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Energy consumption in Nigeria and socio-economic implications: Evidence from household data

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ABSTRACT

The purpose of this study is to examine energy consumption, its socioeconomic determinants, and implications with evidence from household data. The multinomial logistic regression model was used for analysis using data from the General Household Survey 2024 for Nigeria. The findings of this study reveal that per capita expenditure and education are major determinants of kerosene use. While sector shows a significant determinant of coal use for cooking. The determinants of household energy for lighting indicate that regular blackouts and electricity expenditure are major determinants of battery use, and sector influences the use of candles. It is suggested that rural sector electrification should be enhanced and that efforts should be geared towards subsidizing environmentally friendly energy sources for people who do not have the means and currently depend on firewood for survival.

Contribution/ Originality: This study uses 2024 GHS data and multinomial regression to demonstrate how socioeconomic and infrastructural factors influence energy choices for cooking and lighting in Nigeria, linking them to health and environmental impacts. Its comprehensive, dual-focus approach offers new insights rarely explored in prior research.

1. INTRODUCTION

Energy plays a significant role in the socioeconomic development of any nation; this is primarily due to the role played by energy in social, economic, and industrial development (Bisu, Kuhe, & Iortyer, 2016). Opinions from literature suggest that the improved provision of energy resources is largely due to consistent economic outcomes and system improvements. This view has been further extended in the work of Kayode, Akhavan, and Ford (2015) who stressed that energy is crucial to every sphere of human endeavors and increases the growth of an economy. Although several views from various economists around the globe, researchers, as well as analysts, have modified the role of energy and the desire to actualize the constant availability of consumable energy resources.

In Nigeria, energy consumption is primarily categorized into three sectors: commercial, household, and industrial. Household consumption refers to the amount of energy used by households through various appliances (Danlami, Islam, & Applanaidu, 2015). This aligns with the theory of consumer behavior, which states that a rational consumer will choose the best combination of available options. The theory also suggests a positive relationship between energy consumption and income level; higher income leads to increased energy use. Conversely, energy consumption tends to decline as energy prices rise, particularly in the short term. Over time, however, higher prices can lead consumers to adopt more efficient energy combinations (Ngutsav & Aor, 2019). Access to abundant energy

at reasonable costs is crucial for economic and social development (Bergaasse, 2019). Both households and commercial users play key roles in this developmental framework. However, despite the availability of cleaner and renewable energy sources, the use of traditional biomass fuels such as firewood and dung continues to grow, posing environmental and health risks (Hossain, 2012). Ogwumike, Ozughalu, and Abiona (2021) report that biomass fuel use increased from 48% in 1980 to 71% in 2004, while the use of cleaner fuels like kerosene declined from 2.6% to 0.5% over the same period. Alarmingly, the adoption of Liquefied Petroleum Gas (LPG) has remained low, hovering around 11%. More recently, Oyedepo (2022) noted that approximately 86% of Nigerian households still rely on fuelwood for energy. This trend has drawn significant criticism, as it contributes heavily to the emission of carbon dioxide (CO_2), a major greenhouse gas responsible for climate change.

Beyond the issue of energy supply, growing attention is being paid to energy demand and consumption, particularly in developing economies. Traditionally, like most goods, energy demand is influenced primarily by income and price. Income level, often used as a proxy for living standards, is considered a key determinant of energy demand, as higher income typically leads to increased consumption of energy-intensive appliances such as refrigerators, air conditioners, and televisions (Ngutsav & Aor, 2019). However, unlike most consumables, energy demand is derived; people don't demand energy for its own sake but for the services it provides, such as lighting and heating (Kayode et al., 2015). Despite rising environmental concerns and increasing constraints in energy provision, energy has historically been treated as a static issue to be addressed solely by those in power (Schmidt & Weigt, 2013). In recent years, researchers and energy economists, including Oladosu and Adegbulugbe (1994); Ekpo, Chuku, and Effiong (2011); Oyedepo (2022) and Ogwumike et al. (2021) have shifted focus toward understanding energy consumption behavior, especially in developing countries like Nigeria. International organizations have also made notable efforts to shift household energy consumption patterns. These include the World Bank's African Clean Cooking Solutions initiative, which promotes access to clean cooking technologies, and the United Nations' Sustainable Energy for All campaign, which aims to increase adoption of modern, healthy energy alternatives (Malla & Timilsina, 2018). Despite these efforts, household energy consumption decisions remain complex and are influenced by a range of economic, psychological, cultural, and qualitative factors (Ogwumike et al., 2021). Theoretical models have been developed to better explain these patterns. One of the most prominent is the energy ladder model, which posits that low-income households typically rely on traditional energy sources (e.g., firewood, charcoal), while wealthier households are more likely to transition to modern, cleaner energy solutions.

In view of this, the energy ladder model has, however, been met with severe challenges following its inability to accommodate the complex relations involved in energy transition, such as personal differences, cultural and family differences, and new models have been offered (Bisu et al., 2016). For example, the fuel-sticking hypothesis argues that the pattern of household energy consumption is influenced not only by income but also by other factors, which could be cultural, economic, and personal choices (Ogwumike et al., 2021). Several attentions have been channeled to the level of consumer features in the determination of energy consumption. This has deepened the willingness to examine the level of situational differences in household energy decisions.

Following the introductory section, section 2 treats the review of the literature. Section 3 presents the methodology of the study. Section 4 presents the data and interprets it, while section 5 presents the conclusion.

2. LITERATURE REVIEW

2.1. Theoretical Framework

2.1.1. Energy Stack Hypothesis

Emerging hypotheses, such as the energy stacking hypothesis, depict the types of fuel used, but shift the perspective on the basis that consumers do not necessarily transition to better and more robust fuels, and by implication, abandon lower or dirtier fuels as income levels increase. Masera, Saatkamp, and Kammen (2020) emphasized that consumers are not willing to abandon biomass despite consuming higher-grade fuels. Consumers

tend to use a combination of fuel options at various points along the energy ladder. The choice of fuels used by different consumers is influenced not only by the price and cost of energy but also by the security of their availability. In developing countries, households often do not switch to modern energy sources gradually; instead, they consume a mix of fuels such as solid fuels and non-solid fuels (Ogwumike et al., 2021). World Bank (2021) agrees that households tend to combine high-cost fuels depending on their budget, preference and needs.

2.1.2. The Energy Ladder Hypothesis

This was engineered and discussed by Hosier and Dowd (1987) on energy hypothesis (Arthur, Zahran, & Bucini, 2010). This hypothesis is a sterilized extension of economic theory to energy, indicating that as the level of income increases, households consume only more of the same good, but also shift to consuming higher quality goods (Hosier & Dowd, 1987). This theory is premised on the theoretical underpinning that details the shift from primitive fuels to more recent fuels among consumers. The ladders illustrate an improvement movement from lower-efficiency and dirtier primitive fuels (firewood and coal) towards more reliable, purified recent fuels (liquefied petroleum gas, electricity).

This hypothesis revealed that as income levels increase, consumers tend to utilize more purified and usable fuels, thereby reducing the use of unpurified fuels. It is expected that as households become economically buoyant, they tend to shift from the use of charcoal and firewood to kerosene, LPG, and electricity. Baland, Bardhan, Das, Mookherjee, and Sarkar (2020) energy ladder hypothesis assumes that people in low-income households depend on firewood and other biomass fuels as a result of a combination of income and substitution effects. The hypothesis is premised on the fact that more useful and purified fuels are expected to be consumable goods, while non-purified and primitive products are not suitable for the household.

Three stages have been identified by Heltberg (2020) as the process of the energy ladder, these include: traditional and inefficient fuels, transition fuels, and efficient and modern fuels. Consumers usually abandon products that are not good enough, not hygienic, dangerous to health, less expensive like biomass fuels as their economic status improves and by moving from less efficient fuels to more efficient, purified, expensive, less problematic, and non-pollutant fuels like LPG and electricity. The continuous shift on the ladder is premised on consumer choice, ability to use with less stress, hygienic, speed in cooking, and more productivity.

2.2. Empirical Literature

It is instructive to note that Gupta and Köhlin (2021) and Farsi, Filippini, and Pachauri (2020) considered human capital important in the energy use decision process. Human development does not necessarily imply knowledge or educational level, but also the size of the household and the level of age. Moreover, increasing household size reveals that there is much labor available for the absorption of biomass and consequently depreciates the ability to switch to costlier fuel sources. Again, Pundo and Fraser (2021) justified that large households hardly switched to higher fuels. They stressed further that when households increase, there is a need for a corresponding demand for a larger quantity of fuel and the usage of wood, which is less expensive because of its low consumption rate that is low compared to the use of kerosene. Rao and Reddy (2019) are of the view that in developing countries, the income of households with large family sizes is likely to reduce while the chances of subscribing to commercial energy sources. While in the findings of Sathaye and Tyler (2017), low-income households pay more for energy than higher-income households. Leach (2020) observed that modern fuels such as LPG and electricity are paid for in a lump sum, while lower fuels such as firewood and kerosene can be bought with a small amount.

Masera et al. (2020); Murphy (2021); Israel (2021) and Gupta and Köhlin (2021) opined that household preferences with respect to their traditional beliefs, cultural, and social beliefs affect their choice of fuel. Some of the factors responsible for the various choices of energy include the stability of the energy market and its market process. However, the views of various scholars differ on the effects of the energy process on energy preference. Hiemstra-

Van der Horst and Hovorka (2020) posited that pricing of energy influences the consumer from changing to more modern product. In Leach (2020) the process of energy assists consumers in using numerous fuels to switch between fuel sources. Therefore, consumers with substitute fuel equipment can switch when confronted with price differentials or low supply. Sathaye and Tyler (2017); Leach (2020) and Masera et al. (2020) concluded that it is not energy process that restrict transition but the level of modern energy equipment acquired. Mirza and Kemp (2019) pointed out the huge cost associated with purchasing fuel as one of the cogent reasons for energy choice. These are not limited to high transportation costs, varying times, and distances from the market.

In a similar study conducted in Ethiopia, Mekonnen and Kohlin (2018) investigated the determinants of household fuel choice in major cities in Ethiopia, using panel data collection in 2004 and 2006. The multinomial logit model was adopted for analysis. It was revealed that the size of the household and the level of education are key determinants of household fuel choices in Ethiopia. It was further revealed from the study that several fuels are used for cooking, and the maintenance fuel hypothesis suggests that the increasing price of kerosene, as it goes a long way in enhancing consumers' decisions in making choices. It was also revealed that the use of multiple fuels for cooking, supporting the fuel stacking hypothesis, ignites higher prices of kerosene and consequently influences household decisions to choose different fuels.

Pachauri and Spreng (2019) concluded that access to modern and more efficient energy sources as a means of improved energy consumption comes with advantages, which include better indoor air quality and less time wasted sourcing biomass energy. Ogwumike et al. (2021) noted that access to modern energy sources alone cannot ensure household well-being. He posited that consumers who utilize biomass and dirty energy sources effectively are even better than households with clean and modern energy sources but do not have access to using a good quantity of energy. What this implies is that, to ascertain good well-being, there is a need for improved access to contemporary energy sources and full utilization.

In a study conducted by Njong and Johannes (2020) in Cameroon on domestic cooking gas choice. A multinomial logit model was used to examine the social and demographic determinants of households' choice of cooking. It was revealed that educational level and housing ownership are major determinants for cooking in Cameroon. Although Heltberg (2020) and Rao and Reddy (2019) suggested level of education has a positive effect on household use of modern fuels in both rural and urban areas. In the same vein, the level of education significantly increases awareness of the consequences of unpurified and primitive fuels, e.g., firewood, on health.

Adeyemi and Adereleye (2022) investigated the determinants of household choice of cooking energy in Ondo State, using a multinomial logit model for analysis. Evidence from the results shows that sources of energy such as kerosene (45%), firewood (43%), and LPG (12%) are used. Additionally, 53.4% of urban and 12.6% of rural consumers use wood for cooking. Based on this, it was acknowledged that the level of income significantly influences energy cooking preferences, indicating that households may switch from firewood to more purified energy sources as income increases. Household size has a consequential effect on gas usage, showing that the levels of kerosene and gas consumption tend to decline as family size increases. This further supports the notion that education promotes responsiveness to the hazards associated with the continued use of firewood. With an increase in education levels, there are greater possibilities for households to switch to more modern fuel sources. Again, Adetunji, Adesiyan, and Sanusi (2018) explored the system of energy utilization in Osogbo, southwestern Nigeria. The OLS method of analysis was adopted; evidence from the results revealed that consumer income level and household size are noteworthy factors influencing consumer livelihood patterns.

In addition, Bello (2021) examined the impact of wealth distribution on energy consumption in Nigeria, with reference to Gombe State. A multinomial logit model was used for analysis and found that household income, household size, and level of education determined the choice of energy consumption in Gombe State. Similarly, Onyekuru and Eboh (2019) investigated the determinants of cooking energy demand in the rural area of Enugu State. The method of analysis is the bivariate probit technique; size of consumer, level of income, and education are the

variables employed in the model. The results show that the size of the consumer, means of livelihood, and educational level negatively affect the utilization of firewood, implying that as more people are educated with better salaries, the less likely it is for people to use firewood.

The results further show that the level of income and livelihood significantly determine the preference for cooking energy. This further lends credence to the belief that households with good salaries living in rural areas are expected to switch to the more expensive use of kerosene.

Shittu, Idowu, Otunaiya, and Ismail (2019) studied energy demand among households in Ijebu-Ogun State, Nigeria. A linear logit model was employed. The level of income and the consumers' age were shown to have an impactful influence on the causal demand for energy, while the size of the consumer and education were not impactful. The consequence of the level of income was significant for cooking gas and electricity, apart from firewood. Consequently, increasing the level of income increases the need for more robust energy sources, apart from firewood.

Lingering controversies have ensued on the uses of household energy over the years, considering the prominence of climate change consciousness. Supporting evidence from the literature flourishes on this focus both locally and globally. One major lacuna is that. In Nigeria, several related studies examined regions and state, only Ogwumike et al. (2021) examined the entire country, using 2004 national living standard surveys for analysis even though they are not recent for empirical analysis. The focus of this study is to use more robust recent data and justified variables that were not previously used.

3. RESEARCH METHODS

General household data from 2018 for Nigeria encompasses various household energy uses, including gas for cooking, socioeconomic characteristics, and lighting. The data covers an array of 38,000 consumers across all 36 states of the country, including FCT.

The study employs multinomial regression analysis, which is used to forecast the probability of a dependent variable exceeding a single specification and to assess the causes of consumer energy use for cooking and other purposes. A major advantage of multinomial logistic regression is that it does not assume normality, linearity, or homoscedasticity (Hou, 2018).

3.1. Model Specification

The study adopts the energy ladder hypothesis, which emphasizes that fuel preference is largely influenced by income levels. As income improves, consumers tend to increase their consumption of more purified fuels. Consequently, fuel preference is a function of income. Literature additionally informs other socioeconomic characteristics used as independent variables.

For this study, two multinomial logit estimations were utilized: one for household energy sources for cooking, with four categories (firewood, kerosene, electricity, gas, and coal), and the other for household energy sources for lighting, with five categories (electricity, kerosene, firewood, battery, and candles). The rule of thumb is that a specification must be exempted and used as the base specification. The model is specified as follows:

$$L = \mathrm{Ln}\left(\frac{P}{1-P}\right) = \beta_{\emptyset} + \beta_{\varphi} X^{\circ} + \mu \quad (1)$$

Where $\beta_{\emptyset}$, β_{φ} represent the intercept and coefficients respectively, μ is the error term. X° represent the independent variables: sex, age, sector, educational level, household size, expenditure on food, and per capita expenditure for the determinant of household energy cooking; and sex, age, sector, educational level, household size, per capita expenditure, frequency of blackout, and expenditure on electricity for lighting determinants.

4. FINDINGS

4.1. Socioeconomic Determinants of Household Energy Use for Cooking

The multinomial logistic regression result for causes of household energy use for cooking are presented in Table 1.

Table 1. Determinant of household energy use for cooking.

Description	Kerosene	Electricity gas	Coal
Sex	0.008 (0.327)	0.001 (0.835)	-0.0001 (0.632)
Sector	-0.373*** (0.000)	-0.007** (0.002)	-0.018*** (0.000)
Age	0.000 (0.751)	-0.0003** (0.029)	-0.001 (0.918)
Educational level	-0.004** (0.043)	-0.003** (0.032)	0.008 (0.658)
Expenditure on food	0.024 (0.284)	0.007** (0.022)	0.001 (0.778)
Per capita expenditure	0.080*** (0.004)	0.007** (0.032)	0.003 (0.812)
Household size	-0.009** (0.045)	-0.0004 (0.829)	-0.001 (0.538)
Predicted probability	0.324	0.021	0.037
Pro, Chi^2	0.001		
Pseudo R^2	0.049		
Log likelihood	-4.369		

Note: The omitted variable is firewood ** and ***implies significance at 5%, and 10% respectively.

What is glaring from the above result is that sector, education, and per capita expenditure are major variables determining the usage of education, age, food expenditure, kerosene, and expenditure on per capita, which go a long way in determining electricity and gas when linked with others such as firewood. While only sector was a major variable that determines the use of coal when linked with firewood. Conversely, sex is the only variable that does not determine any of the specifications related to firewood. It was more obvious from the result that households consisting of males greatly influence the utilization of cooking with kerosene, gas, and electricity, purposefully for cooking, but negatively influence the utilization of coal for cooking. Marginally, the result indicates that being male influences the chances of using electricity and gas with p-values of 0.0080 and 0.00030, respectively, but reduces the chances of using coal by 0.00007. Notwithstanding, a significant margin is not evident between households headed by males and females given that the p-values are significantly below 0.05, the threshold; therefore, the difference is not substantial at 5%.

Further to this, as the mean p-value of utilizing kerosene, gas, electricity, and coal declines by 0.0002195, 0.0003542, and 0.0000388 respectively, the age of consumers continues to rise. However, this is only significant in defining the proper utilization of gas and electricity. What this indicates is that sector is the only cogent variable that is a major determinant in the use of all categories. The marginal effect revealed that consumers living in rural areas substantially decrease the p-values of utilizing kerosene, gas, electricity, and cooking coal concurrently when linked with the usage of firewood, which is the base sector. As the educational level improves, the p-value of consuming kerosene, electricity, and gas reduces substantially. When the p-value of coal improves, though not substantially. Marginally, a negative household size was reported in the entire result. This implies that as the household size increases, the p-value of the usage of kerosene, gas, electricity, and coal declines.

What is more interesting about the results is that food expenditure, including the entire expenditure per capita, reflecting the level of income of the consumer, all indicate a positive connection in favor of consuming the entire specification, indicating an increasing income level in favor of utilizing coal, kerosene, gas, and electricity, with a decrease in the use of firewood. This suggests that less privileged people are exposed to using firewood. Marginally,

the effects are comparatively substantial, specifically for the utilization of electricity, gas, and food expenditure on the utilization of kerosene, including expenditure per capita concurrently. What is glaring enough is that validated sector variables imply that households living in rural environments are more likely to increase the use of firewood, as it decreases the chances of using other energy sources.

Table 2. Determinant of household energy use for lighting.

Description	Kerosene	Firewood	Battery (torch)	Candles
Sex	-0.033 (0.354)	-0.004 (0.870)	-0.005 (0.625)	-0.004 (0.751)
Education size	0.005 (0.423)	0.004 (0.293)	0.001 (0.659)	-0.001 (0.781)
Household size	-0.003 (0.721)	0.004** (0.047)	0.002** (0.049)	0.002 (0.489)
Per capita expenditure	0.025 (0.435)	0.021 (0.253)	-0.009** (0.044)	0.005 (0.596)
Age	-0.001 (0.848)	0.002 (0.429)	-0.001 (0.992)	0.001 (0.587)
Sector	0.030 (0.433)	0.063*** (0.0000)	0.004 (0.244)	0.030** (0.000)
Expend on elect	-0.004** (0.042)	0.001 (0.417)	-0.002** (0.007)	-0.001 (0.065)
Frequency of blackouts	0.033** (0.057)	0.003 (0.795)	-0.007** (0.024)	-0.006 (0.278)
Predicted prob	0.378	0.064	0.035	0.041
Probability chi^2	0.000			
Pseudo R^2	0.017			
L. likelihood	-346			

Note: The omitted variable is electricity ** and ***implies significance at 5%, and 10% repetitively.
The p-value chi2 also lends credence to the fact that the entire model is significant.

Interestingly, as indicated in Table 2, the excluded variable, which is the electricity consisting of the utilization of public-generated goods and rural electrification self-generated sources, was invariably excluded with the assistance of the software employed. It was revealed from the results that continuous power cuts and electricity expenditure substantially regulate the utilization of kerosene when compared to the electricity-specific category. The size of the household and sector significantly influences firewood usage in comparison to electricity. The size of the household, expenditure per capita, continuous power cuts, and expenses on electricity are all significant regulators of battery utilization in contrast with electricity. Lastly, sectors appear to be the sole regulators of candles compared to electricity. For kerosene usage, the results suggest a continuous rise in power cuts; the p-value is approximately 0.032878, indicating an increased likelihood of utilizing kerosene as a light source with higher electricity expenses. Unvaryingly, consumers who use more electricity may not favor kerosene.

Again, the size of the household substantially increases the p-value supporting the usage of firewood by 0.00042525, which appears far lower than the marginal effect for the sector. This indicates that consumers living in the rural sector significantly improve the p-value for utilizing firewood for lighting by 0.0627289. It suggests that people with lower income levels might prefer using firewood for lighting, considering their income level and the increasing household size. Ironically, the rural population is believed to have a strong connection with poverty. Interestingly, expenditure per capita, as a measure of income level, does not have a significant connection with the usage of firewood for lighting. The size of the household also significantly influences the usage of batteries, increasing the p-value by 0.0020241. Expenditure per capita, continuous blackouts, and electricity expenses significantly and negatively affect the p-value of using battery-powered equipment by 0.0091295, 0.0075949, and 0.0000227, respectively. This implies that as income levels rise, the likelihood of consumers using torches for lighting decreases. Similarly, a negative correlation exists between continuous power failures and torch usage, indicating that torches are less likely to be used for extended periods.

The concluding section, which discusses the usage of candles, has only one substantive factor, which is sector. It exhibits a good relationship with candle usage. Marginally, the effect of sectors indicates that consumers living in the rustic sector substantially increase the chances of utilizing candles for lighting by 0.0296281. This suggests that the use of candles is primarily in rustic area. Therefore, the variables mentioned above substantively regulate the usage for lighting. The results indicate that sex, level of education, and age are not substantively important in the usage of any sources for lighting. This is, however contrary to Heltberg (2020) and Rao and Reddy (2019) who posited that the level of education has a positive effect on household use of modern fuels in both rural and urban areas.

5. CONCLUSION

The focus of this paper is on energy sources specifically for cooking and lighting, with more topical data to support growth and enhance the growing literature. A multinomial regression model was used to analyze data from the GHS, 2024, specifically for Nigeria. The regression results indicate that sector, household size, and per capita expenses were major determinants in the usage of kerosene. Sector, age, level of education, per capita expenditure, and expenses on food were determining factors for the usage of modern light. While only the sector was a major factor for the usage of coal for cooking. Interestingly, household energy for light indicates the frequency of power cuts, and expenses on modern light substantially control the use of kerosene. However, sector and consumer size regulate the utilization of firewood. The size of the household, frequency of power cuts, and expenses on electricity are all major factors that control the usage of these sources, while the sector alone regulates the utilization of candles.

Inference made from the analysis informed the following recommendations: that sector plays a cogent role for all energy sources, specifically for lighting and cooking. It is suggested from this study that more consideration must be given to consumers' energy, thereby channeling it to more rural areas to improve access for those living in urban areas. From the study, per capita income tends to be a major factor that influences the use of kerosene, gas, and electricity. Consumers who are poor tend to use firewood for cooking, which is practically injurious to their health and contributes to deforestation, causing environmental hazards. Additionally, continuous power outages substantially encourage the use of kerosene for lighting, which is also detrimental to health.

It is for this reason that the study advised the government at all levels to rejig their commitment by enhancing conducive energy sources that will be environmentally safe for various users, so as to reduce the utilization of harmful sources both for communities and individuals at large.

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