The dynamics of electricity consumption and private investment in Nigeria

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ABSTRACT

This study investigates the nexus between electricity consumption and private investment in Nigeria. The study spans the period 1981-2013 and uses the Johansen co-integration analysis and error correction model. The results show that the components of electricity consumption induced a positive and significant effect on private investment. The study further shows the possibility of long-run equilibrium convergence between the components of electricity consumption and private investment. The research therefore recommends that the government should ensure that private investments in electricity are properly encouraged in a manner that it will raise the nation's production capacity. Also, the government should create an enabling environment for the development of electricity markets.

1. INTRODUCTION

RECENTLY, THERE HAS BEEN AN ANALYTICAL FOCUS ON ELECTRICITY as an energy input, with the economic importance of stimulating socio-economic and technological development in an economy (Ekpo et al 2011). Likewise, it is important to obtain accurate estimates of electricity consumption parameters for the purpose of forecasting, demand management and investment analysis. In studying the electricity consumption function, concentration has centred on economic factors, mainly electricity prices and real income, while demographic factors like population, urbanisation and environmental factors like climatic condition are often included as additional explanatory variables (Ekpo *et al* 2011).

Electricity consumption in Nigeria is squarely industrial, commercial and residential. Electricity consumption by the residential sector has dominated other sectors since 1978, while the industrial sector has witnessed a continuous downward trend. The fall in the industrial sector's consumption of electricity can be attributed to inadequate power supply, which has forced manufacturers to resort to privately generated electricity for powering their production processes.

Nigeria, in its quest to rank amongst the top 20 economies of the world by the year 2020, targets an ambitious 40,000 MW of electricity generation. With a population surpassing 160 million, Nigeria's current maximum electricity generation capacity, estimated at approximately 5,500 MW, is inadequate to meet even current demand, estimated at approximately 10,000 MW. Only about 41 per cent of the population currently has access to electricity; and for that segment of the population, only 30 per cent of its needs are currently met (CBN Bulletin 2013). To meet the generation targets set for 2020, significant private sector investment is required in the supply chain, including generation and gas, to power infrastructure and distribution networks. The reform of the power sector started in 2005 with the enactment of the Electric Power Sector Reform Act (EPSRA), to prepare the regulatory environment for private sector participation. The reform process was accelerated in 2010 with the Power Sector Reform Roadmap, although Nigeria faces a range of challenges implementing the Roadmap, and providing comfort for private sector investment into its privatised power market is one of the main challenges (ADB 2013).

Reform has led to the unbundling of the Power Holding Company of Nigeria (PHCN) into 18 different companies — 11 distribution companies, 6 generation companies and 1 transmission company (Adenikinju 2008). Some major achievements of the reform include the establishment and/or strengthening of key institutions such as the Nigeria Bulk Electricity Trader (NBET) and the Nigerian Electricity Regulatory Agency (NERC), as well as payment by the distribution and generation successor companies to PHCN of around $2.5 billion, which represents the total value of the share sale price of the privatised assets. A cost-reflective tariff, the Multi-Year Tariff Order (MYTO) II, was introduced on 1 June 2012 to make the sector attractive to both local and foreign investors (ADB 2013).

Given the recent reforms embarked on by government to revamp electricity supply in Nigeria by private investment, it becomes important to model the key drivers of electricity consumption in Nigeria, in order to obtain empirical insights for electricity demand and supply projection and policy analysis. Hence, the motivation for this study is to examine the dynamics of electricity consumption and private investment in Nigeria, taking cognisance of the special characteristics of electricity consumption in an emerging and developing economy like Nigeria. The challenge of securing long-term and competitively priced funding to finance investments is always prominent in an emerging market economy. The Nigerian government estimates that about $3.5 billion of investment each year is required in power generation for a period of 10 years, with correspondingly large investments required in other parts of the supply chain. It has approved some incentives including credit enhancement through government risk guarantee, tax waivers, ring-fencing of labour liabilities, and import duty exemptions on equipment.

There is also the World Bank Partial Risk Guarantee, which together with the foregoing, makes investing in this sector a viable venture (Uwazie 2011). The question then arises if there is any relationship between electricity consumption and private investment in Nigeria, and if electricity consumption has any significant influence on the country's productivity.

2. Literature Review

2.1. Theoretical review

2.1.1 Neoclassical growth theory

Core mainstream growth models do not include resources or energy (Aghion and Howitt 2009). In reviewing the conventional economic theory of growth, based on Solow (1956), the Solow Growth Model is a standard neoclassical model of economic growth. Developed by Robert Solow, it has three basic sources for Gross Domestic Product (GDP): labour (*L*), capital (*K*) and knowledge (*A*). 'Knowledge' is a sort of catch-all category used to augment labour (*AL*), called 'effective labour' (Romer 2012). The model has the following assumptions: the growth rates of knowledge and labour are constant; the portion of production saved for investment, *s*, is constant (and exogenous), as is the rate of depreciation.

In the Solow Growth Model, a constant labour force using manufactured capital produces output, which is equal to total Gross Domestic Product increasing at a decreasing rate as the amount of capital employed rises, resulting into diminishing returns to scale to capital. This implies that successive additions of capital generate decreasing increments to future income, and so a falling rate of return on investment. As 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 halt. Thus, the Solow model is static and has no role for energy/electricity in production processes, necessitating the development of exogenous growth theory by Solow-Swan (Karsten and De Vries 2004).

Extending Solow by introducing exogenous factors of production apart from labour and capital — population growth and technological progress — and postulating that the right combination of capital and labour with an exogenous factor will result into an optimum level of output, the Solow-Swan theory is controversial, with improvements in technology assumed to be exogenous (Stiglitz 1974; Dasgupta and Heal 1979). Consequent to this, the Solow-Swan model has failed to highlight the linkage between energy resources/electricity and growth in output and investment — hence, the need for a model of endogenous growth theory.

2.1.2 Endogenous growth theory

Endogenous growth theorists have demonstrated that growth can continue indefinitely as capital is accumulated. Technological knowledge is a form of capital. Accumulated through research and development (R&D) and other knowledge creating processes, the growth of capital thus means the growth of a composite stock of capital and disembodied technological knowledge. As affirmed by Narayan and Smyth (2009), output rises as a constant proportion (A) of the composite capital stock and, therefore, it is not subject to diminishing returns because diminishing returns to manufactured capital are neutralised by exogenous technology growth.

These growth models also do not consider any natural resources, including energy/electricity. All natural resources are finite in nature and some environmental resources are non-reproducible, making the notion of indefinite economic growth implausible, as shown by Solow-Swan growth model. The standard neoclassical models thus conclude that technical conditions determine whether continuing growth is possible. Technical conditions have to do with the substitutability of renewable and non-renewable resources. Stern (2004) stated that in analysing the neoclassical economists' growth model, the class of growth models that include resources (energy) can account for mass balance and thermodynamic constraints with the 'essentiality condition'. If elasticity is greater than one, then resources are 'non-essential'. If elasticity is less than or equal to one, then resources are 'essential'.

2.2 Methodological Review

To model the determinants of electricity demand, several approaches have been employed in the economic literature. These range from those adopting simple forms containing a single variable like electricity price (Dincer and Dost 1997; Ekpo *et al* 2011) to those involving more than one variable, like electricity price and real income (Ziramba 2008). Other studies have used real income per-capita, electricity price, and price of other electricity substitutes (Al-Faris 2002; Narayan and Smyth 2005), and real income, population growth, electricity price, efficiency improvement and structural changes (Lin 2003; Sa'ad 2009). Apart from important variables such as real income, population growth, and electricity price several studies, such as Donatos and Mergos (1991), Beenstock *et al* (1999) and Nasr *et al* (2000), have gone further to include a variable to measure climatic conditions in their studies.

A recent study by Paul and Bhattacharya (2004) which applied alternative econometric time series models vis-a-vis Engle-Granger (1987) co-integration, as well as the Granger causality test and Johnsen cointegration technique on Indian data for the period 1950-96, observed that Engle-Granger and Johnsen cointegration results showed that economic growth leads to rising energy consumption in the long run. Sahu (2008) reported similar findings and also observed that energy consumption has a bi-directional causal relationship with economic growth. Moreover, while Cheng (1999) reported unidirectional causality running from economic growth to energy consumption, Asafu-Adjaye (2000) found causality running in the reverse direction.

Wolde-Rufael (2004) tested the long-run and causal relationship between electricity consumption per capita and real GDP per capita for 17 African countries for the period 1971-2001, using the then-newly developed cointegration test proposed by Pesaran *et al* (2001) and using a modified version of the Granger causality test from Toda and Yamamoto (1995). The advantage of using these two approaches is that they both avoid the pre-testing bias associated with conventional unit root and cointegration tests. The empirical evidence shows that there was a long-run relationship between electricity consumption per capita and real GDP per capita for only 9 countries and Granger causality for only 12 countries. For 6 countries there was a positive uni-directional causality running from real GDP per capita to electricity consumption per capita; opposite causality for 3 countries; and bi-directional causality for the remaining 3 countries. The result should, however, be interpreted with care as electricity consumption accounts for less than 4 per cent of total energy consumption in Africa and only grid-supplied electricity is taken into account.

Masih and Masih (1996, 1997), in a multivariate framework, examined the relationship between total energy consumption and real income of several Asian economies: India; Pakistan; Malaysia; Singapore; Indonesia; Philippines; Korea; and Taiwan. Energy consumption was found to be neutral with respect to income for Malaysia, Singapore and Philippines, unidirectional causality existed from energy consumption to GNP for India, exactly the reverse for Indonesia and mutual causality was present for Pakistan.

2.3 Empirical review

Starting with the empirical work of Kraft and Kraft (1978), the pattern of causation between energy utilisation and economic variables continues to generate intense controversies. This becomes clear when considering various studies by country or region. The conflicting results have not only extended to developing countries, but also to investigating causation linking electricity use and various economies. Hence, we review literature specifically on electricity use and economic growth, highlighting contradictory results on a country basis.

Sari and Soytas (2007) utilising the recently developed generalised forecast error variance decomposition technique, tried to determine the information content of the growth rate of energy consumption (i.e. how much of variance in the national income can be explained by the growth of different sources of energy consumption) in Turkey. They found that waste seemed to have the largest initial impact, followed by oil. The total energy consumption explained around 21 per cent of the forecast error variance of GDP.

Wolde-Rufael (2006) investigated the long run relationship between energy use per capita and per capita GDP for 19 African countries using the cointegration technique proposed by Pesaran, *et al* (2001) and also the causality test proposed by Toda and Yamamoto (1995). The study found that there is a long run relationship between two series for only eight countries and causality for only 10 countries. In another study Lee (2005), using the Toda and Yamamoto (1995) non-causality test, examined the relationship between energy consumption and income in 11 major industrialised countries. He found that although energy consumption and income are neutral to each other in the UK, Germany, and Sweden, there is bi-directional causality in the USA and unidirectional causality from energy consumption to GDP in Canada, Belgium, The Netherlands and Switzerland, suggesting that energy conservation may hinder economic growth. Further, causality relationships appeared to be unidirectional but reversed for France, Italy and Japan, implying that in these three countries, energy conservation may be viable without being detrimental to economic growth.

Pokharel (2007) showed how energy is important for Nepal, given its economic structure where there exists heavy demand for both traditional as well as commercial sources of energy, in rural and urban areas respectively. Classifying his models into fuel and consumption sector models, he tried to determine the factors influencing energy consumption in different sectors. For fuel sector models, major fuels such as fuel wood, petroleum products, coal and electricity were considered, whereas in consumption sector models the energy-consuming sectors, residential, industrial, transport and agriculture, were considered. From the final regression model, the study found that fuelwood demand is largely affected by rural population. The consumption of kerosene depends upon the price of kerosene, urban population, rural population and GDP of trade, hotels and restaurants. The increase in LPG consumption despite the increase in price indicates the attractiveness of LPG as a major fuel source in urban households and in the service sector. Petroleum consumption is not significantly related to petroleum prices or the urban population. Most vehicles using motor spirit (MS) petrol (or Premium Motor Spirit) are owned by the private sector (and the government) and the growth in the urban population does not correlate with the number of vehicles. However, the relation between the use of MS petrol and the number of vehicles is found to be significant.

Akinlo (2009), and Solarin and Bello (2011), have examined the causal relationship between electricity consumption and economic growth in Nigeria and found one-way causation flowing from electricity use to economic growth. The results also confirmed the existence of a long run relationship between GDP and electricity utilisation, as well as the existence of unilateral causality to real GDP flowing from electricity use. Squalli (2007) suggests similar findings. In contrast, Wolde-Rufael (2006) revealed single causality from economic growth to electricity utilisation in Nigeria.

Clear insights about the dynamic nature of electricity demand and consumption are essential for capacity additions, investments and effective optimal energy policies. Ekpo et al (2011) provide background analysis of electricity demand and consumption trends in Nigeria, with the key determinants of electricity demand and the investment requirements clearly highlighted. The results showed that real GDP per capita, population and industrial output are significant factors driving electricity consumption in the long-run and short-run, while electricity price is not a significant determinant. In the short- run, industrial output has a crowding out effect on the demand for electricity. These results imply that income per capita is the major determinant of electricity demand, and therefore, deregulated pricing of electricity products will ensure efficient product and resource allocation in Nigeria, to reflect the observed income inelasticity for electricity products.

Statistical evidence also suggests that electricity consumption is strongly correlated with wealth, while lack of electricity is strongly correlated with the number of people living below $2 per day (IEA 2002). The elasticity of power system capacity to GDP in developing countries is about 1.4 (Munasinghe and Meir 1993). Ferguson *et al* (2000) also found that for developed countries, there is a strong correlation between increases in wealth over time and increases in energy consumption. Moreover, there is a stronger correlation between electricity use and wealth creation than there is between total energy use and wealth (Ferguson *et al* 2000). The experience of developed countries also shows that the electricity supply sector played a crucial role in their economic development, not only as a key input in their industrial development but also as a key factor in improving the quality of life of their people (Rosenberg 1998). Further, increasing electricity use has been identified as an important source of productivity improvement in developed countries and it is the sector that is currently fuelling the 'new digital economy' (Ebohon 1996; Rosenberg 1998).

Adom (2011) focussed on the nexus between electricity consumption and economic growth in Ghana. The study, which employed ARDL bounds testing cointegration, observed that a long run relationship exists between both variables, and that real GDP per-capita enhanced electricity consumption significantly in the country. Solarin (2011) took a similar approach in applying the study to the Botswanan economy. The study, which included capital formation in a trivariate system, observed that there is bidirectional causality running from electricity consumption to economic growth. This result is also in synch with Odhiambo (2010), who found that unilateral causality runs from electricity consumption to economic growth in Kenya. Solarin and Shahbaz (2013) conducted a similar study in Angola and observed that a bidirectional causal relationship exists between electricity consumption and economic growth. They thus called for a comprehensive energy policy to sustain long run economic growth.

From the foregoing literature review, it is apparent that there are conflicting results for different countries. This could create problems for policy makers on deciding the best action in regards to energy (electricity) policies. However, the quantum of results in favour of one hypothesis may persuade policy makers to choose a particular line of action. For example, in Nigeria, energy (especially electricity) conservation may be disadvantageous to Nigeria's economy, as Squalli (2007) and Akinlo (2009) reveal single causality flowing from electricity utilisation to Nigeria's economic variables. Therefore, energy expansion policy should be pursued. The adequacy of the studies in pursuing such a decision is however questionable.

The present study becomes necessary owing to the fact that the earlier studies have only focused on the nexus between electricity consumption and economic growth (see, for example, Akinlo 2009; Odhiambo 2010; Solarin 2011; Adom 2011; Solarin and Shahbaz 2013) thereby neglecting key channels (such as foreign private investment) through which electricity consumption can impact economic growth. This present study will fill this noticeable gap in the literature. In the same vein, most of the earlier studies in the literature have employed the bounds testing approach to study the nexus between electricity consumption and output. However, the present study differs from the earlier ones by employing an error correction model to determine if the same result will still be arrived at, using a different methodology.

3. Theoretical framework and model specification

3.1 Theoretical Framework: Endogenous Growth Theory

The theory adopted for this study is endogenous growth theory, which is pertinent to the explanation of causality between the pertinent variables. It is germane to this study because economics operates within fairly well-established and generally accepted overarching theoretical frameworks that can guide investigations. The Cobb-Douglas production function has the essentiality condition. This occurs when society invests in sufficient capital over time to replace depleted natural resources and ecosystem services. The extent of investment taking place depends on the institutional setting of the economy. Therefore, a standard Cobb-Douglas production function can be extended to include electricity and private investment. Halicioglu (2007) assumed that the connection between electricity consumption, private investment and output will conceivably function through endogenous factors such as $A(K)$, below. Thus, we can safely assume that $A(K)$ is a function of electricity and other exogenous variables.

3.2 Model specification

Arrow (1962) was the first to introduce technological progress as an endogenous variable into production (Jhingan 2010). Arrow's model, in a simplified form, can be written as,

$$Y = A(K)\, f(K^{\alpha}, L^{\beta}) \tag{1}$$

Where Y stands for output, K for stock of capital, L for stock of labour, A is the technology factor, $A(K)$ stands for total factor productivity (Jhingan 2010).

Therefore, a standard Cobb-Douglas production function of the form in equation 1 can be extended to include electricity/energy. Following the work of Stern (2004) and Oderinde (2011), the impact of electricity consumption on private investment can operate through the endogenous factors, $A(K)$. Thus $A(K)$ is a function of electricity consumption (EC), and other exogenous factors, (C).

Mathematically, the above statement can be expressed as:

$$A(K) = f(EC, C) \qquad (2)$$

For the purpose of this study, it is assumed that the impact of electricity consumption on private investment operates through total factor productivity (A). Since we intend to investigate the impact of electricity consumption on private investment, it is assumed that total factor productivity (A) is a function of EC.

It should be noted that the quantum of electricity generated does not in reality reflect the actual electricity supplied. It is the quantity of electricity consumed which at best connotes what could be supplied, that would best serve as the measure of EC (Ayodele 2001).

Thus,

$$FPI = f(EC, K, L, GDP) \qquad (3)$$

Where FPI is foreign private investment, EC is electricity consumption, **L** is the labour force in the economy, K is capital accumulation (measured by gross fixed capital formation), GDP is growth in real gross domestic product (a proxy for economic growth).

In order to make the regression functions estimable, the functions are reformulated in a log form to include the stochastic error term (U).

$$LOG(FPI)_t = \beta_0 + \beta_1 LOG(EC)_t + \beta_2 LOG(K)_t + \beta_3 LOG(L)_t + \beta_4 LOG(GDP)_t + \mu_t \qquad (4)$$

The a priori expectation is that $\beta_1 > 0, \beta_2 > 0, \beta_3 > 0, \beta_4 > 0$ which indicates that all the coefficients should positively enhance the dependent variable.

3.3 Data sources and operationalisation

The study utilises data obtained from the Central Bank of Nigeria Statistical Bulletin (CBN 2014), Nigeria Bureau of Statistics (NBS 2014) and World Development Indicators (WDI 2014). The data span the period 1981 to 2013. Specifically, the data collected are foreign private investment (proxied by foreign direct investment), electricity consumption (i.e. total electric power consumption, in kilowatts), labour force (the sum of employed and unemployed citizens), capital stock (measured by gross fixed capital formation) and growth in Real Gross Domestic Product (a proxy for economic growth) for the relevant years.

4. Data analysis

4.1 Stylised facts

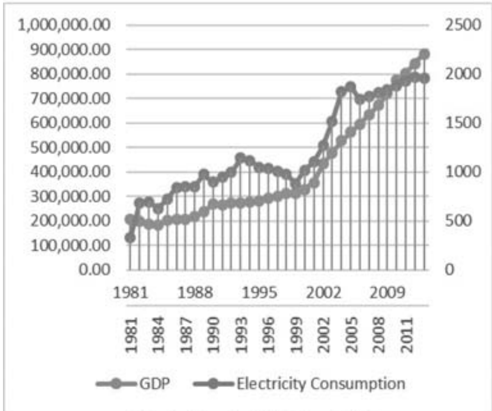

Fig 1: Trend of GDP and EC

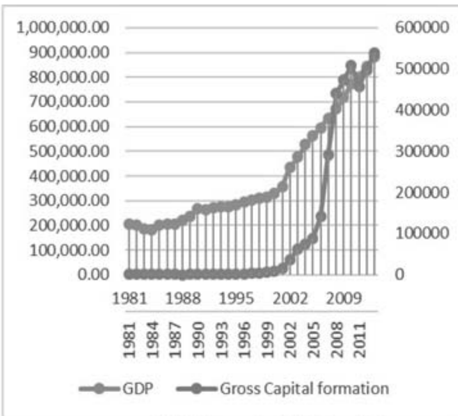

Fig 2: Trend of GDP and K

Fig 3: Trend of GDP and FPI

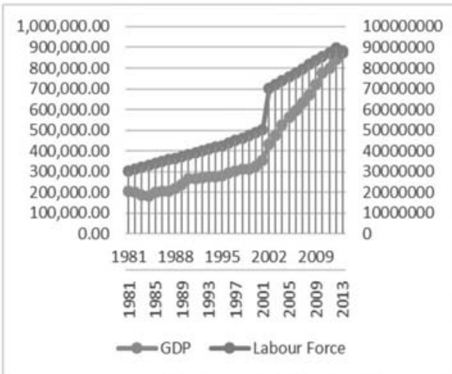

Fig 4: Trend of GDP and L

Figure 1 shows a steady increase in GDP over time. However, increases in electricity consumption have not been steady, but volatile. It rose at a very low rate between the years 1981 and 2000, and then rose to its highest value in 2013. The recent increase is possibly due to the continued growth in demand for electricity and the consequent investment in the power sector in Nigeria. The increased magnitude of economic activities and expansion of businesses has not been met with commensurate rises in electricity consumption. Figure 2 suggests that while there has been a steady rise in GDP, the quantum of the increase of gross capital formation between 1981 and 2001 was rather low. As can be seen in the graph, between 2002 and 2013, gross capital formation exhibited significant growth. Yet this has not been reflected in adequate growth, because of weak economic foundations. It can be seen that gross capital formation and GDP growth follow the same trend more recently, which could mean that the two economic variables are influenced by the same factors.

In Figure 3, though foreign private investment was found to be at very low ebb in the 1980s, it rose steadily between 1991 and 1993, before growing much more rapidly between 1995 and 2007. From 2008 to 2013, growth has stabilised. The trend of Foreign Private Investment has been irregular recently. It has increased with GDP. Figure 4 suggests that while GDP has been growing steadily, the labour force has been growing much more slowly, with the exception of 2002 and 2003. The labour force is very large in Nigeria. This also suggests that there is some form of positive relationship between the GDP and labour force.

4.2 Descriptive statistics of the variables

Table 1 shows the summary statistics of the variables under study. The mean of the variables ranges from 1,216.18 for electricity consumption to 54,411,848 for labour force. GDP is found to be growing at much faster rate than other variables under focus. It is also clear from the table that the volatility of electricity consumption is much less than the other variables, indicating that less attention has been paid to the power sector in boosting electricity output. The values of all the variables are positively skewed away from a normal distribution and the kurtosis level for gross capital formation is above 3, the normal point. This all indicates that all series are leptokurtic. The Jarque-Bera probability of 0.08 for both FPI and GDP, and 0.002 for gross capital formation has a 1 per cent level of significance.

Table 1: Descriptive statistics

	EC	*FPI*	*GDP*	*K*	*L*
Mean	1216.181	190989.5	403290.5	111014.1	54411848
Median	1033.300	128331.9	302022.5	3459.300	45002451
Maximum	1968.021 (2012)	631287.8 (2013)	883545.7 (2013)	538541.7 (2013)	89621290 (2012)
Minimum	333.9000 (1981)	3757.900 (1981)	183563.0 (1984)	255.6000 (1988)	30578274 (1981)
Std. Dev.	475.6051	206241.7	219144.5	188882.7	20848830
Skewness	0.346840	0.890586	0.897533	1.424643	0.519082
Kurtosis	1.818665	2.363920	2.401332	3.250119	1.590959
Jarque-Bera	2.580525	4.918606	4.923413	11.24887	4.211876
Probability	0.275199	0.085495	0.085289	0.003609	0.121731
Sum	40133.97	6302655.	13308588	3663467.	1.80E+09
Sum Sq. Dev.	7238406	1.36E+12	1.54E+12	1.14E+12	1.39E+16
Observations	33	33	33	33	33

Notes: The values in brackets are the years when the maximum and minimum values of each variable occur. The suffix E+n where 'n' is any positive number denotes the exponent 10^n. On the normality of the distribution, if the skewness deviates from 0 and the kurtosis from 3, then non-normality occurs.

4.3 Stationarity test results

As shown in Table 2, the ADF and PP unit root tests indicate that the null hypothesis of unit root is rejected at first difference for all the variables at the 1 per cent level of significance. The KPSS stationarity test indicates that the null hypothesis of stationarity cannot be rejected at 1per cent. Thus all variables are stationary in first differences; they are all integrated of order one.

Table 2: Summary of unit root test results

Variables	*ADF test statistic (first difference)*	*PP test statistic (first difference)*	*KPSS test statistic (first difference)*	*Order of integration*
FPI	-8.752124 (-3.724070)*	-5.45848 (-3.711457)*	0.243874 (0.739000)	I(1)
EC	-3.896061 (-3.857386)*	-3.895942 (-3.857386)*	0.116022 (0.739000)	I(1)
K	-3.674618 (-3.065585)**	-3.917996 (-3.857386)*	0.258687 (0.739000)	I(1)
L	-4.957018 (-3.857386)*	-6.694280 (-3.857386)*	0.504215 (0.739000)	I(1)
GDP	-7.708464 (-3.100073)*	-5.416295 (-3.705277)*	0.235667 (0.739000)	I(1)

Note: (a) MacKinnon critical values for the rejection of the hypothesis of a unit root are in parentheses in Columns 2 and 3 and the tests include intercept but no trend; the single star indicates a 1 per cent level of significance. (b) The figure in parentheses in Column 4 is the KPSS Test critical value at 1 per cent.

4.4 Co-integration Test

When the tests for stationarity are concluded, and if all the variables are found to be integrated of the same order, the next stage will be to conduct a robust test for cointegration to see if there is a long-run or equilibrium relationship among the variables (Johansen 1991).

The Johansen cointegration test results (both the trace test and the maximum eigenvalue test) show that the variables are cointegrated since there are three cointegrating equations at the 5 per cent level of significance. Hence, we conclude that there is a long-run relationship between foreign private investment, electricity consumption, capital stock, labour force and real GDP. The Johansen multivariate cointegration test is the most applicable cointegration technique when the model specified is a parametric type, while ARDL is mostly employed in non-parametric models (see Johansen 1995). Hence, the use of the Johansen Multivariate technique is suitable for our parametric models specified. Furthermore, the Johansen multivariate cointegration technique is used for several I(1) time series. If there are several time series that are integrated as I(1), then using the Johansen multivariate test is appropriate. However, the ARDL technique incorporates both I(0) and I(1) in the same estimate, which is not the case in this current study (see Pesaran *et al* 2001).

Table 3 Results of Johansen Multivariate Cointegration Test

Unrestricted cointegration rank test (Trace)

Hypothesised no. of CE(s)	*Eigenvalue*	*Trace statistic*	*0.05 critical value*	*Prob.***
None *	0.973364	195.2597	69.81889	0.0000
At most 1 *	0.921137	100.9967	47.85613	0.0000
At most 2 *	0.637324	34.95569	29.79707	0.0116
At most 3	0.199741	8.585290	15.49471	0.4051
At most 4	0.101819	2.791982	3.841466	0.0947

Unrestricted cointegration rank test (Maximum eigenvalue)

Hypothesised no. of CE(s)	*Eigenvalue*	*Trace statistic*	*0.05 critical value*	*Prob.***
None *	0.973364	94.26298	33.87687	0.0000
At most 1 *	0.921137	66.04098	27.58434	0.0000
At most 2 *	0.637324	26.37040	21.13162	0.0083
At most 3	0.199741	5.793308	14.26460	0.6399
At most 4	0.101819	2.791982	3.841466	0.0947

Trace test indicates 3 cointegrating equation(s) at the 0.05 level; * denotes rejection of the hypothesis at the 0.05 level; **MacKinnon *et al* (1999) p-values.

Maximum Eigenvalue test indicates 3 cointegrating equation(s) at the 0.05 level; * denotes rejection of the hypothesis at the 0.05 level; **MacKinnon et al (1999) p-values.

4.5 Error correction model

After the iteration process was conducted, a preferred parsimonious regression model was obtained. The parsimonious error correction model results in Table 4 indicate that an R^2 of approximately 64.5 per cent, and this shows a better goodness of fit, meaning that there is a strong relationship between the variables used. Thus, it shows that 64.5 per cent of the variation in FPI is explained by *EC*, *K*, *L* and GDP, leaving per cent 35.5 per cent attributable to the white noise error term. The Durbin-Watson (*DW*) statistic, of 1.98, denotes the absence of autocorrelation in the residuals.

The Error Correction Model (ECM) is negative, less than unity (as expected) and significant. The ECM is an error correction term that guides the variables (*EC, K, L* and GDP) of the system to restore equilibrium, and confirms that there exists a long run equilibrium relationship among the variables. Thus, the value of the ECM gave approximately 73.3 per cent, meaning that the system corrects (or adjusts to) its previous disequilibrium period at speed of 73.3 per cent annually, and thereby gives the validity that *EC, K, L* and GDP have long-run equilibrium relationships between them.

Table 4 Parsimonious Error Correction Model Result

Dependent Variable: D(LOG(FPI))

Variable	*Coefficient*	*Std. error*	*t-statistic*	*Prob.*
C	0.143045	0.056914	2.513368	0.0217
D(LOG(EC))	0.457665	0.411785	2.650364	0.0047
D(LOG(K))	0.585269	0.166954	3.505573	0.0025
D(LOG(L))	0.190995	0.103617	1.843282	0.0818
D(LOG(K(-1)))	0.433678	0.221773	-1.955508	0.0662
D(LOG(L(-1)))	0.116079	0.081313	1.427556	0.1705
D(LOG(GDP(-1)))	1.602766	0.934204	2.715649	0.0055
ECM(-1)	-0.732697	0.216062	-3.391149	0.0033

R-squared	0.645267	Mean dependent var	0.246331
Adjusted R-squared	0.638426	S.D. dependent var	0.185358
S.E. of regression	0.147307	Akaike info criterion	-0.744938
Sum squared resid	0.390588	Schwarz criterion	-0.357831
Log likelihood	17.68419	Hannan-Quinn criter.	-0.633465
F-statistic	3.083379	Durbin-Watson stat	1.982285
Prob(F-statistic)	0.005538		

Source: Authors' Computation from Eviews

From the estimated model, it was observed that *EC, K, L* and GDP have a significant impact on private investment. The positive sign and significance of *EC, K, L* and GDP are attributable to the boom in investment over the years. The function thus shows that a one per cent change in *EC, K, L* and GDP results in, respectively, a 0.46, 0.58, 0.19 and 1.60 percentage point increase in private investment. The coefficient value for electricity consumption is quite low, showing that more still can be achieved if more impetus is given to developing electricity supply.

4.6 Long Run Estimates

The result of the ordinary least squares estimation is given in the table below.

From the table above, the R^2 indicates that changes in all the explanatory variables account for about 99 per cent of the changes in FPI. The F-value of 752.1344 passes the significant test at the 1 per cent significance level. Thus, we reject the null hypothesis (that the model is not significant) and conclude that the overall regression is significant at the 1 per cent level. The goodness of fit is statistically significant and, as such, the model explains the relationship between FPI and the various explanatory variables over the sample period 1981-2013. The T-values show that at the traditional level of 5 per cent significance, three of the explanatory variables (*EC, K* and *L*) passed the T-test; while GDP is not statistically significant at the 5 per cent significance level.

The Durbin-Watson statistic indicates the absence of first order serial autocorrelation in the model, at the 5 per cent level of significance. The long run model indicates that government spending and stock market development have positive impacts on FPI in the long run.

Table 5: Dependent Variable: FPI

Variable	*Coefficient*	*Std. error*	*t-statistic*	*Prob.*
C	0.006303	1.206759	0.005223	0.9959
LOG(EC)	0.233409	0.108489	2.151456	0.0422
LOG(K)	0.962290	0.164405	5.853157	0.0000
LOG(L)	0.223210	0.094365	2.365389	0.0479
LOG(GDP)	0.255434	0.077033	0.719611	0.4790
R-squared	0.992413	Mean dependent var		14.73692
Adjusted R-squared	0.991094	S.D. dependent var		2.068112
S.E. of regression	0.195175	Akaike info criterion		-0.269406
Sum squared resid	0.876147	Schwarz criterion		-0.031513
Log likelihood	8.771687	Hannan-Quinn criter.		-0.196680
F-statistic	752.1344	Durbin-Watson stat		1.973271
Prob(F-statistic)	0.000000			

5. Conclusion

This study has examined electricity consumption and private investment in Nigeria. To achieve this, an empirical model in which electricity consumption indicators were related to private investment was set up. The results obtained were generally satisfactory. The study confirms the earlier findings of Muftaudeen and Omojolaibi (2014), Stern (2011) and Ekpo et al (2011). Clear insights have been established that understanding the dynamic nature of electricity demand and consumption is essential for capacity additions, investments and effective optimal energy policies. For Nigeria, this is particularly important, because of gross underinvestment in the power sector, which has culminated in poor power supply and the loss of thousands of jobs.

Therefore, in agreement with Iwayemi (2008), the elimination of the electricity curse and emergence of the required strong investment response are contingent on radical changes to improve and strengthen industry governance structure, thus to enhance accountability and minimise corruption; and strengthening the current reform effort in the industry to create a more competitive electricity market, where market-responsive pricing predominates. A new partnership has to be forged between the public and private sectors to meet the emerging investment challenges. Ultimately, elimination of the curse of electricity in Nigeria goes beyond delivering adequate and reliable electricity to end-users. It also involves giving consumers a widely accessible, affordable and environmentally friendly electricity service.

We hereby recommend that (i) the government should increase access to financing, by working directly with states and local governments to match project needs with applicable financing tools; and it should also assist localities in exploring and adopting policies and programmes to encourage transparency in energy use and greater efficiency. (ii) The private sector should be encouraged to play a key role in infrastructure financing, through the creation of an enabling operating environment. (iii) The government should reform the power sector with seriousness by empowering the Nigerian Electricity Regulating Commission (NERC) to design appropriate pricing and regulatory guidelines that will be favourable to potential investors and consumers.

Accepted for publication: 22 March 2016

ENDNOTES

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