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Research article

ELECTRICITY CONSUMPTION, EXPORTS AND ECONOMIC GROWTH: EVIDENCE FROM NIGERIA

Adeniyi O. ADENUGA* and Emeka R. OCHU

E-mail: AOADENUGA@cbn.gov.ng;   aoadenuga@cbn.gov.ng

Abstract

Electricity consumption unarguably has an important role in measuring the level of socio-economic development of any country. In recent times, Nigeria has been described as one of the fastest developing countries in Africa with highly endowed natural resources, including potential energy resources. However, having access to energy in Nigeria has continuously been a challenge. It is an accepted fact that economic growth is a prerequisite for a nation to move from the level of developing to a developed country. Thus, this paper investigates the relationship between electricity consumption, export and economic growth, for Nigeria using quarterly secondary data spanning the period 1990-2011. The findings would help to guide decision makers on the neutrality hypothesis of energy consumption and economic growth in Nigeria.

Keywords: consumption, development, electricity, energy, export, growth

Introduction

Electrical energy unarguably plays a key role in economic development of any nation. Thus, the relationship between electricity consumption and economic growth has been a topical issue for academic research and among policy makers for several decades, due to its significance for governments in the formulation of energy policies. This is imperative because when a country is heavily dependent on electrical energy, environmental policies for energy conservation could have a negative impact on economic development. Ovieniuwo (2006) agrees that "energy efficiency is the indispensable component of any effort to improve productivity" and of course contribute to economic wealth. Majority of Nigerian are dependent on fossil fuel and fuel wood (firewood). The over dependence on fossils and fuel wood (used mainly by poor rural commuters) have not yielded enough capacity to meet increasing demands.

Most of the time, Nigeria is described as one of the fastest developing countries in Africa with highly endowed natural resources, including potential energy resources. However, having access to energy in Nigeria has continuously been a challenge. It is an accepted fact that economic growth is a prerequisite for a nation to move from the level of developing to a developed country. With a higher economic growth, Nigeria has brighter prospects of becoming more developed. With adequate utilisation of electricity potentials to meet the demand, the nation would likely experience high levels of economic growth.

The long-term development plan of Nigeria is encapsulated in the Vision 20: 2020 where the ambition of the country to become one of the twenty largest economies in the world by 2020 was stressed. In order to achieve this goal, the energy sector, in particular, the electricity sector has an important role to play in the required transformation process. The general view of most analysts has been that the electricity sector is the major bane of the country's efforts to jump-start and mordernise the Nigerian economy. The provision of adequate, affordable, accessible and sustainable electricity supply is critical to the attainment of the broad goals of high and sustainable exports and economic growth (Adegbulugbe and Adenikinju, 2011).

Nigeria is naturally endowed in varied energy resources, including electricity which remains largely untapped. In 1986, public electricity generation started with the installation at Marina, Lagos of 30 KW generating set by the former colonial Public Works Department (PWD). Thereafter, the Electricity Corporation of Nigeria (ECN) was established to integrate electricity supply and make it more effective. It became the statutory organisation responsible for generation, transmission, distribution and sale of electricity to end-users in Nigeria. The merger of the Niger Dam Authority and the ECN ushered in an era of integrated national transmission grid to achieve the objectives of elimination of duplication of managerial capacity and improved coordination of power supply and reduction of operating costs and wastes, among others. To this end, the National Electricity Power Authority (NEPA) took charge of the responsibility of developing and maintaining an economically efficient electric power system for Nigeria.

The NEPA was replaced by the Power Holding Company of Nigeria (PHCN) and it accounts for about 98.0 per cent of total electricity generation in Nigeria. Other agencies such as Nigerian Electricity Supply Company (NESCO), Jos, Ajaokuta Steel Company Company (ASC), NNPC and Shell accounts for the remaining 2.0 per cent. The total installed generating capacity of the eight major power stations stood at 6,720MW (CBN, 2010). Electricity is generated through a mix of both thermal and hydro systems. This is transmitted evenly across the country to customers through transmission lines totaling 11,000 kilometers.

Electricity consumption has an important place in measuring the level of socio-economic development of particular country. Ferguson et al. (2000) examined the relationship between electricity consumption and economic development for 100 countries and found a strong relationship between the two variables concerned. The record of electricity consumption in the 1970s showed significant growth, reflecting the generating and distribution capacity of NEPA with all-time high of 76.0 per cent capacity utilization rate. In the period 1970-1980, electricity consumption rose persistently at an average of 14.3 per cent to 4,030.3 million KWh. In the post SAP period, total electricity consumption declined by 4.0, 1.7 and 2.4 per cent in 1994, 1995 and 1996, respectively. The fall was largely accounted for by decrease in residential as well as commercial and street-light consumption. However, the electricity consumption rose continuously by 15.1, 8.6, 15.1, 19.5, 20.2, 9.3, per cent in 2000, 2001, 2002, 2003, 2004 and 2005, respectively, but declined in 2006 by 12.3 per cent, mainly due to lower generation as a result of inadequate supply of gas for power generation.

The complexity of relationship and the presence of contradictory evidence between electricity utilisation and economic activity indicate the need for re-examination of long-run and short-run linkages between electricity consumption, export and real output because if the extent of effect of electricity consumption on export and economic growth is known it will have implications for the pace of development in Nigeria.

Given the nature and importance of the issues concerned, various attempts have been made by academics and professionals alike to determine the relationship between these variables for different countries; but no clear consensus has emerged, particularly for developing country such as Nigeria. Different results for different countries are not unexpected given the institutional and structural differences among the countries. In addition, this might be due to differences in methodologies and analytical framework adopted as well as definition of terms, specification of the models and period covered in the study.

The main objective of this paper is to investigate the relationship between electricity consumption, export and economic growth, so as to make policy recommendations based on the findings from the study.

Accordingly, this paper is divided into 7 sections with the introduction discussed under section I. Section II contains the literature review while the theoretical Framework is discussed in Section III. The methodology and data sources are discussed in section IV while section V addresses results of summary statistics and unit root tests. Sections VI and VII contains analysis of findings and policy implications as well as recommendations and conclusion, respectively.

II. Literature Review

The relationship between electricity consumption and gross domestic product has been investigated for many countries. To date, there is no consensus over the relationship. Many of these studies have examined the relationship ignoring other variables that can affect the relationship, thus resulting in omitted variable bias. Hence, significant empirical studies on the relationship between electricity consumption and economic growth have been developed in the field of energy economics over time, especially in the past two decades. A few studies have tried to establish a third variable; export into the equation. A lot of the more recent findings conclude that there is a felt link between these variables. In his study, Ferguson et al. (2000) found a relationship between electricity use and wealth creation in 100 developing countries stressing that correlation is stronger between electricity use and wealth than there is between total energy use and wealth.

II.I Advanced Economies

Ciarreta et al. (2007) in his study of Electricity Consumption and Economic Growth: Evidence from Spain he investigates both linear and nonlinear causality between electricity consumption and economic growth in Spain using annual electricity consumption data for the period 1971-2005. The purpose of the study is twofold. First, it extended the analysis of the dynamic relationship between electricity consumption and economic growth to the Spanish economy with this period. Second, it explored the possible existence of more complex links than the linear ones to study the existence of non-linear dynamic relations. The study used linear Granger causality test in a VAR model to establish a unidirectional causality running from GDP to electricity consumption.

In a related study, Narayan and Prasad (2008) examined the relationship between electricity consumption and economic growth over 38 OECD countries using bootstrapping causality test. The study findings show a causal relationship between electricity consumption and economic growth in the case of Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK. The uni-directional causality was found running from economic growth to electricity consumption in Finland, Hungary, Korea, Netherlands and UK, although they could not establish a causal link between electricity consumption and economic growth in Belgium, Canada, Denmark, France, Germany, Greece, Ireland, Japan, Luxemburg, New Zealand, Norway, Poland, Spain, Sweden, Switzerland, Turkey, Mexico, and the USA. One limitation of the study is that they did not pay attention to examine the presence of long-run relationship between the variables.

Similarly, Böhm (2008) conducted a study to investigate the relationship between electricity consumption and economic growth among Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal, Spain and Sweden; using the VECM framework. The results established a one-way causality running from electricity consumption to economic growth in Belgium, Greece, Italy and the Netherlands. On the other hand, the study could not find causality in Austria, Denmark, Finland, France, Luxemburg and Sweden.

The results are same in individual country studies for some countries as Sweden, Australia and New Zealand. These results indicate that past values of electricity consumption improve forecasts of movements in economic growth, but they do it in a linear manner and thus, the causal relation between the series is not very abrupt or complex to be nonlinear. Also, there is no evidence of non-linear causality between electricity consumption and economic growth. Thus, it is difficult to obtain more complex relationship between both variables.

II.II Emerging Economies

Sami et al (2011) conducted a superior study on the relationship between exports, electricity consumption and GDP (representing economic growth) in an emerging market economy for the period 1971-2007. Specifically, the study intended to find out if electricity consumption and GDP are co-integrated if exports are factored into the analysis. It also tried to investigate if inclusion of exports can affect the long run relationship between electricity consumption and economic growth. Thus, they investigated the existence of long run relationship between electricity consumption and GDP within a multivariate framework for an emerging market economy of Brazil.

Employing bounds testing procedure, there was an evidence of co-integration when real income is considered the dependent variable. The study found that exports, electricity consumption and real income are cointegrated at 5% significance level. In the long run, exports and electricity consumption have statistically significant and positive impact on economic growth.

In a similar study, Sami (2011) examined the relationship between exports, electricity consumption and real income per capita, i.e. GDP (representing economic growth) in Japan using time series data from 1960-2007. Adopting the bounds testing procedure he found that there is co-integrating relationship between electricity consumption, exports and economic growth. On establishing co-integration, the causal relationship between electricity consumption, exports and economic investigation was investigated within a Vector Error Correction Model (VECM) framework. It was discovered by the study that in the long run, there is causality linking exports and real GDP per capita to electricity consumption both in the short run and long run.

Acaravci and Ozturk (2010) conducted a study to examine the short-run and long-run causality issues between electricity consumption and economic growth in Turkey between the period of 1968–2006. They used the Granger causality models augmented with a lagged error-correction term. The bounds F–test for co-integration test showed evidence of a long-run relationship between employment ratio, electricity consumption per capita and real GDP per capita. The overall results from the three error-correction based Granger causality models also showed that there was an evidence of unidirectional short-run, long-run and strong causalities running from the electricity consumption per capita to real GDP per capita. On the other hand, they noted that there was no causal evidence from the real GDP per capita to electricity consumption per capita. This suggests that electricity consumption plays an important role in economic growth.

II.III Developing Economies

Hossain (2012) in his paper empirically examined the dynamic causal relationship between economic growth, electricity consumption, export values and remittance for the panel of three South Asian Association for Regional Cooperation (SAARC) countries i.e. Bangladesh, India and Pakistan using the time series data for the period 1976-2009. Using four different panel unit root tests; adopting the Johansen Fisher panel co-integration and Kao tests, Hossain's study interestingly found that all the panel variables are cointegrated. The panel Granger F test results support that there is only a bidirectional short-run causal relationship between economic growth and export values but there is no evidence of long-run causal relationship. It was found that the long-run elasticity of economic growth with respect to electricity consumption and remittance are higher than short run elasticity. Thus, this means that over time higher electricity consumption and higher remittance from manpower supply in the panel of SAARC countries give rise to more economic growth.

Wolde-Rufael (2004) examined the long-run and causal relationship between electricity consumption per capita and real gross domestic product (representing GDP) per capita for 17 African countries for the period 1971–2001. Using a newly developed co-integration test proposed by Pesaran et al. (2001) and a modified version of the Granger causality test accredited to Toda and Yamamoto (1995), the study examined these variables.

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 (Benin, Cameroon, Morocco, Zambia, Congo Republic, Gabon, Nigeria, South Africa and Zimbabwe) and Granger causality for only 12 countries. For 6 countries (Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe) there was a positive uni-directional causality running from real GDP per capita to electricity consumption per capita; an opposite causality for 3 countries (Benin, the Democratic Republic of Congo and Tunisia)and bi-directional causality for the remaining 3 countries (Egypt, Gabon and Morocco). What the evidence may suggest is that there may be a number of factors at work that differ significantly across countries that account for the different directions of causality detected in this paper. Detecting some of these factors might help in understanding and defining the relationship between electricity consumption and economic growth. The result is subject to varied interpretation as to determining if there is a strong relationship between the variables, especially as electricity consumption accounts for less than 4% of total energy consumption in Africa and only grid-supplied electricity was taken into consideration.

Aliero et al (2012) investigated the causal relationship between energy consumption and economic growth in Nigeria using time series data of energy consumption; including coal, petroleum, gas and electricity from the period 1970-2009. Employing the Augmented Dickey Fuller unit root tests and Johansen cointegration tests, the study revealed that petroleum, col and electricity consumption leads to economic growth, but without feedback.

Similarly, Okonkwo et al (2009) investigated the relationship between energy consumption and the Nigerian economy using crude oil, electricity and coal data from the period of 1970 to 2005. Applying the cointegration technique, the result of the study inferred that there exists a positive relationship between current period energy consumption and economic growth in Nigeria. The same trend is noticeable in various other studies, majority of which infers a positive relationship between electricity consumption and economic growth in Nigeria. This is shown from the studies of Adeniran (2009) whose research evaluates whether energy consumption Granger causes economic growth using Nigeria as a case study. The tests employed are the Augmented Dickey Fuller test (ADF) and the Phillips-Perron test (PP) test. The Granger causality result of the GDP and electricity consumption indicates that GDP granger causes electricity consumption in the case of Nigeria. The results of the analysis show that total energy consumption causes GDP to some extent.

Razzaqi et al (2011) investigates the dynamic relationship between energy use and economic growth in the D8 countries, including Nigeria. The evidence gathered through application of VAR Granger Causality, Johansen Cointegration and VECM proves existence of short-run and long-run correlation between energy use and economic development in all countries. The results supported either uni-directional or bi-directional causality in the long as well as short run for all the D8 countries except for Indonesia where non-causality was established between the two variables in the short run. Specifically in Nigeria's case, in the long run, as suggested by the VECM results, there was uni-directional causality between the energy use and real GDP where there is a positive correlation between energy use and GDP and one time relative increase in energy use leads to a relative increase of 1.69 times in economic development.

These studies imply that electricity consumption act as an engine of growth for various countries, including Nigeria. Thus, it is very important that this sector be given more relevance, harnessing the inherent potentials as much as possible to encourage economic growth and development.

III. Theoretical Framework

The standard aggregate production function (APF) of the endogenous growth theory assumes that along with other "conventional input" of capital and labour employed in the neoclassical production function, "unconventional input" such as electricity consumption can be included in the model to capture its contribution to economic growth. According to Perman et al. (2003), a productive input is essential if output becomes zero whenever the quantity of that input is zero, irrespective of the amounts of other input utilised. Similarly, Lean and Smyth (2009) has argued that for primary products exporters, it is essential to include primary products as it accounts for the omitted variables biasness in the growth accounting specification. Thus, the APF is depicted as in equation 1 below:

$$Y = f(A, K, L)\text{..........................}(1)$$

Where Y is the real output, A is technology (or technological advancement), K is stock of capital and L is stock of labour force. It is noteworthy that A (technological advancement) is based on the investment in research technology.

Technology is seen as an endogenous factor which could be related to energy. Most technology as given per time is dependent on the availability of useful energy to power it. The technology referred to here is that such as plants, machinery, etc. Without adequate energy supply (in this case electricity) then these technology are practically useless. The law of thermodynamics helps to justify this by stating that "no production process can be driven without energy conversion". It is accepted that energy is not the sole determinant of technology but is a necessary factor to ensure that technology (at whatever level) is being utilized. Conversion of energy in its raw state into useful state is highly technology oriented. Following Fosu and Magnus (2006) and Udah (2010), we assume that the impact of electricity consumption (ec) on economic growth (eg) will operate through A. Therefore we assume further that A is a function of electricity consumption, exports (ex) and other exogenous factor (c).

Thus, $A = f(ec, ex, c)\text{...}(2)$

Combining equations (1) and (2), we obtain:

$$Y = f(c, K, L, ec, ex)\text{...}(3)$$

c is a constant parameter and is the white noise error term.

Understandably, the technology oriented nature of electricity production is known to be capital intensive. Huge machineries are required to generate electricity and it requires huge investments. Therefore, capital (K) needs to be incorporated in the model to justify the specification along the lines of the endogenous growth model.

Thus, we obtain equation (4) which is expressed in linear form as:

$$y_t = \delta_0 + \delta_1 k + \delta_2 l + \delta_3 ec + \delta_4 ex + \varepsilon_t\text{...}(4)$$

A-priori expectations: $\delta_1 > 0, \delta_2 > 0, \delta_3 > 0, \delta_4 > 0$

Where δ_1 to δ_4 represents the slope coefficients, δ_0 is the intercept and ε_t is the stochastic term or the error term at time t.

In double logarithms form, equation (4) becomes:

$$ly_t = \delta_0 + \delta_1 lk + \delta_2 ll + \delta_3 lec + \delta_4 lex + \varepsilon_t) \qquad (5)$$

IV. Methodology and Data

To this end, a vector error correction model technique would be employed after cointegration has been established among the variables, using quarterly data spanning 1990 to 2011. This is to ensure enough data points for the econometric analysis in order to cater for loss of degree of freedom. The data are obtained from the Central Bank of Nigeria and National Bureau of Statistics (NBS) official reports and publications. The dependent variable would be economic growth (eg) while the independent variables would be electricity consumption (ec), exports (ex), gross fixed capital formation (k) and labour force (l).

Table 1: Data and Source

Variables	Definition	Unit of Measurement	Source
Eg	Nominal GDP	Million Naira	National Bureau of Statistics (NBS)
K	Gross Fixed Capital Formation (Investment)	Million Naira	National Bureau of Statistics (NBS)
L	Labour Force	Millions of people	Odularu, G. O. and Okonkwo, C. (2009)
Ec	Electricity Consumption	Megawatts	Odularu, G. O. and Okonkwo, C. (2009)
Ex	Exports	Million Naira	National Bureau of Statistics (NBS)

IV.I Econometric Methodology

The paper employs the vector error correction model (vecm) framework after cointegration has been established among the variables. The vecm is adopted to investigate the relationship between electricity consumption, exports and economic growth. The use of this methodology predicts the cumulative effects taking into account the dynamic response among electricity consumption and the other examined variables. According to Ang and McKibbin (2007), once the variables are cointegrated; it becomes easier to distinguish between the short-run dynamics and long-run relationship. Therefore, to capture both the long-run and the short-run dynamics of electricity consumption, exports and economic growth in Nigeria, an error correction model (ecm) using the Johansen and Juselius (1990) multivariate cointegration techniques was estimated. The ecm is therefore characterized by both differenced and long-run equilibrium models, thereby allowing for the estimates of short-run dynamics as well as long-run equilibrium adjustments process. The estimation was conducted using econometric computer software package, EViews 6.1.

IV.II Empirical Investigation Results

The empirical investigations start with summary statistics and this is followed by the unit root test which is conducted to examine the order of integration of each of the variables in the model. Consequently, a multivariate cointegration analysis, using maximum likelihood procedure of Johansen and Juselius (1990) is undertaken. The next stage is the examination of the short-run and long-run dynamics among economic growth, capital, labour force, electricity consumption and exports.

V. Results of Summary Statistics and Unit root Tests

Summary Statistics

The summary statistics for the variables: economic growth, capital, labour force, electricity consumption and exports are as shown in Table 2 below. The mean for economic growth, capital, labour force, electricity consumption and exports are different. This indicates that the variables exhibit significant variation in terms of magnitude, suggesting that estimation in levels may introduce some bias in the results. The Jarque-Bera statistic for all the variables is significant; hence we reject the null hypothesis that the series are normally distributed.

Table 2: Summary statistics of the variables

	EG	EC	EX	K	L
Mean	2574627.	364.2182	985417.9	250544.3	11.15743
Median	1164666.	283.7535	452632.7	85110.43	11.53891
Maximum	10048574	705.6039	3796935.	962532.9	12.86492
Minimum	65929.72	215.8586	23123.90	4095.660	8.397656
Std. Dev.	2830079.	140.0121	1075299.	300029.8	1.441891
Skewness	1.137221	0.758180	1.044985	1.083599	-0.484114
Kurtosis	3.150946	2.193834	2.828426	2.606134	1.743326
Jarque-Bera	19.05154	10.81392	16.12385	17.79022	9.227880
Probability	0.000073	0.004485	0.000315	0.000137	0.009913
Sum	2.27E+08	32051.20	86716773	22047897	981.8542
Sum Sq. Dev.	6.97E+14	1705494.	1.01E+14	7.83E+12	180.8773
Observations	88	88	88	88	88

V.I Unit Root Test Results

To examine the existence of stochastic non-stationarity in the series, the paper tests for the order of integration of the individual time series through the unit root tests using the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP), which are stated in their generic form as follows:

Augmented Dickey Fuller (ADF) Specification for Unit Root

It involves the estimation of one of the following three equations respectively, (Seddighi et al, 2000):

$$\Delta X_t = \beta X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t ...(6)$$

$$\Delta X_t = \alpha_0 + \beta X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t ...(7)$$

$$\Delta X_t = \alpha_0 + \alpha_1 t + \beta X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t ...(8)$$

The additional lagged terms are included to ensure that the errors are uncorrelated. The maximum lag length begins with 4 lags and proceeds down to the appropriate lag by examining the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC). The null hypothesis is that the variable X_t is a non-stationary series (H_0: $\beta = 0$) and is rejected when β is significantly negative (H_a: $\beta<0$). If the calculated ADF statistic is higher than McKinnon's critical values, then the null hypothesis (H_0) is rejected and the series is stationary or integrated of order zero I(0). Alternatively, non-rejection of the null hypothesis implies non-stationarity leading to the conduct of the test on the difference of the series until stationarity is reached and the null hypothesis is rejected.

Phillips-Perron (PP) Specification for Unit Root

Phillips and Perron (1988) use a nonparametric method to correct for the serial correlation of the disturbances. The test is based on the estimate of the long run variance of residuals. Their modification of the Dickey and Fuller Γ test is called Z(Γ) test. The critical values for ΓΓ and Z(ΓΓ) are the same if the residuals are generated by an independent and identical process. Although the Phillips and Perron tests and the Dickey and Fuller tests provide identical results, the power of the (Augmented) Dickey and Fuller tests is more than the Phillips and Perron tests in the presence of negative moving average components.

The variables tested are eg, ex, k, l and ec, respectively. The results presented in Table 3 below indicate that all the variables are non-stationary at levels. However, they became stationary after first difference, which implies that they are I(1) series. Given the unit-root properties of the variables, we proceeded to establish whether or not there is a long-run cointegrating relationship among the variables in equation (4) by using the Johansen full information maximum likelihood method[1]

Table 3: ADF and PP Unit Root Tests

Variable	**ADF**			**Phillips-Perron**		**Remarks**
	Level	**1st Difference**	**Remarks**	**Level**	**1st Difference**	
Leg	-2.250476	-3.987933**	I(1)	-2.070532	-11.61805***	I(1)
Lex	-3.142940	-6.814432***	I(1)	-2.701184	-6.818778***	I(1)
Lk	-2.122008	-8.037026***	I(1)	-2.445566	-8.043679***	I(1)
Ll	0.943855	-8.730856***	I(1)	-0.921993	-8.736158***	I(1)
Lec	-2.078418	-2.601688***	I(1)	-1.342622	-5.146492	I(1)

Note: *** and ** indicates that the variables are significant at 1 per cent and 5 per cent levels, respectively.

[1] The Johansen/Juselius approach produces asymptotically optimal estimates because it incorporates a parametric correction for serial correlation (which comes from the underlying vector autoregression (VAR)) and the system nature of the estimator means that the estimates are robust to simultaneity bias. Moreover, the Johansen method is capable of detecting multiple cointegrating relationships (if they exist) and it does not suffer from problems associated with normalization.

V.II Cointegration Test using Johansen-Juselius Technique

The cointegration tests are undertaken based on the Johansen and Juselius (1990) maximum likelihood framework. The essence is to establish whether long-run relationships exist among the variables of interest. Before conducting the cointegration test, the appropriate optimal lag-length that would give standard normal error terms that do not suffer from non-normality, autocorrelation and heteroskedasticity was determined. Eight (8) lags (since the study uses quarterly data and there are large numbers of observations) were allowed at the beginning. The Schwarz information criterion (SIC) was favoured in line with the literature because it takes into consideration the parsimoniousness of the model and has a more stringent theoretical backing (Mordi, 2008). At the end, a lag order of four was chosen after testing the residuals for normality and autocorrelation and is found to be satisfactory.
The results of the test show that that there exists at least one cointegrating relation in the model as both the trace ($\lambda - trace$) and maximum eigen ($\lambda - \max$) statistics reject the null of $r \leq 0$ against the alternative of $r \geq 1$ at the 5 per cent level of significance. This is indicative of at least one cointegrating vector in the model which drives the relationship toward equilibrium in the long-run (see the Table below). The conclusion drawn from table 4 is that there is a long-run relationship between eg, ex, k, l and ec. The economic interpretation of the long-run economic growth function can be obtained by normalizing the estimates of the unconstrained cointegrating vector on economic growth. The parameters/long-run elasticities of the cointegrating vector for the long-run economic growth are presented in equations (9). The normalised cointegrating vector with the highest log likelihood was used as an error-correction term (ecm) in the overparameterised error correction model, which was refined to derive the parsimonious model. The error correction term (as indicated in equation (10) is *akin* to the residual generated from the static regression when the Engle-Granger (E-G) two-step approach is adopted.

Table 4: Unrestricted Cointegration Rank Test **Result**
Sample (adjusted): 1990:4 2011:4
Included observations: 85 after adjustments
Series: LEG LK LL LEC LEX
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.439472	100.3003	76.97277	0.0003
At most 1	0.228690	51.09586	54.07904	0.0899
At most 2	0.162036	29.02432	35.19275	0.1985
At most 3	0.113930	13.99802	20.26184	0.2895
At most 4	0.042782	3.716508	9.164546	0.4560

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.439472	49.20447	34.80587	0.0005
At most 1	0.228690	22.07154	28.58808	0.2708
At most 2	0.162036	15.02630	22.29962	0.3729
At most 3	0.113930	10.28151	15.89210	0.3094
At most 4	0.042782	3.716508	9.164546	0.4560

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The normalised cointegrating vector with the highest log likelihood is expressed as:

$$leg - 0.290482lk - 3.720429ll - 1.031532lec - 0.477429lex + 11.29056............(9)$$

And the ecm is written as:

$$ecm = leg + 0.290482lk + 3.720429ll + 1.031532lec + 0.477429lex - 11.29056................(10)$$

V.III Vector Error Correction Model (VEC) Framework

The results indicate that the variables in the economic growth model in equation (4) tend to move together in the long-run as predicted by economic theory. In the short-run, deviations from this relationship could occur due to shocks to any of the variables. In addition, the dynamics governing the short-run behavior of economic growth are different from those in the long-run. Due to this difference, the short-run interactions and the adjustments to long-run equilibrium are important because of the policy implications. According to Engle and Granger (1987), if cointegration exists between nonstationary variables, then an error-correction representation of the type specified by equation (11) below exists for these variables. Given the fact that the variables of the economic growth equation are cointegrated, the next step is the estimation of the short-run dynamics within a vector error correction model (VECM) in order to capture the speed of adjustment to equilibrium in the case of any shock to any of the independent variables.

V.IV Over-parameterised Error-Correction Model

The generalized specification framework of the over-parameterised VEC model is expressed below:

$$\Delta ly_t = \delta_0 + \sum_{i=1}^{k-1} \delta_i \Delta ly_{t-i} + \sum_{i=0}^{k-1} \delta_i \Delta lk_{t-i} + \sum_{i=0}^{k-1} \delta_i \Delta ll_{t-i} + \sum_{i=0}^{k-1} \delta_i \Delta lec_{t-i} + \sum_{i=0}^{k-1} \delta_i \Delta lex_{t-i} + \Omega ecm_{t-1} + \varepsilon_t ....(11)$$

where:

Δ indicates the first difference of a series.

$\delta_0, \delta_1, \delta_2, \delta_3, \delta_4 and \Omega$ are parameters of the model to be estimated.

“i” is the number of lags included for the first difference of both the dependent and independent variables. In the estimations, the optimal lag-length for the dependent and explanatory variables in the models was four.

ecm_{t-1} is the lagged error correction term and t represent time period. The error term, ε_t of equation (5) has the same explanations as that in equation (4) as earlier discussed while Ω is expected to be less than one, negative and statistically significant. The negative sign of the ecm_{t-1} term indicate long-run convergence of the model to equilibrium as well as explaining the proportion and the time it takes for the disequilibrium to be corrected during each period in order to return the disturbed system to equilibrium.

The result of the over-parameterised error correction model for economic growth is presented in the appendix as Table 5. Although the model seems fairly well estimated, it cannot be interpreted in this present form.

As is the tradition, the over-parameterised models were reduced to achieve parsimonious models, which are data admissible, theory-consistent and interpretable. Parsimony maximizes the goodness of fit of the model with a minimum number of explanatory variables. The reduction process is mostly guided by statistical considerations, economic theory and interpretability of the estimates (Adam, 1992). Thus, our parsimonious reduction process made use of a stepwise regression procedure (*through the elimination of those variables and their lags that are not significant*), before finally arriving at interpretable models. Tables 6 presents the results of the parsimonious error-correction model and the parameter estimates would be discussed to determine their policy implications.

Table 6: Parsimonious Error-Correction Model of Economic Growth

Dependent Variable: D(LEG)
Method: Least Squares
Date: 09/04/12 Time: 00:33
Sample (adjusted): 1991:1 2011:4
Included observations: 84 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.315028	0.102429	3.075581	0.0029
D(LEG(-1))	-0.316845	0.104839	-3.022209	0.0034
D(LEG(-2))	-0.451460	0.113900	-3.963658	0.0002
D(LK(-2))	0.027395	0.039870	0.687115	0.4941
D(LEC(-3))	0.020054	0.329099	0.060935	0.9516
D(LEX(-1))	0.155078	0.064172	2.416611	0.0181
D(LEX(-2))	0.143647	0.067860	2.116822	0.0376
D(LEX(-3))	0.110051	0.064752	1.699562	0.0934
ECM(-1)	-0.008636	0.003686	-2.342737	0.0218

R-squared	0.303044	Mean dependent var	0.059428
Adjusted R-squared	0.228702	S.D. dependent var	0.121158
S.E. of regression	0.106406	Akaike info criterion	-1.542161
Sum squared resid	0.849161	Schwarz criterion	-1.281716
Log likelihood	73.77075	Hannan-Quinn criter.	-1.437464
F-statistic	4.076352	Durbin-Watson stat	2.231576
Prob(F-statistic)	0.000453		

VI. Analysis of Findings

The result show that all the explanatory variables are positively related to economic growth, except the first and second quarter lags of economic growth. In the same vein, all the explanatory variables are significant, except the second quarter lag of capital and third quarter lag of electricity consumption. The result indicates that each of them conforms to economic theory, using Nigerian data.

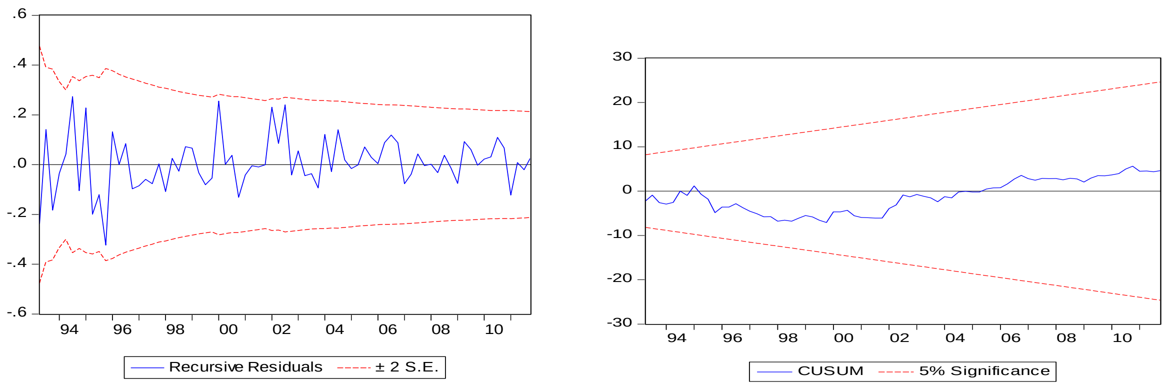
The error correction term (ECM) indicates that 0.9 per cent of the previous quarter's disequilibrium from long-run equilibrium is corrected for within a quarter. In other words, the coefficient of the error correction term which measures the speed of adjustment back to equilibrium whenever the system is out of equilibrium indicates that adjustment is quite slow. The parsimonious model indicates that economic growth in a particular quarter is determined by the second and third quarter lags of capital and electricity consumption as well as the first, second and third lags of exports.

One per cent increase in the first and second quarter of economic growth will lead to 0.32 and 0.45 per cent decline in economic growth. In contrast, capital and electricity consumption have the right signs, however they are not significant. While 1.0 per cent increases in first, second and third quarter lags of exports lead to 0.16, 0.14 and 0.11

per cent rise in economic growth in the short-run and the coefficients are rightly signed and significant at the 5.0 per cent level.

Figure 1 below depicts the recursive residual and cusum which stays within the boundaries of *+/- 2S.E.* and 5 per cent significance level.

Figure 1: Recursive residual and Cusum



VII. Recommendations and Conclusion

VII.I Recommendations

- Though the energy sector is capital intensive, government is encouraged to sustain and enhance energy infrastructure through the issuance of licenses to the private sector for operations of such facilities;
- Increased funding in the sector through public and private sector partnership with the aim of tackling the investment problem is recommended;
- In the diversification of energy sources, the use of wind energy, biofuel and natural gas should be considered in productive activities.

VII.II Conclusion

The paper adopts the modified endogenous growth theory as its theoretical framework and makes use of a VECM framework as the econometric methodology. The paper established a positive relationship between electricity consumption, exports and economic growth. The importance of these variables cannot be overemphasized in the determination of economic growth in Nigeria. In particular, electricity consumption serves as the backbone in the economic development of Nigeria. The speed of adjustment of the model from the short-run to the long-run equilibrium state was found to be low.

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Appendix 1

Table 5: Estimates of overparameterised error correction model for economic growth

Dependent Variable: D(LEG)
Method: Least Squares
Date: 09/04/12 Time: 00:05
Sample (adjusted): 1991:2 2011:4
Included observations: 83 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.362474	0.175430	2.066207	0.0431
D(LEG(-1))	-0.373651	0.133608	-2.796632	0.0069
D(LEG(-2))	-0.362657	0.132956	-2.727655	0.0083
D(LEG(-3))	-0.225220	0.133881	-1.682235	0.0976
D(LEG(-4))	0.401372	0.123674	3.245404	0.0019
D(LK(-1))	0.020072	0.037563	0.534351	0.5950
D(LK(-2))	0.020781	0.037784	0.550003	0.5843
D(LK(-3))	-0.010910	0.037550	-0.290542	0.7724
D(LK(-4))	-0.099813	0.037189	-2.683961	0.0094
D(LL(-1))	-1.167035	2.267502	-0.514679	0.6086
D(LL(-2))	-1.044720	2.268359	-0.460562	0.6468
D(LL(-3))	-0.045742	2.276477	-0.020094	0.9840
D(LL(-4))	-0.287087	2.278619	-0.125992	0.9002
D(LEC(-1))	-0.216501	0.360540	-0.600492	0.5504
D(LEC(-2))	0.133955	0.395246	0.338916	0.7358
D(LEC(-3))	0.233196	0.394299	0.591420	0.5564
D(LEC(-4))	-0.275201	0.355731	-0.773620	0.4421
D(LEX(-1))	0.164990	0.061721	2.673170	0.0096
D(LEX(-2))	0.129216	0.064968	1.988919	0.0512
D(LEX(-3))	0.182963	0.066294	2.759866	0.0076
D(LEX(-4))	-0.147592	0.068632	-2.150497	0.0355
ECM(-1)	-0.009989	0.005658	-1.765485	0.0825

R-squared	0.533513	Mean dependent var	0.058778
Adjusted R-squared	0.372919	S.D. dependent var	0.121747
S.E. of regression	0.096410	Akaike info criterion	-1.618261
Sum squared resid	0.566988	Schwarz criterion	-0.977122
Log likelihood	89.15782	Hannan-Quinn criter.	-1.360687
F-statistic	3.322121	Durbin-Watson stat	2.016435
Prob(F-statistic)	0.000133		

Appendix 2: Long-Run Static Regression

Dependent Variable: LEG
Method: Least Squares
Sample: 1990:1 2011:4
Included observations: 88

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LK	0.128081	0.028746	4.455562	0.0000
LL	4.403210	0.439932	10.00884	0.0000
LEC	0.351097	0.097466	3.602241	0.0005
LEX	0.415484	0.051683	8.039050	0.0000
C	-5.553391	0.683286	-8.127477	0.0000

R-squared	0.988436	Mean dependent var	13.92790
Adjusted R-squared	0.987879	S.D. dependent var	1.498540
S.E. of regression	0.164985	Akaike info criterion	-0.710781
Sum squared resid	2.259271	Schwarz criterion	-0.570023
Log likelihood	36.27437	Hannan-Quinn criter.	-0.654073
F-statistic	1773.594	Durbin-Watson stat	0.546456
Prob(F-statistic)	0.000000		