Determinant Factors of Household Energy Choice in Nigeria: Fresh Evidence from Fuel Stacking Model

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Abstract

The study investigated the factors that determine the choice of cooking energy for households and the energy ladder with the aim of determining the energy model that is valid for Nigerian households between energy ladder model and fuel stacking model. Data was sourced from the Living Standard Survey conducted by the National Bureau of Statistics for the years 1996, 2004, 2010 and 2018. Descriptive statistical tools and multinomial logit model were used to achieve the objectives. Findings from descriptive analysis reveal that in the earlier years of study period, most households used firewood and kerosene. In the later years, there was slight increase in the use kerosene and LPG with little or no change in the use of firewood and kerosene. Also, as per capita expenditure increased, LPG and Kerosene started becoming preferred while fire wood was becoming less preferred but was never abandoned at any point concluding that the energy model that works for Nigerian households is the fuel stacking model. Meanwhile the logit model indicates that only firewood was more accessible and available for households than the modern energy sources. It is therefore recommended that Government should improve on the supply of LPG and kerosene coupled with subsidy for households to have better access to stack clean and more efficient fuels.

Keywords: *Energy use, energy ladder, Fuel Stacking, Multinomial logit*
JEL CODES: Q40, Q43, Q49

Contribution to/Originality Knowledge

The study sought to examine which energy model holds for Nigerian households between energy ladder and fuel stacking. It revealed that increase in the income of households does not necessarily cause an abandonment of the fuel that was in use rather, it causes households to introduce new fuel to combine with existing fuels.

1.0 Introduction

Energy consumption in the household sector is one of the essential needs of human society. It is necessary for human life and progress in technology (Toole, 2016). Energy consumption is a significant determinant of the socio-economic growth of the people in every society. It is fundamental for the satisfaction of diverse human needs; heating, cooking, lighting, preservation, movement, production of agricultural and industrial goods, among others. Household energy for cooking is the largest sources of energy demand and Green House Carbon emission with the increase in population (Heinonen & Junnila, 2014 in Imran & Özçatalbaş 2016).

Household sector is faced with two categories of cooking energy: the unclean traditional biomass fuels and the clean, commercial fuels. Certain factors determine individual use of these categories, and there are dimensions to their uses. The traditional fuels have health, environmental and socio-economic

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implications to their use (World Bank, 2006). The kind of fuels used in different cities is a good indicator of the relative economic situation of households, that is, cities with households that consume more of commercial fuels are often wealthier than cities with households that consume traditional fuels (Sathaye, Ghirardi & Scipper, 1987). Sathaye and Meyers (1985) posit that the type of fuel used in households is usually a good indicator of the economic status of the household. This is not always the situation in Nigeria. According Sathaye and Meyers (1985), as income increases, choice of fuel tends to shift from traditional fuels to commercial fuels. Income is one of the determinant factors of fuel choice in that with increased income, commercial fuels are more consumed because they can be afforded but with low income, traditional biomass fuels are more consumed because they are free and the only thing required for traditional fuel (firewood) is an axe (Sa'ad, 2018).

Some household energy choice is dependent mainly on income, so when income increases, there is likelihood of switching from unclean fuel to a clean one. This explains the energy ladder model. The energy ladder model is a scale which rates the quality of household fuels. The model explains that households might use cleaner fuel as their income increases and they switch from the former fuel to another and abandon the previously used fuel. Modern cooking fuels of higher efficiency and improved cleanliness helps diminish the extent of adverse health, gender, and environmental consequences, but this comes with increased costs (Goldemberg, 2000). Other factors such as availability, accessibility, culture and tradition, household size, type of food to be cooked, location of the house, gender of house head, educational background, taste and other factors also contribute primarily to the choice of the energy of households. These factors are the basis of the fuel stacking model. The fuel stacking model assumes that an increase in income does not necessarily cause an abandonment of former fuels but introduces new fuel to combine with the existing fuel. This is to say that, these other factors that determine choice of fuel may not allow household to shift from unclean fuels already in use even though household income has increased (Ogwumike, Ozughalu and Ahioma, 2014).

Household energy consumption in developing countries has environmental, economic, and gender implications. Several programs have attempted to encourage households to adopt cleaner and more efficient forms of energy with limited success. These include subsidies and financing strategies, distribution of cook stoves, and electrification projects (Barnes & Floor 1996; Heltberg 2005; Kowsari 2011). In some developing countries, nearly 90 percent of the population lack adequate access to continuous or sufficient energy supplies and 2.4 billion people still rely on biomass for their primary source of energy (Barnes & Floor 1996; Link, Axinn, & Ghimire 2011; Idakwoji 2016). In Nigeria, the household sector accounts for the largest share of about 65% of energy usage (Oyedepo, 2012). With the continued debate surrounding energy models and determinants of cooking fuel choice, limited success in awareness creation and encouragement programs to induce households to shift to modern fuels, chances to join residential energy conversation and propose policy solutions abound.

There is a lack of clarity about the energy model that holds for households in Nigeria among energy models that exist. The energy ladder model or the fuel stacking model; Serious issues are rising concerning determinants of the household choice of energy. Among these concerns are the validity of energy ladder hypothesis and that of fuel stacking model; factors that significantly influence the decision and use of household energy. Knowing which hypothesis holds for a country is crucial for successful energy policies. Given that energy ladder model prevailed earlier than fuel stacking, and that the model was significantly applicable to all societies, then it would be unwise to assume energy ladder away from household energy study. Critical to the value and logic of this research is identifying the significant factors that determine household energy choice in Nigeria hence the hypothesis that holds for Nigeria and then to formulate policies that will support and grow household energy efficiency and finally to examine the implications of these fuels on health and environment. Identifying the energy

choice determinants and the hypothesis that holds for the area of study is therefore an area worthy of study and one that would contribute knowledge to the household energy research community. Against this background, this paper seeks examine the validity of the energy ladder hypothesis or fuel stacking in the energy consumption pattern within the context of Nigeria and to identify the factors that account for the choice and pattern of households' energy consumption in Nigeria.

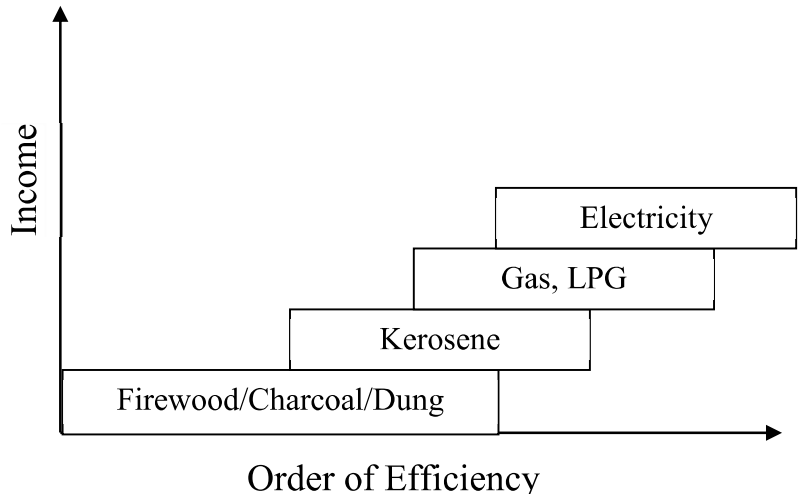
The rest of the paper is organized as follows: Section 2 contains literature review, section 3 focuses on the research methodology and data sources. Section 4 contains presentation of results and discussions while Section 5 concludes and gives policy recommendations.

2.0 Literature Review

This section deals with theoretical literature and empirical literature. It discusses the theories that relates with household energy consumption behaviour, review of Energy Sources and determinants of choice.

2.1 Theoretical literature

Figure 1: The Energy Ladder



Source: authors construct

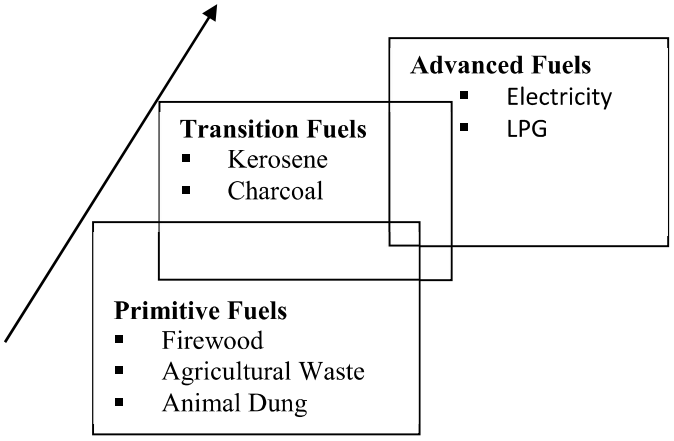
The theory of energy ladder supposes that households should imitate the behavior of rational consumer; this means that these consumers will shift to a more suitable energy form as their inflow of income increases (Hosier & Dowd 1987). In the energy transition process, fuel changing is a paramount concept, meaning neglecting one fuel for another. An upward movement to a new fuel is shift away from the fuel, which was in use before the new fuel (Heltberg, 2005).

The ordering of the fuels on the energy ladder is according to the household right of choice based on features such as cleanliness, easy use, cooking speed and monetary involvement (Hiemstra-van der Host & Hovorka 2008). The climbing of the ladder of energy is in three stages. As households secure a better status in their social and economic life, like Dutch disease, they neglect fire wood energy source because it is inept, cheap and more polluting and shift from world dependence on fire wood to transition fuels such as kerosene and charcoal in the second stage. In the third and last stage, households change to fuels such as Liquefied Petroleum Gas (LPG) and electricity (Heltberg, 2003). Advanced and highly placed fuels are more often attached with premium prices, very efficient and demands little effort before use yet produces minutest pollution per unit of fuel (Masera, Saatkamp & Kammen, 2000).

The theory of energy ladder also supposes that the use of advanced and highly placed fuels is domestically and internationally observed to indicate superior class. Households desire to shift upwards in the energy ladder not only to achieve higher fuel efficiency or less open and direct pollution, but to display an increase in the economic status (Masera, Saatkamp & Kammen 2000).

The theory of energy ladder depicts transition fuels as inferior economic goods, meaning dung waste; fuelwood and charcoal are always seen to be for the less rich and poor within the country. This implies that there is a relationship between income and fuel choice. Cross-country comparisons reveal a positive correlation between economic growth and modern fuel up take, suggesting that as a country progresses through the industrialization process, its reliance on petroleum and electricity increases and the importance of biomass decreases (Hosier and Dowd 1987). However, empirical evidence suggests that the linkages between fuel choice and income level are rarely as strong as assumed by the energy ladder. Both Arnold, Kohlin and Persson (2006) and Cooke, Kohlin and Hyde (2008) pointed out that many income elasticity of demand for dung waste, fuelwood and charcoal are infinitesimal, very low or even positive.

Figure 2: Fuel stack model



Source: *Authors Construct*

The Fuel Stacking model argues that household income is not the determining factor in household decision making to fuel switch, but there are other factors well that should be taken into consideration. In contrast to the single-fuel substitution pattern anticipated by the original energy ladder model, it has become apparent that multiple fuel use is the norm in most households. Thus stacking theory is not driven by the emerging desire for modern fuels which are due to socioeconomic changes. In addition, the transition theory argues that by using the energy ladder theory (model), knowledge on consumer decision making will be restricted (Heltberg, 2004). The fuel stacking model advocates that households do not necessarily switch from one fuel to another, but they prefer using a combination of primitive fuels, transition fuels and advanced fuels for varying reasons, therefore, traditional fuels are not abandoned but they are used to compliment advanced fuels.

2.2 Empirical Literature

A growing number of empirical studies is making effort to examine the fuel switching strategies, households' income, fuel prices, energy choices and also the validity of the energy ladder hypothesis of households in developing countries. The paragraphs below present a brief review of previous studies, focusing on households' fuel choices and switching strategies.

Naseer and Kanayo (2020) conducted an empirical study on fuel-wood energy consumption dynamics among Nigerian households to confirm the validity of fuel stacking theory using micro-level data. In the study, 120 Enumeration Areas (EAs) demarcated for Katsina State by the Nigerian National Bureau of Statistics (NBS) for socio-economic development data were used to capture 992 household fuel-wood consumers. We used descriptive statistics to analyze the results. The findings showed 72.2% of the household respondents used fuel-wood for domestic activities trice in a day, and 48.6% confirmed fuel stacking behavior among households due to family size, 43.6% price and 6.6% culture.

Adamu, Adamu, Ade and Akeh (2020) reviewed various energy sources for household consumption and examines the implications of their dependence on traditional energy sources as well as the energy ladder model as a concept widely used by scholars in describing the role of income in determining energy use and choices. a synthesis and critical analysis of existing literature on household energy consumption was the method diploid. The paper posits that the dependence on energy sources at the lowest rung of the energy ladder by most households in Nigeria is accentuated by rising poverty level consistent with the energy ladder hypothesis but disagrees with the notion of complete fuel substitution given that most households tend to have a mix of energy sources for their activities

Choumert, Combes and LeRoux (2017) embarked on a study, stacking up the ladder: A panel data analysis of Tanzanian household energy choices. The nationally representative three-wave panel dataset (2008-2013) was used to contribute to the literature on household energy use decisions in Tanzania in the context of the stacking and energy ladder hypotheses. They first adopted a panel multinomial-logit approach to model the determinants of household cooking- and lighting-fuel choices. Secondly, they focused explicitly on energy stacking behaviour, proposing various ways of measuring what is inferred when stacking behaviour is thought of in the context of the energy transition and presenting household level correlates of energy stacking behaviour. Finally, since fuel uses have gender-differentiated impacts, they investigated women's bargaining power in the decision-making process of household fuel choices. Findings showed that whilst higher household incomes are strongly associated with a transition towards the adoption of more modern fuels, this transition takes place in a context of significant fuel stacking.

Emagbetere, Odia and Oreko (2016) investigated factors affecting the choice of household energy utilized for cooking and the type preferred in Ikeja area of Lagos state. Data were obtained through oral interview and administration of structured questionnaire on 250 randomly sampled households in the study area. Descriptive statistics, inferential statistics and percentage difference were conducted between used energy and preference energy. Findings showed that kerosene and Gas (LPG) were mostly used for daily cooking with (48.60%) and (36.30%) respectively while charcoal, firewood and electricity for their daily cooking was 7.10%, 5.7% and 2.4% respectively. However preference rating of household energy was highest in Gas followed by electricity, kerosene, charcoal and firewood respectively. Chi-test, linear-by-linear relationship test, likelihood ratio test revealed that level of income, level of education and type of employment affects the choice of fuel used for cooking and the type preferred.

Bamiro and Ogunjobi (2015) examined household energy consumption in Ogun State. Primary data on socio- economic characteristics of household head, expenditure on energy and non-energy sources were collected from 150 respondents using stratified random sampling technique. Descriptive statistics and multinomial logit were used for data analysis. Descriptive statistics was used to analyze socio-economic characteristics of household head and to determine the share of each energy source on total expenditure on energy. Multinomial logit and tobit regression models were employed for the analysis of the determinants of fuel choice, the determinants of energy consumption. The determinants of fuel choice

(solids) are prices of wood and kerosene and family size squared significantly and positively influence the choice of fuels while prices of wood, kerosene and electricity determines the monthly household's expenditure on fuels. The effect of family size on the choice of fuels is negative and nonlinear.

Ogwumike, Ozughalu and Ahioma (2014) examined household energy use and its determinants in Nigeria based on the 2004 Nigeria Living Standard Survey data obtained from the National Bureau of Statistics. The study utilized descriptive statistics and multinomial logit models. Most households in Nigeria use firewood as cooking fuel and kerosene for lighting. This shows that most Nigerian households do not have adequate access to environmentally-friendly modern energy sources. They revealed that energy use in Nigeria supports fuel stacking rather than energy ladder hypothesis. Among the factors that significantly influence household energy use for cooking are educational levels of father and mother, per capita expenditure and household size.

Yonas, Abebe, Kohlin and Mekonnen (2015) used a panel multinomial logit to model Household Cooking Fuel Choice and used three rounds of a rich panel data set to investigate the determinants of household cooking fuel choice and energy transition in urban Ethiopia. They observed that the expected energy transition did not occur following economic growth in Ethiopia during the decade 2000- 2009. Regression results from a random effects multinomial logit model suggest that households' economic status, price of alternative energy sources, and education are important determinants of fuel choice in urban Ethiopia.

Fawehinmi and Oyerinde, (2002) analyzed the Challenges of Pricing and Poverty in Fuel-Switching among households in Nigeria. Findings showed out that every society practices fuel-switching as its economic development gets under way. This is usually from traditional fuels to modern commercial fuel. It noted that due to the issues of pricing, wherein prices of modern fuels have increased astronomically, and the increasing level of poverty in the country, the fuel of choice of many Nigerian homes remains the utilization of wood fuels for consumption. Although this could be reasonable or rational per se but the choice is not sustainable as it portends a threat to the forests, the users, and the economy.

The theory which this study is based is the energy ladder theory of which findings will show if the theory validates the energy consumption pattern of the Nigerian households.

3.0 Methodology

3.1. Data

This study employed data from the Nigeria Living Standards Survey (NLSS), 1996, 2004, 2010 and 2018 conducted by the National Bureau of Statistics (NBS). The 36 states of Nigeria and Abuja [Federal Capital Territory (FCT)] were all captured in the surveys using the two-stage stratified random sampling. At the first stage, 120 enumeration areas (EAs) were randomly selected from each state and 60 from the Federal Capital Territory (FCT, Abuja). The second stage involved random selection of housing units from the selected EAs. A total of 600 housing units were randomly chosen in each of the states and 300 housing units from the FCT.

3.2 Model Specification

In order to determine which energy hypothesis is valid for Nigerian households, households were grouped based on their expenditure so that based on rational consumer notion, households with higher expenditure are expected to use the most efficient and clean fuels (gas and electricity) for cooking while the lower expenditure group is expected to have kerosene as their main cooking fuel and then the least expenditure households is expected to have fuel wood as their main source of cooking energy.

Factors such as quantitative or qualitative, economic or non-economic, cultural, individual and psychological influence the decision of most households on their choice of fuel for cooking needs. This study aims at determining the factors that influence the choice of a particular fuel (firewood, kerosene, liquefied petroleum gas (LPG), or electricity) for cooking activities. That is, dependent variables are the fuel types while the independent variables are the socioeconomic indicators which in this study are sector of residence, household size, availability, per capita expenditure, gender of household head, household ownership of housing unit, age of household head, father's educational level, mother's educational level, poverty and zone of residence (South South, South East, South West, North West, North East and North Central). Following Green (2002) in Ogwumike, Ozughalu and Abina (2014), the following multinomial logit model was adopted for the purpose of analyzing the determinants of energy use for cooking. The model was adopted because of its abilities to predict the probability for multiple choices and it has been vastly used (Bamiro and Ogunjobi (2015). The multinomial logit model (MNL) was chosen from other qualitative response models and the data used on energy choice did not follow a particular order (McFadden, 1980; Jepsen, 2008). MNL assumes residuals as identically and independently distributed, (Maddala, 1983). The Multinomial Logistic Regression is useful for situations in which you want to be able to classify subjects based on values of a set of predictor variables. This type of regression is more general but similar to logistic regression because the dependent variable is not restricted to two categories.

$$\text{Prob}(\text{Yi} = \text{j}) = \frac{\text{e}\beta\text{jXi}}{\sum_{k=0}^{4} \text{e}\,\beta\text{tXi}}, \text{j} = 1,2,3,4$$

where: e is exponential function; Yi denotes the observed energy (fuel) used by households; i denotes observation of household;j denotes the fuel chosen by the household; β is the coefficients' vector; Xi is a vector of household characteristics, Where:X1 represents sector of residence; X2 represents household size; X3 represents per capita expenditure; X4 represents gender of the household head; X5 represents household ownership of housing unit; X6 represents age of household head; X7 represents father's education level; X8 represents mother's education level; X9 represents poverty status; X10 represents zone of residence, namely: South South; South East; South West; North Central; North West; North East

3.3 Definition of Variables

The table below gives the definition of the dependent and explanatory variables of the multinomial logit models for this study.

Table 1. Definition of explanatory and dependent variables of the Multinomial Logit Model

Variables (X_i) Explanatory variables	**Definition**
Sector	Urban = 1, Rural = 0
Household size	Number of household members
Per capita expenditure	Natural Logarithm of per capita expenditure
Accessibility	Accessible = 1, Not accessible = 0
Gender of Household Head	Male = 1, female = 0

Household ownership of the housing unit	Yes = 1, No = 0
Age of household head	In years
Father's educational level	Years of formal education
Mother's educational level	Years of formal education
Poverty	Yes = 1, No = 0
South South	Yes = 1, No = 0
South East	Yes = 1, No = 0
South West	Yes = 1, No = 0
North East	Yes = 1, No = 0
North West	Yes = 1, No = 0
North Central (Base category)	Yes = 1, No = 0
Variables (Y_i) Dependent variables	**Definition**
Firewood	Yes = 1, No = 0
Kerosene	Yes = 1, No = 0
Gas	Yes = 1, No = 0
Electricity	Yes = 1, No = 0

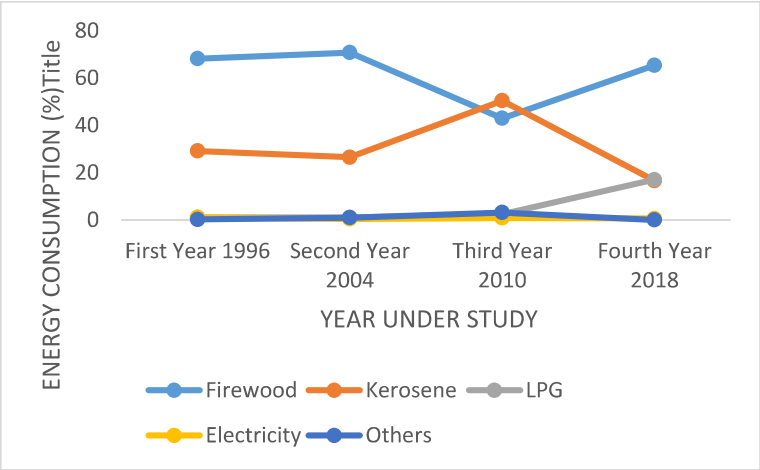
Source: Authors Design.

4.0 Data Analysis and Discussion

4.1 Household Energy for cooking

Figure 1 shows the variation in energy used for cooking by households in Nigeria over the years. From the distribution, in 1996, 68.2 percent households used firewood while kerosene and LPG were used by 29.2% and 1.1% households respectively. Households that used electricity and other energy sources were 1.2% and 0.3% respectively. The percentage of households that used firewood for cooking increased from 68.2% in 1996 to 70.8 percent in 2004 which led to decline in the number of households that used kerosene from 29.2% in 1996 to 26.6% in 2004. Similarly, households' that used electricity for cooking declined from 1.2% in 1996 to 0.5% in 2004 and households that used LPG for cooking remained the same percent in 2004. Meanwhile in 2010, firewood users decreased from 70.8% in 2004 to 43.0% which led to increase in kerosene to 50.48%, also, users of LPG increased to 2.48% and electricity and other sources of energy increased to 0.89% and 3.18% respectively. The year 2018, firewood users increased again to 65.4% percent, kerosene decreased tremendously to 16.7% percent and dramatically, the number of gas users increased to 17.1%, while electricity and other sources were used by 0.7% and 0.1% respectively.

Figure 3: Energy used by households



Source: Authors. Firewood for 2018 include charcoal of which is 14% of the total firewood used, others include crop residue, sawdust and animal waste. All data were sourced from Nigeria Living Standard Survey conducted by the national Bureau of Statistics.

From the energy distribution table, it is obvious that, firewood still thrives among Nigeria households despite health risk and the consumption of modern commercial fuels (especially electricity) is also meager given that Nigeria is relatively industrialized and a significant oil producer. It can be said that the availability and affordability of other energy forms had a significant influence on the consumption of firewood in the years 1996, 2004, 2010 and 2018. The more households used kerosene, LPG and electricity, the less they used Firewood and other inefficient fuels.

An intense examination of energy prices in the years of study shows that in Nigeria, kerosene pump price per litre was N0.50 in 1992. This rose to N2.75 in 1993 and N6.00 in 1994. It maintained this regulated price for a period of six years, price in 1996 was N6 till 2000, with this price, households who used kerosene was 29.2% while households that used firewood was 68.2%, then, kerosene price increased in the year 2000 to sell at the pump for N17.00 per litre. In 2002, the price rose to N24.00 and in 2003, its official selling price was N38.00 until 2004. Due to the increase in kerosene price, households that used kerosene for cooking reduced to 26.6% in 2004 from 29.2 % in 1994 causing the number of firewood users to increase from 68.2% in 1996 to 70.8% in 2004. Kerosene pump price per litre increased to N80.00 by 2005 and this was maintained up until 2010 when price fell back to N50 and maintained till 2015. At the reduced price of N50 in 2010, there was a dramatic increase in the number of households that used kerosene for cooking from 26.6% in 2004 to 50.48% in 2010 and a significant corresponding decline in the number of households that used firewood in the same year from 70.8% in 2004 to 43% in 2010. In 2016, price increased yet to N150 and since then till now, price has been on increase.

In Nigeria, electricity is used by only very few households for cooking. From the data, irrespective of the price of kerosene, the number of households that used electricity for cooking hovered between 0.5% and 1.2% in the years of study. This pattern can be linked to dilapidated power supply in Nigeria. Cooking is a process whereby once started, cannot be stopped until the process is completed, the power supply in Nigeria cannot guarantee that complete process so households prefer electricity majorly for lighting, heating and cooling but prefers LPG, kerosene and firewood for cooking purpose. The

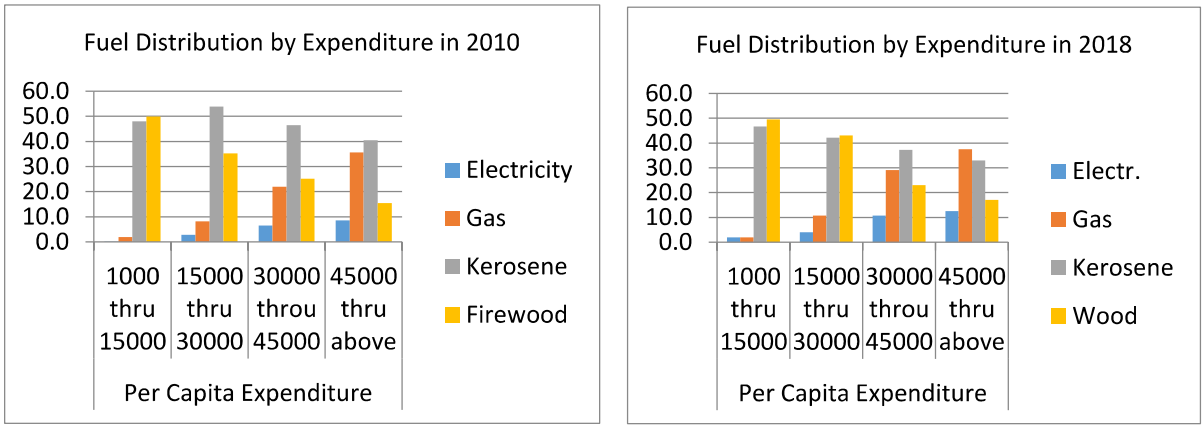
dilapidated electricity supply is blamed on government inadequate policies to generate enough electricity enough to meet the need of residential and commercial sector.

The LPG is also used by very few households in Nigeria. It is believed that households that use LPG are the rich members of any societies, thus the reason for the low number of households that use gas between 1996 and 2018. In 1996 and 2004, only 1.1% households used LPG for cooking and this is traceable to income. Households who earn higher incomes use LPG for cooking and those with lower incomes use less efficient fuel. Since 2010 to 2018, there was an obvious increase in the use of LPG for cooking among households, 2.48% in 2010 and 17.1% in 2018. This is no longer attributed to price or income, rather, convenience that comes with cooking gas, the efficiency and its' cleanliness.

4.2 Household Expenditure and the Energy Ladder

The theory of energy ladder supposes that households will shift to a more suitable energy form as their inflow of income increases. The role of income in determining fuel choices cannot be overemphasized in the theory of energy ladder. However, this study adapts the method of Ogwumike et al (2014) by using expenditure rather than income in households grouping to determine household pattern of energy for cooking. It is therefore expected based on the theory of energy ladder that households with lowest income will use firewood and animal wastes as their energy for cooking; households at an average income will use kerosene while households with higher income will use electricity and gas for cooking.

Figure 4 and 5: Pattern of energy used for cooking in different expenditure groups 2010 and 2018



Source: composed by the authors

The chat displays the percentage of fuel usage for cooking with increase in per capita expenditure and from the chat it can be clearly seen that at the initial level of per capita expenditure of 1000 to 15000, more households used firewood, 49.9% households used firewood, while 48% households used kerosene the closest substitute to firewood, meanwhile 0.2% and 1.9% used electricity and gas respectively for cooking. When per capita expenditure increased to the range of 15000 to 30000, households that used kerosene as their major source of cooking fuel increased to 53.8%, households who used firewood reduced to 35.2% but for electricity and gas, the number of households that used them increased to 2.8% and 8.2% respectively. At another increase in per capita expenditure to 30000 to 45000, households that used kerosene decreased to 46.4%, household that used firewood also decreased to 25.1% but electricity and gas users increased in number to 6.5% and 22% respectively. At yet another increase in per capita expenditure to 45000 above, the number of households that used kerosene decreased to 40.4% and its close substitute firewood also had users decrease to 15.5%, this time, electricity users decreased to 5.5% while gas users increased to 26%. The reason for kerosene

being the major fuel in 2010 is because prices of petroleum products were regulated and kerosene was demanded more than other fuels for cooking.

From the chart, the behavior pattern of cooking of households is such that, at increase in expenditure, there was a decline in firewood usage, increase in use of transition fuel (kerosene) and increase in use of modern fuels (LPG and electricity). As expenditure increased, there came more declines in the number of households that used firewood, a decline in the number of households that used transition fuel kerosene and increase in the number of households' that used modern fuels. At each increase in expenditure, there was no group that had zero use of any fuel; this is to say that in 2010, households' behavioral pattern of energy for cooking was not consistent with the energy ladder hypothesis but applied the energy ladder passage stage or transition stage. With the analysis, it is valid to say that households' behavioral pattern of energy for cooking in 2010 is consistent with the fuel stacking hypothesis rather than the energy ladder hypotheses.

From the 2018 chat, at the initial level of expenditure, firewood was more used for cooking followed by kerosene its close substitute, then electricity and LPG were used by very few households. When expenditure increased, the households that used kerosene and firewood decreased but the decrease in number that used firewood was more than the decrease in number that used kerosene. Both kerosene and firewood were still used by larger proportion of households despite the decline in number of households that used it. While households that used firewood and kerosene decreased in number, those who used electricity and LPG increased in number. The movement from the initial expenditure to a higher expenditure group did not cause an abandonment of fuel that was initially used, rather a decrease in the use of former fuel. This also is consistent with the stages of transition energy ladder but the behavior of households on energy for cooking validates fuel stacking hypotheses and not energy ladder hypotheses.

A close examination of 2010 analysis and 2018 analysis shows that households that used unclean and transition fuels at every change reduced in number while households that used clean and efficient fuel increased in number. Firewood and kerosene were downward sloping with increase in per capita expenditure while LPG and electricity had an upward movement at every increase in per capita expenditure in both years.

4.3 Determinants of Household Energy Use

Table 2. Estimates of Multinomial Logit Model for Household Energy Use for Cooking in Nigeria

Variable	Signs	Electricity	LPG	Kerosene	Firewood
Constant	C	-3.1790* (40.950)	-13.7372* (19.536)	248.96*** (28.326)	51.688*** (12.958)
Sector	SEC	-0.0020** (0.0053)	0.0182*** (0.4263)	0.6356** (1.8936)	-0.4743* (0.5478)
Household size	HS	0.3838** (0.8263)	-0.1928* (0.7175)	-0.5789** (1.5266)	0.1065*** (0.0653)

Accessibility	ACC	0.2668* (0.6357)	0.3828** (0.9162)	0.4112*** (2.6378)	0.8446*** (0.8547)
Per capita expenditure	IPCE	-0.0130*** (0.0184)	0.5363** (0.3828)	0.4804*** (0.2678)	-0.2065* (0.7467)
Gender of household head	GHH	0.0132* (0.0237)	-0.9218** (0.1918)	0.1553 (0.0367)	1.2533* (0.1578)
Household ownership of housing unit	HOHU	-0.0023** (0.0077)	0.3623*** (0.4373)	1.0078*** (0.2699)	-0.6345* (0.7368)
Age of household head	AHH	0.0018*** (0.0031)	0.0127* (1.6273)	0.3215* (1.3748)	-0.6345** (0.1955)
Father's level of education	FEL	-0.1011*** (0.5624)	0.2938** (0.1937)	0.5903* (0.9577)	-0.2132** (0.5624)
Mother's level of education	MEL	1.0744* (0.0067)	0.1937** (0.2841)	0.0255* (0.5267)	-0.7577* (0.2677)
Poverty	POV	0.2156** (0.0048)	-0.0095* (0.5826)	-0.9488* (0.3057)	0.0784*** (0.9845)
North East	NE	0.6428* (0.0533)	0.2278** (0.9527)	0.8256* (0.2677)	0.1552*** (0.0065)
North Central (Base category)	NC				
North West	NW	0.7378* (0.0327)	0.8627* (0.7527)	0.3655*** (0.3834)	0.1665** (0.6346)
South South	SS	0.3667** (0.0256)	0.3728** (0.4835)	1.7984** (0.7037)	0.1678** (0.4884)
South East	SE	0.0177**	0.6383*	0.3663***	-0.0776*

		(0.3775)	(0.0716)	(0.1284)	(0.5357)
South West	SW	1.5305* (0.0488)	0.1992* (0.5396)	0.0478*** (5.3678)	0.4256*** (0.1765)
Likelihood ratio statistics		15.4674	19.145	10.722	10.722
Probability of likelihood ratio		0.0000	0.0000	0.0000	0.0000
Pseudo R^2		0.3584	0.1347	0.2901	0.2901
Note: *The standard errors are within brackets; (***) significant at 1% level; (**) significant at 5% level; (*) significant at 10%*					

Source: Computed by the authors, (2021)

Table 2 shows Multinomial logit results that was used to determine factors that are responsible for the choice of fuel used for cooking in Nigeria and the four major cooking energies that were modeled are: electricity, LPG, kerosene and firewood. From the multinomial logit results, it is revealed that estimates for constant were inversely related to electricity and LPG but positively related to kerosene and firewood. That is to say, if everything remained constant, there is probability that more households will use firewood and kerosene for cooking and probability for fewer households to use electricity and LPG for cooking. The estimates indicates that urban sector is related to electricity and firewood inversely but related to LPG and kerosene positively with electricity and kerosene being at 5% level of significance, LPG is at 1% and firewood at 10% level of significance. Also, the estimate for household size indicates that LPG and kerosene have an inverse relationship to household size but a positive relationship to electricity and firewood with electricity and kerosene being at 5% level of significance, LPG is at 10% and firewood at 1% level of significance.

The estimate for accessibility indicates a positive relationship between all fuels but significant at different levels with firewood and kerosene being at 1% level of significance, LPG is at 5% and electricity at 10% level of significance. The estimate for per capita expenditure indicates an inverse association with firewood but a positive association with other fuels. The level of significance electricity and kerosene being at 1%, while LPG is at 5% and firewood at 10% level of significance. This is result is similar to that of Ogwumike, Ozughalu and Ahioma (2014). This is to say, increase in per capita expenditure increases the probability or chances of using electricity, LPG and kerosene but decreases the chances of using firewood.

The estimates also reveal that Gender of household head is inversely associated with firewood but positively associated with electricity, LPD and kerosene with electricity and firewood being at 10% level of significance, LPG is at 5% and firewood at 10% level of significance while kerosene was not significant at any level. The estimate for Household ownership of housing unit indicates a similar relationship as that of household head. The male household head was used and it was observed that households that male is head and or own the housing unit had higher chances of not using firewood for cooking. The estimate for Age of household head indicates an inverse relationship with firewood but a positive relationship with electricity, LPG and kerosene with electricity at 1% level of significance, LPG and kerosene being at 10% level of significance firewood at 5% level of significance.

The estimate for Father's level of education indicates and mother's level of education are both inversely associated with firewood but positively associated with electricity, LPG and kerosene. The level of significance of LPG for both father and mothers level of education is 5% level of significance, electricity, kerosene and firewood of mother's level of education are 10% each, electricity, kerosene, firewood of mothers level of education and kerosene of fathers level of education significant at 10% each while electricity at father's level of education is significant at 1% level. Poverty estimates reveals that poverty is inversely relate to LPG and kerosene but positively related to electricity and firewood with LPG and kerosene being significant at 10% level, electricity at 5% level of significance and firewood at 1% level of significance. This is to say that with increase in poverty level, households are likely to use more of firewood and electricity but less likely to use LPG and kerosene.

The estimates of the zones reveal that the north east zone is the reference category of which other zones are compared. The estimates reveal that living in the north zones are generally positively related to firewood, kerosene and electricity while living in the southern zones are inversely related to firewood. There is inverse relationship between living in South West and North East zones and LPG consumption and no significant relationship between living in the other zones and LPG consumption. There is inverse relationship between living in the South East zone and electricity consumption and no significant relationship between living in the other zones and electricity consumption.

5.0 Conclusion and Recommendations

The study aimed at determining the energy model that fits the Nigeria household enery behavior and also to examine the various factors that determine the choice of cooking energy in Nigeria. It was observed that in the years of study, firewood was used for cooking by more households followed by kerosene then LPG, then, Electricity. The analysis revealed that clean fuels are not affordably accessible for Nigerian households. Analysis also revealed that there was never an abandonment of any fuel any time by households therefore, the household energy consumption pattern follows the fuel stacking model and not the energy ladder model.

From the multinomial logit, several factors determine the choice of energy for cooking by households. These factors include among others, household size, sector (rural or urban), per capita expenditure, zoning (NSEW), ownership, educational level, poverty status.

Therefore it is suggested that government should come up with reforms to ameliorate accessibility, affordability and availability of efficient fuels hence improve living standards. The government can achieve this by increasing the supply network of efficient fuels to areas where they are not readily available so that households can stack between efficient fuels.

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