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Household Energy Use and Determinants: Evidence from Nigeria

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ABSTRACT: This study 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 utilised 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. 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. Adequate measures should be taken to ensure that most households in Nigeria have access to modern environmentally-friendly sources of energy. This will pave the way for sustainable development in the country. The results of this study should serve as an invaluable guide to the Nigerian government and policymakers.

Keywords: Energy use; Multinomial logit; Poverty; Determinants; Nigeria.
JEL Classifications: I32; Q40; R20

1. Introduction

Nigeria is richly blessed with natural resources. These include abundant traditional and modern energy resources which provide many households with biomass (mostly firewood) and some other households with transition and modern energy sources (such as kerosene, liquefied petroleum gas and electricity) for their use. However, according to UNDP (2010) and World Bank (2012), Nigeria ranks very low among nations with poor living standards in the world. Despite being among the fifteen (15) largest exporters of crude petroleum in the world, a large proportion of the country's population live in poverty.

The poverty problem in Nigeria goes beyond low income, savings and growth rate. It features high inequality such as unequal income and assets, unequal access to basic infrastructure and unequal capabilities (education, health status, etc.). The causes of poverty in Nigeria can be traced to widespread corruption in private and public sectors, poor governance, high level of unemployment, low level of education, the shock occasioned by the external sector, the poor attention given to the non-oil sector of the economy, the weak production base in the manufacturing sector, etc. With the high incidence of poverty in Nigeria, it is important to know how households meet their basic energy needs.

The nexus between poverty and energy can be described in terms of quality and quantity of energy used. Generally, most poor households use biomass fuels because of affordability and they (the

households) do not have sophisticated energy equipment (such as gas cookers, electric cookers, etc). The use of biomass often worsens poverty and results in low welfare in households. Several studies (Foster et al., 2000; Pachauri and Spreng, 2004; Moulot, 2005; Barnes et al., 2010; OECD/IEA, 2010; and Robic et al., 2010) have examined the link between poverty and energy demand. In Nigeria, many households find themselves in energy poverty. The rising prices of modern fuels - such as liquefied petroleum gas (LPG) and electricity - and their erratic supply have made many households revert to the use of traditional fuels- such as firewood and charcoal. This study focuses on cooking and lighting activities of households. These are the fundamental energy needs of households in Nigeria.

Studies on household energy and poverty in Nigeria are scanty. This partly underscores the motivation for this study. This study examines energy use and energy ladder hypothesis as well as how socio-economic variables affect household energy use. It attempts to answer the following research questions.

- Does the pattern of energy use in Nigeria follow the energy ladder hypothesis?
- To what extent do socio-economic variables affect the choice of households' use of energy for cooking and lightening in Nigeria?
- What is the marginal effect of each of the socio-economic variables on fuels used by households in Nigeria?

The rest of the paper is organised as follows. Section 2 contains literature review while Section 3 focuses on the research methodology and data. Section 4 presents the results and discussion while Section 5 concludes.

2. Literature Review

The energy ladder hypothesis is one of the most common conceptualisations of energy use dynamics among households. It postulates that low income households generally use traditional stoves and cooking fuels such as animal dung, charcoal and wood, while those households with higher income use modern cooking technology and fuels. As income increases, households transit from traditional fuels and cooking stoves to modern fuels and cooking technology (Baldwin, 1986; Smith, 1987; Leach, 1992). Furthermore, the literature on household energy demand and choice has shown that households in transition (that is, those between low income and high income) consume transition fuels such as charcoal and kerosene. While low income households use biomass fuels, higher income households consume energy that is cleaner and more expensive such as liquefied petroleum gas and electricity (Hosier and Dowd, 1987; Barnes and Floor, 1999; Heltberg, 2005).

The energy ladder hypothesis is predicated on the economic theory of consumer behaviour (Hosier and Kipondya, 1993). However, when income increases, households not only consume more of the same good they also shift to more sophisticated goods with higher quality. Thus the theoretical assumption underlying the energy ladder hypothesis is that low living standards induce greater dependence on firewood and other biomass fuels owing to a combination of income and substitution effects (Baland et al., 2007). Furthermore, the energy ladder hypothesis assumes that cleaner fuels are normal economic goods while traditional fuels are inferior goods (Rajmohan and Weerahewa, 2007; Demurger and Fournier, 2011).

The energy-ladder hypothesis emphasises the role of income in determining fuel choices. However, it appears to imply that a move up to a new fuel is simultaneously a move away from previously used fuel(s). Mekonnen and Köhlin (2008) suggest the idea of an energy-demand ladder where it is argued that, as incomes rise, households' demand for fuel is guided by the nature of appliances used and that fuel choice and demand depends on the purpose for which energy is required.

More recently, it has been argued that households in developing countries do not switch to modern energy sources but instead tend to consume a combination of fuels which may include combining solid fuels with non-solid fuels as sources of energy. Thus, instead of moving up the ladder step by step as income rises, households choose different fuels as from a menu (Mekonnen and Köhlin, 2008). They may choose a combination of high-cost and low-cost fuels, depending on their budgets, preferences and needs (World Bank, 2003). This led to the concept of fuel stacking (multiple fuel use) as opposed to fuel switching or an energy ladder (Masera et al., 2000; Heltberg, 2005). The reasons for multiple fuel use are varied and not dependent on economic factors alone although the affordability or cost of the energy service also has an important bearing on households' choices. In some cases, households use more than one fuel because they want to increase the security of supply. In

other cases, the choice is dependent on cultural, social or taste preferences (Pachauri and Spreng, 2004).

Empirical evidences based on energy demand studies reveal that both energy ladder hypothesis and fuel stacking hypothesis have been confirmed. For example, Rajmohan and Weerahewa (2007) investigated household energy consumption patterns of urban, rural and estate sectors in Sri Lanka. The results show that the energy ladder hypothesis holds for Sri Lanka and the country as a whole is moving towards modern fuels such as liquefied petroleum gas (LPG) and electricity. The urban sector proceeds much faster than the rural sector.

Mekonnen and Kohlin (2008) examined the determinants of household fuel choice and demand in major Ethiopian cities. The study found widespread use of multiple fuels for a particular purpose (such as cooking) suggestive of fuel stacking rather than energy ladder. The evidences show that higher kerosene prices made households choose either solid fuels (charcoal and wood) only or a mix of solid and non-solid fuels (wood, charcoal, kerosene and electricity).

Energy demand and poverty related issues have been investigated by several studies using different methodologies and estimation techniques. Some of the notable methodological procedures are surveys carried out utilising instrumental variable technique, engineering calculations, weighted least squares technique, multiple regression analysis, the semi-logarithmic model, ordinary least squares (OLS) method, maximum likelihood method, descriptive statistics, tobit model, probit model and logit model.

Pachauri and Spreng (2004) observed that access to more efficient energy sources implies high level of energy consumption associated with enhanced level of energy use which will generate other benefits such as improved indoor air quality, more time for productive or recreational activities and time freed from collecting biomass energy. It is instructive to note that access alone does not provide sufficient information that can be used to draw conclusions regarding wellbeing. For instance, some households that use only biomass and other less efficient energy sources but use sufficient quantities of these sources might be considered better off than others that have access to more efficient energy sources but cannot consume adequate amounts of such efficient energy sources. Thus to improve the wellbeing of the poor, two elements are needed with regard to energy: improve access to efficient energy sources and ensure adequate consumption of such energy sources by making them affordable.

Jackson (2005) showed that the number of people living on less than $2 per day tends to decrease sharply when access to electricity is guaranteed. The study found a strong correlation between modern energy consumption and Gross National Product (GNP) per capita. Indeed, it showed that GNP tends to increase rapidly as commercial energy use per capita increases, mainly for low income countries. When the countries reach a high level of per capita GNP, factors such as efficient utilisation of energy by industries, energy production and transformation systems tend to make the difference for economic growth to continue so that more energy consumption for a country no longer implies more income for the country.

Robic et al. (2010) revealed that Tajikistan suffered from acute case of energy poverty where people lacked both physical access to energy and the ability to afford it. The study provided an overview of energy poverty situation in Tajikistan and recommended that a provision of three kilowatts per household for the most vulnerable group would result in significant benefits that would show not only in the relief for the energy poverty stricken households but which would show in the overall poverty alleviation for the country. Furthermore, Dzioubinski and Chipman (1999) showed that the household sector accounts for 15 to 25 per cent of primary energy use in developed countries and a higher share in developing countries. A huge gap remains between household energy use in developed and developing countries. Increase in energy-based living standards and more efficient energy use are major opposing trends in developed countries that affect household energy consumption. Diffusion of energy efficient technologies for cooking, heating, lighting, electrical appliances, and building insulation in developing countries have been slow. The study also indicated that government policies designed to influence household energy consumption are often contradictory, with mixed results.

Barnes et al.(2010) found that the use of both traditional (biomass energy burned in conventional stoves) and modern (electricity and kerosene) sources improve household consumption and income; the return on modern sources is 20 to 25 times higher than that on traditional sources. In addition, after comparing alternate measures of the energy poverty line, they observed that some 58

per cent of rural households in Bangladesh were energy poor compared to 45 per cent that were income poor. The findings implied that growth in electrification and adoption of efficient cooking stoves for biomass use can lower energy poverty in a climate-friendly way by reducing carbon dioxide emissions. The study concluded that reducing energy poverty helps in reducing income poverty as well.

Demurger and Fournier (2011) used descriptive statistics from the household survey carried out in ten villages in Labagoumen township in northern China to analyse the general dependence of households upon forest resources as well as energy consumption patterns in the studied villages. The study used the probit model to determine the marginal effects of various socio-economic variables on coal consumption. It observed that income is a key factor in explaining energy use and fuel substitution. It also noted that wealth is a significant and negative determinant of household firewood consumption. Further evidence on the relationship shows that at the top of the wealth distribution, there may be some floor effect in decreasing firewood consumption and that moving away from traditional ways of cooking may not be so easy in an area, even with improved living standards. Wealthier households may not be rich enough to afford changing stoves or may still be reluctant to change their traditional cooking and heating habits. Besides the income effect, the analysis also shows the importance of own-price effect in explaining firewood consumption behaviour. The opportunity cost of firewood collection was found to be significant and negative for the wealthiest group of households indicating that the price effect gains importance with rising incomes. Modernisation in the form of increasing education or family network is also found to be a key factor in the energy consumption behaviour, especially when dealing with energy source switching behaviour.

Ouedraogo **(**2006) used multinomial logit model to analyse the factors determining urban household energy preferences for cooking in Ouagadougou. The analyses show that the inertia of household cooking energy preferences are due to poverty factors such as low income, households' poor access to electricity for primary and secondary energy uses, low housing standards and household size. The utilisation rates of firewood decrease from low income households to households with higher incomes. The marginal effects of ''household income'' are not significant for firewood and charcoal. The marginal effect of ''primary education level'' is significant at one per cent level and with positive sign: when this variable changes from higher education level to primary education, the probability of using firewood as main cooking energy increases by 0.61 per cent. The household size, cooking habits and formal education level of household heads have significant effects on wood energy preferences.

3. Methodology and Data

3.1 Methodology

Household energy use could be best described by the theory of consumer behavior. The basic hypothesis about consumer behavior is that a rational consumer will always chose the most preferred bundle from a set of feasible alternatives (Varian, 2010). Most households make their decisions on the fuel types they will use based on some factors - quantitative or qualitative, economic or non-economic, cultural, individual and psychological. This study aims to determine how changes in households' socio-economic variables affect their (the households') choice for a particular fuel (firewood, kerosene, liquefied petroleum gas (LPG), or electricity) for cooking and lighting activities. The socio-economic indicators used in this study are sector of residence, household size, 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).

Drawing from Green (2002), we adopt the following multinomial logit models (Equations 1 and 2) for the purpose of analysing the determinants of energy use for cooking and lighting respectively.

$$\Pr ob(Y_i = j) = \frac{e^{\beta_j X_i}}{\sum_{k=0}^{4} e^{\beta_k X_i}}, \text{j=1,2,3,4} \quad \text{---------- (1) [for cooking]}$$

$$\Pr ob(Y_i = j) = \frac{e^{\beta_j X_i}}{\sum_{k=0}^{2} e^{\beta_k X_i}}, \text{j=1,2} \quad \text{---------- (2) [for lighting]}$$

where:
e is exponential function;
Y_i 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;
X_i is a vector of household characteristics,
where:
X_1 represents sector of residence.
X_2 represents household size.
X_3 represents per capita expenditure.
$X_{4\ represents}$ gender of the household head.
X_5 represents household ownership of housing unit.
X_6 represents age of household head.
X_7 represents father's education level.
X_8 represents mother's education level.
X_9 represents poverty status[1].
X_{10} represents zone of residence, namely:
-South South
- South East
- South West
- North Central
- North West
- North East

The estimation of the multinomial logit model is best carried out by utilising the maximum likelihood estimation technique (Green, 2003; Wooldridge, 2006; Gujarati and Porter, 2009). Maximum likelihood estimation technique gives parameter estimates that are asymptotically efficient, consistent and normal and the analogue of the regression t-test can be applied.

Table 1 comprehensively defines the explanatory variables of the multinomial logit models for this study.

Table 1. Definition of Explanatory Variables of the Multinomial Logit Model

Variables (X_i)	Definition of the Variables
Sector	Urban=1, Rural=0
Household size	Number of household members
In per capita expenditure	This is natural logarithm of per capita expenditure in regionally deflated prices.
Gender of household head	Male=1, Female=0
Household ownership of the housing unit	Yes=1, No=0
Age of household head	This is in years
Father's educational level	This is in years of formal schooling
Mother's educational level	This is in years of formal schooling
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

Source: Authors' design.

The *a priori* expectations in household energy use for cooking purpose are that for firewood, the coefficients of household size and poverty status should have positive signs; the signs for the

[1] A household is taken to be poor if its per capita expenditure is less than two-thirds of mean per capita household expenditure in regionally deflated prices.

coefficients for per capita expenditure, father's educational level, mother's educational level, household ownership of housing unit, sector of residence and age of household head should be negative. The converse of the foregoing is expected to be the case for the use of kerosene, LPG and electricity. The coefficients of gender of household head and zone of residence could be positive or negative for the use of any of the various fuels for cooking. With regard to household energy use for lighting, the *a priori* expectations are that for kerosene, the coefficients of household size and poverty status should have positive signs; the signs of the coefficients for per capita expenditure, father's educational level, and mother's educational level, sector of residence, household ownership of housing unit and age of household head should be negative. The converse of the foregoing is expected to be the case for the use of electricity. The coefficients of gender of household head and zone of residence could be positive or negative for the use of any of the various fuels for lighting.

3.2 Data

The data used for this study were obtained from the Nigeria Living Standards Survey (NLSS), 2004, conducted by the National Bureau of Statistics (NBS) formerly called the Federal Office of Statistics (FOS). The survey covered all the 36 states of Nigeria and Abuja [Federal Capital Territory (FCT)]. The sampling design is a 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. However, some households did not fully complete the questionnaires; only 19,158 households were eventually used made up of 14,512 rural and 4,646 urban households.

4. Results and Discussion

4.1 Household Energy Consumption

Nigeria is rich in renewable energy such as biomass, wind and solar as well as non-renewable energy such as petroleum and natural gas. In the country, crude petroleum accounts for about 90 per cent of exports and 85 per cent of government revenue. The country depends heavily on imported petroleum products such as petrol, kerosene, diesel and liquefied petroleum gas (LPG) for domestic use. As a result of government subsidy policy in the downstream petroleum sub-sector, petroleum products are relatively cheap when compared with prices in the global market. However, agriculture and forestry still supply the bulk of households' energy consumption for cooking to majority of the population.

Distribution of households by types of energy used for cooking shows that 47.6 per cent used wood (including charcoal) in 1980 compared with 70.8 per cent in 2004. The percentage of households that used kerosene for cooking declined from 49.0 per in 1980 to 26.6 per cent in 2004. Similarly, households' use of electricity for cooking declined from 2.6 per cent in 1980 to 0.5 per cent in 2004; and households that used LPG for cooking increased marginally from 0.8 per cent in 1980 to 1.0 per cent in 2004 (see Table 2).

Table 2. Distribution of Households by Types Energy Used in Cooking

Type of Energy	1980	1985	1996	2004
Firewood*	47.6	62.0	68.2	70.8
Kerosene	49.0	33.2	29.2	26.6
LPG	0.8	3.7	1.1	1.1
Electricity	2.6	0.6	1.2	0.5
Others**	0.0	0.5	0.3	1.0

Note: *Firewood includes charcoal. **Others include crop residue, sawdust and animal waste.
Sources: Data for 1980, 1985 and 1996 were derived from the National Integrated Survey of Households conducted by the Federal Office of Statistics. Data for 2004 were derived from the Nigeria Living Standard Survey (NLSS) conducted by the National Bureau of Statistics.

The heavy and non-sustainable consumption of firewood have resulted in environmental hazards such as deforestation, air pollution, soil erosion and desertification in most parts of the country. Energy consumption patterns in the world today show that Nigeria and indeed African countries consume the least. Observably, Nigeria suffers from inadequate supply of energy due to rapidly increasing demand concomitant with erratic supply, typical of a developing economy.

A closer scrutiny of Nigeria based on the 2004 Nigeria Living Standard Survey shows that despite the high level of urbanisation and resurgence of the middle class after the structural adjustment programme, a significant proportion of the country's households (44.8 per cent) still use firewood as their source of energy for cooking in the urban areas.

Kerosene is mostly consumed by households in the urban areas because of easy accessibility and relative affordability. Most households in Nigeria use it for cooking through kerosene stoves and for lighting via kerosene lanterns. A total of 26.6 per cent of households use kerosene as their main source of cooking fuel in 2004. About 50.1 per cent of urban households and 8.0 per cent of rural households use kerosene for cooking.

Electricity and liquefied petroleum gas (LPG) are used for industrial and residential purposes. In Nigeria, they are used by very few households for cooking. The 2004 NLSS data show that a total of 0.5 per cent of households in Nigeria use electricity for cooking; 0.9 per cent of urban households and 0.2 per cent of rural households use it for cooking. The reason for this observed pattern of energy use is partly attributable to government policy on downstream petroleum sub-sector which has created a lot of constraints on the supply side.

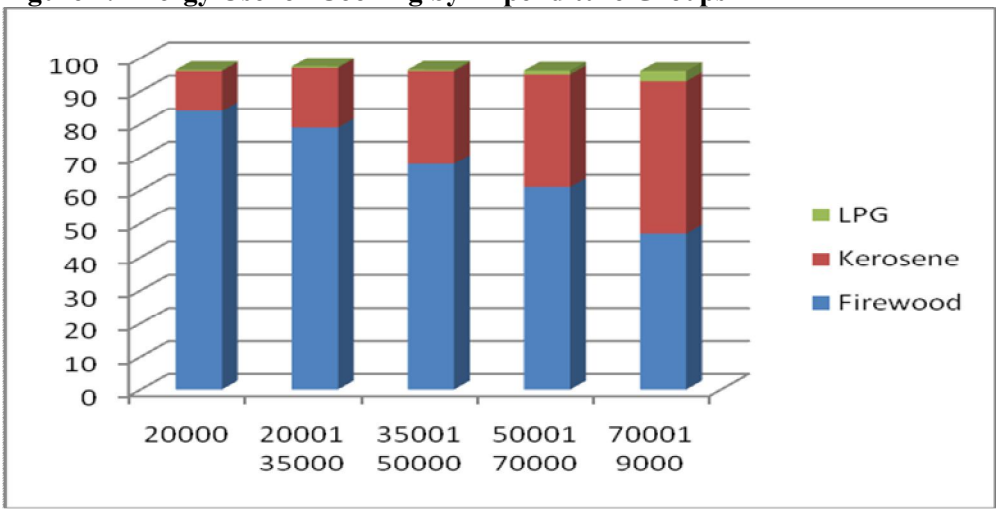
There are many sources of energy for lighting in Nigeria. These include batteries, candles, firewood, kerosene, LPG, main electricity and electricity from generator. However, the main energy sources for lighting purpose are electricity (from the national grid) and kerosene. The other sources such as candles, batteries, gas lamps and electricity from generator are used mostly as back up fuels. Technically, main electricity is a more efficient source of lighting than kerosene both in illumination efficacy, safety and in the volume of energy utilised. The 2004 NLSS data show that about 45.4 per cent of households use electricity from national grid for lighting. Almost 80 per cent of urban households and 18.7 per cent of rural households depend on this source of energy for lighting. Nationwide, about 50 per cent of households use kerosene for lighting, 74.5 per cent of rural and 18.2 per cent of urban households respectively. LPG is used by only about 1.0 per cent of the households for lighting and firewood is used by about 2.4 per cent of households for lighting.

4.2 Household Expenditure and the Energy Ladder

The "energy ladder" hypothesis affirms that households switch their fuel use from biomass to modern energy sources as a country develops and income increases. The energy-ladder model has emphasised the role of income in determining fuel choices. However, in this study we have used expenditure rather than income to group the households. Therefore, we expect that households at higher expenditure category will use gas and electricity as their main fuel while the relatively lower income category will employ kerosene. The least income households will use firewood as their main fuel if the energy ladder hypothesis holds in this context.

Figure 1 shows the pattern of energy used for cooking by households in different expenditure groups. The vertical axis shows percentage of energy type used and the horizontal axis shows the expenditure groups in Naira.

Figure 1. Energy Use for Cooking by Expenditure Groups



The results show that the percentage of households using firewood as main fuel for cooking declined as the expenditure class increases while the percentage of households that use kerosene as their main fuel rose as households move to higher expenditure class. This is consistent with the transition stages of the energy ladder hypothesis: whereby low income households use biomass resources, middle income households use transition fuels and high income households use modern fuels. However, the energy use pattern confirms energy stacking rather than energy ladder hypothesis. Instead of abandoning lower energy types as expenditure increases, households tend to stack different forms of energy. This is consistent with consumer preferences in the face of supply constraints. Also, depending on the purpose, households even at higher expenditure group still use firewood for cooking. Due to data limitation (since the questionnaire did not probe deeper into household energy use and preferences), one could only infer that such multiple use of different forms of energy for cooking even by high income group households may be explained by factors other than income as noted by previous studies such as Pachauri and Spreng (2004), Ouedraogo (2006), and Demurger and Fournier (2011).

4.3 Descriptive Analysis

Table 3 presents the descriptive statistics for the dependent and explanatory variables used in this study.

Table 3. Descriptive Statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Sector	0.2424	0.42854	0	1
In per capita expenditure	124185	213203	6.7452	14.6032
Household size	4.8287	2.9078	1	26
Gender of household head	0.8546	0.35256	0	1
Household ownership of housing unit	0.7657	0.4236	0	1
Age of household head	47.4310	14.5961	18	99
Father's level of education	1.6094	2.9585	0	16
Mother's level of education	0.9520	2.1035	0	16
Poverty	0.5011	0.5000	0	1
Firewood for cooking	0.7651	0.4239	0	1
Kerosene for cooking	0.2038	0.4029	0	1
LPG for cooking	0.0064	0.0795	0	1
Electricity for cooking	0.0043	0.0657	0	1
South South	0.1512	0.3582	0	1
South East	0.1407	0.3477	0	1
South West	0.1594	0.3660	0	1
North Central	0.1814	0.3854	0	1
North East	0.1677	0.3736	0	1
North West	0.1997	0.3998	0	1
Kerosene for lighting	0.6219	0.4850	0	1
Electricity for lighting	0.3193	0.4662	0	1

Source: Computed by the authors

The table clearly shows, among other things, that about 50 per cent of the households are poor, about 24 per cent of the households live in the urban areas while the mean household size is about 5. About 77 per cent of the households use firewood for cooking while only about 20 per cent use kerosene for cooking; and less than 1 per cent use LPG for cooking; also, less than 1 per cent use electricity for cooking. Furthermore, about 62 per cent use kerosene for lighting, while about 32 per cent use electricity for lighting.

4.4 Determinants of Household Energy Use

Table 4 shows estimates of the multinomial logit model for household energy use for cooking in Nigeria. Four energy types - firewood, kerosene, LPG and electricity- have been modelled. The estimates are generally robust. This is shown by the values of the likelihood ratio statistics, all statistically significant at one per cent.

The multinomial logit estimates show the determinants of household energy use for cooking; the results indicate that the urban sector is inversely related to household firewood use but positively

related to kerosene, LPG and electricity use. The estimates also reveal that household size is positively related to firewood and LPG use but inversely related to kerosene use. Observably, the level of significance for LPG use is 10 per cent while electricity use is not statistically significant at 1 per cent, 5 per cent or even 10 per cent. These findings are similar to Mekonnen and Kohlin (2008) for Ethiopia. Per capita expenditure is inversely related to firewood use but positively related to kerosene and LPG use; it is not significantly related to electricity use. These results corroborate Mekonnen and Kohlin (2008) as well as Ogwumike and Ozughalu (2012). Male headship of household affects firewood use negatively and kerosene use positively; it does not significantly affect LPG and electricity use. This is plausibly because households headed by males are more financially buoyant than households headed by females, suggesting that they (male-headed households) can afford more expensive fuel types other than firewood. Contrary to this, Ouedraogo (2006) found no significant relationship between gender of household head and energy use for cooking. Household ownership of housing unit is positively related to firewood use but inversely related to kerosene use and electricity use; however, the level of significance for electricity use is 10 per cent. Household ownership of housing unit is not significantly related to LPG use. Ogwumike and Ozughalu (2012) attributed this to the fact that cooking often requires space not only for the use of wood but also for its storage, especially during rainy season.

Table 4. Estimates of Multinomial Logit Model for Household Energy Use for Cooking in Nigeria

Exogenous variables	Firewood	Kerosene	LPG	Electricity
Constant	-1.6863*** (0.4955)	1.7129*** (0.5200)	-13.2453*** (1.7882)	-7.4599*** (2.4888)
Sector	-1.8726*** (0.0495)	1.9048*** (0.0520)	1.4361*** (0.2272)	0.6838** (0.2670)
Household size	0.0684*** (0.0096)	-0.0668*** (0.0104)	0.0563* (0.0353)	-0.0273 (0.0459)
In per capita expenditure	-0.1634*** (0.0439)	0.1541*** (0.0461)	0.8565*** (0.1522)	0.3442 (0.3121)
Gender of household head	-0.2530*** (0.0602)	0.2921*** (0.0629)	0.3195 (0.2996)	-0.3940 (0.3121)
Household ownership of housing unit	1.2171*** (0.0483)	-1.2460*** (0.0503)	-0.2645 (0.2289)	-0.5155* (0.2790)
Age of household head	0.0100*** (0.0016)	-0.129*** (0.0018)	0.0197*** (0.0071)	0.0019 (0.0085)
Father's educational level	-0.0731*** (0.0080)	0.0559*** (0.0083)	0.0989*** (0.0272)	0.0864** (0.0341)
Mother's educational level	-0.0621*** (0.0115)	0.0450*** (0.0117)	0.0813*** (0.0314)	-0.0286 (0.0482)
Poverty	0.1224* (0.0529)	-0.2505*** (0.0755)	0.4627 (0.2317)	0.4281 (0.4005)
South South	-0.1205* (0.0716)	0.2190*** (0.0756)	0.1631 (0.2895)	-0.0419 (0.4012)
South East	-0.1813** (0.0771)	0.3259*** (0.0817)	-0.6476 (0.3826)	-1.2651* (0.6501)
South West	-0.5556*** (0.0692)	0.6587*** (0.0717)	-0.8644*** (0.3086)	-0.2017 (0.3765)
North East	1.4098*** (0.0928)	-1.7043*** (0.1104)	-0.8382** (0.4180)	0.2267 (0.3932)
North Central (base category)				
North West	1.1801*** (0.0826)	-1.3489*** (0.0939)	-0.2370 (0.3015)	0.5064 (0.3561)
Likelihood ratio statistics	7121.10	7047.51	230.43	48.39
Probability of likelihood ratio	0.0000	0.0000	0.0000	0.0000
Pseudo R^2	0.3408	0.3636	0.1383	0.0453

Note: The standard errors are within brackets; (***) significant at 1 per cent level; (**) significant at 5 per cent level; (*) significant at 10 per cent level.

Source: Computed by the authors.

The results further show that age of household head is positively related to firewood use and LPG use but inversely related to kerosene use. It is not significantly related to electricity use. Father's and mothers educational levels are inversely related to firewood use but positively related to kerosene use and LPG use. Notably, father's education level is positively related to electricity use but mother's education level is not statistically significant with respect to electricity use. A possible reason for these findings is that education enhances individuals' awareness of the detrimental consequences of using firewood on people's health and the environment. Poverty is directly related to firewood use but inversely related to kerosene use. However, it is not significantly related to LPG use and electricity use. These findings are consistent with expectations given the fact that households that are poor can only afford firewood for cooking.

With regard to zones, the North Central zone is the omitted category (the base outcome) with which the estimated coefficients of the other zones are compared. The results indicate that there is positive association between living in the southern zones of the country and kerosene consumption whereas there is negative association between living in the northern zones and kerosene consumption. There is generally inverse relationship between living in the southern zones and firewood consumption whereas there is positive relationship between living in northern zones and firewood consumption. 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.

Coming to marginal effects, Table 5 shows that households in the urban sector, in general, have an increase in probability of about 24 per cent for firewood use, a decrease of about 19 per cent probability for kerosene use, a decrease of 0.43 per cent for LPG use and a decrease of 0.22 per cent for electricity use [as main fuel used for cooking]. The marginal effects of household size are not significant for LPG use and electricity use while firewood and kerosene have about 0.9 per cent rise and about 0.7 per cent decline respectively. Increases in per capita expenditure tend to change the consumption of fuels except for electricity. A marginal increase in household per capita expenditure brings about a decrease in probability of about 21 per cent in the consumption of firewood, an increase of about 1.5 per cent in kerosene consumption and an increase of 0.25 per cent in the consumption of LPG. The marginal effect of the variable gender of household head indicates that an increase in the proportion of households headed by males is associated with a decrease in probability of about 3.0 per cent for firewood use and an increase of about 2.6 per cent in the use of kerosene. An increase in household ownership of housing unit leads to about 20 per cent rise in firewood use and about 16 per cent decrease in the use of kerosene. An increase in age of household head leads to 0.13 per cent rise in the use of firewood, 0.13 per cent decrease in the use of kerosene and 0.01 per cent increase in the use of LPG. Ouedraogo (2006) findings indicate that the probability of consuming kerosene and LPG drops as the age of the household head increases while the probability of firewood use increases as the age of household head increases.

As the educational level of the father increases by a year, the probability of consuming firewood falls by 0.95 per cent but increases by 0.55 per cent for kerosene, increases by 0.03 per cent for LPG and increases by 0.03 per cent for electricity. Similarly, an increase in the educational level of the mother by one year is associated with 0.81 per cent probability decrease in the use of firewood, 0.44 per cent probability increase in the use of kerosene and 0.02 per cent probability increase in the use of LPG. A change in the poverty status of the household would result in 1.59 per cent probability increase in firewood use and 2.45 per cent probability decrease in kerosene use. Increase in South South residency leads to about 23 per cent probability increase in the use of kerosene. Increase in South East residency brings about 2.46 per cent probability decrease in the use firewood, about 3.5 per cent probability increase in the use of kerosene, 0.16 probability decrease in the use of LPG and 0.28 per cent probability decrease in the use of electricity. Increase in South West residency leads to 8.19 per cent probability decrease in the use of firewood and 7.68 per cent probability increase in the use of kerosene. Increase in North East residency leads to about 13 per cent probability increase in the use of firewood, about 11 per cent probability decrease in the use of kerosene and 0.19 per cent probability decrease in the use of LPG. Increase in North West residency is associated with about 12 per cent probability increase in the use of firewood and about 10 per cent probability decrease in the use of kerosene.

Table 5. Marginal Effects of the Multinomial Logit Model for Household Energy Use for Cooking in Nigeria.

Explanatory Variables	Firewood	Kerosene	LPG	Electricity
Sector	0.2430*** (0.0068)	-0.1864*** (0.0056)	-0.0043*** (0.0007)	-0.0022*** (0.0009)
Household size	0.0089*** (0.0012)	-0.0065*** (0.001)	0.0002 (0.0001)	-0.0001 (0.0002)
Per capita expenditure	-0.2121*** (0.0057)	0.0151*** (0.0045)	0.0025*** (0.0005)	0.0011 (0.0007)
Gender of household head	-0.0308*** (0.0069)	0.0264*** (0.0053)	0.0009 (0.0007)	-0.0015 (0.0013)
Household ownership of the housing unit	0.1951*** (0.0093)	-0.1584*** (0.0081)	-0.0008 (0.0008)	-0.0019 (0.0012)
Age of household head	0.0013*** (0.0002)	-0.0013*** (0.0002)	0.0001*** (0.0000)	0.0000 (0.0000)
Father's educational level	-0.0095*** (0.0011)	0.0055*** (0.0008)	0.0003*** (0.0001)	0.0003** (0.0001)
Mother's educational level	-0.0081*** (0.0015)	0.0044*** (0.0012)	0.0002** (0.0001)	-0.0001 (0.0002)
Poverty	0.0159* (0.0092)	-0.0245*** (0.0074)	-0.0014 (0.0009)	0.0014 (0.0012)
South South	-0.0161 (0.0098)	0.2276*** (0.0083)	0.0005 (0.001)	-0.0002 (-0.0013)
South East	-0.0246** (0.0110)	0.03495*** (0.0096)	-0.0016** (0.0008)	-0.0028*** (0.0009)
South West	-0.0819*** (0.0116)	0.0768*** (0.100)	-0.0020 (0.0006)	-0.0006 (0.0012)
North East	0.1335*** (0.006)	-0.112*** (0.0047)	-0.0019*** (0.0008)	0.0008 (0.0015)
North West	0.1206*** (0.0065)	-0.0989*** (0.0051)	-0.0007 (0.0008)	0.0019 (0.0016)
Predicted probabilities	0.8467	0.1100	0.0029	0.0032

Source: Computed by the authors.

Note: The standard errors are in parentheses; (***) significant at 1 per cent level; (**) significant at 5 per cent level; (*) significant at 10 per cent level.

Table 6 shows estimates of the multinomial logit model for household energy use for lighting in Nigeria while Table 7 presents the estimates of the marginal effects associated with the model.

Table 6. Estimates of Multinomial Logit Model for Household Energy Use for Lighting in Nigeria

Explanatory Variables & the Constant	Kerosene	Electricity
Constant	0.3222 (0.3519)	-0.7746** (0.3659)
Sector	0.0040 (0.4087)	0.0030 (0.0425)
Household size	-0.0001 (0.0060)	0.0001 (0.0062)
Per capita expenditure	0.0097 (0.000)	0.0113 (0.0321)
Gender of household head	0.0111 (0.0457)	0.0094 (0.0475)
Household ownership of the housing unit	0.0396 (0.0418)	-0.0161 (0.0434)
Age of household head	0.0001 (0.011)	-0.0009 (0.0012)
Father's educational level	-0.0073 (0.0062)	0.0082 (0.0064)
Mother's educational level	0.0066 (0.0086)	-0.0069 (0.0090)
Poverty	0.0603 (0.0538)	-0.04212 (0.0505)
South South	-0.0241 (0.0561)	0.0094 (0.0556)
South East	0.0626 (0.0561)	-0.1021* (0.0584)
South West	0.0659 (0.0554)	-0.0914 (0.0576)
North East	-0.0583 (0.0509)	-0.0175 (0.0528)
North West	-0.0243 (0.0501)	-0.0515 (0.0520)
North Central (base category)		
Likelihood ratio statistics	11.93	13.70
Probability of likelihood ratio	0.6120	0.4720
Pseudo R^2	0.0005	0.0006

Source: Computed by the authors.
Note: The standard errors are within brackets; (**) significant at 5 per cent level; (*) significant at 10 per cent level.

Table 6 shows that all the socio-economic variables are statistically insignificant with respect to kerosene use for lighting; they have no significant effect on the use of kerosene by households for lighting. As regards electricity use for lighting, only South East residency is statistically significant; the rest of the variables are statistically insignificant; even the South East residency has a weak statistical significance (i.e. at 10 per cent). Table 7 indicates that the marginal effects of the individual variables on the uses of kerosene and electricity by households for lighting are all statistically insignificant except for South East residency with respect to electricity use which has weak statistical significance(i.e. at 10 per cent). However, the predicted probabilities from their simultaneous change show that kerosene consumption would change by about 62 per cent while electricity consumption would change by about 32 per cent.

Table 7. Marginal Effects of the Multinomial Logit Model for Household Energy Use for Lighting in Nigeria

Explanatory Variables	Kerosene	Electricity
Sector	0.0009 (0.0096)	0.0007 (0.0092)
Household size	0.0002 (0.0014)	0.0000 (0.0014)
In per capita expenditure	0.0023 (0.0726)	0.0025 (0.0698)
Gender of household head	0.0026 (0.0108)	0.0020 (0.0103)
Household ownership of the housing unit	0.0093 (0.0099)	-0.0035 (0.0095)
Age of household head	0.0000 (0.0003)	-0.0002 (0.0003)
Father's educational level	-0.0017 (0.0015)	0.0018 (0.0014)
Mother's educational level	0.0015 (0.0020)	-0.0015 (0.0020)
Poverty	0.0141 (0.0114)	-0.0092 (0.0110)
South South	-0.0057 (0.0127)	0.0020 (0.0121)
South East	0.015 (0.013)	-0.0219* (0.0123)
South West	0.0154 (0.0128)	-0.0196 (0.0122)
North East	-0.0138 (0.0121)	-0.0038 (0.0114)
North West	-0.0057 (0.0118)	-0.0111 (0.0112)
Predicted probabilities	0.6220	0.3192

Source: Computed by the authors.
Note: The z- statistics are in parentheses; (*) significant at 10 per cent level.

5. Conclusion

This study focused on household energy use and determinants in Nigeria based on a comprehensive and representative household survey data. It has shown that most households in Nigeria use firewood as cooking fuel and kerosene for lighting. The foregoing suggests that most Nigerians do not have adequate access to modern sources of energy that are less environmentally harmful. Household energy use pattern in Nigeria supports fuel stacking rather than energy ladder hypothesis. However, the general trend is that of gradual transition from biomass fuel to modern energy sources as one move from low expenditure (income) households to high expenditure households. Efforts should be made by the government to improve access to modern energy sources (that are environmentally-friendly).

The study has also shown that many factors significantly determine the energy use by households in Nigeria. These factors, in general, include sector and zone of residence, household size, per capita expenditure, gender of household head, household ownership of housing unit, parents' educational levels and poverty status of household.

The government and policymakers should take adequate steps to ensure that all Nigerian households have adequate access to modern sources of energy that are environmentally-friendly. This will help the country to break the yoke of underdevelopment. The determinants of energy use in Nigeria should serve as invaluable guide to the country's government and policy makers in the formulation and implementation of policies and strategies that will guarantee optimal access to clean energy sources in the country. The government should provide incentives for households which will encourage them to use clean fuels and motivate them to efficiently use the fuels. Targeted subsidy should be used, premised on the variation across geopolitical zones. Government should improve on

the supply and distribution of environmentally-friendly energy sources. Suffice it to say that to put Nigeria on the path of rapid and sustainable development, adequate access to environmentally-friendly sources of energy for all households or at least most households must be guaranteed.

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