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Residential and Industrial Electricity Consumption Dynamics and Economic Growth in Nigeria 1980 - 2010

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Abstract: This study applies the growth accounting framework of the Cobb-Douglass production function to explain the dynamic interaction between residential and industrial electricity consumption on economic growth in Nigeria from 1980-2010. The study employed the both Augumented Dickey-Fuller and Pillips Perron unit root test, Johansen Co-integration test, Granger causality test and Ordinary Least Square regression technique. The data for residential and industrial electricity consumption for the period of study were sourced from the Central Bank of Nigeria (CBN) statistical bulletin [3] and the data for Gross Domestic Product (GDP) and per capita income were obtained from the World Development Indicators (WDI) [13] while, data for investment was obtained from the CIA World Fact Book [14]. The study revealed that a uni-directional causality exist running from industrial electricity consumption to residential electricity consumption, also there exists a bi-directional causality between residential electricity consumption and per capita income growth in Nigeria for the period of study. Residential electricity consumption (LREC) is Positive and statistically significant, the industrial electricity consumption ratio (IEC) ratio is positive and statistically significant in model 1 but negative and statistically significant in models 2 and 3 while the interaction between LREC and IEC ratio is positive and statistically significant in models 2 and 3. Given the positive value of the interaction variable the study concludes that residential electricity consumption is constrained by industrial electricity consumption in Nigeria and unless this situation improves the positive benefit of electricity consumption might be eroded. And therefore recommended that Efforts should be geared towards improving the supply of electricity in both residential and industrial sector.

Keywords: Residential, Industrial, Electricity Consumption, Economic Growth, Nigeria

1. Introduction

Electricity consumption in Nigeria is divided into residential, commercial and industrial consumption and these sectoral consumptions impact the economy differently. Given the fact that Nigeria economy is characterised by large informal sector where small and medium scale entrepreneurial activities take place, it is important to examine the importance of electricity in this informal sector on the aggregate output growth. Majority of household electricity consumption is made for productive services as many small businesses operates from the residential areas and as such are not accounted for in the industrial areas electricity consumption data.

Most businesses are not located in the industrial areas for reasons such as huge capital investment involved in securing a site in the industrial park, the stiff competition which most of the small businesses cannot survive due to presence of large national and multinational corporations, lack of initial start-up capitals required to locate a business in the industrial zone corruption and bureaucratic processes and so on. As such many individuals with business initiative prefer to start small and most people start production from the corner of their rooms. Examples are nylon manufacturing and cutting factories, pure water manufacturing factories, ice block making factories, the tailoring shop with electric machines, pepper grinding business, welding and fabricating of irons etc. all of which are sited in the residential areas whose demand for electricity are counted for residential purposes.

This may also account for the reason why residential electricity consumption data seems to be larger than that of the industrial or manufacturing sector in reality *[5, 7]*. An important fact is that most independent variables do not stand alone, they most likely relate with each other and their interaction sometimes have policy implications on the regressand. This study therefore proposes the possibility of

an interaction between residential and industrial electricity consumption in Nigeria.

If this interaction exists, a thin line between residential and industrial or manufacturing sectors electricity consumption would have been established. It is essential, therefore, to examine the possibility of such interaction as a partial examination of the impact of industrial electricity consumption may not reveal the true picture of the situation thus a complete model which will cater for this interaction has to be formulated.

Also, it is worthy of note that, electricity supply has not been able to meet the growing demand for electricity in the various sectors of the economy and as a result the industrial and commercial establishments have operated below their production capacity as some have resorted to the use of alternative power generation strategies through diesel and gasoline generators, resulting into increased cost of productions and high costs of goods and services in the nation as well as business closure or relocation for those businesses that cannot survive this harsh conditions *[1, 2, 7]*.

As such an empirical examination of the sectorial impact of these sectoral consumptions of electricity on economic growth is essential for policy formulation.

Many authors have contributed to the energy-growth literature but to the best knowledge of the researcher, none have specifically empirically examined the possibility of this dynamic interaction. This possible interaction will be empirically examined and if found true will in no small way shape our thought with probably new implications for policy making.

To achieve this, we shall first explore the possible causal relationship between residential and industrial electricity consumption, as well as between residential electricity consumption and industrial output growth in Nigeria. Also electricity consumption literatures have concentrated on aggregate analysis *[See 2, 10, 9]* while, the sectoral or disaggregated aspect has been almost totally neglected. This study hopes to bridge these gaps in literature.

This study is divided into six sections. Section one is focused on introduction and problem statement while section two contains a detailed review of both theoretical and empirical literature. Section three focuses on the stylized facts about electricity consumption in Nigeria during the period under review and section four deals with theoretical framework and model specification as well as definition of variables, while section five is concerned with data analysis, interpretation and discussion of results and finally section six contains summary, conclusion and recommendations.

2. Literature Review

Although plethora of study exists on the nature of relationship between energy consumption and economic growth in Nigeria, very few of them relates directly to the objective of the study. A review of the few relevant ones is hereby carried out in this section.

Nwachukwu, Ezedinma & Jiburum *[7]* explored a comparative analysis of electricity consumption among residential, commercial and industrial sectors of the Nigeria's economy using time series data from 1970-2004. The study employed Analysis of Variance (ANOVA) Technique for the hypotheses postulated.

The result suggested that electricity consumption differed significantly among the three sectors, the residential sector was found to have the highest mean electricity consumption followed by industrial and commercial sectors in descending order. The study concluded that there is need to boost the supply of electricity in order to meet the consumers demand in the residential, industrial and commercial sectors of the economy.

Mahedi *[6]* empirically examined electricity consumption and economic growth in Bangladesh using co-integration and causality analysis with time series data covering 1981-2011. The study confirmed the existence of a unidirectional causality running from electricity consumption to economic growth, a long-run relationship was also found between electricity consumption and economic growth in Bangladesh. The study also suggested that electricity consumption impact growth with investment as a channel. The study concluded that the only alternative was to provide adequate electricity supply in order for the economy to grow. Ogundipe *[8]* examined electricity consumption and economic growth in Nigeria from 1980-2008. Using vector error correction modelling (VECM) and pairwise granger causality test, the study established the existence of a unique co-integrating relationship among the variables in the model with the indicator of electricity consumption impacting significantly on growth, the study also found a bi-directional causality between electricity consumption and economic growth in Nigeria. The study concluded that there is the need to strengthen the effectiveness of the energy generating agencies by ensuring periodic replacement of worn-out equipment so as to curtail power transmission losses.

Olarinde & Omojolaibi *[10]* examined electricity consumption, institutions and economic growth in Nigeria from 1980-2011. The study employed the bound test approach to Vector Autoregressive regression and the wald test approach. The study reported the existence of co-integration among the variables as well as a bi-directional causality between electricity consumption and economic growth. The study concluded that policies capable of driving investment in infrastructure should be pursued. Akomolafe & Danladi *[2]* carried out a multivariate investigation on electricity consumption and economic growth in Nigeria from 1990-2011. Vector error correction mechanism and granger causality test was employed. The study showed a unidirectional causality from electricity consumption to economic growth, electricity consumption is also positively related to economic growth in the long run. The study concluded that given the energy dependent nature of the economy, the adequacy of electricity supply impacts greatly on capital formation and economic growth.

Okoligwe & Ihugba *[9]* explored the relationship between electricity consumption and economic growth in Nigeria from 1971-2012. The study employed the error correction mechanism (ECM) and granger causality test. Contrary to

existing literature, the study reported the non-existence of causal relationship between electricity consumption and economic growth in Nigeria. The study concluded that increase in electricity consumption is not determined by the economic growth due to the gap between electricity demand and the actual consumption.

Given the above review it is obvious that existing literature vary significantly with respect to the existence and direction of causality between electricity consumption and economic growth in the country. This study will therefore help to extend the literature in this regard. Also the deficiency in literature with regards to empirical investigation of sectoral electricity consumption will also be corrected. Most significantly, this study will explore the possible interaction between residential and industrial electricity consumption in Nigeria as well as the impact of this possible interaction on economic growth, with probable policy implications for the government. This is a major gap in literature which this study will try to bridge.

Theoretical Review

A review of the theoretic scientific basis of the role of energy in production and hence the increasing scale of production involved in economic growth shall be conducted in this section.

The physical science theory has their basis from the second law of thermodynamics (the efficiency law) which implies that a minimum quantity of energy is required to carry out the transformation of matter. Therefore there must be limits to the substitution of other factors of production for energy in the production process *[10]*. All economic activities require energy, both at the micro and macro levels. The mainstream theory of economic growth based on the work of Solow *[12]* indicated that a constant sized labour force using manufactured capital to produce outputs which is equal to total gross domestic product. The assumption here is that output increases at a decreasing rate as the amount of capital employed increases, resulting into diminishing returns to scale. By implication successive additions of capital generates decreasing increment to future income and so a falling rate of returns on investment. Hence, the incentive to accumulate capital weakens. This simple economy must eventually reach a steady state in which there is no increment to net investment and economic growth must eventually come to a halt. This Solow model is therefore tagged a static model which gives no role to energy in the production process. This led to the development of Solow-Swan model (an exogenous growth model).

This Solow-swan model introduced exogenous factors of production apart from labour and capital; population growth and technological progress. They postulated that a right combination of capital and labour with an exogenous factor will result into an optimal level of output. However, this Solow-Swan model failed to explain how improvement in technology came about, they are just assumed to happen exogenously. Thus, the model could not bring to fore the linkage between energy resources and economic growth, hence, the development of the endogenous growth models. Arrow *[3]*, was among the first to introduce technological progress as an endogenous factor into the production function:

$$Y_i = A(K) f(K_i^{\alpha}, L_i^{\beta}) \quad (1)$$

Where Y_i = output, K_i = stock of capital, L_i = stock of labour, A (K) stands for total factor productivity. K = the aggregate stock of capital and A is technological factor. This endogenous growth model have been able to reveal that under reasonable assumptions the term A in the expression above is a constant so growth continues indefinitely as capital is accumulated. The key point is that technical knowledge is now regarded as a form of capital, accumulated through research and development (R&D) and other knowledge creating processes. The growth of K implies the growth of a composite stock of capital and disembodied technical knowledge.

Thus, output is able to rise as a constant portion of the composite capital (A) stock and is not subject to diminishing returns, because the diminishing returns to manufactured capital will be neutralized by exogenous technology growth. This model also failed to include any natural resources including energy. The finiteness and exhaustibility of resources also invalidates the notion of indefinite economic growth. The standard neoclassical aggregate production framework is centred on what conditions permit continuing growth and non-declining consumption and utility.

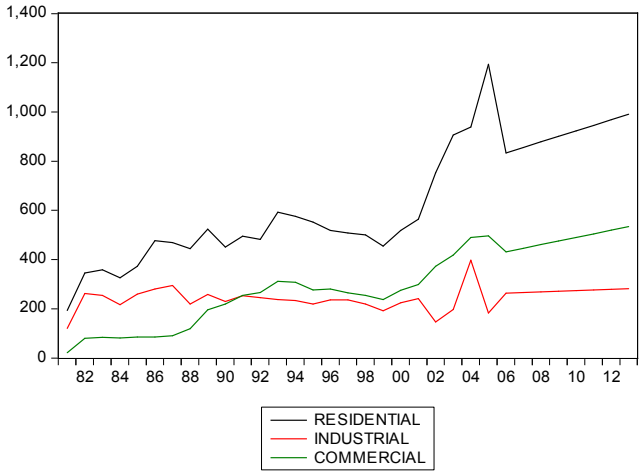
It is worthy of note that technological progress determines whether continuing growth is possible or not. This technical condition have to do with the substitutability of renewable and non-renewable resources and the initial endowment of capital and natural resources and the ease of substitution among inputs. Stern (2004) opined that the class of growth models that include resources (energy) can account for mass balance and thermodynamic constraints (the basis of physical science theory) with the essentiality condition.

It is essential in this case that given positive non resource inputs, output is only zero when the resource input is zero and strictly positive otherwise. The Cobb-Douglas production function which is a frequently used growth model satisfied this essentiality condition. Economists argued that this model accounts for the fact that some amount of energy and materials are required to produce goods and services. Therefore a standard Cobb Douglas production function of the form in equation 1 can be extended to include electricity consumption divided into residential and industrial electricity consumption.

3. Stylized Facts

In Nigeria, electricity demand far outstripped the supply due to a number of factors such as ageing infrastructure due to lack/poor level of maintenance, vandalization, low/zero level of new investment in the sector for a long period, low water level as a result of climate change, sabotaging of government's efforts by unscrupulous individuals for selfish or political reasons. Electricity is widely consumed by all sectors of the economy. The following figure reflects the

electricity consumption in the residential, industrial and commercial sectors of the economy.

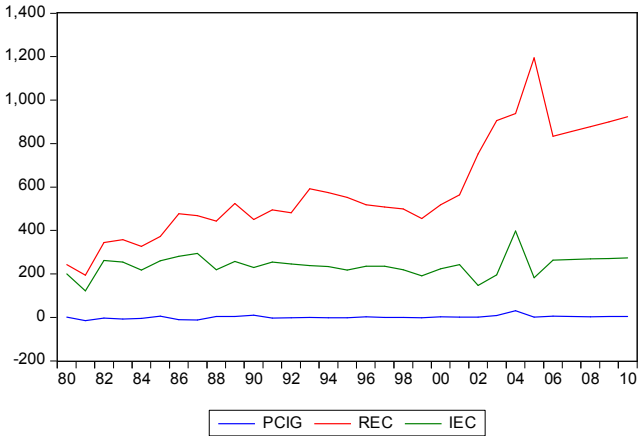


Source: Authors Computation (2015).

Figure 1. *Trend of Residential, Industrial and Commercial Sectors' Electricity Consumption. 1980-2012.*

It is very clear that electricity consumption in the residential sector is far greater than that of the industrial sector (see fig. 1). This reveals the fact that electricity supply in the industrial sector has been very low and epileptic in nature. This may somehow account for the high rate of unemployment in the nation due to downsizing of most organisations capacity as a result of high cost of production which emanated from low and epileptic electricity supply to the sector. In fact many small and medium enterprises have shut down their operations because they cannot cope with the rising cost of production resulting from alternative power generation strategies. This explains the high rate of unemployment and the prevalent poverty in the midst of growth.

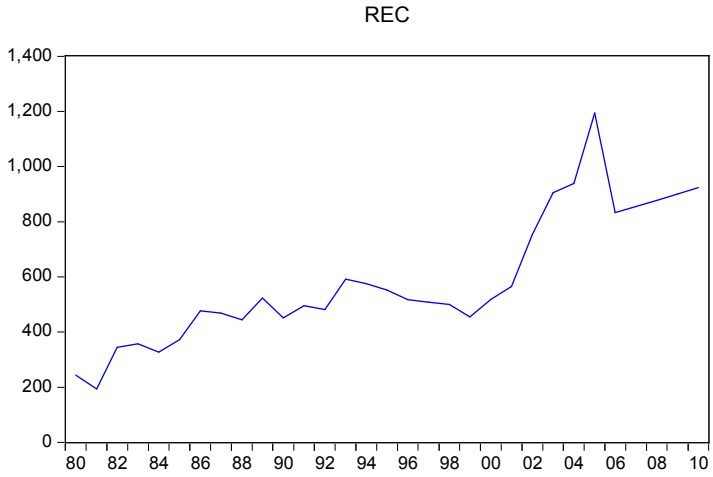
Also less than 40% of the population have access to electricity and the power sector suffers from huge energy losses. The low tariff structure of energy prices due to subsidy has resulted in inadequate revenue generation to cover the costs and finance supply expansion.



Source: Author's Computation 2015

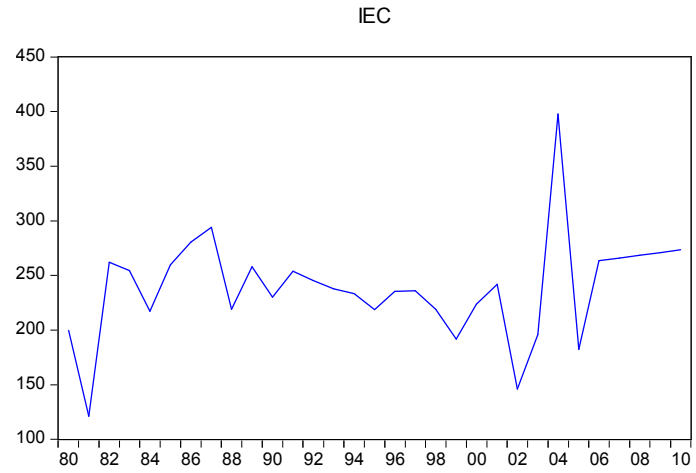
Figure 2. *Trend of Industrial Electricity Consumption, Residential Electricity Consumption and Per Capita Income growth (1980-2010).*

From figure 2 above, it could be observed that residential electricity consumption far outstripped the industrial electricity consumption. This is supported with the known fact that the informal sector thrives better than the formal sector in Nigeria and most of this informal sector are domiciled in the residential areas and as such benefit from the increased supply of electricity in the residential sector, probably because their consumption would not be properly accounted for and they could even beat the officials to it, so that they pay very little for whatever is consumed. It was also observed that the growth of per capita income is low or negative for most of the period under study. Implying a decline or very small improvement in the welfare and living standard of people in the country. Given the fact that electricity is needed in almost all facets of human life such as health, education, production, clean water generation etc. increased electricity consumption in both residential and industrial sector from 2002 to 2004 witnessed a mild increase in the per capital income growth during the same period.



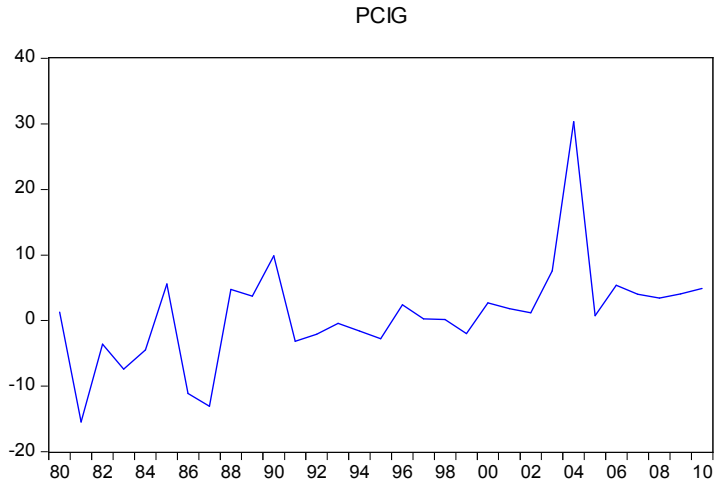
Source: Author's Computation (2015)

Figure 3. *Trend of Residential Electricity Consumption in Nigeria 1980-2010.*



Source: Author's Computation (2015)

Figure 4. *Trend of Industrial Electricity Consumption in Nigeria 1980-2010.*



Source: Author's Computation (2015)

Figure 5. *Trend of per capita income Growth in Nigeria 1980-2010.*

Figure 3, 4 and 5 revealed that electricity consumption in the residential and industrial sectors as well as the growth of per capita income has been very volatile over the period of study. These changes might be as result of policy changes by the government and improved efforts to revamp the moribund power sector of the economy during the democratic regime.

4. Theoretical Framework and Model Specification

A granger causality equation will be specified in order to examine the possible causal relationships that may exist among the key variables of interest in this study;

$$PCIG_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i PCIG_{t-i} + \sum_{j=1}^{n} \beta_j LREC_{t-j} + \sum_{k=1}^{n} \delta_k IEC_{t-k} + U_{1t} \quad (2)$$

$$LREC_t = \gamma_0 + \sum_{m=1}^{n} \gamma_m LREC_{t-m} + \sum_{p=1}^{n} \varphi_p PCIG_{t-p} + \sum_{v=1}^{n} \theta_v IEC_{t-v} + U_{2t} \quad (3)$$

$$IEC_t = \eta_0 + \sum_{\varepsilon=1}^{n} \eta_\varepsilon IEC_{t-\varepsilon} + \sum_{w=1}^{n} \pi_w PCIG_{t-w} + \sum_{\lambda=1}^{n} \delta_\lambda LREC_{t-\lambda} + U_{3t} \quad (4)$$

Where; $PCIG_t$ = per capita income growth

$LREC_t$ = residential electricity consumption

IEC_t = Industrial electricity consumption

This study follows the framework of the growth accounting cobb-douglas production function. And

specifically adopts the model used by Omran and Bolbol *[11]* to explain the dynamic interaction between electricity consumption in the industrial and residential sectors of the economy and how this interaction affects economic growth.

$$Y = a_0 + a_1X_1 + a_2X_2 + a_3Z + e \quad (5)$$

Y = per capita income growth

X_1= Vector of variables generally recognised to explain growth (e.g. Initial Per capita income, investment, Electricity Consumption etc.)

X_2= Vector of variables that are under study presumed to affect growth.

Z = Vector of Selected variable usually used as controls in estimating growth (e.g. inflation)

e = error term.

A priori expectation

$a_1>0$

$a_2>0$

$a_3>0$

It is important to provide an explicit mathematical treatment of the inclusion of the interaction variable under study. The focus is to modify equation (6) based on the growth accounting framework of the cobb-Douglas production function, and then estimate it in order to account for the interaction variable.

Given that,

$$Y = AL^{\alpha}K^{\beta} \quad (6)$$

$$Y = A(EI.ER)L^{\alpha}K^{\beta} \quad (7)$$

Where EI = Energy Consumed in the Industrial Sector

ER = Energy Consumed in the Residential Sector

$$\hat{Y} = A'(EI.dER + ER.dEI)/A + \hat{\alpha}L + \hat{\beta}K \quad (8)$$

Where,

$dEI = IEC$ (Industrial Electricity Consumption)

$dER = REC$ (Residential Electricity Consumption)

Let $A'Y/A = \lambda$, then

$$\hat{Y} = \lambda.EI.dER/Y + \lambda.ER.IEC/Y + \hat{\alpha}L + \hat{\beta}K \quad (9)$$

$EI.IEC/Y$ captures the relationship between residential electricity consumption and industrial electricity consumption ratio. Equation (9) can be transformed from a growth accounting equation to an estimable functional form and this is only possible if K is proxied by investment ratio I/GDP while $\lambda.EI.dER/Y$ is designated as constant and $PCYG$ IS plausibly substituted as growth in Y/L. Leaving IPCY, REC, IEC and Investment ratio as the elements in vector X1.

$$PCYG = a_0 + a_{11}IPCY + a_{12}IEC/GDP + a_{13}I/GDP + a_{14}REC + a_2REC*IEC/GDP + a_3Z + e \quad (10)$$

Equation (10) will be estimated for different successive models in order to capture all the vector of independent variables with the use of Ordinary Least Square regression estimates and the results will be presented and discussed in the next section of this study.

5. Results and Discursion

The analysis began with an examination of trends for our variables of interest viz: Residential electricity consumption, Industrial electricity consumption and economic growth in Nigeria. The data for residential and industrial electricity consumption for the period of study were sourced from the Central Bank of Nigeria (CBN) bulletin *[3]* and the data for Gross Domestic Product (GDP) and per capita income and investment were obtained from the World Development Index *[13]* and CIA World Fact Book *[14]* respectively. The trend of residential electricity shows a steady growth overtime although, it reflected some fluctuations in between. It was seen to be consistently increasing with the level of industrial electricity consumption and economic growth for the periods under review although the trend of industrial electricity consumption reflect high volatility and seems to be unstable. See Figures 3, 4 & 5.

Table 1. *Unit Root Test.*

Variables	ADF		PP		Order of Integration
	Level	First Difference	Level	First Difference	
IEC	0.050864 (0.9561)	-4.515582 (0.0012)**	-0.518107 (0.8741)	-4.517312 0.0012)**	I (1)
REC	-1.23954 (0.6438)	-6.798088 (0.0000)	-1.239524 (0.6438)	-6.767761 (0.0000)	I (1)
PCIG	-4.141227 (0.0031)**	-8.728453 (0.0000)*	-4.146859 (0.0031)**	-23.46420 (0.0001)*	I (1)
IYPC	-0.319699 (0.9102)	-4.506191 (0.0013)**	-0.879316 (0.7803)	-4.510161 (0.0013)**	I (1)
GDP	0.050864 (0.9561)	-4.515582 (0.0012)**	-0.518107 (0.8741)	-4.517312 (0.0012)**	I (1)
INV	-2.041395 (0.2686)	-5.231093 (0.0002)*	-2.041395 (0.2686)	-5.231093 (0.0002)*	I (1)
INF	-2.791522 (0.0715)	-5.424820 (0.0001)*	-2.788604 (0.0719)	-9.714388 (0.0000)*	I (1)

*Stationary at 1%, **Stationary at 5% LOS Source: Author's Computation (2015)

Unit root test was also conducted via the Augumented Dicky-Fuller and Philips Perron tests, the variables were either stationary at level or first difference as shown in Table 1 above.

Table 2. *Descriptive Statistics.*

	PCIG	REC	IYPC	INV	INF	IEC	GDP
Mean	0.864958	596.7738	642.0567	21.28333	21.14	239.9174	647.23
Median	0.992755	518.4	570.35	20.99	12.55	239.8	570.35
Maximum	30.34408	1194.3	949	29.34	72.8	398	995.7
Minimum	-15.45826	193.6	494.2	15.145	5.4	121	494.2
Std. Dev.	8.066782	231.8332	133.7622	3.115914	18.12289	48.4715	144.2888
Skewness	1.15834	0.723787	1.046721	0.639977	1.352867	0.428636	1.149622
Kurtosis	7.593186	2.822839	2.654911	4.410381	3.82691	6.06303	2.944821
Jarque-Bera	33.08046	2.658573	5.626986	4.534323	10.00597	12.64633	6.611956
Probability	0.0000	0.264666	0.059995	0.103606	0.006718	0.001794	0.036663
Sum	25.94873	17903.21	19261.7	638.5	634.2	7197.523	19416.9
Sum Sq. Dev.	1887.116	1558652	518877.6	281.5588	9524.732	68135.11	603758.5
Observations	30	30	30	30	30	30	30

Source: Authors Computation (2015)

Table 2 above revealed the descriptive characteristics of the variable employed in the model for the analysis of the objectives of this study. The mean value of residential electricity consumption if far above the value of industrial electricity consumption.

Table 3. *Johansen Co-integration Result.*

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.79574	106.2948	69.81889	0.0000
At most 1 *	0.661078	61.8207	47.85613	0.0015
At most 2 *	0.472669	31.52508	29.79707	0.0313
At most 3	0.378529	13.60712	15.49471	0.0944
At most 4	0.01025	0.288483	3.841466	0.5912

From table 3, trace test indicates the existence of 3 co-integrating equations, implying the possibility of the variables moving together in the long run.

Causality Analysis

A unidirectional causal relationship was observed flowing from industrial electricity consumption to residential electricity consumption as shown in table 4. This further gives credence to the hypothesis proposed by the author at the beginning of the study. Also a bi-direction causality was established between Per capita income growth and residential electricity consumption Indicating the possibility of a strong interaction between residential electricity consumption and output growth, thus it is possible that the joint interaction between residential electricity consumption and industrial electricity consumption would yield a better influence on the growth of the economy, while no causality was found between per capita income growth and industrial electricity consumption over the period of study.

Table 4. *Pairwise Granger Causality Tests.*

Null Hypothesis:	Obs	F-Statistic	Prob.
IEC does not Granger Cause REC	29	3.94084	0.0331
REC does not Granger Cause IEC		1.17061	0.3273
PCIG does not Granger Cause REC	29	6.25417	0.0065
REC does not Granger Cause PCIG		4.61162	0.0202
PCIG does not Granger Cause IEC	29	0.14565	0.8652
IEC does not Granger Cause PCIG		2.23666	0.1286

Source: Author's Computations (2015).

However, the study proceeds by estimating equation 5 using the ordinary least square technique in order to empirically evaluate the possible impact of the proposed interaction between residential electricity consumption and industrial electricity consumption on economic growth. Table 5 below shows the result in relation to the variables of interest. In model 1 IYPC is negative and statistically insignificant contrary to a priori expectation indicating that there is no convergence between initial per capita income and the current level of per capita income growth in the economy, that is, past level of living does not influence the current level of income. The industrial electricity ratio (IEC/GDP) is positive and statistically significant indicating pace of growth in the economy being explained by industrial electricity consumption. This also implies that the industrial electricity consumption shows convergence to the high growth in GDP recorded in the economy. It is important to note that LREC is positive and statistically significant as expected implying that electricity consumption in the residential sector is likely to impact growth significantly. This is evident from the fact that the electricity supply in the country has been very low and unpredictable especially in the industrial sector, Investment ratio I/GDP the proxy for capital is negative and statistically insignificant contrary to a priori expectation. The Adjusted R^2, FSTAT and Durbin Watson statistics are also very good.

Table 5. *Ordinary Least Square Regression Estimates.*

Dependent Variable PCIG			
Independent Variable	Model 1	Model 2	Model 3
Constant	-76.69 (-3.95)*	85.28 (1.50)	96.19 (1.69)
IPCY	-0.01 (-1.40)	-0.02 (-2.62)**	-0.03 (-2.90)*
LREC	12.39 (3.56)*	-12.02 (-1.38)	-12.69 (-1.47)
IEC/GDP	0.32 (1.86)***	-4.74 (-2.79)**	-4.95 (-2.93)*
I/GDP	-1.14 (-0.41)	-0.72 (-0.30)	-1.13 (-0.47)
LREC*(IEC/GDP)		0.79 (2.99)**	0.82 (3.12)*
INF			-0.07 (-1.21)
N	30	30	30
Adj. R2 (%)	39	54	55
Fstat	5.64**	7.74*	6.82*
DW	1.93	1.93	1.90

*, **, *** Significant at 1%, 5% and 10% respectively.

Source: Author's Computations (2015). Figures in between parentheses are t-statistics.

The result of the second model (Model 2) which includes the interaction term between LREC and IEC ratio as presented above revealed that the interaction term is positive and statistically significant validating as a result the main hypothesis of the study. It should however be noted that LREC became negative and statistically insignificant. The IEC ratio also became negative but remained statistically significant while the various statistics of the model are still very good and more robust.

In model 3 the inclusion of inflation rate (INF) also leaves the parameters more statistically significant and robust with no change in the signs of the variables. This is reported in table 5 above.

It is also interesting to find the threshold level beyond which LREC interacted with IEC will affect PCIG negatively. This can be obtained from model 2 by differentiation LGDP with respect to IEC ratio and setting the derivative equal to zero:

$$-4.74 + 0.79LREC = 0 \quad (11)$$

Solving equation 11, one can calculate LREC, which is equal to 6%: as a result REC = 6% is the desired threshold level.

This positive value of interaction coefficient reveals the true nature of the relationship between residential and industrial electricity consumption on economic growth in Nigeria. It suggests that both residential and industrial electricity consumption do play complimentary role on economic growth. One simple justification for this finding may be the thriving informal sector of the economy with many small and medium scale outfits. Also, the load-shedding nature of electricity supply in Nigeria. Since during working hours of the day the industrial sector gets the supply, though inadequate and epileptic, while the residential sector run on alternative power sources and vice versa. It is also an observable fact that during festive periods and public holidays electricity supply increases in the residential sector due to the fact that the industry is on break. Thus, domestic electricity consumption is somehow constrained by industrial electricity consumption in Nigeria and unless this situation improves the positive benefit of electricity consumption might be eroded.

6. Conclusion and Recommendations

Existing literature failed to empirically examine the impact of sectoral electricity consumption and the interaction between residential electricity consumption and industrial electricity consumption in particular on growth in the Nigerian economy. This study established the empirical relationship between electricity consumption in both residential and industrial sectors as well as the impact of their interaction on economic growth in Nigeria. It was concluded from the findings of this study that a unidirectional causality exist running from industrial electricity consumption to residential electricity consumption, also there exists a bi-directional causality between residential electricity consumption and Per Capita income growth. LREC is Positive and statistically significant, the IEC ratio is positive (in model 1) and statistically significant and the interaction between LREC and IEC ratio is also positive and statistically significant. Given the positive value of the interaction variable the study concludes that residential electricity consumption is constrained by industrial electricity consumption in Nigeria and unless this situation improves the positive benefit of electricity consumption might be eroded.

The author hereby recommends that:

1) Policy actions should be geared towards improving the supply of electricity in both residential and industrial sectors
2) Seeing the complementary role of residential electricity consumption to economic growth, it is essential that proper and cost effective billing system be implemented in order to encourage the entrepreneurs in the large informer sector with very low capital who cannot afford alternative power supply
3) The moribund power sector of the nation should be rejuvenated in order to curb to outflow of resources from the economy. As this will reduce the rate of exit of firms and multinational companies from the economy.

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