The Determinants of Electricity Demands in Nigeria from 1970-2016 Error Correction Mechanism Approach

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Abstracts
This research work seeks to examine the determinants for electricity demand in Nigeria via ADF, PP unit root testing and Johansen Co-integration techniques covering the period 1970-2015 with the objectives of ascertaining the relationship between electricity demand and economic growth. ELED was the dependent variables, while IPC, PPE, DU, PD, LD, NHP, NMP and ERP served as the independent variables. all the variables were stationary at first difference with ADF and PP, with the exception of ERP being at level. The study found the existence of a unique co-integrating relationship among the variables in the model using the trace statistics, which led us to determine the ECM, where three variables (PD, NMP, NHP) were significant at the short run, the remaining five (IPC, PPE, DU, LD, ERP) were not significant in the short run to explain ELED. The ECM coefficient divulges that the disequilibrium in the country is corrected at the speed rate of 118.8% annually, while all the coefficient of the independents variables conforms with the a prior expectations with 0.006384, 0.49117, 0.92357, 0.130045, 1.42573, 4.74446 for IPC, DU, PD, LD, NHP, NMP and ERP respectively. Prominent among the policy recommendation, is the need for government to undertake a guided process of liberalizing the electricity sector to allow new entrants into the market for competitiveness and improved efficiency as the insignificance of the electricity price.
Keywords: Electricity Demand, Domestic Output, Economic Growth.

INTRODUCTION

Energy has been an important resource for socio-economic growth in Nigeria. Energy exists in different systems like, mechanical, electrical, heat, light etc. Nigeria is richly blessed with raw energy resources, also designated as the world's tenth largest reserves of crude oil with 37.07 billion barrel (Worldatlas). Nigeria has many natural resources which can be used for electricity generation. Nigeria's coal production of about 95 percent is consumed locally, for railway transportation, electricity supply, and used in cement industry for heating. The Power Holding Company of Nigeria (PHCN) consumed the larger share of natural gas in Nigeria, used about 70 percent for electricity-generating gas plants in the country. Nigerian consumption rate of petroleum product has seriously increased with motor gasoline and diesel oil taking a significant lead (Ajayi, et.al, 2003).

Since 1958, energy has steadily grown to become the mainstay of Nigeria’s economy, playing a significant role in the growth and development of the country. Energy has continued to serve as the major tradable commodity for generating the national income and as a key tool of international diplomacy for the country. Energy is presently the springboard for production in all the sectors of the Nigeria’s economy (industry, transport, agriculture, health, education, politics and security). In fact, any change in the energy sector could lead to over a 100 percent effect in the entire economy of not just Nigeria, but alongside her many trading partners. But despite the great importance and role of the large quantum of energy resources in Nigeria, the inadequate development and inefficient management of these potentials have led to a continuous widening supply-demand gap in the energy sector, and this has had adverse effect on the economic development of the country (Choji, 2014).

Electricity supply has been identified as an important constraint to industrialization and economic development in Nigeria. Despite the country’s vast oil wealth, much of the Nigeria’s citizens do not have access to stable power supplies. Nigeria has approximately 5,900 megawatts (MW) of installed electric generating capacity. Power outages are frequent and the power sector operates below its estimated capacity.

Nigeria’s power sector had operated for several decades as a state monopoly then called National Electric Power Authority (NEPA) until 2005. NEPA controls electricity generation, transmission and distribution facilities with all the profound problems inherent in public monopoly. This over centralization made it impossible for electricity supply to keep pace with the geometric population growth population and ever rising economic activities. Nigeria has the biggest gap in the world between electricity demand and supply, providing its population of over 160 million with less than 4000 megawatts of electricity. In contrast, South Africa with a population of less than 50 million people generates more than 40,000 megawatts while Brazil, an emerging economy like Nigeria, generates over 100,000 megawatts for its 201 million citizens (FG, 2013). Indeed, the gap in the power sector has far reaching implications for improving the business climate, sustaining economic growth and the social wellbeing of Nigerians. About 45 percent of the population has access to electricity, with only about 30 percent of their demand for power being met. The power sector is plagued by recurrent outages to the extent that some 90 percent of industrial customers and a significant number of residential and other non-residential customers provide their own power at a huge cost to themselves and to the Nigerian economy. Installed capacity is 12,000 megawatts, while 688MW was generating capabilities, with 6,700 megawatts wheeling capability (Premium Times, 2017). At 125 kWh per capita, electricity consumption in Nigeria is one of the lowest in the world (AfDB, 2009).

Although, researchers have dwelt into the supply side of electricity in Nigeria, little is known about the electricity demand. The quest for more accurate estimates of key electricity demand parameters as short and long run price and income elasticity derives from two factors. Firstly, the critical importance in the projection of future electricity demand. Secondly, understanding electricity demand dynamics through improved and more robust estimates of electricity demand parameters for more informed and successful electricity policy decision making and implementation.

The demand for electricity in Nigeria is squarely for industrial, commercial and residential purposes. By visual inspection, electricity consumption by the residential sector has dominated other sectors since 1978, while the industrial sector's demand has witnessed continuous downward trend. The fall in the industrial sector's demand for electricity can be attributed to inadequate power supply which has forced manufacturers to resort to privately generated electricity for powering their production processes. Given the recent reforms embarked on by government to revamp electricity supply in Nigeria, it becomes important to model the key drivers of electricity demand in Nigeria in order to obtain empirical insights for electricity demand and supply projection and policy analysis.

Economic factors (price and real income) have assumed the fulcrum in modeling electricity demand functions, while population, urbanization and climatic condition are often included as additional explanatory variables. In general, the dynamics of electricity demand and consumption are known to exhibit seasonality, mean-reversion, high volatility and spikes. These special characteristics of electricity products, necessitates the use of special models for the estimation and forecasting of these variables Chuku and Effiong, (2011).

Energy demand and economic development can be said as the two sides of a coin; the absence of one inadvertently queries any claim in the true existence of the other. With the abundant energy resources, over half a century of independence and exploitation of energy resources in Nigeria, the country is supposed to be among the economically independent developed countries of the world, but the reverse is the case. Nigeria is still grossly underdeveloped; groping the path for energy supply to meet up with its energy demand. This has not only led to the slow pace of full-fledged large scale industrial (manufacturing) take-off in the country, but has led to crushing penury and much impoverishment of Nigerians. This is made manifest in the high cost of living, inadequate supply of finished products, dependence on imported finished goods, gross contraction on the industrial and agricultural sectors because of high cost of production, increasing environmental pollution due to much usage of generators, unpleasant social cost of living due to erratic and incessant power supply. It's noteworthy that the energy situation in Nigeria has not been able to produced and managed in a way to ensure sustainable energy development. Nigeria has limited technological capacity but it should be able to manage the scarce energy resources efficiently. The aforementioned problems caused by the low consumption of energy in the midst of abundant energy resources are the basis of the study. Although corruption, incessant changes in government and poor national orientation have been seen as reasons that deprive Nigeria of the expected development in the energy sector, the study sought to find out the factors responsible for these and to develop strategies that can stem the deteriorating performance of the sector for an enhanced economic growth and development.

Aftermath the above statement, which will give the empirical analysis of the study to arrive at a logical conclusion. Econometrics methods will be used in analyzing the empirical data to demonstrate the nexus between electricity demand and Nigeria economic growth. The study resolves around answering the following question:

1. What are the determinants of electricity demand in Nigeria?
2. Is there a relationship between electricity demand and economic growth in Nigeria?
3. Is there any long-run co-integration between domestic output and power sector development in Nigeria?

The main objective of this research is to establish, both theoretically and empirically, the electricity demand determinants in Nigeria during the period 1970 to 2015, while in the broader sense, the study intends to: Examine the concept of electricity demand, ascertain the relationship between electricity demand and economic growth, analyze the impact of widened electricity demand-supply gap on the welfare of the consumers and Make policy recommendations on sustainable electricity supply in Nigeria.

2. Conceptual and Literature Review

Electricity Demand

Electricity demand is the necessity for energy input to make available for production of goods and services

(McCraken, 2005). The demand of electricity is also the amount of electricity consumed in a process by an organization or society Approximately, 45% of the final consumer energy in the world used for heating, 25 % used in industries for high-temperature, and 20% for electric automobile and electronics device and 10 % for conveyance (International Energy Association, 2016). The increase in the world population has made electricity demand to continuously increase. The increase in prices and insecurity of electricity supply has also compromised consumption growth.

Energy demand in the Group of 20 developed nations of the world (G 20) rose higher than 10% in 2013, following the increase in 2010. Industrialized economies experienced acute decrease in energy demand in 2010, redeemed actively from 2010. While China and India did not exhibits trace of reducing electricity demand in 2009, but continued their extreme demand for energy sources. About 64 percent of world electricity supply is currently from non-renewable resources, from nuclear fission 16 percent and 19 percent from hydro (California Energy Commission, 2012). No prospect can be achieved without any of these as such the need for a strong electricity supply policy mix.

Nigeria's Renewable Energy

Nigeria is endowed with abundant renewable energy resources, the significant ones being solar energy, biomass, wind, small and large hydropower with potential for hydrogen fuel, geothermal and ocean energies. The estimated capacity of the main renewable energy resources is given in the Table 1.

Table 1 -Nigeria's Renewable Resource Estimate

Resource	Potential	Comment
Large Hydropower	11,250MW	1,900MW exploited
Small Hydropower	3,500MW	64.2MW exploited
Solar	4.0kWh/m^2/da-6.5kWh/m^2/day	Significant potentials for solar infrastructure; both for on-grid and on-grid use
Wind	Average of 2-4m/s @ 10m hub height	Moderate wind potentials in the country.
	Municipal waste	18.5 million tonnes produced in 2005 and now estimated at 0.5kg/capita/day
Biomass	Fuel wood	43.4 million tonnes/yr of fuel wood consumption
	Agricultural residues	91.4 million tonnes/yr. produced
	Energy crops	28.2 million hectares of arable land; 8.5% cultivated

Source: ECN (2014), Energy Implications of Vision 20: 2020 and Beyond, Report no.: ECN/EPA/2014/01

Except for large scale hydropower which serves as a major source of electricity, the current state of exploitation and utilization of the renewable energy resources in the country is very low, limited largely to pilot and demonstration projects. The main constraints in the rapid development and diffusion of technologies for the exploitation and utilization of renewable energy resources in the country are the absence of market and the lack of appropriate policy, regulatory and institutional framework to stimulate demand and attract investors. The comparative low quality of the systems developed and the high initial upfront cost also constitute barriers to the development of markets. Therefore, if the country is to unleash the enormous potential of its renewable energy resources on its drive to match electricity with demand and achieving the MDG's and Vision 2020, these barriers must be eliminated through significant investment in critical areas of R&D, building of indigenous human and manufacturing capacities and the intensification of the on-going economic reform to create an investor friendly environment.

Empirical Review

According to a previous report by Udo, Chuku and Effiong (2011), which investigated the dynamics of electricity demand and consumption in Nigeria between 1970 and 2008 using bounds testing approach, they observed that real GDP per capita, population and industrial output significantly drives electricity consumption in the long-run and short-run while electricity price is not a significant determinant. In the short run, industrial output has a crowding out effect on the demand for electricity. Their results imply that income per capita is the major determinant of electricity demand, and therefore, deregulated pricing of electricity products, will ensure efficient product and resource allocation in Nigeria.

Adetunji and Isa (2007) examined the residential demand for electricity in Nigeria between 1970 and 2006 and observed that income, the price of substitute and population emerges as the main determinant of electricity demand in Nigeria, while electricity price is insignificant. The relationship among variables is more stable and significant.

Usman (2013) however focused on the determinants of electricity consumers' satisfaction in selected electricity distribution zone in Nigeria. The paper was designed to evaluate customer's satisfaction with a view to determine their level of satisfaction and in the process compute satisfaction index. He observed that consumers are at corner solution until the unbundling of the sector into DISCOs and also employed the Fussy

Entropy to identify three classes of determinants of consumers' satisfaction. The resulting indexes of consumers' satisfaction shows that the consumers are not satisfied with the services of the DISCO.

However, Ubi, Effiom, Okon and Oduneka (2009) in their study analyzed the determinants of electricity supply in Nigeria (from 1970-2009), using a parametric econometric methodology of ordinary least squares. Their results showed that technology, government funding, and the level of power loss were the statistically significant determinants of electricity supply in Nigeria and that an average of 40% of power is lost in transmission per annum and recommend that the government should inject more funds into the power sector to complete power projects with state of the art technology in order to enhance electricity supply.

In another study by Gbadebo and Chinedu (2009), which based on co-integration analysis to examine the impact of energy consumption in Nigerian economy used the period of 1970 to 2005. The dependent variable was real GDP and the independent variables were crude oil consumption, coal consumption and electricity consumption. The result shows a negative relationship between the lagged values of electricity consumption and economic growth. Their research however suggested that there should be an increase in electricity supply and to enhance energy infrastructure.

Simon (2012) examined the impact of electricity crisis on the manufacturing productivity growth in Nigeria from 1980 to 2008, using ordinary least square multiple regression to analyze the time series data. The result shows a positive relationship between capacity utilization, exchange rate and the index of manufacturing productivity, while electricity generation and government capital expenditure produced negative relationship with manufacturing productivity index as the dependent variable. It shows that 67% variation in manufacturing productivity is explained by the explanatory variables. It also shows that among all the variables, electricity generation is not significant at 5% level, which identifies inadequate electricity supply as a result of low manufacturing productivity in Nigeria.

Audu, Nathan and Apere (2013) empirically analysed the dynamics of demand and supply of electricity in Nigeria, using RFRM and VECM approach. The analysis revealed that electricity demand is price inelastic while income is elastic. The study shows that 1 percent increase in electricity price would lead to an average of 32.45 percent decline in the quantity of electricity demanded. And a 1percent increase in income would lead to an average of 39.57 percent rise in the quantity of electricity demanded. The researchers indicates that for electricity demand not to shrink , PHCN should not charge an average unit price that is higher than 1.3 times of the citizen per capita income.

In another previous study by Busanimoyo (2012), which investigated the reaction of power disruption of productivity in the production system of Nigeria, using the Ordinary Least Square and the Tobit models to analyse the impact of these disruptions on firm output. Variables used for this study were periods without power per month, number of hours without power per day, percentage of productivity lost due to disruptions in power. The result in this study shows a negative and significant effect on production. It was suggested that government should create ways of enhancing energy production and supply in the country.

Alawiye (2011), in his study of the impact of electricity and industrial development in Nigeria using qualitative research method, he found that there is a positive impact from the power sector on the industrial development of Nigeria.

Nigerian Chronological Electricity reforms

The history of electricity reforms in Nigeria started in 1896 with a pioneer electric power generating plant with total capacity of 60 kw installed at Marina, Lagos State and was managed by the Public Works Department (PWD). The amalgamation of 1914 to form a new Nigeria created room for other towns to generate electric power for themselves, whereby the controlling powers of Public Works Department over Lagos electricity generation and distribution was handed over to the Nigerian Government Electricity Undertaking (NGEU) in 1946 and the responsibility for supplying electricity in Lagos as well as the assets and liabilities of the former operator were also handed over.

In 1950, Electricity Corporation of Nigeria (ECN) took over all electric power supply facilities within Nigeria and Niger Dams Authority (NDA) which was saddled with the responsibility of generating electricity through hydro power systems was inaugurated (Isola, 2012; Awosepe, 2014) which however improved power generation, transmission and supply in the Nigeria.

The Niger Dams Authority (NDA) was legally set up through an Act of Parliament in 1962 and were saddled with the responsibility of construction of Kainji Dam in 1962 which was completed in 1968. The wide network of electricity transmission of grid power commenced from 1966 through the collaborative efforts of NDA and ECN. These efforts saw the linkage of different towns to the national grid and the extension of electricity power to all the regions that made up Nigeria which linked the thirty-six state capitals and the Federal Capital Territory, Abuja.

ECN and NDA were merged to form the popular National Electric Power Authority (NEPA)" on April 1, 1972. The network continued to grow under NEPA and between 1978 and 1983, the Federal Government sponsored two panels of enquiry to fashion out models for restructuring NEPA into an independent unit or toward privatization. This empowered it to supply power to rural areas and new cities (Isola, 2012; Awosepe, 2014).

An Act was enacted establishing Power Holding Company of Nigeria (PHCN) between 1999 and 2005, which was an Initial Holding Company (IHC), as a result of Government effort to revitalize the power sector. This was an intended name for privatization which was meant to transfer assets and liabilities of NEPA to PHCN which was eventually commissioned on 5th of May, 2005 and was to carry out business of NEPA which were still on. Also, the National Integrated Power Projects (NIPP) was inaugurated in 2004 to quicken the upgrading of capacity in the country which was basically a private initiative and was supervised by the Niger Delta Power Holding Company (NDPHC) (Awosepe, 2014).

Later, the PHCN was disaggregated into 18 independent firms composing of six electricity generating firms, one electricity transmission firm, and eleven electricity distribution firms. The generating companies are Egbin Electricity Generating Company (EEGC), Kainji, Afam, Shiroro, Sapele, and Ughelli.

There are also some new Independent Power Producers under the auspices of the Niger-Delta Power Holding Company (NDPHC). The eleven distribution companies are the Electricity Distribution Companies of Abuja, Kano, Port-Harcourt, Ibadan, Ikeja, Jos, Benin, Eko, Enugu, Yola, and Kaduna respectively (Awosepe, 2014).

The demand of Electricity in Nigeria

The demand for electricity in Nigeria is geometrically increasing, this can be attributed to the population increase, industrial base growth of Nigeria and the pursuit of development on the part of the citizenry. In an attempt to find out the current demand for electricity in Nigeria and to project electricity demand, model was analysis of electricity demand which is used to model the demand structure of Nigeria energy sector. It is pertinent to note, electricity demand increase serves a major yardstick for the transformation of Nigeria which is being pegged at a growth rate of 13% annually till 2020, with a forecast of at least 312.61 metric tons of oil equivalent energy in the country. The table show culled from ECN display the said projection.

Table 2: Total Projected Electricity Demand in megawatts (MW)

Scenario/year	2005	2010	2015	2020	2025	2030
Reference (7%)	5,746	15,730	28,360	50,820	77,450	119,200
High Growth (10%)	5,746	15,920	30,210	58,180	107,220	192,000
Optimistic (11.5%)	5,746	16,000	31,240	70,760	137,370	250,000
Optimistic (13%)	5,746	33,250	64,200	107,600	172,900	297,900

Source: *Energy Commission of Nigeria, (2006)*

Determinants of electricity demand Nigeria

The demand for electricity is majorly a factor of the users, which can either be households or corporate entities. Nevertheless, it's determined by the electricity tariffs and the company/household's income as the case may be. However, there are some, lifestyles of household and improvement of efficiency. It can therefore be argued that, when estimating energy demand functions, it is instructive to consider all of these factors to avoid producing other important factors that determines electricity demand. This other factors is not limited to structural factors biased estimates of price and income elasticity.

Economic structure changes could lead to either increase or decrease in electricity consumption. Factors such as size of households, age distribution and climatic condition of an area will have impact on the household's consumption of electricity. Gladhart *et al*. (1986) found that socio demographic factors such as family size, age distribution, and the number of wage earners in the household were significant in determining the energy use. Similarly, climate also plays an important role in residential energy consumption. It is well known that people tend to use more electricity and fuel to warm their homes during the winter and air conditioning during the summer season. On the other hand, Household's lifestyles can also bring about a significant increase or decrease in household electricity demand. A household may decide to change from using fire-wood sources of energy to more convenient and environmentally friendly electric cookers and heating systems. The price and income elasticities can be used to show the impact of changes in households' incomes and electricity prices on electricity demand. Another streaming factor is the income of the household, which is most important determinant of electricity demand. An increase in income and its impact on living standards is the main driving force of electricity demand. An increment in household income leads to a higher demand for entertainment, comfort, and convenience which will in turn speedup the ownership of household appliances e.g refrigerators, radio, air conditioners, televisions, heaters e.t.c. These newly acquired appliances will in turn increase the energy required for cooking, heating, and lighting. Many studies show that there should be significant and stable positive correlation between electricity consumption and household's income. Individual households demand for electricity is a derived demand, it is derived from the demand for services like heating and cooling obtained from using appliances and equipment (such as heaters and air conditioners).The technology embedded in such equipment and appliances determines the utility obtained from electricity. Also, the modification of existing appliances and introduction of new ones in to the market will change the technical characteristics of the appliance and equipment which can also bring about energy efficiency, thereby reducing overall electricity. Lastly, Electricity price is also another important factor affecting electricity income as exorbitant electricity price may lead to less usage of energy for a while. This can lead to stimulation in purchasing much more effective and efficient household appliances lesser electricity to power the appliances at a considerable prices.

3. Theoretical Framework

This research work is guided by Shepard's lemma demand equation, but for simplicity, household and company electricity demand will be presented. When adjusting electricity consumption, we distinguish between domestic consumers and companies and large consumers. The theoretical framework for each of these groups is presented below.

a) Households

Households do not demand electricity for direct consumption but rather use it to produce a series of final goods and services (light, hot water, prepared food, etc.). In this vein, demand for electricity can be considered an intermediate consumption for households, so we can analyze the demand for electricity following the basic framework of the household production theory. According to this theory, households acquire goods that they use as inputs in the production process to obtain goods that are useful for households (Becker, 1965; Muth, 1966 or Deaton and Muelbauer, 1980). It should be of note that households combine electricity, natural gas and capital equipment (appliances) to produce a composite energy output. Adapting Filippini's model of 1999, the production function of the final energy output (x) can be defined as a function dependent on the electricity consumed (e) as well as the natural gas consumed (g) and the stock of household appliances (a),

$$x = x(e, g, a) \quad \text{……………………………………………1}$$

The household has a utility function that depends on the quantity of the composite energy good and the quantity acquired of a composite numeracy good (y) that directly provides utility, as well as household characteristics that influence their preferences (z), thus:

$$u = u(x, y; z) \quad \text{……………………………………….2}$$

Deaton and Muellbauer (1980), the household decision process can be modeled in each period as a problem of optimization in two stages. With stage one being how consumers acts rationally like a company, i.e. minimizing the costs of producing the energy goods, on the other hand, the second stage they maximize their utility. The problem for the consumer in the first stage is,

$$Min\ p^e e + p^g g + p^a a$$

$$s.t$$

$$x = x(e, g, a) \quad \text{……………………………….3}$$

Where P^e is the price of electricity, P^g is the price of natural gas and P^{a} is the price of the stock of appliances. As a result, the cost function is obtained,

$$c = c(p^e, p^g, p^a, x) \quad \text{………………………………………..4}$$

Applying Shepard's lemma, we obtain the demand derived from inputs, so, for electricity,

$$e = \frac{\partial c(p^e, p^g, p^a, x)}{\partial p^e} = e(p^e, p^g, p^a, x) \quad \text{…………………………5}$$

In the second stage, the household maximizes its utility, subject to its budget constraint,

$$Max\ u(x, y; z)$$

$$s.t$$

$$c(p^e, p^g, p^a, x) + y = r \quad \text{……………………………………..……....6}$$

Where r is the household income level. Solving this problem, we obtain the demand functions of the goods x and y. In the case of the composite energy goods, we get,

$$x^* = x^*(p^e, p^g, p^a, r; z) \quad \text{……………………………. ………..7}$$

Substituting this demand function in the demand function derived from electricity,

$$e = e(p^e, p^g, p^a, x^*(p^e, p^g, p^a, r; z) = e(p^e, p^g, p^a, r; z) \quad \text{……………………8}$$

In response to variations in the price of electricity, households can modify their stock of appliances or reduce their use. However, given that the temporal scope of this research, we assume that the in the short run stock of appliances remains constant, likewise prices of appliances can be considered constant and be excluded from the model without causing biases in the estimation (Halvorsen, 1975).

b) Companies and large consumers

In the case of companies and large consumers, electricity is an input in their production process. Assuming that all companies consider the price of electricity and other factors exogenous and that each minimizes its production costs, the demand for electricity can be expressed as a function of the price of the factors and of the level of production (Bjørner et al., 2001).

As such, the problem for companies is the minimization of their production costs in the short term, subject to their production function (technology),

$$Min\ p^e e + p^g g + p^o o + FC$$
$$s.t$$
$$m = m(e, g, o, \bar{k}) \qquad \ldots\ldots 9$$

where *m* is the company's production level of the final compound good, *o* is other inputs that are necessary in the production process, P^e is the price of those inputs, and *FC is* the company's fixed costs, determined by the company's capital stock ($\bar{k}$).

Solving the problem, we obtain the company's cost function, where we can distinguish between fixed costs (*FC*) and variable costs (*VC*)

$$c = c(p^e, p^g, p^o, m, \bar{k}) = FC(\bar{k}) + VC(p^e, p^g, p^o, m) \qquad \ldots\ldots 10$$

Applying Shepard's lemma, we derive the demand for electricity,

$$e = \frac{\partial c(p^e, p^g, p^o, m, \bar{k})}{\partial p^e} = \frac{\partial VC(p^e, p^g, p^o, m)}{\partial p^e} = q(p^e, p^g, p^o, m) \qquad \ldots\ldots 11$$

Applying the determinants of electricity demand in Nigeria for both households and organisations, we inculcate and adjust the Shepard's lemma function above by merging equation 5 and 11 together thus:

ED = f (IPC, PPE, DU, PD, LD, LT, NHP, NMP, ERP) …………………..…………..12

Where, ED = Electricity Demand, IPC = Income Per capita income, PPE = price per unit of electricity, DU = Degree of urbanization PD = Population density, LD= Land Density, LT = Level of Technology, NHP = Number of households per capita, NMP = Number of manufacturing industry per capita, ERP = Employment rate per capita.

Model Specification

$$ED = \beta_o + \beta_1\Sigma IPC_t + \beta_2\Sigma PPE_t + \beta_3\Sigma DU_t + \beta_4\Sigma PD_t + \beta_5\Sigma LD_t + \beta_6\Sigma LT_t + \beta_7\Sigma NHP_t + \beta_8\Sigma NMP_t + \beta_9\Sigma ERP_t + \varepsilon_t \qquad \ldots\ldots 13$$

β_o is constant of regression equation $\beta_1 \ldots \beta_9$ = Regression coefficients)

ε = Residual error term

we expect the coefficients of IPC, DU, PD, LD, LT, NHP, NMP and ERP to be positive (i.e $\beta_1, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ and $\beta_9 > 0$) while, the coefficient of PPE to be negative (i.e $\beta_2 < 0$).

This study covers a time frame of 45 years with annual time series data spanning through 1970 to 2015. Data for the research were collected through following secondary sources; the total electricity demand within the study period, and serves as the explained variable. The sources of the data were National Electric Power Authority/Power Holding Company of Nigeria.

Other data include price per unit of electricity in kobo (defined as the ratio of total revenue to quantity consumed; degree of urbanization; population density; Land-total land density (km^2); and number of household's per capita. Others were obtained from the Central Bank of Nigeria statistical bulletin.Furthermore, other secondary data include number of households with electricity per capital, state and level of technology, obtained from National Bureau of Statistics for several years, number of major manufacturing firms (industries) per capital. These data were the socioeconomic and physical determinants used in the study, and they served as the independent variables.

The study makes use of Multiple Linear Regression (MLR) analysis, employing different econometric tools in the analysis of the data. The method ranges from unit root test to Error Correction Mechanism (ECM) in other to estimate the parameter in achieving the different objectives of the study. The ECM was used because some of the variables were stationary at level while some at first Difference and this called for co integration test as a pre-requisite for ECM.

4. Result Analysis

Stationary Test

It has shown in econometric studies that most macroeconomic time series are non-stationary at levels (Engle and Granger, 1987). This implies that most ordinary least squares (OLS) regressions that are carried out at levels may not be reliable. Giving this knowledge, testing for stationarity of variables to obtain a more reliable result becomes very essential. Augmented Dickey-Fuller unit root (ADF) and Philip Perron test were used to examine the properties of the time series data. The test revealed that at 5% critical values, degree of urbanisation, electricity demand, income per capita income, land density, number of households per capital, number of manufacturing industry per capita, population density and price per unit of electricity were all stationary at first differencing with probabilities of 0.0000, 0.0000, 0.0000, 0.000, 0.0000, 0.0000, and 0.0000 respectively, while only employment rate per capita was stationary at level with 0.0321 using the ADF approach. With the aid of PP approach, DU, ELED, IPC, LD, NHP, NMP, PD, PPE were stationary at first differencing, with 0.0000, 0.0000, 0.0001, 0.0000,0.0000,0.0000 and 0.0000 probabilities respectively, while only ERP was stationary at Level with probability of 0.03211 as shown in Table 3

Table 3: ADF and Philip Perron

Variable	Statistics values		Sig.	Order of integration
DU	ADF	-6.604960	0.0000	I(1)
	Philip Perron	-6.622958	0.0006	I(1)
ELED	ADF	-7.612202	0.0000	I(1)
	Philip Perron	-7.546891	0.0000	I(1)
ERP	ADF	-3.120190	0.0321	I(0)
	Philip Perron	-3.120190	0.0321	I(0)
IPC	ADF	119.327	0.0000	I(I)
	Philip Perron	-5.345782	0.0001	1(1)
LD	ADF	-6.644279	0.0000	1(1)
	Philip Perron	-6.644261	0.0000	1(1)
NHP	ADF	-5.298436	0.0000	1(1)
	Philip Perron	-5.492981	0.0000	1(1)
NMP	ADF	-5.975355	0.0000	1(1)
	Philip Perron	-7.433562	0.0000	1(1)
PD	ADF	-5.975955	0.0000	1(1)
	Philip Perron	-5.975355	0.0000	1(1)
PPE	ADF	-6.430425	0.0000	1(1)
	Philip Perron	-6.450826	0.0000	1(1)

Source: Authors' computation from E-view 9

Johansen Co-integration test

When a linear combination of variables that are I (1) produces a stationary series, then the variables may be cointegrated. This means that a long-run relationship may exist among them, which connotes that they may wander from one another in the short-run but in the long run they will move together (Pesaran and Smith 2001). To establish whether long-run relationship exists among the endogenous series, Co-integration test using Johansen's

Table 4: Johansen Co-Integration Test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.724015	227.3793	197.3709	0.0006
At most 1 *	0.656736	170.7333	159.5297	0.0106
At most 2	0.588366	123.6861	125.6154	0.0652
At most 3	0.524231	84.63077	95.75366	0.2272
At most 4	0.382051	51.94654	69.81889	0.5518
At most 5	0.329912	30.76715	47.85613	0.6790
At most 6	0.173166	13.15193	29.79707	0.8846
At most 7	0.094622	4.785261	15.49471	0.8312
At most 8	0.009309	0.411531	3.841466	0.5212

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.724015	56.64598	58.43354	0.0743
At most 1	0.656736	47.04724	52.36261	0.1583
At most 2	0.588366	39.05531	46.23142	0.2384
At most 3	0.524231	32.68423	40.07757	0.2670

At most 4	0.382051	21.17939	33.87687	0.6706
At most 5	0.329912	17.61521	27.58434	0.5274
At most 6	0.173166	8.366673	21.13162	0.8799
At most 7	0.094622	4.373730	14.26460	0.8179
At most 8	0.009309	0.411531	3.841466	0.5212

Max-eigenvalue test indicates no Cointegration at the 0.05 level
** denotes rejection of the hypothesis at the 0.05 level*
Source: Authors' computation from Eviews 9

Table 4 above showed that at 5% critical value (197.3709) is less than the Trace Statistic (227.3793), while also the 5% critical (58.43354) value is greater than Maximum Eigenvalue Statistic (56.64598) and probability values of 0.0006 and 0.0743 respectively with the trace test depicting Cointergration among all the variables while the maximum Eigenvalue is not depicting any Cointegration among them. Since the two methods are relating different result, we can opt for one of these two result to decide. If we go for the trace test, we can run our error correction model, but if we are to accept the maximum eigenvalue result, we will run unrestricted error correction model.

For the purpose of this research, the researchers used their discretion in accepting the decision of the trace test, and also to establish that there is a long run relationship among all the variables used in this research. On this note, we can now run the error correction model (ECM) to find out properly whether the model emanating won't be a spurious one.

Table 5: Error Correction Model (ECM)

Variable	Coefficient	Standard error	T-Stat	Prob.
C	-199.9281	145.7205	-1.371997	0.1786
IPC	0.006384	0.011791	0.541390	0.5916
D(DU)	0.491173	1.101070	0.446087	0.6582
D(PD)	0.923572	0.341121	2.707458	0.0103
D(LD)	0.130045	1.890920	0.068773	0.9456
D(NHP)	0.669928	0.161159	4.156939	0.0002
D(NMP)	1.425730	0.501061	2.845421	0.0073
ERP	4.744461	3.549629	1.336608	0.1897
U(-1)	-1.188408	0.165896	-7.163567	0.0000
R^2= 0.768423 Adjusted R^2 =0.716961 D-Watson = 1.991471				

Source: Authors' computation using E-view 9

The estimated ECM:

$$\mathbf{ED_t=-199.9281+0.006384IPC_t+0.491173DU_t+0.923572PD_t+0.130045LD_t+0.669928NHP_t+1.425730NMP_t+4.744461\,ERP_t-1.188408\,U(-1)} \quad \ldots\ldots 14$$

In in the above estimated ECM, all the coefficient of the ECM depicts -199.92, 0.006384, 0.491173,0.923572, 0.130045, 0.6699281.425730, 4.744461 showing short run coefficient, while only 0.923572, 0.669928 and 1.425730 with probabilities of 1.037%, 0.2% and 7.3% respectively are significance at 5%, we can therefore assert that at first difference, population density (PD), number of household per capita (NHP) and number of manufacturing industry per capita (NMP) is a significance variable at short run to explain the dependent variable electricity demand (ELED), while the remaining four (4) variables are not significant at short run to explain ELED. Likewise, the ECM coefficient of 118.8% means that the error correction term actually corrects the disequilibrium in the country, the reason for this is that the speed at which the error correction corrects disequilibrium in the country is at the rate of 118.8% annually, i.e. it adjusts the previous period disequilibrium at the rate of 118.8%. Due to the negative sign of the ECM, and its significance, it validates that there exists a long run relationship among all our variables as stated in the model above. From the above table, we can also deduce that since the R^2 < D-Watson coefficient (i.e. 0.768423<1.991471) we can hereby conclude and satisfy that our ECM is not a nonsensical model.

From the estimated ECM above, we can see that as the income of the citizen increases by ₦1, it will increase their electricity demand unit by 0.00634 kobo, while a percentage increase in the degree of urbanisation will bring a 49.11% increase in electricity demand, likewise, as the population density upsurge by 1%, it roared a 92.35% increase in the level of electricity demand in the country, more so, as the land mass increase by a unit, it will lead to a 0.13004 unit increase in electricity demand. In addition, as the number of household increases by 1%, it will give rise to a 66.99% increase in electricity demand, while, a percentage increase in the number of manufacturing industries should increase demand for electricity by 142.5%, and finally, if the employment rate increases by 1%, it is caused by a 474.44% increase in the demand for electricity.

An important assumption of the ARDL/Bounds Testing methodology of the estimated ECM result above is that the errors must be serially independent. The Durbin-Watson statistics of 1.991471 indicates that the model is free from serial correlation. As a cross check, we perform the Breusch-Godfrey (B-G) LM test to support our conclusion of the non-existence of serial correlation in the model.

Table 5: Breusch-Godfrey Serial Correlation LM test

f-statistics	0.392367	Prob. F(2,34)	0.6785
Obs* R-squared	1.015188	Prob. Chi-Square(2)	0.6019

Source: Eviews 9 output

Based on the result in table 4, the probability value of the B-G LM test indicates the rejection of the null hypothesis of serial correlation and conclude that the model is free from serial correlation.

Conclusion and Recommendations

However, this study comes with a caveat that, although we used as explanatory variables what we considered the main determinant of electricity demand, some variables were not included for one reason or the other. Therefore, we believe that further research is needed to identify the factors behind the loop holes in electricity demand in Nigeria. This research work has provided an empirical explanation for the demand if electricity in Nigeria. This can better be felt if the federal government opens more sources of generating electricity and limits its dependence on the hydro generation, likewise, the natural abundance of the solar energy in the northern are of the country can also be as a way of creating diversification in the energy industry, why gradual development of electricity through liquefied gas should be intensified, so that substitute can be for the archaic hydro form of generation.

Based on the findings and the conclusion arrived at in the study, the following are recommended:

Electricity demand studies have important practical implications. The results indicate that the estimated household demand for electricity can be used for policy purposes since it is stable. The finding that a stable aggregate residential electricity demand function seems to exist would make forecasting of electricity need at the national level possible. Also, urbanisation should be intensified through provisions of various facilities that will create room for establishment of manufacturing industries which also has a very high significant on electricity demand. It also shows that income, population and the land mass influence demand for electricity in Nigeria. All these useful information is expected to help policy-makers and government in providing and enabling a conducive environment in supplying electricity in Nigeria. The policy implications drawn from the analysis is that government should undertake a guided process of liberalizing the electricity sector to allow new entrants into the market for competitiveness and improved efficiency as the insignificance of the electricity price.

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