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Household Energy Choice in Rural and Urban areas of Kano State: An Empirical Test of Energy Ladder Hypothesis

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Abstract

The main objective of this study is to analyse household energy usage for cooking and assess the energy ladder hypothesis. This study used ordered logit version of the energy ladder to household energy consumption data from Kano State to explain households' transition to more sophisticated fuels as their economic situation improves. A field survey was conducted to gather data for this study and questionnaires were administered to households in Tarauni, Makoda, and Karaye local government areas of Kano State, each of which represents a different senatorial zone. For the study, a multi-stage cluster sampling approach was used. The result of the study shows negative relationship between location and household energy switching, age of the household head and household energy switching, household size and household energy switching. The findings of the study also show positive relationship between education and household energy switching, household income and energy switching which supports the assertion of energy ladder hypothesis. The study recommends among others; that the state government which is closest to the people should implement policies and programs that promote employment, women's empowerment, and skill development with the goal of raising personal income.

Keywords: Household, cooking, fuel-switching, energy-ladder, ordered-logit

1. INTRODUCTION

In Nigeria, the household cooking sector utilizes roughly 80% of total energy, with 90% of that coming from biomass, predominantly firewood (International Energy Agency, 2015). Most poor countries employ a variety of energy sources for cooking, including animal dung, plant waste, fuel wood, kerosene, gas, and electricity (Julius, 2013). Similarly, multitude of factors, including socioeconomic considerations, household demographics, meteorological conditions, housing, product, or vehicle features, attitudinal variables, and environmental factors combine to determine whether a household chooses one or more of these energy sources (Danlami & Islam, 2020). The "energy ladder," which links changes in household energy consumption patterns to disparities in economic status, is a popular concept used to characterize household fuel choices in developing nations (Hosier & Dowd, 1987; Leach, 1992; Barnes & Floor, 1996).

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In Nigeria, the energy sector is one of the least efficient in terms of serving people's needs. There is chronic instability in the markets for electricity and petroleum products, particularly kerosene and premium motor spirit (PMS) (Danlami, 2017a; Iwayemi, 2008). Due to the high degree of poverty and other socio-economic challenges, both rural and urban inhabitants are unable to obtain reliable and adequate sources of energy for residential uses. Due to its excessive reliance on biomass for cooking fuels, Nigeria accounts for around 10% of all smoking-related illnesses that result in yearly global mortality (Newsom, 2012; Nwofe, 2013).

Therefore, to lessen the negative impacts of traditional energy on human health and the environment as well as to improve the conditions of the poor's way of life, a transition to cleaner and more efficient energy sources is required (Danlami & Applanaidu, 2021). In order to develop strategies to make such a move easier, it is essential to first understand household fuel choice and ladder or switching.

There are very few empirical studies that take into account the diverse households in the rural and urban areas of Kano when analyzing energy usage for cooking. Due to the critical role that energy plays at the household level, the study will evaluate household energy use in both rural and urban regions of Kano State and test the energy ladder hypothesis. This will assist in bridging the gap in the state and throughout the nation.

Therefore, the main objective of the study is to examine the pattern of household's energy use based on the economic status of the households in Kano State. Specifically, it will examine the pattern of household energy choice for cooking in Kano State and also test the energy ladder hypothesis.

2. EMPIRICAL LITERATURE REVIEW

The energy ladder theory has been used to examine the demand for various energy sources both theoretically and experimentally (Kebede et al., 2002; Arnold et al., 2006; Davis, 1998; Masera et al., 2000; Barnett, 2000).

As households' socioeconomic status rises, they abandon on inefficient, less expensive, and more environmentally damaging technologies and switch from a universal reliance on biomass fuels to second-phase transition fuels like kerosene, coal, and charcoal. Households convert to fuels like LPG and electricity in the last phase (Heltberg, 2004). Higher rated fuels are often more expensive and efficient, but they also need less labor input and emit less pollutants per unit of fuel (Masera et al., 2000).

The energy ladder also presupposes that more costly technologies are viewed as denoting better prestige both nationally and globally. Households want to climb the energy ladder not just to achieve greater fuel efficiency or less exposure to direct pollutants but to reflect an improvement in socioeconomic level (Masera et al., 2000: 2084).

In Sri Lanka, Rajmohan and Weerahewa (2010) looked at the patterns of household energy usage in the urban, rural, and estate sectors over the course of time and across income groups. The idea of an energy ladder is applicable to Sri Lanka since the nation as a whole is moving toward modern fuels like electricity and liquefied petroleum gas (LPG).

Mensah and Adu (2013) investigated household energy choices for cooking and their determinants in Ghana using information from a statewide household survey. Additionally, their data support the energy ladder concept, which contends that household income is a significant determinant of energy consumption.

Moreover, households in transition use transitional fuels like charcoal and kerosene. While higher-income families prefer more expensive and clean energy sources like electricity and liquefied petroleum gas unlike lower-income households who rely on biomass fuels (Hosier and Dowd, 1987; Barnes & Floor, 1999; Heltberg, 2005; Danlami et al., 2018a; Danlami et al., 2019).

3. METHODOLOGY

3.1 Study Area

The Study Area is Kano State. It is the major commercial centre in Nigeria, Second-most industrialized state, the economic center of the north, and the region with the most politically active and educated people (K-SEEDS, 2000). Additionally, the study was conducted in three local government areas; Tarauni, Makoda, and karaye, each of which represents a different senatorial zone.

All of the households in Kano State were included in the study's population. Thus, according to NBS (2012), there are 1,603,335 households in Kano State, including high-, low-, and middle-income families.

3.2 Sample Size and Sampling Technique

In order to calculate appropriate sample sizes, Dillman (2011) provides the formula below:

$$n = \frac{(N\text{p})(P)(1-P)}{(N\text{p}-1)(B/C)^2 + (P)(1-P)}$$

Where:

Ns = completed sample size needed (notation often used is n)

Np = size of population (notation often used is N)

p = proportion expected to answer a certain way (50% or 0.5 is most conservative)

B = acceptable level of sampling error (0.05 = ±5%; 0.03 = ±3%)

$C = Z$ statistic associate with confidence interval (1.645 = 90% confidence level; 1.960 = 95% confidence level; 2.576 = 99% confidence level)

Therefore, the sample size is calculated as follows;

$$n = \frac{(1{,}603{,}335)(0.5)(1-0.5)}{(1{,}603{,}335-1)(0.05/1.645)^2+(0.5)(1-0.5)}$$

$$n = \frac{(1{,}603{,}335)(0.5)(1-0.5)}{(1{,}603{,}335-1)(0.05/1.645)^2+(0.5)(1-0.5)}$$

$$n = \frac{(1{,}603{,}335)(0.5)(0.5)}{(1{,}603{,}334)(0.0255)^2+(0.5)(0.5)}$$

$$n = \frac{(1{,}603{,}335)(0.25)}{(1{,}603{,}334)(0.0006502)+(0.25)}$$

$$n = \frac{400833.75}{1042.7378}$$

$$n = 384.4$$

$$n = 384$$

Using the aforementioned formulae, 384sample size was derived. However, the sample size was expanded by two to mitigate sampling errors and address the non-response rate problem (Hair et al., 2008). The sample for the study thus consisted of 768 households in total.

Similarly, the multi-stage cluster sampling method was also employed.

Therefore, to accommodate both qualitative and quantitative data, a semi-structured questionnaire was employed and was personally administered. With personally administered questionnaires, a researcher or member of the research team may quickly compile all the completed replies, and any questions that respondents might have can be clarified immediately.

Therefore, in order to reach the targeted heads of household or spouses, 768 questionnaires in total were distributed for Tarauni, Makoda, and Karaye Local Government Areas.

The questionnaire for this study includes a variety of energy usage-related questions and their determinants. Additionally, research assistants who received the necessary training to manage data collection assist with administration. Studies that used questionnaires include Bashir and Danlami (2022), Kofarmata and Danlami (2021), Tsauni and Danlami (2016), Kadiri and Alabi (2014), Ampitan and Oyerinde (2015).

3.3 Method of Data Analysis

3.3.1 The Empirical Model (Ordered Logit)

An ordered logit model was used to estimate household energy choice for cooking in Kano State and evaluate the energy ladder. It involves households switching from traditional biomass energy, transitional energy (kerosene), and cleaner energy (gas and electrical sources of energy) due to the ordinal character of the dependent variable. Thus, the model can be stated as in equation (1):

$$Y_i = \beta_1 X_1 + \varepsilon i \quad \ldots\ldots (1)$$

Where: yi is the observed and exact dependent variable (categories of fuel switching in hierarchical order); coded as 0, 1, ...n, Xi is the vector of the independent variables. β is the vector of parameters to be estimated and εi is the random variable for the ordered logit model. If the score on the observed variable say yi is 0, means that the household uses traditional biomass energy. However, if the household adopts the transitional fuel (such as kerosene), then yi=1; and if the household adopts cleaner source of energy (electricity/gas) then yi= 2.

Then the estimated empirical model is written as:

$$Y_i = \propto_0 + \beta_1 loc_i + \beta_2 gen_i + \beta_3 age_i + \beta_4 msta_i + \beta_5 educ_i + \beta_6 hsize_i + \beta_7 employer_i + \beta_8 income_i + \beta_9 Ic\_loc_i + \beta_{10} gen\_lgic_i + \varepsilon_i \quad \ldots\ldots (2)$$

Where:

Yi =The dependent ordered variables summarized as: Traditional biomass (yi= 0), Transitional energy (yi= 1) and cleaner energy (yi= 2)

loc = household location

gen= gender of household head

age= age of household head

msta= marital status of household head

educ = educational level of household head

hsize= household size

employer = employment sector of household head

income= income earn by the house head

Ic_loc = interaction variable income and location of household

gen_lgic = interaction variable gender and log of income.

4. RESULTS AND DISCUSSIONS

Table 1 shows the estimated ordered logit model analysing the determinants of household fuel switching.

Table 1: Estimated Ordered Logit Coefficients and Marginal Effects of Fuel Switching

Variable	Coefficients	Marginal Effects
Loc	-1.796***	0 .41621***
	(0.5278)	(0 .1106)
Gender	0.4846	-0.10622
	(4.8327	(0.9823)
Age	-.0498***	0 .01161***
	(0.0117)	(0 .0027)
Mstatus	0.2405	-0.05460
	(0.4266)	(0.0940)
Hhsize	-0.09896***	0 .02308***
	(0.0318)	(0.0074)
Employer	0.01352	-0.0032
	(0.07380)	(0.0172)
Income	0 .000047***	-0.00001***
	(0.00001)	(0.0000)
educ2	0 .05934**	-0.0138**
	(0.0234)	(0.0054)
ic_loc	0.00001	-2.53e-06
	(8.63e-06)	(0.0000)
gen_lgic	-0.08692	0.0203
	(0.45909)	(0.1071)
Observations	652	
Pseudo R2	0.2302	
LR chi2(10) = 286.44		
Prob > chi2 = 0.0000		

Source: *Author's computation using Stata 17.0* .Note: Standard error in paranthesis.* ** *** denotes statistical significance at 10%,5%and 1 %

Based on the probability value of the Chi sq (X2) in Table 1, the estimated coefficients of the ordered logit model are jointly significant at 1%, thereby implying the validity of the estimated ordered model.

The variable location was found to be statistically significant at 1% level. The result shows a negative relationship with household energy switching. Based on the result of the estimated ordered logit model, households that reside in rural areas of Kano State have lower odd of switching to cleaner energy by about1.796 units compared to their urban counter parts this is in line with the findings of Danlami (2017b) who concluded that households living in the urban areas have more tendency of adopting cleaner source of cooking fuel than those living in the rural areas. Additionally, the discrete effect of this variable indicates that households living in the urban areas have about 42% higher probability of switching to cleaner energy than their rural counter fact. This conforms to the findings of Danlami (2017b).

According to the findings, the coefficient of variable Age is statistically significant at 1% level. The result indicates that there is a negative relationship between the age of the household head and the household energy switching. Based on the estimated result, a one-year increase in the age of the household head decreases the log odd of switching to cleaner energy by about0.0498 units. This finding conforms to a priori expectations because when people use a commodity for a long period of time, they find it difficult to change the pattern of their consumption when they become older. This finding is also in line with the findings of previous studies (Danlami *et al,* 2018b;

Nlom & Karimov, 2014; Mensah & Adu, 2013). Furthermore, the estimated marginal effect of this variable indicates that an increase in years of the household head by 1% will lead increase in the movement along the energy ladder by about 0.01% all things being equal.

The coefficient of household size was found to be negatively related with the household energy switching. This coefficient was found to be statistically significant at 1% level. According to the estimated result, a one unit increase in the size of households decreases the log odd of switching to cleaner energy by about 0.09896 units. This is consistent with the findings of Danlami et al. (2019). Moreover, the estimated marginal effect of this coefficient indicates that an increase in the household size by 1% lead to increases in the energy switching by about 0.02% all things being equal.

Moreover, the coefficient of household income was found to be statistically significant at 1% level. According to the estimated result, a 1% increase in household income results in a 0.000047unit increase in the log odd of households switching to cleaner energy. This is tally with the a priori expectations and also supports the assertion of energy ladder hypothesis. As the household income increases, the affordability of the household to substitute traditional biomass energy with a cleaner energy increase. This supports the findings of Danlami (2017b). In the same vein, the estimated marginal effect of this variable indicates that 1% increase in the income level of the household head decreases the tendency of adopting traditional non solid fuel by about 0.00001% all things being equal. This is in line with the findings of Danlami (2019) who concluded that there is a negative relationship between the use of firewood as a main source of cooking fuel and the level of income of the household.

The coefficient of education was found to have a positive relationship with the household energy switching. This coefficient was found to be statistically significant at 5% level. Based on the estimated result, a one unit increase in the level of education of the household head increases the log odd of switching to cleaner energy by about 0.05934 units. Also, the estimated marginal effect of the coefficient of this variable indicates that higher level of education is associated with the decrease in the probability of adopting traditional cooking fuel by about 1.3% all things being equal.

5. CONCLUSION AND POLICY RECOMMENDATIONS

Using an ordered logit model, this study examines household energy switching along the energy ladder. The household's decision to move from traditional biomass energy use to cleaner energy has a positive, considerable impact on the household head's education and income levels. home energy switching is negatively impacted by the home's location, the household head's age, and the size of the household.

The following suggestions are provided in accordance with the study's findings in order to improve the situation:

Income was found to be a significant factor in cooking energy choice. Therefore, the state government, which is closest to the people, should implement policies and programs that promote employment, women's empowerment, and skill development with the goal of raising personal income. Due to a rise in income, households will have easier access to modern energy.

The State, Local Government, and Nongovernmental Organizations (NGO) should work together to educate the public about the effects of using firewood through campaigns and workshops. A village by-law should be created to ensure that all families who utilize wood fuel have upgraded stoves.

The state government should also provide the citizens with an enabling environment by way of sufficient electricity, good roads, and financing options. The use of upgraded stoves in every family that uses wood fuel will help to reduce the consumption of dirty energy. Educating the public should be a priority for the state, local government, and nongovernmental organizations (NGO).

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