Relationship between Electricity Consumption and Economic Growth: Evidence From Nigeria (1971-2012)

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Abstract

Few scholars disagrees that electricity consumption is an important supporting factor for economy growth. However, the relationship between electricity consumption and economy growth has different manifestation in different countries according to previous studies. This paper examines the causal relationship between electricity consumption and economic growth for Nigeria. In an attempt to do this, the paper tests the validity of the modernization or depending hypothesis by employing various econometric tools such as Augmented Dickey Fuller (ADF) and Johansen Co-integration test, the Error Correction Mechanism (ECM) and Granger Causality test on time series data from 1971-2012. The Granger causality is found not to run from electricity consumption to real GDP and from GDP to electricity consumption during the year of study. The null hypothesis is accepted at the 5 per cent level of significance where the probability value (0.2251 and 0.8251) is greater than five per cent level of significance because both of them are probably determined by some other factors like; increase in urban population, unemployment rate and the number of Nigerians that benefit from the increase in GDP and increase in electricity demand is not determined by the increase in GDP (income) over the period of study because electricity demand has always been greater than consumption. Consequently; the policy makers in Nigeria should place priority in early stages of reconstruction on building capacity additions and infrastructure development of the electric power sector as this would force the sustainable economic growth in Nigeria.

Keywords: *Economic growth, Electricity consumption, Error Correction Mechanism (ECM) and Granger Causality test.*

1. Introduction

Electricity is the most flexible form of energy and constitutes one of the critical resources for modern life and economic growth of any nation (Enebeli, 2010). Economic growth results from growth in three factors: capital input, labour input and productivity. The relationship between use of energy and economic growth has been a subject of greater inquiry as energy is considered to be one of the important driving forces of economic growth in all economies (Pokharel, 2006). The importance of energy in production was neglected until 70's and although energy is seen as an outside variable, two petroleum crises that took place in 1973 and 1979 caused energy to be included in production function as inside variable (Karagol, Erbaykal, and Ertugrul, 2007). These incidents showed that economic growth is closely related with the use of energy and caused economy to be defined within the context of energy (Jobert and Karanfil, 2007). According to Sheng-Tung, Hsiao-I and Chi-Chung (2007) the relationship between energy consumption and economic growth has been widely discussed since Kraft and Kraft (1978) found evidence of a uni-directional causal relationship running from GNP to energy consumption in the US using data over the 1947–1974 periods. Toman and Jenelkova (2003) as reported by Costantini and Martini (2009) argue that most of the literature on energy and economic development discusses how development affects energy use rather than vice versa. This strand of literature considers economic growth as the main driver for energy demand and only advanced economies with a high degree of innovation capacity can decrease energy consumption without reducing economic growth.

From the publication of the seminal paper of Kraft and Kraft (1978), as reported by Kiran and Guris (2009) the results of studies in this field can be summarized into three main categories, each of which has important implications in energy policy: (1) no causality, (2) uni-directional causality, (3) bi-directional causality between energy consumption and economic growth. We can divide the uni-directional causality results into two types: electricity consumption causes economic growth and (b) economic growth causes electricity consumption.

The main objective of this study is to find out if the economic impact of electricity consumption helps to increase economic growth. To achieve this purpose, we will try to explore the possible existence of causality relationship between electricity consumption and economic growth either it has bi-directional, unidirectional causality or no causality.

2. Review of Previous Studies

The directions that the causal relationship between electricity consumption and economic growth could be categorized into four types each of which has important implications for electricity policy. First, the uni-directional causality running from electricity consumption to economic growth implies that restrictions on the use of electricity may adversely affect economic growth while increases in electricity may contribute to economic growth (Altinay and Karagol, 2005; Shiu and Lam, 2004). Second, the uni-directional causality running from economic growth to electricity consumption would suggest that the policy of conserving electricity consumption may be implemented with little or no adverse effect on economic growth, such as in a less energy-dependent economy. Furthermore, a permanent increase in economic growth may result in a permanent increase in electricity consumption (Ghosh, 2002). Third, a bi-directional causal relationship implies that electricity consumption and economic growth are jointly determined and affected at the same time (Jumbe, 2004; Yoo, 2005). Finally, the absence of a causal relationship implies that electricity consumption is not correlated with economic growth, which means that neither conservative nor expansive policies in relation to electricity consumption have any effect on economic growth.

Many studies have recently focused on investigating the causal relationship between electricity consumption and economic growth in developing countries to confirm national electricity policies as shown in Table 1. However, we find that such studies lead to mixed results that in turn give rise to some heated discussions regarding the effect of electricity conservation policies on economic growth in developing countries. For example, Yoo (2005), Jumbe (2004), Morimoto and Hope (2004) and Yang (2000) found that bi-directional causality existed between electricity consumption and economic growth in Korea, Malawi, Bangladesh and Taiwan. On the other hand, Shiu and Lam (2004) showed that there was uni-directional causality running from electricity consumption to economic growth in China without any feedback effect, as did Altinay and Karagol (2005), Wolde-Rufael (2004), Aqeel and Butt(2001) and Narayan and Singh (in press) and in the case of Turkey, Shanghai, Pakistan and Fiji. Moreover, Ghosh (2002) found evidence of unidirectional causality running from economic growth to electricity consumption in India. In addition to these, Murry and Nan (1996) and Wolde-Rufael (2006) found that there are diverse causality between economic growth and electricity consumption in different countries.

These studies show that the results regarding the causal relationship between electricity consumption and economic growth are sometimes conflicting and mixed across different countries when time-series analysis is applied to a single country data set shown in Table 1. These diverse results arise due to the different data set, alternative econometric methodologies and different countries' characteristics (Al-Iriani, 2006).

The actual causality is different in the different countries might be due to different countries' characteristics such as different indigenous energy supplies, different political and economic histories, different political arrangements, different institutional arrangements, different cultures, different energy policies, corruption etc. For example, Yoo, 2006 (in press) indicates that the absence of causal relationship from electricity consumption to economic growth in Indonesia and Thailand is understandable in view of the fact that a considerable part of electricity in the two countries has been actually consumed for basic human life, with the remainder going for economic activities that can induce an increase in real GDP. Any increase in electricity consumption will not significantly affect real GDP in Indonesia and Thailand.

Table 1: Summary of the Empirical Results from Causality Tests between Electricity Consumption and GDP for Developing Countries

Authors	Countries	Methodology	Time Period	Causality relationship
Altinay and Karagol (2005)	Turkey	Standard Granger causality test	1950–2000	Electricity-Income
Aqeel and Butt (2001)	Pakistan	Hsiao's version of Granger causality method	1955–1996	Electricity-Income
Ghosh (2002)	India	Standard Granger causality test	1950–1997	Income-Electricity
Jumbe (2004)	Malawi	Granger causality and Error-correction model	1970–1999	Electricity-Income
Morimoto and Hope (2004)	Sri Lanka	Standard Granger causality test	1960–1998	Electricity-Income
Mozumder and Marathe (in press)	Bangladesh	Cointegration test and vector error correction model	1971–1999	Income-Electricity
Murry and Nan (1996)	India	Standard Granger causality test	1970–1990	No causality
Murry and Nan (1996)	Colombia	Standard Granger causality test	1970–1990	Income-Electricity
Murry and Nan (1996)	Pakistan	Standard Granger causality test	1970–1990	Electricity-Income
Narayan and Singh (in press)	Fuji	Standard Granger causality test and Cointegration test	1971–2002	Electricity-Income
Shiu and Lam (2004)	China	Error-correction model	1971–2000	Electricity-Income
Wolde-Rufael (2004)	Shanghai, China	A modified version of Granger causality (Toda and Yamamoto, 1995)	1952–1999	Electricity-Income
Wolde-Rufael (2006)	Senegal	A modified version of Granger causality (Toda and Yamamoto, 1995) and Cointegration test	1971–2001	Income-Electricity
Wolde-Rufael (2006)	Nigeria	A modified version of Granger causality (Toda and Yamamoto, 1995) and Cointegration test	1971–2001	Income-Electricity
Yang (2000)	Taiwan	Standard Granger causality test	1954–1997	Electricity-Income
Yoo (2006)	Singapore	Standard Granger causality test and Hsiao's version of Granger causality	1971–2002	Electricity2Income

Note: Income-Electricity means that the causality runs from electricity consumption to income. Electricity-Income means that the causality runs from income to electricity consumption. Electricity to Income means that bi-directional causality exists between electricity consumption and income.

3. An Overview of the Nigerian Electricity Sector

The electricity demand in Nigeria far outstrips the supply and the supply is epileptic in nature. The country is faced with acute electricity problems, which is hindering its development notwithstanding the availability of vast natural resources in the country. It is widely accepted that there is a strong correlation between socio-economic development and the availability of electricity. The history of electricity in Nigeria dates back to 1896 when electricity was first produced in Lagos, fifteen years after its introduction in England. Despite the fact that its existence in the country is over a century, its development has been at a slow rate. In 1950, a central body was established by the legislative council, which transferred electricity supply and development to the care of the central body known as the Electricity Corporation of Nigeria, now defunct. Other bodies like Native Authorities and Nigeria Electricity Supply Company (NESCO) have licenses to produce electricity in some locations in Nigeria. There was another body known as Niger Dams Authority (NDA) established by an act of parliament.

The Electricity Corporation of Nigeria (ECN) was established in 1951, while the first 132KV line was constructed in 1962, linking Ijora Power Station to Ibadan Power Station. The Niger Dams Authority (NDA) was established in 1962 with a mandate to develop the hydropower potentials of the country. However, ECN and NDA were merged in 1972 to form the National Electric Power Authority (NEPA). In 1998, NEPA ceased to have an exclusive monopoly over electricity generation, transmission, distribution and sales. Kainji Hydro Power Station located in Niger State along the River Niger is the first Hydro Power Station in the country. The generating units are listed in table 2. Electricity production by source in Nigeria was 61.90% fossil fuel, 38.10% hydro, 0% nuclear and 0% others (see figure 1).

The Energy Commission of Nigeria (ECN) was established by Act No. 62 of 1979, as amended by Act No. 32 of 1988 and Act No. 19 of 1989, with the statutory mandate for the strategic planning and co-ordination of national policies in the field of energy in all its ramifications. By this mandate, the ECN is the government organ empowered to carry out overall energy sector planning and policy co-ordination. As part of its contribution to the resolution of the problems of the electricity sector along the line of its mandate, the ECN has been collaborating with the International Atomic Energy Agency (IAEA) under an IAEA regional project titled “Sustainable Energy Development for Sub-Saharan Africa (RAF/0/016)”

As part of the restructuring, the Electric Power Sector Reform Act 2005 was enacted. Subsequently, the defunct NEPA is currently known as Power Holding Company of Nigeria (PHCN). The reform act paved way for the unbundling of NEPA into 18 companies: 6 generating companies, 1 Transmission Company and 11 distributing companies. The generating companies are made up of 2 hydro and 4 thermal (gas based) stations. Of recent, PHCN has an installed capacity of about 6000MW through a number of hydro (Kainji, Jebba, Shiroro), and thermal stations (Egbin, Ughelli, Afam, Sapele). The transmission voltage levels are 330KV for the grid transmission; 132KV for the sub-transmission lines, whilst the 33KV, 11KV and lower voltages constitute the distribution networks. The System normal frequency is 50Hz. Most of these electricity plants in country are underutilized or not functioning (Enebili, 2010).

The Challenges facing the electricity Sector includes:

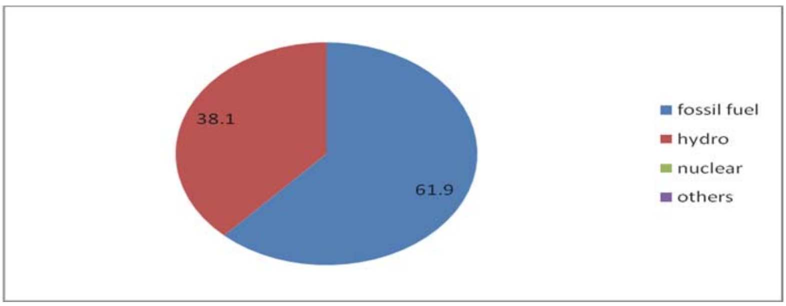
- Electricity generation capacity in excess of 8,000 MW, while electricity supply is inadequate at just about 3,000 MW now.
- The rate at which new power plants are added to into the system is very low.
- The new licenses of NERC have not made appreciable progress due to problems of bankability of proposals, agreements on power purchase and securitization.
- Coal and Renewable energy resources are grossly underutilized in the country despite their availability in reasonable quantities.
- Natural gas supply is grossly inadequate for the existing gas power

Table 2: Details of the Power Generation Stations

Power Station	State	Generating Capacity	Year Of Commission
Kainji Hydro	Niger	4x80MW	1968
		2x10MW	1976
		2x120MW	1978
Jebba Hydro	Kwara	6x95MW	1986
Shiroro Hydro	Niger	1x150MW	1989
		3x150MW	1990
Afam Thermal	Rivers	2x10.5MW	1965
		2x17.5MW	1965
		4x23.9MW	1976
		4x27MW	1978
		6x75MW	1982
Delta Thermal	Delta	2x36MW	1966
		6x20MW	1975
		6x20MW	1978
		1x100MW	1989
		5x100MW	1990
Egbin Thermal	Lagos	2x220MW	1985
		2x220MW	1986
		2x220MW	1987
Sapele Thermal	Delta	6x120MW	1978
		4x75MW	1981
Ijora Thermal	Lagos	3x20MW	1978
Oji Thermal	Enugu	2x5MW	1956
		2x10MW	1956

Source: Central Bank of Nigeria (2009)

Figure 1: Electricity Production by source 2008



Source: CIA World Factbook, July 12, 2011

4. An Overview of Nigeria Economy

Nigeria is the most populous country in sub-Saharan Africa, with an estimated 170.1237 (World Bank, 2012 est.) people, nearly triple the population of South Africa and more than one-fifth of the continent's total population. Economic performance of the country since Independence in 1960 has been decidedly unimpressive. It is estimated that Nigeria received over US$300 billion from oil exports between the mid 1970's and 1999 (Okezie and Amir, 2011), and yet the number of Nigerians living in abject poverty subsisting on less than $1 a day more than doubled between 1970 and 2012, and the proportion of the population living in poverty rose from 36% to 70% over the same period. At official exchange rates, Nigeria's per capita income of US$260 in 2000 was precisely one-third of its level in 1980. World Bank 2005 as reported by (Iyoha, 2007).

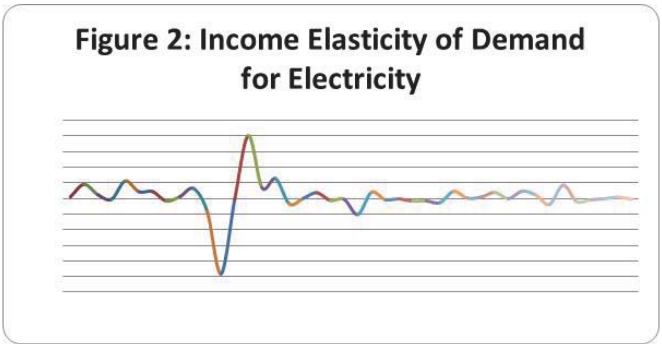
According to Wikipedia (2012) the economy of Nigeria is a middle income, mixed economy emerging market with well-developed financial, legal, communications, transport, and entertainment sectors. It is ranked 31st in the world in terms of GDP (PPP) as of 2012, and its emergent, though currently underperforming manufacturing sector is the second-largest on the continent, producing a large proportion of goods and services for the West African region. Previously hindered by years of mismanagement, economic reforms of the past decade have put Nigeria back on track towards achieving its full economic potential. Nigerian GDP at purchasing power parity more than doubled from $170.7 billion in 2005 to $374.3 billion in 2010, although estimates of the size of the informal sector (which is not included in official figures) put the actual numbers closer to $520 billion. Correspondingly, the GDP per capita doubled from $1200 per person in 2005 to an estimated $2,500 per person in 2009 (again, with the inclusion of the informal sector, it is estimated that GDP per capita hovers around $3,500 per person). It is the largest economy in the West Africa Region, 3rd largest economy in Africa (behind South Africa and Egypt), and on track to becoming one of the top 30 economies in the world in the early part of 2012.

Table 2. GDP, Electricity Consumption and Electricity Production

Year	Rate of Growth in GDP	Rate of Growth in Electricity consumption	Rate of Growth in population	Rate of Growth in Inflation	Rate of Growth in Unemployment	Rate of Growth in Labour Force	Demand Elasticity	% Change in Urban Population
1971	11.8	6.5	2.4	13.0	10.4	2.7	0.6	7.9
1972	3.8	17.3	2.4	-79.4	-62.3	2.6	4.5	1.4
1973	8.5	10.5	2.5	68.8	60	2.5	1.2	1.3
1974	19.9	-4.5	2.5	148.1	93.8	2.5	-0.2	1.3
1975	7.7	43.1	2.7	152.9	-22.6	2.4	5.6	0.5
1976	7.3	16.0	2.8	-37.5	-10.4	2.7	2.2	1.5
1977	8.1	18.2	2.9	-27.4	-51.2	2.7	2.2	0.9
1978	-7.3	5.7	3.1	7.8	290.5	2.6	-0.8	0.8
1979	2.5	1.5	3.1	-28.9	26.8	2.9	0.6	0.9
1980	5.3	17.1	3.0	-16.1	-25	3.5	3.2	1.2
1981	5.5	-23.2	2.9	111.1	-16.7	2.0	-4.2	1.3
1982	-2.7	65.1	2.7	-63.2	-35.4	3.0	-24.1	1.4
1983	-7.0	2.4	2.6	201.3	-19.0	2.6	-0.3	1.6
1984	-1.1	-22.1	2.5	70.7	114.7	2.8	20.1	1.6
1985	9.5	32.9	2.5	-86.1	12.3	2.8	3.5	1.7
1986	2.5	15.9	2.6	-1.8	-35.4	2.4	6.4	1.4
1987	-0.5	0.9	2.6	88.9	33.9	2.6	-1.7	1.7
1988	7.3	0.2	2.6	275.5	-28.2	2.5	0.0	1.3
1989	7.7	14.3	2.6	6.8	-19.6	2.5	1.9	1.6
1990	13.0	-7.9	2.6	-81.7	65.9	2.4	-0.6	1.6
1991	-23.0	5.5	2.5	73.3	-39.7	2.9	-0.2	1.7
1992	-0.6	3.1	2.5	242.3	-21.9	2.8	-5.1	0.4
1993	7.3	14.9	2.5	28.5	68.8	2.5	2.0	-0.5
1994	7.7	-2.9	2.4	-0.3	-59.3	3.4	-0.4	-0.4
1995	18.8	-1.8	2.4	27.7	-18.2	3.1	-0.0	-0.4
1996	4.4	-3.7	2.4	-59.8	111.1	3.0	-0.8	-0.3
1997	2.8	-2.1	2.4	-70.9	-5.3	2.9	-0.8	-0.6
1998	2.9	-3.8	2.4	17.6	-11.1	2.8	-1.3	-0.2
1999	0.4	0.9	4.8	-34	-6.3	2.7	2.3	-0.2
2000	5.4	0.8	2.4	4.5	833.3	2.4	0.1	-0.3
2001	8.4	4.0	2.4	139.1	0	2.8	0.5	-0.3
2002	21.3	42.0	2.5	-26.7	-99	2.5	2.0	-0.3
2003	10.2	-0.1	2.5	96.7	9900	2.8	-0.0	-0.2

2004	10.5	24.4	2.5	-57.9	-57.9	2.9	2.3	-0.4
2005	6.5	7.3	2.5	16	0.8	0.4	1.1	0
2006	6.0	-11.3	2.5	-26.7	-75.6	0.4	-1.9	-0.2
2007	6.4	27.6	2.5	-22.4	100	0.4	4.3	-0.2
2008	6.0	-5.9	2.5	128.8	0	0.4	-1.0	-0.2
2009	7.0	-2.6	2.5	-23.8	103.4	0.2	-0.4	-0.4
2010	7.9	-0.6*	2.5	19.1	66.9	0	-0.1	0.4
2011	7.4	3.5*	2.6	-21.1	7.1	0	0.5	-0.1
2012	6.6	-1.6*	4.7	12.9	13.3	0	-0.2	-0.1

S**ource:** International Monetary Fund – 2011; World Bank, 2005, 2007& 2012; International Energy Agency, 2012, CIA World Factbook, 2012 CBN Statistical Bulletin 2010; **: Projected by author



Using historical aggregate data on Nigeria real gross domestic (GDP) and electricity consumption (kilowatt-hours) from 1971 to 2012, the responsiveness of electricity demand to growth in real GDP was derived. In economic theory, this responsiveness is known as elasticity of demand. The income elasticity of demand for electricity measures the percentage change in electricity demand, in response to a percentage change in the country's real GDP. The figures are shown in Table2, and graphically presented in figure 2.

The line in figure 2 represents the historical income elasticity of demand for electricity. It was positive elastic growth in 1971-1973, 1975-1977, 1978, 1981-1983, 1987-1988, 1990-1992, 1994-1998, 2003, 2006, 2008-2010 and 2012 (see table 2). This shows that an increase in income (GDP) resulted to a greater increase in the consumption of electricity. In 1972, 1974, 1978, 1981-1983, 1987, 1990-1992, 1994-1998, 2003, 2006, 2008-2010 and 2012 however, as presented in Table 2, show a negative elasticity growth in electricity demand. The negative sign was driven by the negative growth in real GDP in the years listed above. This is explained by the economic crisis faced by Nigeria in the late-1970s and early 1980s which was triggered by the fall in the price of oil. In 2003, the GDP grew by 10.2% but demand elasticity for electricity was negative (-0.2%) showing that the growth was not as a result of the sector that employs up to 40% of the workforce. The rate of GDP growth and electricity consumption is represented in figure 3.

The reasons for the declining elasticity of electricity demand in relation to GDP may have more to do with the change in the number of people leaving in the urban areas. In 2006, the GDP grew by 6% but the rate of electricity consumption had a negative growth (-0.0) and the income elasticity of demand for electricity had a negative elasticity (-1.9) while the percentage of the population leaving in the urban areas decreased by 0.2% and it is believed that almost all the people leaving in the urban areas have access to electricity (figure 4).

Figure 3: The rate of GDP growth and electricity consumption

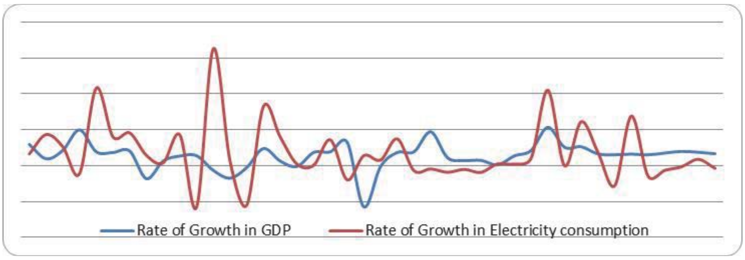
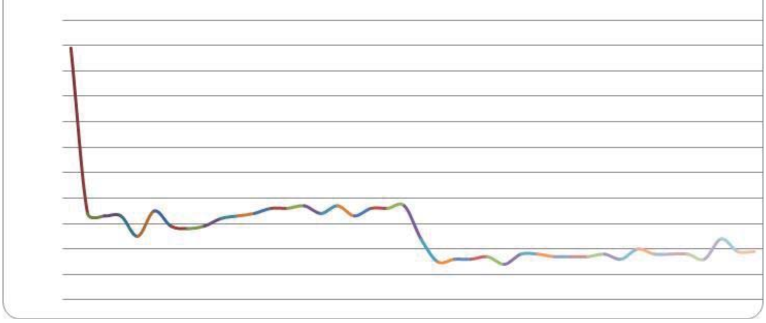


Figure 4: % Change in Urban Population



5. Data and Econometric Methodology

5.1 Data and Variables

Time series data on real GDP, total commercial energy consumption, unemployment rate, labour force, inflation rate and population over the period 1971-2012 is used to investigate the causal relationship between electricity consumption and economic growth. The real GDP data, measured at constant 1990 prices and denominated in Naira, and inflation rate are extracted from the Central Bank Statistical Bulletin (2009), while 2010-2012 was gotten from World Bank (2012). The total electricity consumption data, expressed in terms of kilo-watt hours (kwh), total population, unemployment rate and labour force are obtained from the World bank (2012). All the data are presented in Fig. 5, 6, 7 & 8.

5.2 Econometric Methodology

The time series data present a number of methodological problems. It is convenient to estimate relationships through the regression method only if the series are stationary. In the context of a time series, "stationary" refers to a condition wherein the series have constant mean and constant variance. Most of the time series data reflect trend, cycle and/or seasonality. These deterministic patterns must be removed to make the series stationary Kamal (2008). Time series that are not stationary and whose properties have not been subjected to an examination could produce invalid inferences. The coefficient determination (R^2) measures the variability in dependent variable explained by the independent variable. High value of R^2 will likely give rise to spurious regression (Granger and Newbold 1974). To examine the Granger causality between electricity consumption and real GDP, as well as between electricity consumption and GDP, the following methodology has been adopted.

5.3 Co-Integration Test

Co-integration analysis and error correction models have become the standard techniques for the study of electricity demand. Engle and Granger (1987) applied both techniques to forecast electricity demand. Since 1987, subsequent developments related to this approach have relied on the use of new techniques to identify co-integrating relationships. Johansen's method is the latest improvement on the theory of co-integration as applied in long-run analysis of time series data.

The concept of co-integration has become popular in recent years. It states that if a long-run relationship exists between two variables, then the deviations from the long-run equilibrium path should be bounded. If this is the case, the variables are said to be co-integrated. For variables to be co-integrated, two conditions must be satisfied: the series for the individual variables must have the same statistical properties, and the variables must be integrated in the same order. If a series is stationary after differencing once, it is said to be integrated of order one or I (1).

When using time series data, the test of unit root is very important for determining stationarity. Stationarity tests which determine the unit root in a series are proposed by Dickey and Fuller (1981). The standard approach to test for non-stationarity of each observed time series (Y observed over T time periods (Y_t)) is to estimate an augmented Dickey Fuller (ADF) test regression, as shown below.

We consider a simple autoregressive (AR) (1) process:

$$Y_t = pY_{t-1} + X_t\delta + \varepsilon_t \quad (1)$$

Where X_t represent optional regressors that may consist only of a constant, or a constant and trend; ρ and δ are parameters to be estimated; and ε_t are assumed to be white noise. If | ρ | ≥ 1, y is a non-stationary series and the variance increases with time and approaches infinity. If | ρ | ≥ 1, y is a (trend-) stationary series. Thus, the hypothesis of (trend-) stationarity can be evaluated by testing whether the absolute value of ρ is strictly less than one.

The ADF test is carried out by estimating equation (1) after subtracting Y_{t-1} from both sides of the equation:

$$\Delta Y_t = \alpha Y_{t-1} + X_t \ \delta + \varepsilon_t \quad (2)$$

Where α = ρ – 1. The null and alternative hypotheses may be written as:

H_0: α = 0 and H_1: α < 0

The simple Dickey Fuller unit root test described above is valid only if the series is an AR (1) process. If the test does not provide enough basis to reject the null hypothesis, then the series are said to be level stationary. This would imply that they satisfy the condition to construct a co-integration system.

If the series are integrated of the same order, a static regression in the levels of the variables is run and tested to see if linear combinations of the variables are themselves integrated of the same order as the individual variables. If the variables are co-integrated, then there should exist a linear combination of these variables which is integrated of order one less than the individual variables. In the co-integrating regression

$$Y_t = b_0 + b_1 X_t + u_t \quad (3)$$

If Y→I(n) and X→I(n), then Y and X are said to be co-integrated if u_t→I (n-1). In equation (3), b_1 measures the long-run relationship between Y and X, and u is the divergence from the equilibrium path. If there is a long-run relationship between Y and X, then the divergence from it should be bounded. Engle and Granger (1987) argue that if co-integration holds, then the error correction model is a valid representation of the adjustment process.

5.4 Granger causality test

The Granger (1969) approach to the question of whether X causes Y is to determine how much of the current Y can be explained by past values of Y, and then to see whether adding lagged values of X can improve the explanation. Y is said to be Granger-caused by X if X helps in the prediction of Y, or if the coefficients on the lagged Xs are statistically significant. Note that two-way causation is frequently the case: X Granger causes Y and Y Granger causes X.

It is important to note that the statement "X Granger causes Y" does not imply that Y is the effect or the result of X. Granger causality measures precedence and information content but does not of itself indicate causality in the more common use of the term. It is better to use more rather than fewer lags in the test regressions, since the Granger approach is couched in terms of the relevance of all past information.

It is necessary to pick a lag length, l, which corresponds to reasonable beliefs about the longest time over which one variable could help predict the other. If two series are co-integrated, then a Granger causality test must be applied to determine the direction of causality between the variables under consideration.

The following equations are used to determine the causality:

$$\Delta Y_t = \alpha + \sum_{i-1}^{k} \beta_1 \Delta Y_{t-1} + \sum_{i-1}^{k} \gamma_i \Delta X_{t-1} + \mu \quad (4)$$

$$\Delta X_t = \alpha + \sum_{i-1}^{k} \beta_1 \Delta X_{t-1} + \sum_{i-1}^{k} \psi_i \Delta X_{t-1} + \mu \quad (5)$$

Where Y_t and X_t are defined as Y and X observed over t time periods; Δ is the difference operator; k represents the number of lags; α, β, ψ and γ are parameters to be estimated; and μ represents the serially uncorrelated error terms. The test is based on the following hypotheses:

H_0: $\gamma_i = \psi_i = 0$ for all i's

H_1: $\gamma_i \neq 0$ and $\psi_i \neq 0$ for at least some i's.

At this point, it is necessary to examine the criteria for causality. The hypothesis would be tested by using t-statistics. If the values of the γ_i coefficient are statistically significant but those of the ψ_i are not, then X causes Y (X→Y). On the contrary, if the values of the ψ_i coefficients are statistically significant but those of the γ_i coefficients are not, then Y causes X (Y→X). If both γ_i and ψ_i are significant then there exists bidirectional causality between X and Y (X→Y).

Figure 5: Nigeria Real GDP

Figure 6: Electricity Power Consumption (Kwh)

Figure 7: Inflation Rate and Unemployment Rate

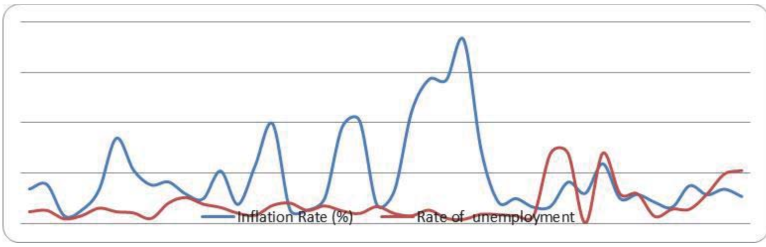
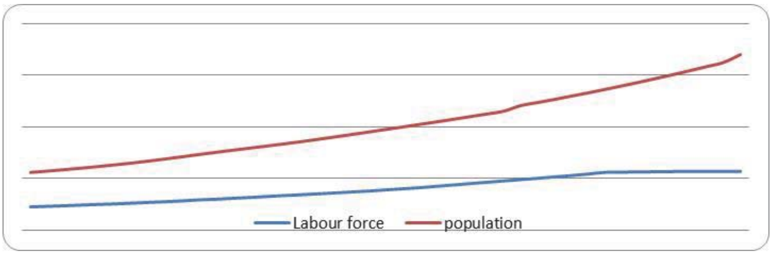


Figure 8: Nigeria Labour Force and Population



5.5 Model Specification

Taking inference from the empirical findings and theories, which has been derived from the theoretical exposition of the exogenous growth theories and then making electricity consumption central to the equation, a model will be drawn up to determine economic growth in Nigeria context. If electricity consumption is taken as an independent variable then the model can be stated as:

$$Y = f(E, I, UM, L,)$$

Where;
Y= Real GDP
E= Electricity Consumption
I= Inflation rate
UM= Unemployment
L= Labour force
Rewriting the model above in a linear form, we obtain:

$$RGDP_t = \alpha_0 + \alpha_1 E_t + \alpha_2 I_t + \alpha_3 U_t + \alpha_4 L_t + U_t$$

Priori expectations:

$$\alpha_1 > 0, \alpha_2 > 0, \alpha_3 > 0, \alpha_4 0$$

Where; a1 to a4 represents the slope coefficients, a0 is the intercept, *Ut* is the stochastic term or the error term at time t.

5.6 Data Analysis and Presentation

To examine the relationship between Real GDP, electricity consumption, inflation rate, unemployment rate and labour force in Nigeria, a two-step procedure is adopted as stated in the methodology. The first step investigates the time series properties of the data. The second step explores the casual relationship between real GDP, unemployment, labour force, inflation rate, total population and electricity consumption. The first step is an important one because, according to

Engel and Granger (1987), if the series are integrated of order one, in the presence of cointegration, VAR estimation in the first differences will be misleading.

If the series are stationary, then standard Granger's causality test should be employed. But if the series are non-stationary and cointegrated, VECM approach should be adopted. To determine the time series properties, recently developed minimum LM unit root test with two structural breaks is applied to the natural logs of the series. The LM unit root test has two main advantages. One of them is that this test is the most flexible unit root test in terms of the number of breaks at unknown time. Another advantage is that this test permits to avoid the problem of spurious rejections of the null hypothesis in the presence of unit root with breaks. We need to take into account the structural breaks because there are important energy crises in the past history of Nigeria.

Table 3: Unit root test

Variable	Levels	First difference	Second difference	Probability
	ADF	ADF	ADF	
RGDP	-0.104829	-5.308060		0.0000
E	-0.045176	-8.723965		0.0001
INF	-3.250545	-6.469096		0.0000
UM	-3.889001	-		0.0241
LF	-1.456096	-	-7.331354	0.0000

Note that Augmented dickey fuller (ADF) is used here instead of Dickey fuller (DF) because the ADF is more sophisticated in testing for stationarity of variables. Significant at 5%, ** Significant at 10% UM it is stationary at level

6. Analysis of Results

6.1 Unit Root Test

The ADF test was used in most of the studies of the present paper to examine the unit root in the set of five series comprising the relationships between electricity consumption, inflation rate, unemployment rate, labour force and real GDP. In the level form the ADF test supports the hypothesis that all five series under consideration are non-stationary. However, in the first difference all become stationary. The ADF test for the data of first difference indicates that the five series under consideration are all of order I(1). However, the labour force variable is second difference stationary, or I(2). The ADF coefficients in the level and first difference are reported in table 3.In Table 3 it is observed, using the ADF, that the variables are stationary at 5% levels with the exception of Unemployment which is stationary at level. Subject to first difference, we notice that all the variables are significant (stationary) either at 5% or 10%.

6.2 Co-integration test

The empirical findings of Johansen co-integration tests (table 4) reveal that both the Eigen and Trace tests indicate the existence of a consistently co-integrating vector or long-run equilibrium relation among variables during the sample period of 1971-2012. When the values of the test were estimated, linear deterministic trend was assumed. The lag interval in first differences is three.

Table 4: Unrestricted Co-Integration Rank Test

Null hypothesis (H_0)	Alternative hypothesis (H_1)	Maximum Eigen statistics	Trace Statistics	0.05 Critical Value (Eigen)	0.05 Critical Value (Trace)
r = 0	r = 1	48.96587	111.4739	33.87687	69.81889
r = 1	r = 2	34.03359	62.50799	27.58434	47.85613
r = 2	r = 3	21.33354	28.47440	21.13162	29.79707
r = 3	r = 4	6.574353	7.140858	14.26460	15.49471
r = 4	r = 5	0.566505	0.566505	3.841466	3.841466

The trace test indicates that there are two co-integrating equations at the 5 per cent level. Moreover, the maximum Eigen value test indicates two co-integrating equations at 5 per cent level. More specifically, table 4 shows that at the 5 per cent level of significance the likelihood ratios (trace statistics) for the null hypothesis having no (r = 0), one (r = 1) co-integrations (111.4739 and 62.50799) are higher than the critical values (69.81889 and 47.85613). The likelihood ratios of having two, three and four co-integrating relationships (28.47440, 7.140858 and 0.566505) are less than the critical values (29.79707, 15.49471 and 3.841466). At the 5 per cent level of significance, the maximum Eigen value statistics for the null hypothesis having no, one and two co-integrations (48.96587, 34.03359 and 21.33354, respectively) are higher than the critical values (33.87687, 27.58434 and 21.13162).

The maximum Eigen value statistics of having three and four co-integrating relationships (7.140858 and 0.566505, respectively) are less than the critical values (14.26460 and 3.841466). Hence, according to likelihood ratio and maximum Eigen value statistics tests, electricity consumption and GDP, inflation rate and GDP, unemployment rate and GDP and labour force and GDP series are co-integrated. Thus, a long-run equilibrium relationship between these series is co-integrated.

6.3 Durbin Watson (DW)

The DW measures for the presence of autocorrelation in the model. However, it is noticed that the model is free from autocorrelation since the DW Statistic observed in the model is 2.02 which is approximately 2. This means that the model is reliable in explaining the economic growth in Nigeria.

6.4 Granger causality test

The series are stationary, that is why standard Granger's causality test is employed using Pair wise Granger Causality Tests using two lag periods. The results of Granger causality electricity consumption, inflation rate, unemployment rate, labour force and real GDP as well as the computed F values and their respective probabilities for the data of those series during the period 1971-2012 with specific period, as calculated through equations (4) and (5), are presented in table 6. To assess whether the null hypothesis is to be accepted or rejected, a significance level of 0.05 (5%) per cent is chosen.

The Granger causality is found not to run from electricity consumption to real GDP and from GDP to electricity consumption. The null hypothesis is accepted at the 5 per cent level of significance in table 6 where the probability value (0.2251 and 0.8251) is greater than five per cent level of significance. Both results were calculated using two lag periods. In terms of inflation, the Granger causality is found not to run from inflation to electricity consumption. The null hypothesis of "inflation does not Granger cause electricity consumption and there is no bi-directional feedback. The null hypothesis is accepted at the 5 per cent level of significance in table 6 where the probability value (0.4673 and 0.2106) is greater than five per cent level of significance. The null hypothesis “labour force does not Granger cause electricity consumption” is accepted in table 6, where the probability value is 0.1694 and 0.2464 is greater than five per cent level of significance.

Turning to unemployment, the Granger causality is found to run from unemployment to electricity consumption. There is bi-directional feedback. The null hypothesis of “unemployment does not Granger Cause electricity consumption” is rejected at the 5 per cent level of significance in table 6 where the probability value is 0.0134 and 0.4170 is less than five percent level of significance which is expected. The null hypothesis “inflation does not Granger Cause real GDP” is accepted where the probability value is 0.5115 and 0.2509 is greater than five percent level of significance. With probability of 0.6633 and 0.5630, it indicates that labour force does not Granger Cause real GDP, as the value of the test statistic is not significant at 5 percent level of significance in table 6.

The null hypothesis “unemployment does not Granger Cause real GDP” is rejected where the probability value is 0.05146 and 0.6154 is less than ten percent level of significance. With probability of 0.2955 and 0.6633, it indicates that labour force does not Granger Cause inflation, there is no bidirectional causality as the value of the test statistic is not significant at 5 percent level of significance in table 6. The null hypothesis of “Unemployment does not Granger Cause inflation” is rejected at the 5 per cent level of significance, where the value of probability is 0.6572 and 0.9219 is higher than the alpha value. The null hypothesis “unemployment does not Granger cause labour force” is also accepted because the probability value 0.0038 is less than the significant level of 5% and the null hypothesis that labour force is does not granger cause unemployment is rejected because the probability value 0.9299 is greater than the significant value of 5% in table 6.

Table 6: Pair wise Granger causality test results

Null Hypothesis:	Obs	F-Statistic	Prob.
DGDP does not Granger Cause DELCON	39	1.55863	0.2251
DELCON does not Granger Cause DGDP		0.19340	0.8251
DINF does not Granger Cause DELCON	39	0.77796	0.4673
DELCON does not Granger Cause DINF		1.63161	0.2106
DLF does not Granger Cause DELCON	39	1.87128	0.1694
DELCON does not Granger Cause DLF		1.46031	0.2464
UNEM does not Granger Cause DELCON	39	4.90701	0.0134
DELCON does not Granger Cause UNEM		0.89748	0.4170
DINF does not Granger Cause DGDP	39	0.68376	0.5115
DGDP does not Granger Cause DINF		1.44041	0.2509
DLF does not Granger Cause DGDP	39	0.41550	0.6633
DGDP does not Granger Cause DLF		0.58432	0.5630
UNEM does not Granger Cause DGDP	39	3.17152	0.0546
DGDP does not Granger Cause UNEM		0.49255	0.6154
DLF does not Granger Cause DINF	39	1.26396	0.2955
DINF does not Granger Cause DLF		0.41550	0.6633
UNEM does not Granger Cause DINF	39	0.42504	0.6572
DINF does not Granger Cause UNEM		0.08155	0.9219
UNEM does not Granger Cause DLF	39	6.60891	0.0038
DLF does not Granger Cause UNEM		0.07283	0.9299

The causality test results for the null hypotheses that electricity consumption does not Granger-cause GDP, and that GDP does not Granger-cause electricity consumption are reported in Table 6. The Granger test results show that there is bidirectional causality between electricity consumption and GDP in Nigeria. A bi-directional causal relationship has significant implications for energy conservation and economic development, and implies that electricity consumption and GDP are jointly determined and affected at the same time. The increase in electricity consumption results in an increase in economic growth, while a permanent increase in economic growth results in a permanent increase in electricity consumption within the period of study in Nigeria.

7. Conclusion

There is a large and growing literature on the relationship between electricity consumption and GDP. This study has investigated the relationship between electricity consumption, inflation rate, unemployment rate, labour force and real GDP in Nigeria during the period of 1971–2012. The causality running from electricity consumption to income (GDP) can be interpreted that electricity consumption precedes the economic growth in Nigeria. The two variables, in fact, cannot be directly related, because both of them are probably determined by some other factors like; increase in urban population, the number of Nigerians that benefit from the increase in GDP.

The study carried out by Wolde-Rufael (2006) using A modified version of Granger causality (Toda and Yamamoto, 1995) and Cointegration test on the relationship between electric consumption and income in Nigeria (1971-2001), show that causality runs from electricity consumption to income . Enebili (2010) in his own study on the causality analysis of Nigerian electricity consumption and economic growth (1979-2008) also show empirically the existence of Granger causality running from economic growth to electricity consumption without any feedback effect. The two findings are not in line with my findings.

The difference in the findings might be due to different years of study, but going by our findings, increase in electricity demand is not determined by the increase in GDP (income) over the period of study because electricity demand has always been greater than consumption. In this case, an increase in electricity consumption can be viewed as a leading indicator of growing economy. This implies that the supply of electricity is vitally important to meet the growing electricity consumption, hence to sustain the economic growth in Nigeria.

Finally, we want to emphasize the importance of this type of studies in terms not only of the amount of literature that has been published, but also of how policy makers have used them. In particular, the US Department of Energy requested a report in 1986 (Committee on Electricity in Economic Growth (1988)) on the relationship between economic growth and electricity to design development programs and suitable incentives for the private sector. We believe this is also necessary in Nigeria to meet the challenges in the near future, such as the Electric Power Sector Reform Act 2005 which ended government monopoly and created institutions to build a power sector in which the private sector will become a key partner in development.

References

Al-Iriani, M.A., (2006). Energy–GDP relationship revisited: an example from GCC countries using panel causality. Energy Policy 34 (17), 3342–3350.

Altinay, G., Karagol, E., (2005). Electricity consumption and economic growth: evidence from Turkey. Energy Economics 27, 849–856.

Burcu K. and Burak G. (2009). Relationship between electricity consumption and GDP in Turkey. Problems and Perspectives in Management, Volume 7, Issue 1.

Dickey, D.A. and Fuller, W.A. (1981). "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica,* vol. 49, pp. 1057-1072.

Enebeli, E.E. (2010). Causality Analysis of Nigerian Electricity Consumption and Economic Growth. Journal of Economics and Engineering, ISSN: 2078-0346, №4, December.

Energy information Administration (2011). Country Analysis Brief, Nigeria Last Updated: August.www.eia.doe.gov.

Engle, R.F. and Granger, C.W.J. (1987). "Co-integration and error correction: representation, estimation and testing", *Econometrica,* vol. 55, No. 2, pp. 251-276.

Ghosh, S., 2002. Electricity consumption and economic growth in India. Energy Policy 30, 125–129.

Granger, C.W.J. (1969). "Investigating causal relations by econometrics models and cross spectral methods", *Econometrica,* vol. 37, pp. 424-438.

Granger, C.W.J. and Newbold, P. (1974). "Spurious regressions in econometrics", *Journal of Econometrics,* vol. 2, No. 2, pp. 111-120.

Iyoha, M. A. (2007). Leadership, Policy-Making and Economic Growth in African Countries: The Case of Nigeria.

Jobert, T. and Karanfil, F. (2007), "Sectoral Energy Consumption by Source and Economic Growth in Turkey", *Energy Policy*, 35: 5447 – 5456.

Jumbe, C.B.L. (2004). Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi. Energy Economics 26, 61–68.

Kamal, R.D. (2008). A Causal Relationship between Energy Consumption and Economic Growth in Nepal *Asia-Pacific Development Journal Vol. 15, No. 1, June.*

Karagol, E., Erbaykal, E., Ertugrul, H.M. (2007), "Turkiye'de Ekonomik Buyume ile Elektrik Tuketimi Iliksisi: Sinir Testi Yaklasimi", *Dogus Universitesi Dergisi*, 8(1): 72 – 80.

Morimoto, R., Hope, C., 2004. The impact of electricity supply on economic growth in Sri Lanka. Energy Economics 26, 77–85.

Murry, D.A., Nan, G.D. (1996). A definition of the gross domestic product–Electrification interrelationship. The Journal of Energy and Development 19 (2), 275–283.

Okezie, C and Amir, B. (2011). Economic crossroads: The experiences of Nigeria and lessons from Malaysia. *Journal of Development and Agricultural Economics* Vol. 3(8), pp. 368-378, August.

Sheng-Tung, C. Hsiao-I K. and Chi-Chung, C. (2007). The relationship between GDP and electricity consumption in 10 Asian countries. Energy Policy 35; 2611–2621

Shiu, A., Lam, P.L. (2004). Electricity consumption and economic growth in China. Energy Policy 32, 47–54 should know about unit roots. In:. Toda, H.Y., Phillips, P.C.B., 1993. Vector autoregressions and causality. Econometrica 61, 1367–1393.

Wolde-Rufael, Y. (2004). Disaggregated industrial energy consumption and GDP: he case of Shanghai. Energy Economics 26, 69–75.

Wolde-Rufael, Y. (2006). Electricity consumption and economic growth: a time series experience for 17 African countries. Energy Policy 34, 1106–1114.

www.cia.gov/library/publications/the-world-factbook/geos/ni.html

Yang, H.Y. (2000). A note of the causal relationship between energy and GDP in Taiwan. Energy Economics 22, 309–317.

Yoo, S.H. (2005). Electricity consumption and economic growth: evidence from Korea. Energy Policy 33, 1627–1632.

Yoo, S. H. (2006). The causal relationship between electricity consumption and economic growth in the ASEAN countries. Energy Policy, in press.