the rural areas as this will go a long way in curbing rural-urban migration. Since energy consumption spurs economic growth, there is a dire need for improvement in energy generation in the country. The increase in the country's population which is in excess of 180million calls for an increase in electricity generation given that the country's generational deficit.

Nigeria still generates about 7,000MW, which is far from 51,309MW generated in South Africa from all sources with a population of about 56.72 million. It is important for Nigeria to concentrate on renewable energy sources like, inter alia, solar, wind power, geothermal, biogas, tidal power and wave power, which are environmentally friendly. This is necessary given the global consciousness and pressure to move towards sustainable and renewable energy sources. Thus, policymakers, energy, and environmental economist in Nigeria are encouraged to re-position the Nigerian energy mix to more environmentally friendly sources to meet global practices.

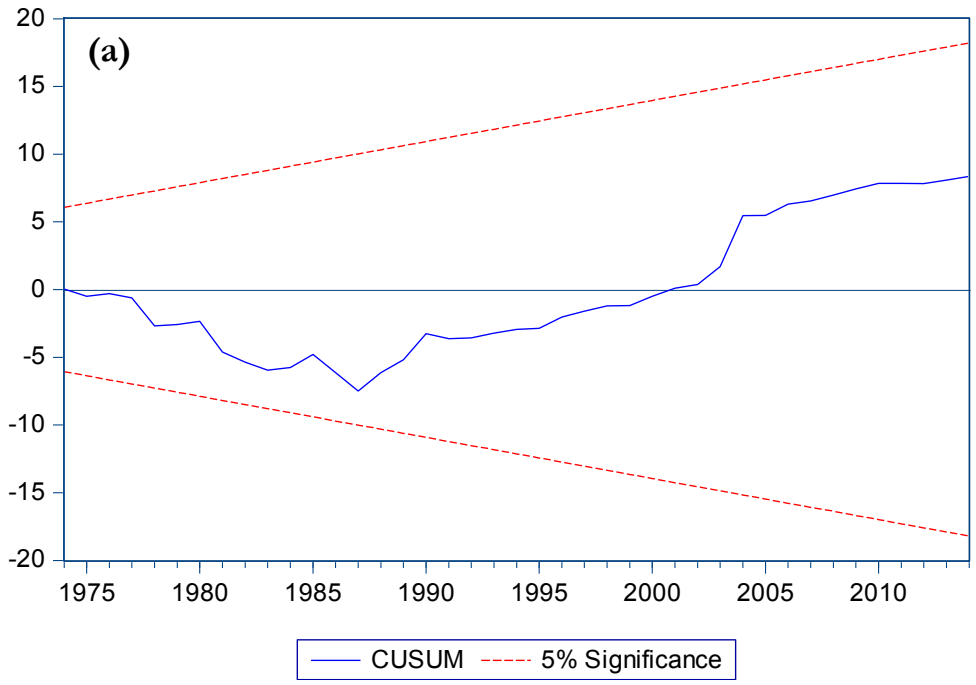
Appendices

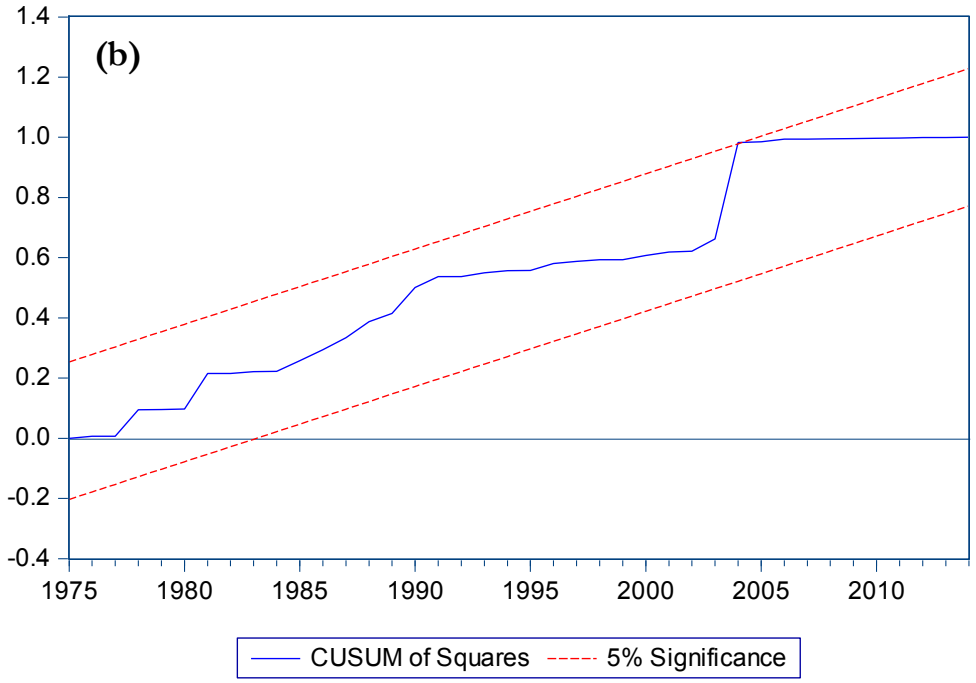
Appendix A. Lag-length selection criterion

Endogenous variables: LEC LURB LY D1 D2 D3 D4 D5

Lag	LogL	LR	FPE	AIC	SC	HQ
0	18.48744	NA	9.07e-05	-0.794228	-0.666262	-0.748315
1	243.2534	403.4261*	1.42e-09	-11.85915	-11.34729*	-11.67550*
2	252.8079	15.67910	1.40e-09*	-11.88758*	-10.99182	-11.56619
3	260.7449	11.80383	1.51e-09	-11.83307	-10.55341	-11.37394
4	268.9541	10.94553	1.64e-09	-11.79252	-10.12896	-11.19565
5	277.4534	10.02483	1.82e-09	-11.76684	-9.719381	-11.03223

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion





AppendixB.Stability test for the long-run coefficients (a) CUSUM (b) CUSUM of Squares

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