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Electricity Consumption and Economic Growth in Nigeria: A Multivariate Investigation

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ABSTRACT

There is a lingering puzzle as to whether electricity consumption has positive, negative or neutral impact on economic growth and also regarding the direction of causation between them. This study examines this relationship in the case of Nigeria. The study introduces capital formation as well as labor stock in a multivariate system for the period covering 1990-2011. Augmented Dickey Fuller test and Philip Perron unit roots test; Johansen test for co integration, vector error correction and Granger causality test are employed. The result of the study shows unidirectional causality from electricity consumption to real gross domestic product. The long run estimates however, supports the Granger causality tests by revealing that electricity consumption is positively related with real gross domestic product in the long run. Investigation further indicates that there is unidirectional causality from capital formation to real gross domestic product. This implies that Nigeria- being a country highly dependent on energy- will have capital formation's contribution to the economy relatively determined by adequate electricity.

Keywords: *Electricity consumption, Economic growth, Stationarity, Vector Error Correction Mechanism, Causality, Nigeria*

1. INTRODUCTION

The advanced and developed economies of the world today would not have been what they are today without relying on one form of energy or the other for their rapid growth recorded. According to Mulegeta et al [1], energy consumption is an indispensable component in growth, directly or indirectly as a complement to capital and labor as an input in the production process as shown by the growth hypothesis. Yet, studies have shown that the relationship between energy consumption and economic growth remains indeterminate in terms of the direction of the causal relationship and their long run as well as short run relationships.

In Nigeria, electricity is one of the major forms of energy driving production and facilitating services. It is a flexible form of energy and a highly demanded resource for modern life. It is a vital infrastructural component of economic growth. In all economies, households and companies have extensive demand for electricity. This demand is driven by several important factors such as industrialization, extensive urbanization, population growth, rising standard of living. One of the key policy objectives of any nation is to promote a sustainable economic growth process that could improve the living standard of the people.

Several policies have come and gone as an attempted act for policy makers to decide on what approach to pursue- whether to attend to growth issues, which would in turn lead to increased electricity consumption or to emphasize on electricity consumption in order to attain higher income levels. But with the inclusion of the classical production propellers i.e. capital and labor stock, the augmentable capacity of electricity consumption and economic growth can be determined.

Electricity consumption plays an important role in economic growth of Nigeria. It is, therefore important to identify the relationship between electricity consumption and national output and also the direction of causality in order to get a better understanding of the vital related issues and also determine if the results are ideal for policy formulation. The impact and causation of electricity consumption on economic growth in Nigeria has however being studied in several existing literatures, but in relationship with variables ranging from foreign direct investment to energy use and so on. This study is to however analyze the influence of other variable on the initial relationship i.e. electricity consumption and economic growth

This study is divided into five sections. Section one of this study is the introductory part. The rest of the study is organized into another five sections. Section two is the literature review section, where we present relevant literature that will give us sound conception of the fact. The section three provides an avenue regarding research methodological approach and the relevant information on the time series data sets that are used for this study, while section four discusses the empirical results. Finally, section five provides the conclusion that will point out the possible policy recommendations of the study.

2. ELECTRICITY CONSUMPTION IN NIGERIA: STYLIZED FACTS

Nigeria is a populous nation of 162 million and has a land area of 923,768 sq. km. Nigeria is made up of 36 states and the Federal Capital Territory (FCT). Access to energy, and specifically electricity, is a driving force behind economic and social development. Energy exists in various forms and has its sources such as coal, oil and gas. Electricity on the other hand is an efficient, safe and easily distributed energy transporter. Dependable and

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affordable access to electricity is essential for improving public health, providing modern information and education services, and saving people from subsistence tasks, such as gathering fuel. Electricity is widely consumed in the residential, industrial and commercial sectors in Nigeria but the sector is characterized by power shortages, poor quality supply and low voltage. Although, consumption has been on the increase over the years, partly due to the convenience of use and population growth, the supply has been inadequate.

Electricity in itself is not an energy source but can be used to transport energy from one point to another using the grid. Electricity as one of the commercial energy forms in Nigeria is inadequate to meet the demands of the ever increasing population. It currently constitutes less than 1% to the country's GDP and the demand for electricity is more than the supply. Less than 40% of the population has access to electricity and the power sector suffers from high energy losses (30-35%) and a low collection rate of money owed to the power supplier. This is due mainly to ageing and broken equipment, vandalisation of equipment and poor management associated with public enterprises in Nigeria. Another problem has been the fact that the low prices of energy (due to subsidy from the government) has to an extent made energy affordable but has also resulted in inadequate revenue to cover costs and finance expansion of supply. The unreliability of energy supplies brings about an economic burden on the nation and because electricity supply is generally of poor quality, it discourages the use of efficient technologies that are usually dependent on high quality energy supplies.

The National Bureau of Statistics notes that not only is electricity generation in Nigeria characterized by excess capacity and inadequate supply, but that peak demand is often about one-third of installed capacity. The inadequate supply is mainly because of the non-availability of spare parts and poor maintenance of the system. Another reason is the fluctuation in water level powering the hydro plants. According to the CIA [2], Nigeria produced 18.62 billion kWh of electricity with an installed capacity of 5.9 million Kw but consumed 17.66 billion kWh in 2009. The transmission network is overloaded, with poor voltage resulting in low current in most parts of the network. The technologies used generally deliver very poor voltage stability and profile.

Electricity generation is mainly from the thermal power plants, which make up for 77% with two-thirds from natural gas and the rest from oil. The hydroelectricity constitutes 23%, however, according to IEA [3], the amount generated reduced from 8.2 billion KWh in 2002 to 4.5 billion KWh in 2009. This has been due to the trend in the climate change leading to fluctuation in the water level.

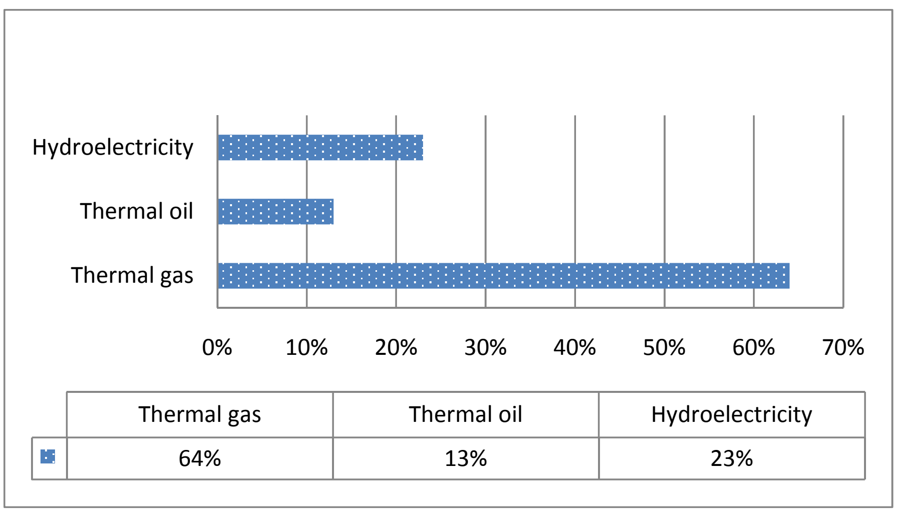

Fig 1: Total installed electricity net generation in Nigeria by type, 2009
Source: IEA, 2010

There was, however, an improvement of 1.8% in the electric power generation in 2011compared to 2010 attributed to increased gas supplies to the thermal stations [4]. The increased supply from the generating stations allowed for the increase in electricity in the same year.

3. REVIEW OF RELATED STUDIES

In the theoretical literature, there is a growing distinction between the mainstream growth literature and the ecological economics literature. While the former investigates whether limited energy and other resources could be a constraint on growth, the latter puts forward that the role of energy in driving growth cannot be emphasized, however, that limits to substitutability and or technological change might limit or reverse growth in the future. However, the mainstream growth models that ignore energy resources can at least partly explain economic growth over the last half a century.

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There are currently two principal mainstream theories that explain the growth regimes of both the pre-industrial and modern economies and the cause of the industrial revolution, which formed the transition between them. The endogenous technical change approach, represented by Galor and Weil [5], emphasizes the role of human capital and fertility decisions in the transition. The rate of technological change in Galor and Weil's model is a function of the size of the population and the level of education. Initially there is a low technological change and education steady-state equilibrium. As population grows, a second high technological change and education equilibrium emerges, which eventually is the only equilibrium. The second approach, represented by Hansen and Prescott [6],models the slow transition from a stagnating traditional economic sector (the Malthusian Sector) to a modern economic sector that experiences sustained economic growth (the Solow Sector). The "Malthusian Sector" depends on a land input and has decreasing returns to combined labor and capital. The modern "Solow Sector" does not use land and has constant returns to capital and labor combined.

In the empirical literature, there have been conflicting evidences with respect to the nature of the relationship between energy consumption and growth. This is largely due to chosen methods of estimation, variables as well as period of study, etc. Odhiambo [7] applied autoregressive distributed lag (ARDL) bounds test approach and Granger non-causality test to examine the type of relationship between the variables in Tanzania within the period 1971-2006. Results from the study show a unidirectional causality running from energy (and electricity) consumption to economic growth. However, Mehrara [8] considers 11 oil-exporting countries for the period 1971-2002 where the author looks at the relationship between the per capita energy consumption and per capita GDP on the basis of panel data. The results show a unidirectional causality from economic growth to energy consumption for all the countries. In another study conducted by Shunyun and Donghua [9], the causal relationship between energy consumption and economic growth is considered for the period 1985-2007 and this was captured within a multivariate framework by applying fully modified OLS (FMOLS), the results indicate the presence of bidirectional relationship between energy consumption and economic growth.

4. METHODOLOGY

4.1 Model Specification and Data

This study follows a neo-classical one-sector aggregate production model, which was proposed by Ghali and El-Sakka [10] that treats capital, labor, electricity as separate inputs. This is represented below as;

$$RGDP_t = [CAPITAL_t, LABOUR_t, ELECTRICITY_t] \quad (1)$$

Where RGDP is the real general output; CAPITAL represents the gross capital stock; LABOUR is the total level of employment; ELECTRICITY is total electricity consumption, and the subscript **t** denotes the time period. The study computes per capita form of the variables by dividing through by the total population and then taking the logarithmic form of (1). This results in:

$$\mathbf{0}RGDP_t = \alpha(\mathbf{0}CAPITAL)_t + \beta_1(\mathbf{0}LABOUR)_t + \beta_2(\mathbf{0}ELECTRICITY)_t \quad (2)$$

To keep all the concerned variables on the same unit of measurement, the 0 before each variable converts that variable to its per capita state. The parameters; α, β_1 and β_2, measures the augmenting effects of capital, labor and electricity respectively on RGDP. EQN (1) suggests that long-run movements of the variables may be related [10]. Furthermore, for short-run dynamics in factor-input behavior, the model specification in (2) implies that past changes in variables such as capital, labor and electricity could contain useful information for predicting the future changes of output, ceteris paribus. Therefore, causality tests can be employed to determine the relationship among the concerned variables.

4.2 Data: Sources and Proxy

The annual data of real gross domestic product per capita (RGDP), labor stock per capita and gross capital formation (which was subsequently divided by population figure from WDI to arrive at the per capita figures), are in US dollars (2000=100) were all sourced from the World Bank data bank. These studies also used gross capital formation (CAPITAL) to proxy the stock of physical capital, total labor stock (LABOR), to proxy the level of labor and electricity consumption to proxy the usage of electricity.

4.3 Estimation Techniques

Although the Ordinary Least Square (OLS) technique can be utilized in determining the relationship between electricity consumption and economic growth, it has long been avoided for such non-stationary variables in order to avoid spurious regression. Therefore most past empirical studies make use of causality test in collaboration with a co integration test, in estimating the relationship with between electricity consumption and economic growth as in [10]

However, the estimation techniques adopted in this study include the employment of co integration test to examine the long-run equilibrium influence of some the concerned independent variables on economic growth in Nigeria and then subsequently adjust for short-run shocks or disequilibrium with the aid of the vector error correction mechanism (VECM). The use of this method employs a single reduced form equation, rather than using systems of equations to estimate long run relationship.

5. RESULTS AND FINDINGS

5.1 Diagnostic Test: Stationarity Test

In the course of this study, the Augmented Dickey-Fuller (ADF) as well as the Philips Perron (PP) test for stationarity was employed to test for stationarity in the variables.

The Augmented Dickey-Fuller lag selection is based on the Schwarz Information Criterion (SIC) with a maximum lag of 2. The Philip Perron test is estimated based on Bartlett kernel with Newey-West bandwidth. Generally, the specifications of the tests include intercept and trend; critical values are based on Mackinnon [11] and the null hypothesis is that of no stationarity. The stationarity test (unit root) carried out for the concerned variables revealed that some of the variables are I (2) variables (i.e. integrated 2). Therefore, they are not stationary at levels, but at second differences. We are however able to reject the null hypothesis of the presence of unit root.

Table 1: Summary of the Unit Root Tests

VARIABLES	ADF	PP	ORDER OF INTEGRATION	MAX. NO OF LAGS
RGDP	-5.881498	-7.116728	I(2)	2
CAPITAL	-6.641629	-11.49453	I(2)	2
LABOR	-4.908481	-4.935383	I(2)	2
ELECTRICITY	-6.882692	-25.03296	I(2)	2

Source: authors' computation

5.2 Co integration

The results of the Johansen test for co integration, together with critical values of Mackinnon-Haug-Michelis [12] are reported in table 2. The Johansen test for both trace statistics and maximum-Eigen statistics indicates that there are co integrating relationships. In as much as the Trace Statistics or the Maximum-Eigen Statistics surpasses the critical values, we reject any of the hypothesized numbers of co integrating equations. For example, at none, we reject the null hypothesis that there are no co integrating equations. At most 1, we also reject the null hypothesis that the highest number of co integrating equations present, is one. Therefore, in this analysis, there are 4 co integrating equations in the system.

Table 2: Summary of the co integration test result

Variables	LNGDP LNCAPITAL LNLABOUR LNELECTRICITY						
HYPOTHESIZED No OF CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.	Max-Eigen Statistics	0.05 Critical Value	Prob.
None*	0.939288	112.1950	47.85613	0.0000	53.23080	27.58434	0.0000
At most 1	0.831463	58.96418	29.79707	0.0000	33.83139	21.13162	0.0005
At most 2	0.583468	25.13279	15.49471	0.0013	16.64006	14.26460	0.0207
At most 3	0.360447	8.492730	3.841466	0.0036	8.492730	3.841466	0.0036

Source: authors' computation

5.3 Error Correction Estimation Result

The purpose of the Johansen co integration test carried out earlier was to show why the OLS method is often avoided. The VECM however makes adjustments for short run shocks and dynamics in the model, and also keeps the variables at their stationary levels. From the result in table 3, we can see that only labor has a negative relationship with real GDP in the long-run. Capital and electricity on the other hand shows positive relationships with real GDP in the long-run.

Table 3: Summary of the Vector Error Correction Mechanism

Error Correction		Dependent Variable: D(LNGDP)	
		Coefficient	t-value
Coint. Eq1	D(LNCAPITAL(-1))	0.025546	0.907689
	D(LABOUR(-1))	-4.611238	1.181093
	D(ELECTRICITY(-1))	0.136274	2.058496

Source: authors' computation

5.4 Causality

The result of the causality test as shown above in table 4 is the Granger Causality Test/Block Exogeneity Test that states the null hypothesis as zero causality. The table also shows the chi-square values, as well as the probability values. The latter is represented by the values in parenthesis. We therefore reject the null hypothesis that capital does not granger cause GDP, as long as p < c.v. where p represents the p-values and c.v. represent the MacKinnon critical values at 1%, 5%, 10%. For example, the movement of causality from capital to real GDP shows that granger causes real GDP at 5% level of significance, and therefore, we can reject the null hypothesis and therefore conclude that capital granger causes real GDP.

Table 4: Summary of the Granger Causality Test/Block Exogeneity Test Results

Equations	D(LNGDP)	D(LNCAPITAL)	D(LNLABOUR)	D(LNELECTRICITY)
D(LNGDP)		1.550344 (0.4606)	24.68173 (0.0000)	0.184430 (0.9119)
D(LNCAPITAL)	1.137966 (0.5661)		16.30470 (0.0003)	1.818582 (0.4028)
D(LNLABOUR)	2.264745 (0.3223)	0.741647 (0.6902)		2.976882 (0.2257)
D(LNELECTRICITY)	7.247282 (0.0267)	0.154170 (0.9258)	2.921967 (0.2320)	

Source: authors' computation

6. CONCLUSIONS AND RECOMMENDATIONS

Summarily, the results of this study may be interpreted to mean that Nigeria is a highly energy dependent country. This is not surprising as the economy depends on electricity for its industrial activities. Thus, improving electricity could improve income generation. Furthermore, the results suggest a unidirectional causality from labor stock to real gross domestic product, with the coefficient of labor stock being negative and insignificant in the long run. Thus, we interpret this to mean that labor stock will have adequate impact on the economy if there is adequate electricity supply in the economy. From the foregoing, it is obvious that electricity policy that focuses on securing the long- term supply will naturally spur sustainable growth of economic activities. In this regard, the authorities in Nigeria should intensify the issue of diversification of electricity sources and management. Solar energy is described as a viable alternative to other sources of electricity. One additional benefit of solar energy is that it is cheaper to generate locally. Diversification into solar energy will reduce the dependence of Nigeria dependence on crude electricity sources.

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