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ENERGY DEMAND AND COOKING ENERGY COST IN AN OIL-RICH ECONOMY: A NEW EVIDENCE FROM NIGERIA

Anthony Orji
Department of Economics, University of Nigeria, Nsukka, Nigeria
Email: anthony.orji@unn.edu.ng

Stephen Obinozie Ogwu
University of Nigeria, Nsukka, Nigeria
Email: stephenobinozie1@gmail.com

Peter Nwachukwu Mba
Department of Economics, University of Calabar, Nigeria
Email: petermbanta@yahoo.com

Onyinye Imelda Anthony-Orji*
Department of Economics, University of Nigeria, Nsukka, Nigeria
Email: onyinye.anthony-orji@unn.edu.ng

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Abstract: *According to several recent studies, energy is seen as a commodity, due to the fact that energy sector markets are more like commodity markets. Essentially, it serves as an enabler of social and economic development and so cannot be neglected. This study, therefore, estimated the impact of cooking energy cost on energy demand in Nigeria using the ARDL model and quarterly data spanning from 1990-2018. The result from the study showed that in the long-run both liquefied petroleum gas (LPG) price and kerosene price has a negative impact on energy demand. In the short-run, the result remained the same for kerosene while it reversed for LPG. The study, therefore, recommended that government should enact policies that will moderate or minimize the cost of cooking energy and enhance the removal of all forms of barriers in making cooking energy affordable to users in the country.*

Keywords: Energy, Cost, Demand

JEL Classification: Q41, R22

* Corresponding author: **Onyinye Imelda Anthony-Orji** *Email: onyinye.anthony-orji@unn.edu.ng*

1. Introduction

According to several recent studies, energy is seen as an essential commodity that serves as an enabler of social and economic development, and it cannot be neglected (Kroom, Brouwer and Beukering 2012). Over 4 billion people depend on energy across the globe. This has over time led to rising demand for energy products across the world as the global population is on the rise coupled with the discoveries of new uses for these energy products.

Aside from the industries and transportation sectors, the households are the main consumers of these energy commodities, mostly for cooking and other domestic purposes. For instance, the U.S. Energy Information Administration, Monthly Energy Review for (2018) revealed that among the various sectors that made up the economies, between 2014 to 2018 all being key users of energy commodity, that the household being behind the industrial and transportation sector utilizes more energy than other sectors of the economy in each of the years considered. For the year 2018, household energy consumption was at the ton of 21,651 trillion being 21.40% of overall energy consumption for that year. The report further showed a significant rise in energy consumption each year. These, no doubt are directly or indirectly among the many causes of the prevalent energy crisis at the global level. This crisis manifest itself in the form of shortages in the supply of energy across the world's energy market when compared to demand, and the accompanying rising cost.

In Africa, the situation is the same, as the energy crisis co-exists with the energy paradox for countries richly endowed with energy resources. Kroom, Brouwer, and Beukering (2012) noted that about 90 percent of households in developing countries depend on biomass, and with Africa being the home continent of the majority of the developing countries where most of the world's poorest households come from, the impact of the crisis is strongly felt

Though energy is reckoned as an essential good in all sectors of a country's economy (Ogbuabor, Orji, Manasseh and Nwosu, 2018; Oyedepo, 2012), a peep into the Nigerian energy market reveals the prevailing crisis especially for cooking energy commodities. This may not be unconnected with the ever-increasing population which stands at about 198 million people presently, whereas the supply of cooking energy rises at a rate that is far below the demand. While the Nigerian population forms about 2.35% of the world's population, the growth rate is around 3.2% and living costs keep rising daily. These two jointly account for a greater percentage of the rise in the demand for energy commodities (World Bank, 2018).

According to Ohimain (2012), the major cooking fuels in Nigeria are fuelwood and kerosene, which constantly face supplying difficulties; instabilities in price; and imposes safety, environmental and health challenges on man. In urban cities, Kerosene is the commonest cooking fuel and thus the urban areas are responsible for about 42% of Kerosene consumption in Nigeria while 33% is utilized by rural dwellers. 10% of total liquefied petroleum gas (LPG) consumption in Nigeria is utilized in urban cities while only about 4% is utilized by rural dwellers (Ohimain, 2012). It is worrisome that LPG which is the cleanest among these cooking fuels received the lowest patronage and is underutilized, but several studies have identified cost as a major bane behind this underutilization of LPG.

Table 1.1 Total energy demands in Nigeria based on a 10% GDP growth rate (MTOE)

Item	2005	2010	2015	2020	2025	2030	Average growth rate (%)
Industry	8.08	12.59	26.03	39.47	92.34	145.21	16.2
Transport	11.70	13.48	16.59	19.70	26.53	33.36	4.7
Household	18.82	22.42	28.01	33.60	33.94	34.27	2.6
Services	6.43	8.38	12.14	15.89	26.95	38.00	8.7
Total	45.01	56.87	82.77	108.66	179.75	250.84	8.3

Source: Adapted from Energy Commission of Nigeria in Oyedepo (2012)

From the table above, it is obvious that households are the major users of energy in Nigeria. The table also tries to predict future energy demand as can be seen. The household energy demand will surely increase with increasing population and greater access to energy by more people, and the figure is likely to exceed this prediction if the living standard of the people gets better. For the industry, the prediction can only hold if the policies geared toward economic diversification are successfully leading to the revival of the industrial sector. Furthermore, a table was used to depict the electric power capacity in Nigeria, which he showed "supply by fuel mix and the demand for 7% and 13% GDP growth". If the figures depicted on the table hold, it only suggests that access to electricity is poor especially among the rural dwellers, and secondly that the people in reacting to the epileptic power situation in the country have resorted to private generators as alternatives.

The situation in the Nigerian energy market has been described as a paradox, this is because Nigeria has a rich resource endowment, but still suffers scarcity of cooking energy as revealed by the constant shortage in supply and price instability. Nigeria has a growing energy resource reserve base but the households still live in a scarcity of cooking fuels coupled with high cost (Oyedepo, 2012).

This supply shortages with fluctuation in prices of cooking energy may not be unconnected with certain economic and social factors like low refining capacity which is insufficient to meet local demand; constant conflict between marketers and the government and hoarding of product especially during festive periods (artificial scarcity); inefficient price control system in the country; civil unrests in the production areas and pipeline vandalism. According to Oyedepo (2012), there are four factors that explain the existence of this crisis in Nigeria from 1970 to 2005. They are the prevalence of price regulation regime, laxity towards cost recovery and the absence of prompt and sufficient economic incentives to motivate the state-owned companies like Nigeria National Petroleum Corporation (NNPC) and Power Holding Corporation of Nigeria (PHCN), to engage inefficient production and investment behavior that will ensure the existence of large input and output subsidies, numerous economic and non-economic objective without proper identification of the trade-offs among these different objectives, governance and institutional failures which led to gross distortions and inefficiencies in investment choices, huge costs in operation, low returns on investment, and expensive delays alongside cost overruns engaged in by the state energy enterprises. This reveals the under-developed nature of the country's energy sector with so many untapped resources and low production capacity for those presently being utilized.

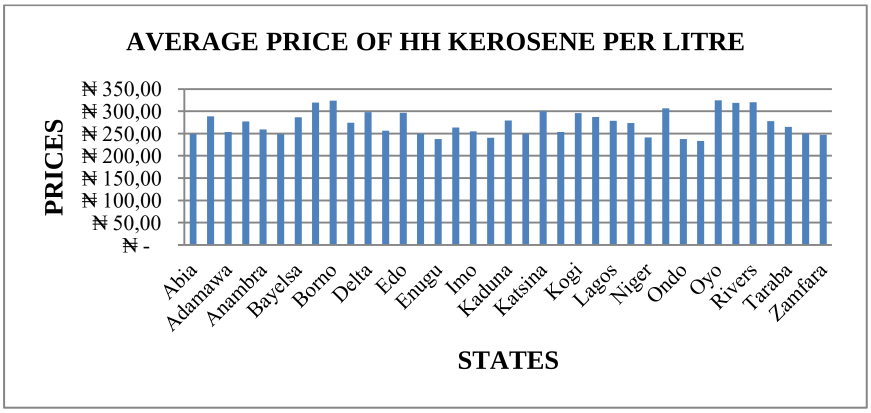

Figure1.1 Average kerosene price per liter across the states in Nigeria in October 2017
Source: Authors' computations from the NBS National Household Kerosene Price Watch - October 2017, using Microsoft Excel.

The implication of this is that the local prices of cooking energy is tied to international oil prices which when added to import expenses raises the domestic prices of these cooking fuels above the international price and so depriving the masses of the benefit of resource endowment. Furthermore, with the existence of a failed price system and inefficient product regulation framework marketers constantly hijack the market at will causing undue shortages in product supply and inflation of prices hence, the constant fluctuation in price leading to non-uniform

pump prices across the different states in the country. Figure 1.1 and 1.2 below explains the case of kerosene which is a major household cooking fuel in Nigeria.
As the chart shows Oyo, Borno, and Rivers are the states with the highest average prices of kerosene at 324.76, 323.61, and 320.37 per liter, respectively. While Enugu, Ondo, and Osun are the states with the least prices of kerosene at 237.78, 237.50, and 233.33 per liter, respectively. This seems to give evidence of the failed price system in the country and disequilibrium in the energy market especially for cooking energy.

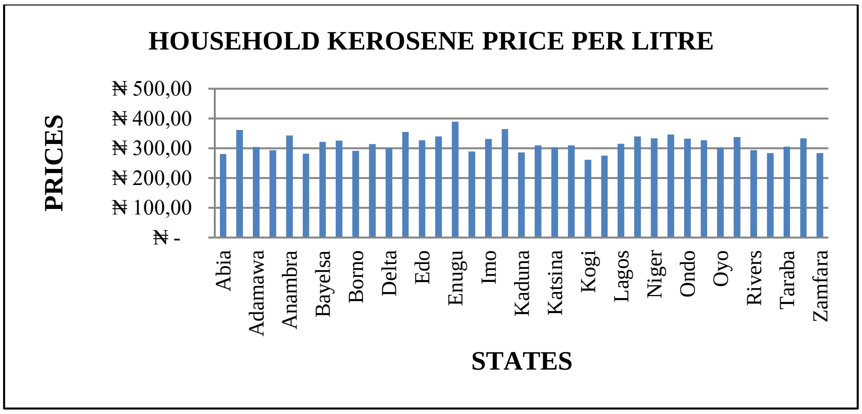

Figure1.2 Average kerosene price per liter across the states in Nigeria in October 2018
Source: Authors' computation from the NBS National Household Kerosene Price Watch-October 2018, using Microsoft Excel.

Figure 1.2 shows that even after one year that the price disharmony or disequilibrium still exists with some states like Ogun, Enugu, and Abuja selling at an average of 346.30, 348.33, and 360.67 per liter, respectively being the highest. While states like Borno, Abia and Kogi have the lowest prices, selling at an average price of 240.44, 248.08 and 261.11 respectively. The two charts when compared indicate that the highest averages for 2018 are larger than those of 2017; the same applies to the lowest average prices. This seems to suggest that the situation is not getting better. The data from the NBS price watch report showed inconsistencies in the supply of this product across the states of the country, with cases where state received a different number of trucks in different months with some month being higher and some lower, there are even months where some state received zero (0) truck of kerosene.
The implication of these supply shortages and high cost for consumers will be to seek alternatives, and the readily available alternative in the midst of these challenges will be fuelwood, which costs less and can easily be fetched in the

nearby bushes or farm. The government and ministries in charge of the energy sector have not done so much to arrest this menace as the energy crisis cum paradox continues to escalate. Programs such as the subsidy intended to reduce the cost and increase local production of these commodities have not been successful. Just a few years back the subsidy program which targets energy cost reduction majorly, was scrapped by the government for several reasons thereby compounding the crisis.

As the crisis in the energy market is now at its peak we find a scenario where cooking energies in Nigeria cost much more than the others. It is on this backdrop that this study seeks to examine the impact of cooking energy cost on energy demand in Nigeria from 1990 to 2018. Since related research on this topic at the macro level in Nigeria is almost a decade old, it is now imperative to look at the changing trend in the energy sector coupled with the development of new technologies and proffer some policy recommendations. The rest of the paper is structured as follows: Section 2 is the review of related literature while Section 3 is the methodology. Results and discussion are presented in Section 4, while Section 5 has the conclusion and recommendations.

2. Review of related literature

2.1. Cooking Energy Cost

The cost of obtaining energy at any point in time and place could be monetary or in the form of opportunity costs. Some fuel type requires an initial fixed cost or sizable irregular expenditures which may burden households that lack a constant source of income (Toole, 2015); of which plant wastes and fuelwood are perfect examples, because it requires the cost of fetching them from the farmlands and bushes especially, by the women. The concept of cost emerged as a way of measuring the value of goods it includes production expenses, transportation, tax at various points, etc. All these expenses culminate to determine the final cost which can be called the price of the good. Hence, by cooking energy cost we mean the final amount paid by the consumers in purchasing these energy commodities in the domestic retail market. According to theory, price is the most important determinant of demand or level of consumption with a given income. In several works of literature, it has been recognized as one of the many factors responsible for the transition into the energy ladder model and multiple cooking energy patterns. Unlike in the monopolistic market system where the producer single-handedly influences the price or through bargaining with the buyer, the energy market is more a perfectly competitive market where many factors counteract to assume price.

2.2. Energy Demand

According to Koutsoyiannis (1979), demand is a multivariate relationship, this means that many factors influences the demand for any commodity including the previous level of demand for the same good. Energy demand is the quantity of energy commodity consumers are willing and able to buy at any given time and the ruling price given the consumers income and the level of energy supplied to the market, other things have been equal. Amongst them, any factors listed above price happens to be the determinant of the quantity of energy the consumer can obtain. Energy demand is a derived demand, (Medlock, 2009). Due to the lack of data for energy demand in Nigeria, this research work will use energy consumption as a proxy for energy demand. This is ideal as the total demand approximates total consumption other things being equal. This means that what is consumed is what was demanded in the absence of a supply shortage.

2.3. Empirical Literature

A basic element in the energy policy of Nigeria is cost. This is because of the role it plays in household energy decisions. Some studies have investigated some issues around energy cost and other allied matters but there is still a yawning gap in the literature, which this work fills. For example, Haruna, Mulugetta, and Azapagic (2015) investigated the life cycle environmental impacts and costs of the household cooking sector in Nigeria from 2003 to 2030. They considered five scenarios which include business as usual; a period when fuelwood stoves dominated; low penetration of solar stoves and improved fuelwood; high penetration of these stoves; increased use of fossil fuel stoves; and increased use of electric stoves. They pointed out that environmental impacts would increase by up to four times and cost by five times if business as usual continues, this is linked to high fuelwood consumption. If the government plans to introduce improved fuelwood and solar stoves to households, this would likely not yield any environmental advantage because the proposed quantity of stove is limited in number. It is only when the number of the advanced stoves is large that significant improvements will be felt by some, while others would be worse off thereby necessitating some trade-offs. Looking from the economic point of view, increased use of advanced stove has the least total cost but the capital cost is three times more than business as usual. They recommended that the introduction of an advanced cooking stove should be made a priority by the government so as to reduce the health risk associated with indoor air pollution and cut down the pressure on biomass resources, even if it requires subsidizing the cost. This is because electric stoves and fossil fuel will to a large extent reduce greenhouse gas emission, cut down the danger associated with fuelwood use and save the fossil resource from depletion. Anozie, Bakare, Sonibare, and Oyebisi (2006) evaluated cooking energy cost, efficiency, air pollution impact of cooking energy consumption and government policies on cooking energy in Nigeria; adopting water boiling and cooking experiments with the use of common cooking energy sources, which are fuelwood, kerosene, liquefied petroleum gas (LPG) and Electricity; and common food items namely water, yam and beans were used. They also carried out an energy survey to determine the cooking energy use patterns in both urban and rural areas. Their findings revealed that kerosene is the cheapest cooking fuel while LPG is the most expensive. When water was boiled using fuel wood, kerosene, cooking gas, electric immersion coil, electric coil, electric heating coil, and electric hot plate the energy use efficiency was estimated to be 25%, 46%, 73%, 79%, 66%, and 90%, respectively. Their finding shows that energy intensity is the comparative measure of energy efficiency. They found also that apart from the use of gas, the rest of the energy carriers are significant air pollutants contributing to the pollution of the ambient environment. Fuelwood is the predominant cooking energy source used for cooking in the rural area whereas kerosene is dominant as the energy source for cooking in the urban area as depicted by the result of the energy use pattern. This goes to suggest that the energy policy in the country has not made any impact in the cooking energy sector, they, therefore, recommended that the energy supply situation in the country should be improved and the barriers that hinder the implementation of recommendations removed. Babatunde and Enehe (2018) while studying the determinants of household electricity demand in Nigeria employed the survey method using the Ordinary Least Square (OLS) analysis. The survey used was to gather data from a total of 404 households between March and November 2010. They found that Household electricity consumption was income and cross-price inelastic and that socioeconomic variables such as household size, number of rooms in the household and hours of power supply are the factors determining household electricity demand in Nigeria. They concluded that income inelasticity across all models shows the importance of electricity as a basic need of households in the country. Akinola, Oginni, Rominiyi and Eiche (2017) did a comparative study of residential household energy consumption in Ekiti State-Nigeria to identify, determine and evaluate households' energy choices,' costs of domestic energy consumption and quantities; and to provide a database for documentation: using structured questionnaires administered on households to obtain data. Independent and paired t-tests were conducted at 5% and 10% levels of significance for the annual energy consumption between the low and high-income earners as a method of data analysis. As shown by their results, the densely populated areas consume a larger proportion of energy which is 827,411.20MJ being 63% against the less populated areas which consumes 486,267.60MJ that is 37%. However, by considering the income of households, the low-income earners consume a more significant amount of energy than the high-income earners at

790,719.30MJ and 522,959.49MJ, respectively. They established from the study that fuelwood and charcoal are the poor man's energy sources accounting for 6.5% and 11.2% of the energy used by low-income earners with high demand in the sparsely populated areas. Income and population size were the key determinants of Kerosene consumption (29.6%), having a positive significance; while those living in densely populated areas utilize 44.9% of LPG and 7.8% of electricity. The results indicate that a positive relationship exists between income and choice of energy consumed by households thereby suggesting that those that earn low income consume more energy when compared to those that earn a high income due to their frequent cooking and unit energy purchase index.

3. Methodology

3.1. Theoretical Framework

The theoretical framework of this research follows the energy demand theory by Medlock in 2009 which borrowed its idea from the work of Johanson and Schipper (1997) in forecasting long-term motor-fuel demand in several countries. According to the theory, energy demand is a derived demand and there are three choices to the decision of energy consumption. These choices which are made simultaneously includes investing in capital stocks, choice of a particular type of capital stocks, and choice of a rate of capital utilization: for the firm; while the households are faced with two-stage allocation to budget aggregates which are food, clothing, energy, etc. The first stage involves obtaining information on the total budget and prices of the aggregates; and the second stage looks at expenditures on energy and the prices of the various energy products. These choices result in the utilization of a particular quantity of energy services. The theory applied the dynamic investment behavior to capture the short-run and long-run responses of energy demand to changes in economic variables. This dynamic model perfectly captures the energy demand of households.

The dynamic model of energy demand incorporates the intertemporal choices that consumers or firms must make when maximizing a particular objective function over some time. The model shows how energy consumption decision is made simultaneously with the decision to acquire and maintain energy-using capital equipment. This model also allows the analysis of transition that occurs in one state to another while responding to changes in any variable.

Based on the assumption that energy is proportional to the services derived from it the utility of the consumer is affected by energy demand. Thus, the household consumer seeks to maximize the present value of lifetime utility.

$$\underset{C,E,S}{\text{Max}} \sum_{t=0}^{T} \beta^t U(C_t, E_t) \quad (1)$$

Subject to: $pc_{,t}\, C_t + p_{E,t} E_t + Pk_{,t}\, I_t +$ PE1E + PkrIs + Si ≤ Yi + (1 + r) St − 1 (2)

$$E_t \equiv \frac{U_t}{E_t} K_t \quad (2a)$$

$$I_t = K_t - (1-\delta) K_{t-1} \quad (2b)$$

$$C_{t,} U_t, K_t \geq 0, t = 1, \dots, T$$

The first condition for the maximization of this consumer's utility yield:

$$U_{K\frac{u_t^*}{\varepsilon_t}} = U_{Z\left[P_{E,t}\frac{u_t^*}{\varepsilon_t} +\, P_{K,t} - P_{K,t-1}\left(\frac{1-\delta}{1+r}\right)\right]} \quad (3)$$

The star denotes the optimal value. Going by this, the consumer will divide his income between purchasing of energy, capital, savings and all other goods in a way that the marginal value of energy services attained from capital stock will be equal to the marginal value from the consumption of all other goods. This decision among other things will be based on the energy cost of capital utilization.

$$\mu_{K,t} = P_{E,t}\frac{U_t^*}{\varepsilon_t} + P_{K,t} - P_{K,t-1}\left(\frac{1-\delta}{1+r}\right) \quad (4)$$

$\left(\frac{1-\delta}{1+r}\right)$ is users cost, μ_k, of the capital stock $P_{E,t}\left(\frac{\mu_t}{\varepsilon_t}\right)$, who shows that the consumer chooses the uses of cost as long as capital utilization is still a choice variable, $u_t^* = 0$; $P_{K,t} - P_{K,t-1}\left(\frac{1-\delta}{1+r}\right)$, represent the price of owning capital equipment

From the last equation, it is clear that any rise in energy price will not automatically raise the cost of obtaining energy services; this is because the net effect on consumer behavior is expected to be zero as $P_{E,t}\frac{U_t^*}{\varepsilon_t}$ will not change.

Going by this, energy demand can, therefore, be expressed as a function of the user cost of capital, capital stocks and capacity utilization. Energy price, energy efficiency and rental price of capital are the variables that determine users' cost; capital stock on its own is dependent on the rental price of capital and income, and capacity utilization depends on the price of energy and income. Thus, energy demand is expressed as:

$$E_t^* = E\left(Y_t, P_{Z_t}, P_{E_t}, P_{R_t}, \varepsilon_t\right)$$

Accounting for the elasticity of energy demand, all things being equal, the income elasticity of energy demand is given as:

$$\varepsilon Y = \frac{\%\Delta E}{\%\Delta Y} = \frac{\delta E}{\delta Y} \times \frac{Y}{E} \quad (5)$$

where E - energy demand, Y - income measured using GDP in most cases.

The own-price elasticity of energy is stated as:

$$\sum P = \frac{\%\Delta E}{\%\Delta P} = \frac{\delta E}{\delta P} \times \frac{P}{E} \quad (6)$$

where P is the price of energy while other variables remain as defined.

Our log-linear specification becomes

$$InE_t^* = \propto_0 + \propto_1 InY_t + \propto_2 InP_E + \propto_3 InX_t \quad (7)$$

E* equals the optimal long-run amount of energy demand, Y represents income, P_E represents the price of energy, X is the variable that influences energy demand.

The above equation implies a function of the form:

$$E_t^* = \propto_0 Y_t^{\propto_1} P_t^{\propto_2} X_t^{\propto_3}$$

This is normally referred to as the approximation of the true demand function.
To capture the effect of variables like habits, etc. on the exogenous variable, we include lag endogenous variable, or income and price in the form:

$$(InE_t - InE_{-1}) = \gamma(InE_t^* - InE_{t-1}) \text{ where } \gamma\epsilon(0,1) \quad (8)$$

being the speed of adjustment. We then substitute it into equation (6) to have

$$InE_t = \gamma\alpha_0 + \gamma\alpha_1 InY_t + \gamma\alpha_2 InP_{E,t} + \gamma\alpha_3 X_t + (1-\gamma)InE_{t-1} \quad (9)$$

where $\propto$ is the long-run elasticity of the variable 1I and $\gamma\alpha_0$ are the short-run elasticity.

3.2 Model Specification

This study will use the Autoregressive Distributed-Lag (ARDL) Model. This will make it possible to account for the impact of the lagged values of the dependent and the independent variables on the dependent variable. The ARDL was introduced by Pesaran, Shin and Smith (2001) to accommodate variables that are stationary at order 1(0) and 1(1) in the same model estimation.

Due to psychological, technological and institutional reasons, a regressant may respond to regression with a time lag, enabling us to establish the dynamic across time. The OLS could ordinarily be applied to estimate the DLM if not for the problem of autocorrelation arising from successive lags of the regressors. This drawback has necessitated the development of alternative estimation techniques that are short cuts and includes the Koyck, adaptive expectation, and the partial adjustment mechanism. The koyck approach is algebraic in nature whereas the other two follow economic principles. The outstanding advantage of these approaches over the OLS is the inclusion of the past values of the dependent variable making it autoregressive in nature. The autoregressive distributed-lag (ARDL) model has been proven to be useful in time series econometrics work in economics due to the fact that they can account for both long-run and short-run movement due to time or because of the response of the dependent variable to changes in the independent variables across time.

In this work our objective is to determine how cooking fuel cost (prices) impact on energy demand in Nigeria, using quarterly data spanning from 1990-2018. These data were sourced from the central bank of Nigeria (CBN), National Bureau of Statistics (NBS), Nigerian National Petroleum Corporation (NNPC), World Development Indicators (WDI), and the US Energy Information Agency (US EIA). These data were originally annual data but was transformed to quarterly data with the use of E-views 9.0

To estimate the impact of cooking energy cost on the demand for energy in Nigeria in time (t), we specify the model below:

$$CEC_t = (\beta \sum CEP_{tj}) \quad (10)$$

where CEC_t is energy consumption (a proxy for energy demand), and $\sum CEP_{tj}$ is vector of prices of cooking energy at time (t), with j=1, 2, i.e the prices of kerosene and LPG.

To control for the model, we add other variables that affect the demand for energy at the macro level. This will help take care of the autocorrelation problem that may arise from the non-inclusion of core variables in the model. The new model is then stated as:

$$CEC_t = F(CEP_{t,} GDP_t, POPGR_{t,} SUBD_t, CEC_{t-1}) \quad (11)$$

where CEC_t and CEP_t are as defined before, GDP_t is the income of the household, $POPGR_t$ is the population of the country; $SUBD_t$ is the subsidy for energy products, CEC_{t-1} is the previous energy demand.

To capture the effect of other variables not included in the model, we include the error term. We then express in a natural log to have an econometric model of the form:

$$InCEC_t\alpha + \beta_1 \sum InCEP_t + \beta_2 InGDP_t + \beta_3 POPGR_t + \beta_4 InSUBD_t + \beta_5 InCEC_{t-1} + \mu t \quad (12)$$

where α is the intercept, and β is the constant indicating the magnitude of change in the independent variables.

To account for the short-term and long-term dynamics in the regression equation, an ARDL model of the form is stated:

$$\Delta InCEC_t = \partial InCEC_{t-1} + \sigma InCEP_{t-1} + \alpha InGDP_{t-1} + \gamma POPGR_{t-1} + \rho InSUBD_{t-1} + \sum_{i=1}^{n} \omega \Delta InCEC_{t-i} + \sum_{j=0}^{n} \beta \Delta \mathrm{InCEP_{t-j}} + \sum_{k=0}^{n} \emptyset \Delta \mathrm{InGDP_{t-k}} + \sum_{l=0}^{n} \theta \Delta \mathrm{POPGR_{t-l}} + \sum_{q=0}^{n} \varphi \Delta \mathrm{InSUBD_{t-q}} + ¥ECM_{t-1} + \mu t \quad (13)$$

where $\omega, \beta, \emptyset, \theta, \varphi$ *and* are the short-run dynamics of the parameters of the regression equation, ¥ is the coefficient of the ECM indicating the speed of adjustment from short-run equilibrium towards long-run equilibrium.

3.3. Pre Estimation and diagnosis tests

Stationarity Test: On many occasions, times series data is said to behave abnormally and one of such instances is when they fail to follow a regular trend. The ARDL was introduced by Pesaran et al (2001) to accommodate variables that are stationary at order 1(0) and 1(1) in the same model estimation. Thus, we shall check if our time series is stationary at order 1(0) and 1(1) seeing that the ARDL can still obtain an accurate estimate at both level and first difference, unlike the OLS. A common rule of thumb for detecting stationarity is as follow:

$$E(Y_t) = E(\varepsilon_t - \varepsilon_{t-1}) = 0$$
$$Var(Y_t) = (Y_t^2) = \sigma^2$$
$$Cov(Y_t, Y_{t-1}) = E(Y_t - \dot{Y})(Y_{t-1} - \dot{Y}) = -\sigma^2$$

Cointegration Test: Cointegration is the existence of a long-run or equilibrium relationship between two variables of a time series. To check if long-run equilibrium exists, we shall apply the Bound test. Since there is always disequilibrium within the short-run we can introduce the error term into the cointegrating equation to represent the error in our cointegrating equation. By doing so we would have tied the short-run behavior or impact of our variables to its long-run behavior or impact, (Gujarati, 2013).

Autocorrelation: When a mutual relationship or effects exist between two or more members of a series of observation, it is called autocorrelation.

$E(\mu_i\mu_j) \neq 0,\ i \neq j$

Serial correlation is the commonest kind of correlation associated with the autoregressive lagged models, especially when daily weekly, monthly and quarterly data are involved, (Gujarati, 2013). This study shall make use of the Breusch-Godfrey LM test to check if the serial correlation exists or not. Where the H_0: a state that there is a serial correlation. A common rule of thumb is to accept H_0 if the probability of the F-statistic is less than 5%. Otherwise, we reject the H_0 (null hypothesis).

Heteroskedasticity Test: The test for equal variance among the variables shall be based on the Breusch-Pagan-Godfrey test. The test is an F-test. The H_0: states that there is heteroskedasticity. The common decision rule is to reject the H_0 if the probability of the F-statistic is greater than the conventional 5% significance. Otherwise, we accept the H_0(null hypothesis)

Stability Test: it a stylized fact that an unstable model is not ideal for predictions and thus not suitable for policy purposes. This study will apply the cusum and cusum squared test at the 5% conventional significance level, to as certain the stability of the models.

4. Results and discussion of findings

4.1. Descriptive Analysis

Table 4.1 Descriptive Statistics

	CEC	GDP	HHKP	LPGP	POPGR	SUBD
Median	1686.094	17939.88	50.00000	1500.000	0.025682	2.83E+11
Maximum	2740.844	127762.5	365.9400	5259.170	0.026777	8.71E+11
Minimum	826.2813	523.7688	0.430000	13.75000	0.024882	4.02E+10
Skewness	0.372939	0.888458	1.902976	0.490715	0.078250	0.422619
Jarque-Bera	3.542363	16.21074	94.04088	9.792533	12.73153	12.30974
Probability	0.170132	0.000302	0.000000	0.007474	0.001719	0.002123
Observations	112	112	112	112	112	112

Source: Authors' computation using E-views 9.0

Table 4.1 above showcases the descriptive statistic of the initial data used in the study, the result shows positive skew for all the variables. Based on the descriptive statistic the data for CEC looks normal while the rest are abnormal.

4.2. Pre-estimation test

4.2.1. Unit Root of the Variables

In analyzing the long-run relationship among variables of this study the time series data is expected to be stationary either at level 1(0) or first difference 1(1), as stipulated by economic theory. However, the ARDL permits the use of both the 1(0) and 1(1) jointly for the same model. This study adopted the Augmented Dickey-Fuller (ADF), Philip-Perron (PP), and the Breakpoint unit root test in the check for stationarity, in order to take care of variables affected by the structural break.

Table 4.2 Result of the ADF, PP and Breakpoint Unit Root Tests

Variables	ADF		PP		BREAKING POINT	
	Level	First difference	Level	First difference	Level	First difference
LCEC	-3.788(1)***	-4.847(0)***	-2.634(4)*	-4.307(11)***	-4.540(1)**	-6.185(0)***
LLPGP	-1.904(1)	-6.666(00***	-2.513(4)	-6.359(4)***	-8.300(13)	-7.233(3)***
LHHKP	-2.446(0)	-7.874(0)***	-2.118(4)	-7.990(3)***	-3.513(0)	-8.476(0)***
POPGR	-2.677(4)*	-1.686(3)	-0.953(10)	-11.639(10)***	-3.659(4)	-3.050(3)
LGDP	-3.385(1)**	-2.994(0)**	-4.774(7)***	-2.956(3)**	-4.209(1)*	-5.085(0)***
LSUBD	-1.460(5)	-3.899(4)***	-1.066(2)	-4.216(19)***	-5.571(1)***	-6.780(0)***

NOTES:
1. ***, **, * imply significance at 1%, 5%, 10% level, respectively.
2. The numbers in parentheses for the unit root tests represent the lag of the dependent variable used to obtain the white noise residual.
3. The lag length for the ADF, PP, and Breakpoint was selected using Schwarz Information Criterion (SIC), Newey-West Bartlett Kernel and Schwarz Information Criterion (SIC), respectively.

The result of the various unit root tests displayed in Table 4.2 above indicates that the variables are all stationary (integrated) at I (0) and I (1) hence, permitting the use of ARDL approach for the cointegration model.

4.2.2. Cointegration and Bound Approach

As posited by Pesaran, Shin and Smith (2001), the ARDL cointegration test assumed that a cointegration relationship between the dependent variable and the regressors is singular. To check the validity of this proposition in this study, we shall adopt the Bound F-statistics test to check for the joint significance of the ARDL by transforming all our variables into a dependent variable (Ahmad Abd Halim et al. 2008). Because the Bound F-test is sensitive to the number of lags imposed on each differenced variable this study, therefore, used a lag length of 5 which was subjected to Akaike Information Criterion (AIC), to compute the Bound F-test of joint significance of lagged levels of the variables.

The result of the Bound F-test shows that the F-statistic is greater than the critical values of the upper Bound at all levels of significance, implying that there is cointegration between the dependent variable (cooking energy demand: CEC) and the regressors: income (GDP), cooking energy prices (HHKP and LPGP), previous demand (CEC_1), population (POPGR) and Subsidy (SUBD).

Table 4.3 Result of the ARDL Bound Test for the Model

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	K
F-statistic	6.396347****	5
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

NOTE:

1. **** imply that cointegration exist at 10%, 5%, 2.5% and 1% significance level.
2. k=5 represents the number of regressors.

4.3. Result of the Estimation Based On the Research Objective

The result of the ARDL model (2, 4, 1, 1, 1, 0) estimated is presented in table 4.3. The regression result presented as table 4.4. shows that in the short-run, household cooking kerosene price(HHKP) is negatively related to cooking energy demand in Nigeria however, it is not significant at all as the t-value of (-0.9246) and p-value of (0.358) depict, the insignificance of HHKP does not agree with many of the micro studies in this respect such as (Baiyegunhi and Hassan, 2014). The negative relationship supports our theoretical expectation according to demand theory whereas, the insignificant status indicates that household kerosene (aside from fuelwood) is a major cooking fuel among rural and urban households in Nigeria without any close rival (Ohimain, 2012). This same negative relationship exists in the long-run with high significance at 95%, as the t-value of (-3.3552) and p-value of (0.001) shows. This implies that in the long-run cost will have a strong impact on cooking energy demand in Nigeria in a much significant way, supporting (Baiyegunhi and Hassan, 2014). In the short-run, Liquefied petroleum gas price (LPGP) has a positive relationship with cooking energy demand and is highly significant above the 95% level with a t-value of (2.6509) and p-value of (0.009), contradicting (Ozoh et al, 2018). Although this fell out of economic a priori, indicating that energy demand is not affected by the price of LPG. It suggests that users of LPG do not consider its price since they know its environmental and health gain hence, kerosene is not a close rival/substitute to it. The long-run result is negative and insignificant. Meaning that in the long-run users of LPG will respond to cost but not like with HHK, because of the awareness of its health benefits (Masera, Saatkamp and Kammen, 2000). The ECM (-1) value of (-0.1339) which is significant, indicates that about 13% of the disequilibrium will be corrected in the next period, and validates the presence of cointegration between the regressand and the regressors.

Table 4.4 The Short-Run and Long-Run Result of the ARDL (2, 4, 1, 1, 1, 0)

Short-run Form

Variable	Coefficient	t-Statistic	Prob.
ΔLCEC(-1)	0.592294	4.318844	0.0000
ΔLHHKP	-0.046623	-0.924670	0.3575
ΔLHHKP(-1)	-0.000977	-0.021404	0.9830
ΔLHHKP(-2)	0.015105	0.333472	0.7395
ΔLHHKP(-3)	0.089706	2.134759	0.0354
ΔLLPGP	0.094443	2.650970	0.0094
ΔLGDP	1.754117	3.429835	0.0009
ΔPOPGR	-0.565282	-0.643612	0.5214
ΔLSUBD	0.084359	2.237400	0.0276
ECM(-1)	-0.133900	-3.119168	0.0024

Long-Run Form

Variable	Coefficient	t-Statistic	Prob.
LHHKP	-0.793170	-3.355286	0.0011
LLPGP	-0.041704	-0.534472	0.5943
LGDP	0.927061	2.418869	0.0175
POPGR	-7.517791	-1.779992	0.0783
LSUBD	0.630010	1.812426	0.0731
C	3.631803	0.875805	0.3834

R^2 = 0.96; **F-stat**. 158.5595(0.000); **RSS** = 0.40878; **DW** = 2.08; **S.E**=0.0659

The long-run model corresponding to the ARDL (2, 4, 1, 1, 1, 0) for the impact of cost on cooking energy demand is written as:

$LCEC = 3.6318 – 0.7932LHHKP_t + 0.0417LLPGP_t + 0.9271LGDP_t – 7.5178POPGR_t$
(0.383) (0.001) (0.594) (0.018) (0.078) $+ 0.6300SUBD_t$
(0.073)

4.4. Diagnostic tests

To validate the output of the regression result in this study the following diagnostic test is conducted: normality test; serial correlation test; heteroskedasticity test; dynamic stability test; and specification error test. The result of the Breusch-Godfrey LM serial correlation test for the model shows rejection of the null hypothesis at the 5% conventional significant as depicted by table 4.5.

Table 4.5 Results of the diagnostic test

Diagnostic Tests	F-statistic	Prob.
Auto. Test	0.602847	F(1,93) 0.4340
Hetr. Test	3.200471	F(14,94) 0.0000
Ramsey test	8.0224	F(1,93) 0.0057

One of the assumptions in the time series analysis when using ARDL model is that there is equal variance among the variables of interest in order to obtain a consistent result that will meet the need of policy purpose and forecasting. The result of the Breusch-Pagan-Godfrey heteroskedasticity test above indicates the presence of the problem of heteroskedasticity at the 5% significant level leading us to accept the null hypothesis. However, the effect of this heteroskedasticity in the model was off-set using the Whites' coefficient covariance matrix, leaving us with a consistent regression result.
The result of the Ramsey Reset test for omitted variables is presented in Table 4.5 shows that at a 5% level of significance the null hypothesis is accepted, as it shows that there are omitted variables in the model and further validated by the F-prob. of (0.0057).

4.5. Dynamic stability test

The result of figure 4.1 below is the output for our omitted variable test. The cusum test shows that model one is stable as it lies within the 5% significance line whereas the cusum squared test shows slight instability as it at some points moved out of the 5% significant boundary. This instability in the model seems to explain the existence of the energy crisis cum paradox inherent in the Nigerian energy market.

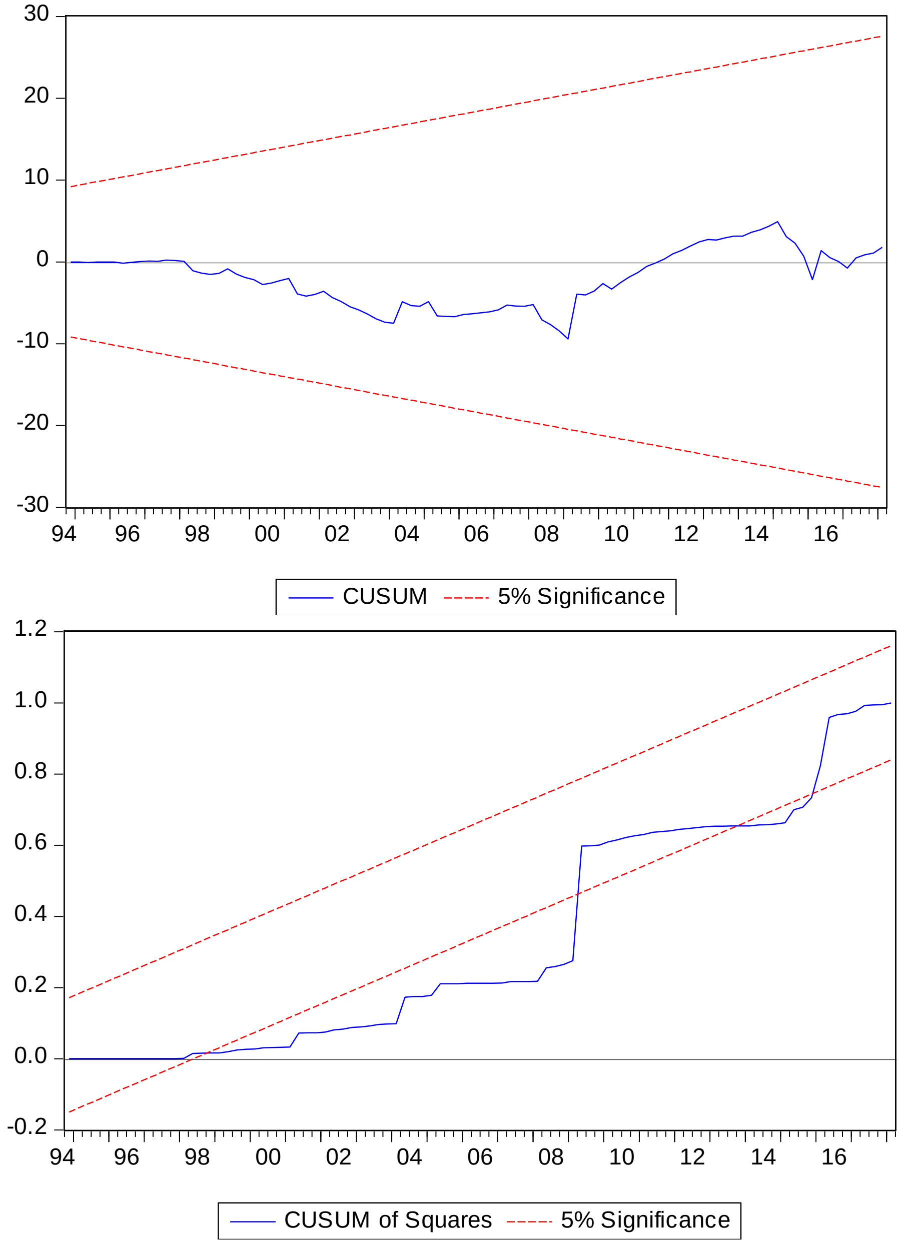

Figure 4.1 The Dynamic Cusum Test and Cusum Squared Test for Model One

5. Conclusions and recommendations

Based on the objective of this study, the cost has a negative and insignificant impact on cooking energy demand in Nigeria but, the case of LPG showed otherwise: with a positive and significant impact on cooking energy demand. Although this is in the short-run, the case of the long-run seems to be the opposite. This means that people still depend much on HHK compared to LPG, in Nigeria.
This may be as a result of safety factors, cost and lack of awareness of the fact that LPG is green energy. Essentially**, t**his study found that the cost of cooking energy significantly impacts its demand both in the current period and in the long-run hence, calling for policies that help maintain a steady price for cooking fuels at a level that is within the reach of the common man in the country.
Based on the findings of this study, the following recommendations are proffered: First, the relevant agencies of the government in the country should undertake policies that will help reduce the cost of basic cooking fuels and possibly improve the supply of green energies. Second, the government should embark on policies that will help better the welfare of the common man via job creation and income increment.

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Author Contributions
Anthony, Stephen and Onyinye conceived the study and were responsible for the design, data collection and development of the data analysis and data interpretation. Anthony, Peter and Stephen were responsible for the literature and proofreading the work.

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