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Electricity Consumption and Economic Development in Nigeria

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ABSTRACT

The study examines the relationship between electricity consumption and economic development using an extended neoclassical model for the period 1970-2013. The study incorporates the uniqueness of the Nigerian economy by controlling for the role of institutions, technology, emissions, and economic structure in the electricity consumption-development argument. The study adopted a cointegration analysis based on the Johansen and Juselius (1981) maximum Likelihood approach and a vector error correction model. In order to ensure robustness, the study adopted the wald block endogeneity causality test to ascertain the direction of causal relationship between electricity consumption and economic development. The study found an existence of long-run cointegration equation with electricity consumption inversely related to economic development. Likewise, the vector error correction model failed to reject the null hypothesis of non-convergence in the long-run. Finally, the study found evidence supporting unidirectional causal relationship running from economic development to electricity consumption.

Keywords: Electricity Consumption, Economic Development, Cointegration, Causality
JEL Classifications: L94, O1, N17

1. INTRODUCTION

Energy is increasingly becoming a major force in the pursuit of sustainable development. The attribute of neutrality ascribed to energy by neoclassical model is contestable as consistent growing sources of modern energy could directly aid livelihoods, and indirectly via promotion of economic growth. As a major source of energy, accessibility of electricity aids the process of meeting residential and domestic needs, positively contributes to capital and labour productivity, promotes export potentials of countries (Narayan and Smyth, 2009), creates employment and reduces the poverty level (Poveda and Martínez, 2011); this ultimately improves socio-economic development. According to Saleheen et al., (2012), countries' level of development appears to be associated with intensity of electricity wage as only 24.84% of the population in least developed countries had access to electricity in the year 2009. In the same year, electricity consumption in European union was 11 fold of the consumption in Sub-Saharan Africa, inspite of Sub-Saharan having a larger population in 2009 (World Bank, 2011).

Unavailability of electricity has been a critical problem in Nigeria, as its widely acknowledged that most Sub-Saharan Africa states is in the midst of power crisis (Eberhard et al., 2011; UN 2007). Outages are not just frequent and long but also erratic. According to the World Bank enterprise surveys, pertaining to the years 2006-2010, the average length of an outage is 6.6 hours. Unsurprisely, more than 50% of Africa businesses surveyed cite inadequate power supply as a major infrastructural challenge that dampens development (Jones, 2011). The situation is more challenging in Nigeria, as many businesses have relocated to neighboring countries due to poor electricity infrastructure and rising cost of production, also, power shortages is adjudged a major deterrent to SMEs development and culminating into rising unemployment and civil disturbances.

Recognizing the importance of electricity in economic development agenda, there has been upsurge of empirical literatures to verify the true connection between electricity consumption and economic activity in different countries and regions. Including the pioneering study of Kraft and Kraft (1978), causality tests are recurrently employed in existing energy papers to determine the direction of causal relationship between electricity consumption and economic growth. The causality running from electricity consumption towards economic growth infers that electricity influences economic growth and thus expansion of electricity services is compatible with improvement of economic performance of the country. The causality running from economic growth to electricity consumption implies that economic growth is not dependent on electricity usage and therefore conservation policies should be pursued. The feedback hypothesis between electricity consumption and economic growth means both variables are interrelated, supporting expansionary policies. Neutral hypothesis between economic growth and electricity consumption suggests the limited role of electricity consumption for economic growth.

Empirical studies on causal relationship between electricity consumption and economic growth are wide-ranging providing ambiguous results, Aqeel and Butt, (2007); Yoo, (2005); Yoo, (2006); Chen et al. (2007); Ho and Siu, (2007); Hu and Lin, (2008); Jamil and Ahmad, (2010); Narayan and Smyth, (2005); Shahbaz et al. (2011); Shahbaz and Feridun, (2012); Shahbaz et al. (2014). Further, few studies have considered electricity consumption and economic growth relationship in selected African economies (Jumbe, (2004); Wolde-Rufael, (2006); Akinlo, (2009); Squalli, (2007); Odhiambo, (2009, 2009, 2010); Solarin, (2011) and, Solarin and Bello, (2011)). However, this study differs from earlier attempt as it incorporate the role of institutions, environmental degradation, technology and economic structure in evaluating the effect of electricity consumption on economic development. Also, majority of these studies had evaluated the effect of electricity consumption on economic growth but this study adopts economic development; and we are not aware of any study investigating causal relationship between electricity consumption and economic development that controls for the influence institutional quality, emissions, state of technology and economy structure.

The remainder of the paper is patterned as follows. Section 2 stylized facts on electricity consumption and economic development, Section 3 deals with issues relating to literature review surrounding electricity consumption and economic development Section 4 provides the research methodology as seem suitable for the study and the Nigeria economy and Section 5 provides empirical results and the last section concludes the paper.

2. DATA AND STYLIZED FACTS

The data used in the empirical analysis of the study were sourced from the World Development Indicators of World Bank (2013), the World Governance Indicators of the World Bank (2013), United Nations Conference on Trade and Development (UNCTAD) Handbook of Statistics and the Data market of Iceland available at http://datamarket.com/.

Evidences have shown that Nigeria is primarily an energy store house accommodating resources such as coal and lignite, natural gas, crude oil, solar, hydro, nuclear, woodfuel, geothermal, tide, biogas and biomail. In spite of the available vast resources, only four sources (coal, crude oil, natural gas and hydro) are currently utilized in processed forms while two others (woodfuel and solar) are used in their crude forms for heating, cooking and lighting (Table 1).

In spite of the growing energy need for emerging economies to match the constantly increasing production in these economies; diversifying the sources of energy production in order to have a robust energy mix has been at the peak of development agenda. This is obvious in Table 1 where emerging markets such as India, Brazil, China and South Africa has consistently increased their energy sources, diversifying into cleaner and efficient energy sources. Amidst the economies considered in Table 1, only Nigeria has consistently remained on the same energy sources for the period of three decades considered.

Also, Figure 1 shows that in line with the trend witnessed in most developing countries, Nigeria energy consumption has increasingly experienced an upward trend with over 23% increase in energy use between 2000 and 2008.

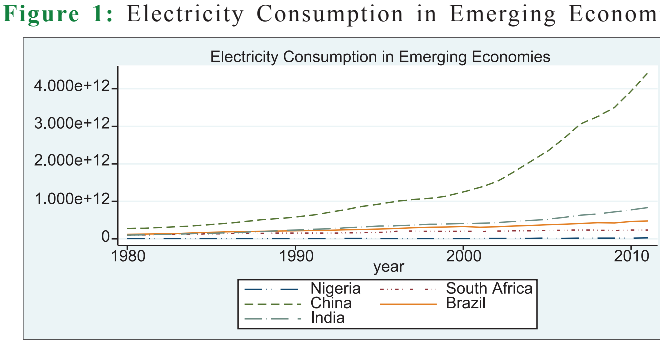
Since 1970, Nigeria's electricity consumption has consistently maintained an upward trend. Likewise the same upward trend is witnessed in the emerging economies. From Figure 2, Nigeria exhibits the slowest rate of growth in electricity consumed, while China took the lead. This reveals that electricity availability can translate into economic leap and serves as a wake call for the

Table 1: Electricity sources as percentage of total electricity produced

Year	Coal	Hydro	Natural gas	Nuclear	Oil	Renewable
Nigeria						
1990	0.10	32.59	53.65	0	13.67	0
2010	0	24.40	64.29	0	11.3	0
South Africa						
1990	94.28	0.61	0	5.11	0	0
2010	94.23	0.82	0	4.71	0.08	0.16
China						
1990	71.27	20.40	0.44	0	7.88	0.01
2010	77.24	17.16	1.64	1.76	0.32	1.67
Brazil						
1990	2.13	92.77	0.14	1.01	2.22	1.73
2010	2.33	80.55	7.07	2.82	3.11	3.28
India						
1990	66.20	24.76	3.44	2.12	3.47	0.01
2010	67.11	11.92	12.01	2.73	1.77	4.44

Compiled by author from World Development Indicators of World Bank

Figure 1: Electricity Consumption in Emerging Economies



Source: Compiled from World Development Indicators (WDI) of World Bank

Nigeria economy. In the same manner the energy use per capita has steadily been rising until 2005 where a decline was witnessed and afterwards has been steadily increasing. The continuous increase in electricity consumption is quite inconsistent with gross domestic product (GDP) per Capita because electricity consumption has been increasing at a faster rate; in fact, it was in 2002 that GDP per capita begins to show an upward trend (Figure 2).

The issue of power losses has been a major challenge for the electricity generating agencies in Nigeria (Figure 3), majority of this problem is due to vandalism, inadequate and worn-out electricity transmission equipments.

Over 45% of the electricity generated are unavoidably lost in transmission process (Table 2), several power plants have been erected in the country from the inception of democratic governance in 1999 but the Nigeria economy is yet to appropriate the benefits of the huge investment, as electric power still remains an invisible ghost haunting the nation's economy and has successfully wiped off cottage industries due to high cost of generating power independently.

Table 2 provides some insights into the state of electricity generation capacity and electricity access in some emerging economies in Asia and Africa. A careful examination of these statistics reveal a critical state of electricity and energy access in Nigeria; for instance, the electricity installed capacity in South Africa and Egypt are almost five times and three times of Nigeria's respectively. Among the countries considered, Nigeria has the lowest per capita installed and generating capacity (Table 3 and Figure 4) and paradoxically with the highest power distribution losses reaching 40% in 2000.

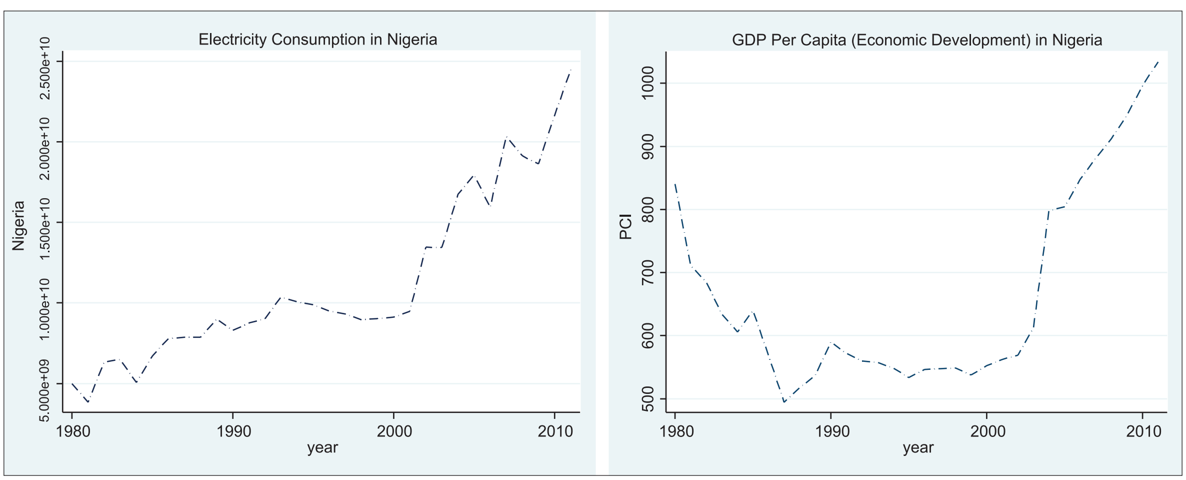
3. BRIEF REVIEW OF LITERATURE

Theoretical and empirical studies on electricity consumption and economic growth linkage are widespread partly due to the significant role of energy in sustainable economic development. However, researchers are unable to arrive at a consensus on the flow of causality between energy consumption and economic growth. Conflicting evidences from developed and developing economies abound in the literature, Stern, (2000); Fatai et al. (2002); Glasure, (2002); Hondroyiannis et al. (2002); Ghali and El-Sakka, (2002); Oh and Lee, (2004); Ho and Siu, (2007) and Payne, (2009); Akpan and Akpan (2012); Acaravci and Ozturk (2012); Pempetzoglou (2014); Acaravci et al. (2015). For a detailed literature survery, see the studies of Bouoiyour et al. (2014) and Ozturk (2010).

Electricity as a secondary energy resource obtained from the conversion of primary energy such as fossil fuels (Yilmaz and Hasan, 2014), is a key component of consumption structure of households and industries. Its accessibility enhances productive domestic activities and industrialization. This further explains the focus on arguments addressing electricity consumption is the one that enhances growth or it is *vice-versa*.

The work of Kraft and Kraft (1987) is identified as the pioneer work on examining the causal relationship between energy consumption

Figure 2: Electricity Consumption and GDP per Capita in Nigeria



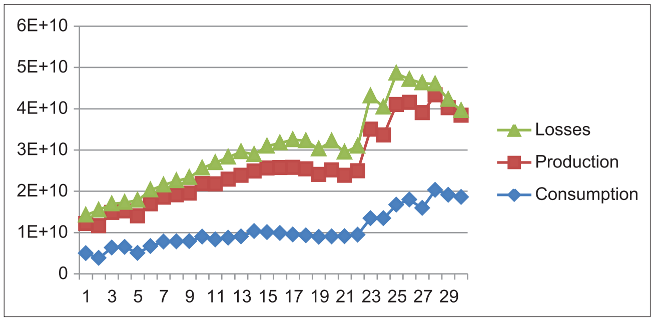
Source: Compiled from World Development Indicators (WDI) of World Bank

Table 2: Electricity generation and consumption

Year	Installed capacity (mw)	Total generation (million kwh)	Total consumption (million kwh)	Power losses in transmission	Losses (million kwh % of total)
1980	2507	6867	4685	2094	30.5
1985	4192	9929	6446	3358	33.8
1990	5958	12029	8027	3902	32.4
1995	5881	13889	7908	5981	43.1
2000	5888	14131	8491	5618	39.8
2005	5895	22515	16935	5580	24.8
2010	5900	24872	20375	4497	18.1

Source: Compiled from international energy statistics, 2013 and economic growth (Masuduzzaman, 2012). Analysis on the dynamic relationship that exists between electricity consumption and economic growth (income) including the direction of causality has been widely researched. Generally, evidence from empirical literature suggests four hypotheses on this relationship and results of different studies fall within these hypotheses. They include the neutrality hypothesis, feedback (bi-directional) hypothesis, conservation hypothesis and the growth hypothesis.

Figure 3: Total Electricity Production, Consumption and Losses (1980-2010)



Source: Compiled from World Development Indicators (WDI) of World Bank

The neutrality hypothesis and the proponents of this hypothesis state the absence of any form of relationship between the two variables, thus policies targeted towards energy conservation will fail to retard economic growth (Bildirici, 2013). Studies that found a bi-directional causality between economic growth and electricity consumption fall under the feedback hypothesis category. In this case, any change to one of the variables will bring about a corresponding change in the other variable and *vice-versa*. The conversation hypothesis posits a uni-directional causality running from economic growth to energy (electricity consumption) and in this case, such economy will be less dependent on energy resources. Therefore, energy conservation policies such as the phasing out (or reform) of fuel subsidies may not negatively impact growth (Bildirici, 2013). Finally, the growth hypothesis

Figure 4: (a-d) Installed and Generating Capacities across Countries

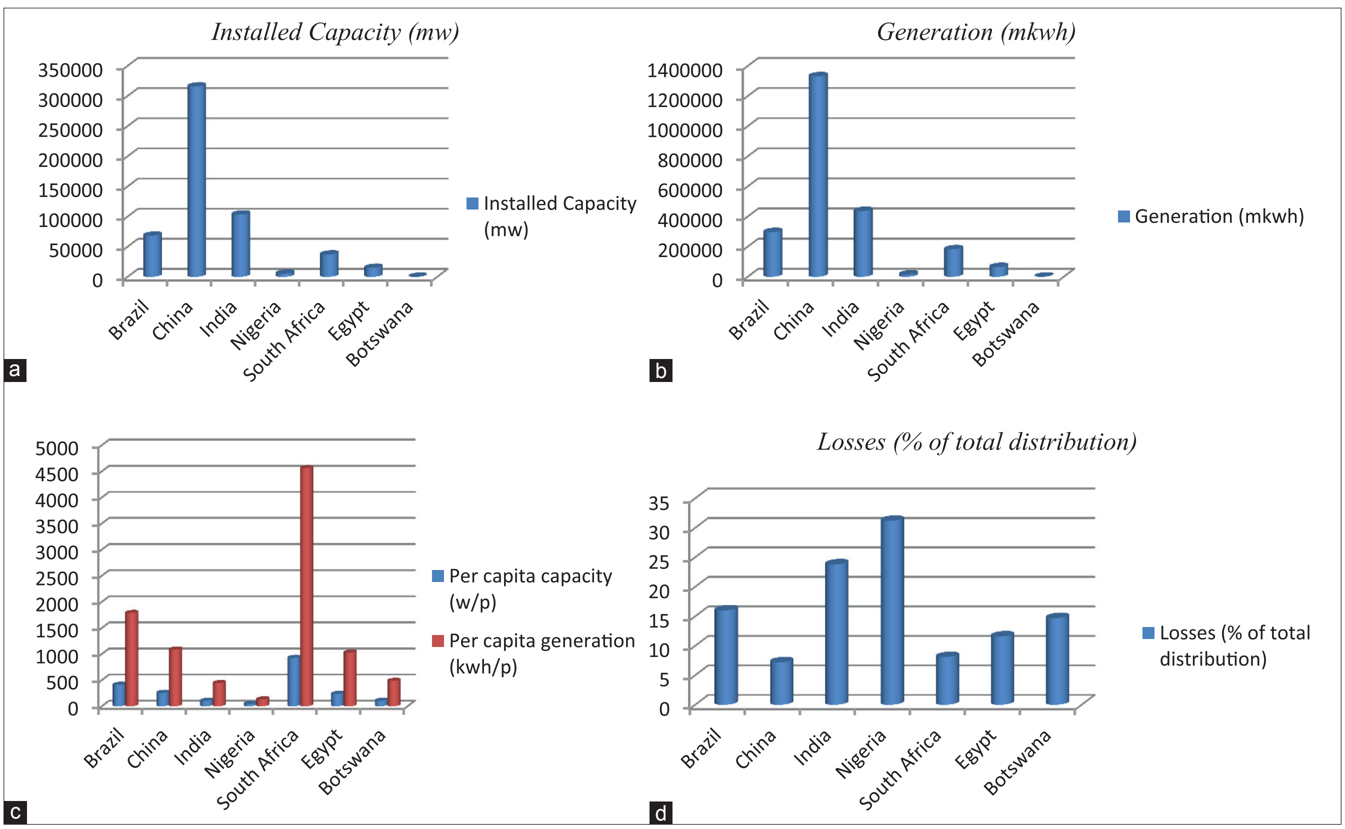


Table 3: Macroeconomic and electricity statistics 1980-2010

Country/measures	Brazil	China	India	Nigeria	South Africa	Egypt	Botswana
Population (million)	166	1225	986	115	40	63	1.6
PCI (constant $USD)	4515.1	1036.6	546	675	5170	1051.2	4206.4
Installed capacity (mw)	68219.9	315769.4	103438.4	5387	37061	14938.2	170.2
Generation (mkwh)	296876.8	1331770.1	437282.2	15315	182414.9	64813.9	777.9
Distribution losses (mkwh)	47523.6	95994.2	104141.7	4778.7	14778.1	7499.7	114.7
Per capita capacity (w/p)	410.96	257.77	104.91	46.84	926.53	237.11	106.25
Per capita generation (kwh/p)	1788.41	1087.16	443.49	133.17	4560.35	1028.78	486.19
Losses (% of total distribution)	16.0	7.2	23.8	31.2	8.1	11.6	14.7

Source: Computed using WDI, 2013 and International Energy Statistics, 2013 represents the uni-directional arguments where causality runs from energy (electricity) consumption to economic growth and as such, any form of decrease in energy consumption can result to a fall in economic growth.

A number of researchers have presented varying results for different countries using different method of analyses. Some of these works are single country analysis; others panel studies and a few others, regional analysis. Yilmaz and Hasan (2014) investigated this relationship for the 21 emerging economies and found a positive relationship with bi-directional (feedback) causality. On the other hand, Bildirici (2013) found co-integrating relationship between electricity consumption and economic growth in 10 of the 11 countries analyzed with direction of causality differing among the countries. In the study of Masuduzzaman (2012), three variables (electricity consumption, GDP and investment) were modeled for Bangladesh and the results confirmed the existence of a unidirectional causality running from electricity consumption to economic growth. Similarly, Atif and Siddiqi (2010) provided new evidence on the relationship between electricity consumption and economic growth for Pakistan. They found the existence of a unidirectional granger causality from electricity consumption to economic growth using the standard granger causality test and the modified WALD test.

However, literature on African economies studying this relationship is relatively few when compared with Asia and European countries (Bildirici, 2013). In the case of Nigeria, Akinwale et al. (2013) employed the (vector autoregressive) VAR and vector error correction mechanism (VECM) technique and their results indicated a unidirectional relationship flowing from real GDP to electricity consumption with no feedback effect. The study attributed this to low level of electricity generation which has minimal impact on economic growth. For Mauritius, Harris and Prakash (2012) investigated the economic growth and electricity nexus using co-integration with the result showing a short-term unidirectional causality from electricity consumption to economic growth. An empirical study by Odularu and Okonkwo (2009) analyze the contribution of energy consumption to economic performance for the Nigerian economy using crude oil, electricity and coal as the energy sources. Applying the co-integration technique of estimation, their results indicated that for the current period, there was a positive relationship between energy consumption and economic growth while for the lagged values, a negative relationship was observed with the exception of coal. As stated by Odularu and Okonkwo (2009), greater energy consumption implies greater economic activity in the country and then resulting in a greater economy.

In the same vein, Adeniran (u.d) presented empirical evidence on whether energy consumption granger causes economic growth. The results showed a uni-directional causality runs from GDP to electricity consumption; GDP granger causes gas consumption and no causality between oil consumption and GDP. The study thus concluded that energy consumption granger causes economic growth in the case of Nigeria, therefore suggesting that policies targeted at tackling greenhouse gas emissions through the reduction of energy consumption may be harmful to the growth of the economy.

Solarin (2011) also carried out a trivariate investigation of the relationship between electricity consumption and economic growth in Botswana with capital formation. The study thus found a unidirectional causality running from capital formation to real GDP and a unidirectional causality from electricity consumption to real GDP. Onakoya et al. (2013) evaluated the causal relationship between energy consumption and Nigeria's economic growth and showed that petroleum, electricity and aggregate energy consumption have significant and positive relationship with economic growth in Nigeria. An important aspect of this paper is its focus on causality between GDP and total energy consumption in Nigeria and that of each of the basic sub-components of energy consumption with a view to finding out if different sources of energy have varying impact on economic growth. Likewise, Olusanya (2012), petroleum and electricity showed a positive relationship to economic growth in Nigeria, while there was a negative relationship for coal and gas.

Overall, existing energy literature shows that there is none of the studies investigating the relationship between electricity consumption and economic development controlling for the role of institutions, emissions, technology and economic structure in Nigeria. And most importantly, earlier studies focus economic growth, examining the effect of electricity consumption on the general living standard is quite pertinent since energy has been adjudged a principal driver of SMEs. And SMEs is widely acknowledged as an engine of transformation for developing/emerging economies. The direction of causality between both variables is very important and helpful for policy makers in articulating a comprehensive energy policy to stimulate economic development in long span of time. This study is deemed fit at this time and relevant to fill this gap in energy literature regarding the Nigeria economy.

4. METHODOLOGY

In attempt to ascertain the effect of electricity consumption on economic development in Nigeria, the study adopted an extended neoclassical model by incorporating several control variables adjudged relevant in capturing the unique features of the Nigerian economy. The general form of neoclassical production function following the study of Saleheen et al., (2012) are as follow:

$$Y = AK^{\alpha} L^{\beta}$$

$$PCI_t = \alpha_0 ECN^{\alpha_1} KAP^{\alpha_2} LAB^{\alpha_3} GE^{\alpha_4} STR^{\alpha_5} TEC^{\alpha_6} EDG^{\alpha_7}$$

The expression above can be written in an explicit form as stated below:

$$PCI_t = \alpha_0 + \alpha_1 ECN_t + \alpha_2 KAP_t + \alpha_3 LAB_t + e^{\alpha_4 GE_t} + \alpha_5 STR_t + \alpha_6 TEC_t + \alpha_7 EDG_t + U_t$$

The explicit form of the model stated in a log-linearized form can be presented as follow:

$$PCI_t = \alpha_0 + \alpha_1 LECN_t + \alpha_2 LKAP_t + \alpha_3 LLAB_t + GE_t + \alpha_5 LSTR_t + \alpha_6 LTEC_t + \alpha_7 LEDG_t + U_t$$

In equation 3 above; PCI_t represents GDP per capita, ECN_t is the electricity consumption (kilowatt per hour), KAP_t is the stock of capital available in the economy, LAB_t is the total labor force, GE_t is government effectiveness, STR_t is the structure of Nigeria economy, TEC_t is the state of technology, EDG_t is a measure of environmental degradation and U_t is the random stochastic term. It is expected that all the parameters in the model exhibit an increasing returns; that is, $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7 > 0$.

Since there is possibility of feedback relationship between electricity consumption and economic development, in the sense that electricity availability and consumption can be a major drive of economic development; and also, commitment and realization of development path can enhance electricity consumption. It therefore becomes pertinent to ascertain the directional of causal relationship between economic development and electricity consumption.

5. DISCUSSION OF RESULT

In the analysis of the components of energy consumption and other variables in the model; standard time series unit root tests can be applied. To ensure the robustness, the study use two different unit root tests namely; the augmented Dickey and Fuller (1979) (ADF) test and the Phillips and Perron (1988) (PP) test. The unit root test is necessary to ascertain the stationarity property of the series employed in the model because empirical studies have shown that most economic variables are not stationary at level.

The ADF and PP tests the null hypothesis indicating an existence of unit root (non-stationarity), an order of integration of I(0). Where the null hypothesis is rejected, we assume the variable is stationary with an order of integration of I(1). From Table 4, it is not surprising that the all variables are not stationary at level but became stationary at first difference, I(1), using both ADF and PP test.

The Table 5 presents the correlation matrix for the variables in the model; an incidence of strong correlation among the independent variables may violate the working assumptions of our estimation technique and hereby produce an unrealistic results. Here, we test for the likely occurrence of multi-collinearity among the independent variables using the pairwise correlation matrix. The Table 5 indicates a positive correlation between electricity consumption (lecn) and other variables in the model except government effectiveness (ge) and economic structure (lstr). The Table 5 likewise shows a positive strong correlation between lecn and indicators of technology (ltec), environment degradation (ledg) and electricity losses (legl) and labor force (llab). An overall consideration of the result of the correlation coefficients indicates that multicollinearity is not a considered problem in the model to be estimated. Though, the result as shown in the Table 5 is not conclusive but the level or magnitude of correlation that is problematic still stand unresolved in the literature; but the statistical package used in obtaining empirical estimates (Stata 11.0) possesses an inbuilt program that automatically drop a problematic variable.

In order to ascertain the extent of relationship between electricity consumption and economic development, the study adopts the Johansen and Juselius maximum likelihood cointegration technique and the vector error correction technique. The former is necessary to ascertain the combined stationary of our variables while the latter enables to obtain the short-run error correction model. The study hereby proceeds to test for the existence of long-run relationship among the variables in the model; from Table 5, the trace statistics indicate evidence supporting two cointegrating equations at 1% significance level. This is obtained at the point where the critical value is greater than trace statistics.

Table 6 here reveals a long-run relationship between electricity consumption and other variables in the model. This evidence supports the existence of a converging relationship in the long-run and indicates the existence of causality in at least one direction in our model. That is, given that all errors are corrected on the long-run equilibrium path and disturbances are short-lived; our model exhibits a combined series stationarity and suitable for future forecasting of relationship among the observed variables.

Table 7 presents the long-run estimates for GDP per capita and electricity consumption in Nigeria. Estimates from the Table 7, shows an inverse significant relationship between electricity consumption and economic development. This is not unconnected with the high cost of generating electricity in Nigeria, which had led to the relocation of major industries to neighboring countries and as well-grounded the operation of SMEs and displacement of the middle class. The result obtained from the estimation differs from that of Wolde-Rufael (2004), Akinlo (2009) and Kouakou (2011) which found a positive cointegrated and significant impact of electricity consumption on the level of economic growth.

Also, an indicator of institutional quality (government effectiveness) exerts a negative and significant variation on GDP per capita; this is due to the weak governance quality and inefficient bureaucratic processes that has left virtually stranded all government agencies and parastatals. It is worthy of note, that the indicator capturing the structure of the Nigeria economy exerts a very strong significance and large negative influence on economic development; this draws from the fact that the Nigeria economy is highly dependent on few primary export commodities with zero technical spill-over to the economy. The empirical investigation likewise found indicators of technology and environmental degradation to influence economic development positively.

Table 8 indicates that estimated lagged error correction term of economic development from the VECM estimates is positive and insignificant; its implies that in case of an external shock in the model, the per capita GDP model would diverge in the long-run. The result suggests that there is short run causality from Per Capita GDP to electricity consumption, capital, labor, government effectiveness, economy structure, state of technology and environmental degradation. But there is no short run causality from electricity consumption to per capita GDP. Also, short run causality run from capital, labor and environmental degradation (CO2 emissions) to Per Capita GDP.

5.1. Causality Test

The causality test using the wald approach shows an existence of a unidirectional causal relationship between electricity consumption

Table 4: Stationarity test

Variables	Unit root test							
	Level				First difference			
	ADF	P*	PP	P*	ADF	P*	PP	P*
lpci	0.2764	0.9742	–0.2902	0.9178	–5.6182	0.0000	–5.7544	0.0000
lecn	1.5941	0.9993	1.8249	0.9997	–0.7097	0.0000	–7.6589	0.0000
lkap	–1.2865	0.6215	–2.2646	0.1892	–3.2244	0.0290	–3.3875	0.0195
llab	2.0685	0.9997	4.3342	1.0000	6.9822	0.1019	–0.3589	0.8996
ge	3.0841	1.0000	1.5172	0.9991	–13.1128	0.0000	–2.4549	0.1339
lstr	–4.1556	0.0022	–4.0509	0.0030	–7.5693	0.0000	–12.9803	0.0000
ltec	5.5193	1.0000	1.51722	0.9991	–5.2277	0.0001	–2.4549	0.1330
ledg	–2.3322	0.1673	–2.3106	0.1737	–6.9034	0.0000	–6.8791	0.0000
legl	–2.1360	0.2323	–1.9905	0.2897	–9.0956	0.0000	–9.2731	0.0000
Critical values								
1%	–3.6010		–3.6010		–3.6105		–3.6056	
5%	–2.9350		–2.9350		–2.9390		–2.9369	
10%	–2.6058		–2.6058		–2.6079		–2.6069	

Note: ADF: Augmented dickey fuller test, using lag length of 1 and SIC maxlag of 9, PP: Phillip Perron test, bandmoth of 3 (newey-west automatic) using Bartlett kernel, *Probability

Table 5: Pairwise correlation matrix

Variables	lecn	lkap	llab	ge	lstr	ltec	ledg	legl
lecn	1.0000							
lkap	0.3854	1.0000						
llab	0.9356	0.3948	1.0000					
ge	–0.0159	–0.4604	0.2408	1.0000				
lstr	–0.0833	0.2500	0.3245	0.0659	1.0000			
ltec	0.7976	0.6211	0.9070	0.0269	0.1641	1.0000		
ledg	0.5710	0.4546	0.4481	–0.0823	0.1063	0.6540	1.0000	
legl	0.7336	–0.5311	0.1769	0.0033	–0.2369	0.2952	0.3105	1.0000

Compiled by author using stata 11.0

Table 6: Johansen and Juselius cointegration rank

Eigen value	Trace statistics	Max. statistics	1% CV*trace	1% CV*max.	Hypothesized no. of CE (s)
	222.2323	77.1385	168.36	57.69	0
0.91695	145.0939	43.9851	133.57	51.57	1
0.75801	101.1088*	36.1601	103.18	45.10	2
0.68853	64.9487	23.4692	76.07	38.77	3
0.53096	41.4795	17.6648	54.46	32.24	4
0.43438	23.8147	15.8501	35.65	25.52	5
0.40028	7.9645	5.3991	20.04	18.63	6
0.15984	2.5655	2.5655	6.65	6.65	7
0.07942					8

Computed by author using stata 11.0, *Critical values

Table 7: Long-run normalized coeffwwwicients

Co-integrating coefficient normalized on per capita GDP								
lpci	lecn	lkap	llab	ge	lstr	ltec	ledg	C
1.000000	3.313	0.175	–3.5907	2.443	41.094	–0.0284	–1.8910	–0.001
	(7.50)	(0.83)	(–4.72)	(4.20)	(5.27)	(–0.24)	(–8.25)	
P	0.000	0.407	0.000	0.000	0.000	0.811	0.000	

Computed by author using stata 11.0, Note: Since the Johansen cointegration test assumes all variables as endogenous, we alternate the signs of the magnitudes, GDP: Gross domestic product

Table 8: Vector error adjustment

Vector error correction model for GDP per capita								
Variable	D (lpci)	D (lecn)	D (lkap)	D (llab)	D (ge)	D (lstr)	D (ltec)	D (ledg)
ECT_1	0.1737	–0.099	0.0702	0.0030	–0.0235	–0.0004	–0.0150	0.0003
	(1.28)	(-3.81)	(1.53)	(7.11)	(–1.21)	(–0.24)	(–0.23)	(0.01)
	[0.135]	[0.026]	[0.046]	[0.0004]	[0.0195]	[0.0017]	[0.0537]	[0.03993]
	0.199	0.000	0.125	0.000	0.228	0.813	0.730	0.995

Computed by author using Stata 11.0, GDP: Gross domestic product

Table 9: Granger causality wald test

Null hypothesis	χ^2	P*	Decision	Causality
lecn does not granger cause lpci	4.4169	0.110	Accept	Unidirectional
lpci does not granger cause lecn	5.4626	0.005	Reject	
lkap does not granger cause lpci	5.1527	0.076	Reject	Feedback
lpci does not granger cause lkap	32.78	0.000	Reject	
llab does not granger cause lpci	4.4009	0.111	Accept	Unidirectional
lpci does not granger cause llab	5.395	0.067	Reject	
ge does not granger cause lpci	3.6918	0.158	Accept	Unidirectional
lpci does not granger cause ge	4.6759	0.097	Reject	
lstr does not granger cause lpci	0.1826	0.913	Accept	Unidirectional
lpci does not granger cause lstr	9.7845	0.008	Reject	
ltec does not granger cause lpci	4.8342	0.089	Reject	Feedback
lpci does not granger cause ltec	16.416	0.000	Reject	
ledg does not granger cause lpci	2.6528	0.265	Accept	Unidirectional
lpci does not granger cause ledg	5.8597	0.053	Reject	
legl does not granger cause lpci	7.0273	0.030	Reject	Unidirectional
lpci does not granger cause legl	3.5854	0.167	Accept	

Compiled by author using stata 11.0, *Probability

and an indicator of economic development with χ^2 of 5.4626 and P of 0.005, due to the significance of the probability; we hereby conclude that economic development (GDP per capita) does granger cause electricity consumption for the observed period. This implies that as the economy drives its development path, electricity consumption becomes more enhanced. The existence of a unidirectional causal relationship lpci→lecn, implies that electricity consumption does not Granger cause economic development. The result obtained was consistent with Ciarreta and Zaraga (2007) using a standard Granger causality test in a VAR found a unidirectional linear causality running from real GDP to electricity, and Ahmed, Hayat, Hamed and Inqman (2012) who investigated the relationship between energy consumption and economic growth in Pakistan for the period of 1973-2006 and found a positive relationship with a unidirectional causality from GDP to energy consumption. On the other hand, the obtained result contradicts the empirical works of Odhiambo (2010), Ouedraogo (2012) and Akinlo (2009) where a bi-directional relationship between electricity consumption and economic growth was obtained. The contradiction could have accentuated from the fact that (Akinlo, for instance whose study was carried in Nigeria) their study used economic growth.

The wald granger causality test was as well used to obtain the likely causal determinants of electricity consumption. As seen in Table 9, labor force, Capital stock, government effectiveness, and technology all granger cause electricity consumption. This shows clearly that investment in technologies and strengthening of institutions is very pertinent for enhancing the availability of energy in Nigeria. This above inferences confirms the outcry of civil groups in Nigeria, lamenting on dilapidated state of national power generating, distribution facilities and general performance of the power holding agencies in Nigeria. In the same manner, regulatory agencies need to take seriously the effect of environmental degradation on electricity availability. As seen in the Table 9 below, there exists a bi-directional relationship between the indicator of environmental degradation (CO_2 emissions) and electricity consumption. This poses a significant implication for hydro-power generation sources which is the second largest source of electricity generation in Nigeria.

6. RECOMMENDATION AND CONCLUSION

The study attempts to investigate the relationship between electricity consumption and economic development using an extended neoclassical model for the period 1970-2011. The study incorporates the uniqueness of the Nigeria economy by controlling for the role of institutions, technology, emissions, and economic structure in the electricity consumption-development argument. The study adopted a cointegration analysis based on the Johansen and Juselius (1988) Maximum Likelihood approach and a vector error correction model. In order to ensure robustness, the study adopted the Wald Block Endogeneity causality test to ascertain the direction of causal relationship between electricity consumption and economic development.

The empirical analysis of the study found an existence of a long-run cointegration relationship among our variables. The study also found that electricity consumption impacts a significant inverse relation on economic development. This might not be unconnected with highly erratic nature of power in Nigeria which led to the displacement of industries to neighboring countries due to high cost of generating electricity privately. The vector error correction model failed to reject the null hypothesis of non-convergence of our model in the long-run with the error correction mechanism (ECM statistics) being positive and insignificant. The study hereby concludes that long-run convergence is not attainable. But the causality test indicates a unidirectional relationship running from economic development to electricity consumption. Prominent among recommendations in the study was the need to re-strategize investment into the power sector and strengthen institutions/agencies saddled with the responsible of electricity production and distribution.

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