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An Empirical Analysis of Household Energy Demand in the North East Region of Nigeria.

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ABSTRACT

This study empirically analyzed the household energy demand in the North-East Zone of Nigeria. Secondary data was obtained from NBS on general household survey (2013) and AIDS model was employed on the data collected. The results revealed that all the energy sources considered were comfort goods (had elasticities=1) except for kerosene which was found to be a necessity (elasticity<1). Also, all the energy sources were price elastic (elasticities=1) and had a complementary relationship (negative elasticities). The study therefore, recommended policy to improve LPG and electricity demand by supplying it at subsidized rate to households.

Key Words: Household, Energy, Demand

1. INTRODUCTION

The term energy in the context of this paper refers to the utilization of chemical resources which is aimed at providing a source of power or light for cooking, space heating and cooling, ironing and for other purposes. While household energy demand means the total amount of energy purchased and used by households for the various purposes mentioned above. Thus, energy demand is essential for household welfare, public investments and environmental considerations. Moreover, efficient exploitation and development of a nation's energy resources is truly of great importance to the progress and wellbeing of the people (Ogunleye & Ayeni, 2012).

The household sector is responsible for about 36% of the world's energy use, out of which, 80% of it is used for primary energy use in developed countries. In addition, a higher share is used in many developing countries. The average per capita household energy use in developed countries is about nine times higher than in developing countries, even though, a large share of household energy is provided by non-commercial fuels that are often not reflected in official statistics (Energy Information Administration [EIA], 2015).

Fossil energy development and exploration have recently become rapid all over the world, all with the aim of improving economic growth as well as delivering of efficient and affordable energy to meet the demand of poor households in order to fight against poverty (Dilip & Tatsutani, 2009). However, in Nigeria despite been endowed with huge reserves of both renewable and non- renewable energy resources, the inadequate development and inefficient management of the energy sector has led to a supply-demand gap and consequently high solid fuel demand among households (Adepoju, Oyekale & Aromolaran, 2012).

Moreover, Adepoju *et.al* (2012) showed that about 86% of rural households in Nigeria depend on fuelwood as their source of energy. This is because apart from lack of electricity supply they also have little access to conventional energy such as petroleum products due to absence of good road networks. In addition, petroleum products such as kerosene and gasoline are purchased in the rural areas at very high prices in excess of their official pump prices. The rural populace, whose needs are often basic, therefore depend to a large extent on fuelwood as a major traditional source of fuel. Similarly, the low income households in the urban areas also rely on biomass fuels, such as wood and dung, due to fuelwood supply/demand imbalance in some parts of the country (Ogunleye and Ayeni (2012). In the northern part of Nigeria such as Borno State, there is a high rate of charcoal consumption because apart from its use in cooking, space heating and ironing clothes, charcoal is widely used in homes to heat pieces of local scent sticks used as room air freshener. Moreover, the household which were hitherto using fossil fuels now had to rely more on wood because of availability and affordability (Ojo & Chuffor, 2013).

Due to the epileptic electricity supply in Nigeria a lot of households have switched to the use of alternative energy sources through the use of power generating plants and other means. However, there is little empirical research findings on the household expenditure on these alternative energy sources especially the fossil fuels that are commonly used by households. Although, there are a lot of studies on household energy demand or consumption in the Nigeria such Bello (2011), Ojo and Chuffor, (2013) and Olaleye and Akinbode (2012) amongst others which used different data sets from Nigeria. However, each study has some short-comings for example Bello (2011) gave consideration to determinants of household cooking fuels consumption in Gombe state. Ojo and Chuffor (2013) dwelled on rural household wood fuel consumption in Dambua Local Government while Olaleye and Akinbode (2012) focused on households' demand for alternative Power supply but in Lagos (different study area). These necessitated for further empirical investigation of the problem. Therefore, against this background, this study seeks to empirically analyze household energy demand of both fossils and solid fuels in the north-east region of Nigeria. Specifically, the study determines the expenditure, own-price and cross price elasticity of demand households. The energy sources considered in this study include Electricity, Charcoal, Fuel wood, Kerosene, Petroleum, while LPG and Diesel were dropped due to lack of available data on household expenditure.

2 METHODOLOGY

2.1 Study Area

The study was conducted in the North-East Zone of Nigeria. The region lies between latitudes $6^o25^’$ -$13^o43^’$ north of the equator and longitudes $8^o35’$- $14^o39’$ east of the Greenwich meridian. It has a total land area of 923,773 sq kilometers. The zone is made up of Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe States. The combined population was 18, 832, 995 as at the end of 2006 (NPC, 2006), which was projected to rise to 22, 847, 445 by the end of 2017.

2.2 Data Type and Variables

Secondary data was used for the study. The data was obtained from the database of the National Bureau of Statistics (NBS) General Household Survey, Panel 2012-2013. A total of 709 households were interviewed from the north-east region. The relevant information collected in the survey include household socio-economic characteristics, information on farm, non-farm enterprise, income generating activities, food consumption expenditure, and other non-food expenditure (NBS, 2013). This paper considered five independent variables. Table 2.1, presents how each of the variables is measured.

2.3 Model Specification and Method of Estimation

2.3.1 Almost Ideal Demand System Model (AIDS)

The AIDS model was employed following Ogunniyi, Adepoju and Olapade-Ogunwole (2012) in order to estimate the budget share of the various energy sources used by household. The equation is expressed as:-

W_i = $\alpha_i + \sum \gamma_{ij} \log P_{jt} + \beta_i \log (X/P)$……..(v)

where,

W_i = The i^{th} budget share

X = Total expenditure

α_i = intercept and also represents average budget share when all logarithm price and real expenditures are equal to one (1)

γ_{ij} = ($\delta w_i / \delta \log p$) it equals to price coefficient, change in i^{th} budget share with respect to change in j^{th} price with expenditure held constant.

β_i = $\delta w_i / \delta \log X/P$ is equal to expenditure coefficients, change in the i^{th} budget share with respect to a percentage change in real expenditure with all prices held constant. If β_i = + is a luxury, if β_i = - is necessities

P_j = Price of j^{th} item

P = consumer price Index

On the basis of the above results, the expenditure, own-price and cross price elasticities were obtained. Thus, the coefficients estimated above were substituted into the expenditure elasticity equation to determine the elasticity of the various household energy types. The equation is given as:-

$E_i = 1 + \beta_i / W_i$……………………… (vi),

where;

E_i = expenditure elasticity of energy source item *i*

B_i = Expenditure coefficient of energy source item *i*

W_i = Budget share of energy source item *i*

To obtain the own-price elasticity, the estimated expenditure elasticity and the coefficients estimated in equation (2) above was substituted in to the Marshallian Price elasticity equation. The equation specified as follows:-

$e^{m}_{ij} = \gamma_{ij} - \beta_i w_j / w_i - \delta_{ij} / w_i$ ………………………….(vii),

where;

β_i = expenditure coefficient of energy source item *i*

w_i = budget share of energy source item *i*

w_j = budget share of energy source item *j*

$\delta_{ij} = 1$, when i = j, otherwise $\delta_{ij} = 0$

Hicksian price elasticity will also be computed using the slutsky's equation given as,

$e^{h}_{ij} = e^{m}_{ij} + w_j e_i$,...........................(viii)

where,

e^{h}_{ij} = Hicksian price elasticity

e^{m}_{ij} = Marshallian price elasticity

w_j = budget share of energy source item j

e_i = expenditure elasticity of energy source i

w_j = budget share of energy source item j

***A priori expectation*:**

The price elasticities of demand for energy products was expected to be both price elastic and inelastic depending on the energy products aggregation. The demand for energy products was expected to be income elastic for electricity and inelastic for the other energy sources. The cross price elasticities between electricity and the other energy sources are expected to be positive.

3 Results and Analysis

3.1 Expenditure, Price and Cross Price Elasticities of Energy Demand

The estimated parameters of AIDS for the energy sources demand in the North-east region i.e expenditure elasticities, price and cross-price elasticities are presented in Table 3.1. We estimated the model using the SAS package.

Expenditure elasticity of demand: The expenditure elasticity for all the energy sources were positive ranged from 0.886-1.003, implying that all the energy sources considered for this study were normal good, this corresponds with findings of (Authur, Bond & Wilson, 2012; Gundimeda & Kohlin, 2008 and Kebede, Bekele & Kedir, 2012). This also means that their demand will increase with increase in income. Moreover, all the expenditure elasticities were unitary income elastic because they approximate to one (1) except for kerosene. Implying that all the energy sources are comfort goods. The expenditure elasticity for kerosene on the other hand was low/less than unity (0.886), indicating that it was a necessity to the people of the north-east region of Nigeria this corresponds with the findings of (Kebede, Bekele & Kedir, 2012). Moreover, having expenditure elasticity equal to one for the electricity agrees with the *a priori* expectation which assumed that its demand would be income elastic while the elasticities equal to (1) for the remaining energy sources is contrary to the *a priori* expectation which assumed that they would be income inelastic.

These findings suggest that for all the energy sources with elasticity equals to one (1) as incomes of the consumers increase they spend the same proportion on all the energy sources. The reason for this could be because for all the energy sources with elasticity equal to unity are comfort goods. Hence, they are basic goods that are required by the consumers out of compulsion such as habit. Consequently, the change in income will result into same proportionate change in their expenditure.

Another justification for this result is the fact that all the energy sources have multiple uses. Electricity for instance is used for lighting of homes, cooking food, space heating and ironing clothes. Petrol is used in vehicles and for power generating plants to light homes and also used in grinding machines that are used for both domestic and commercial purposes etc. Firewood on the other hand is used for cooking, room heating and as a source of charcoal. Thus, if the tariff for electricity or the prices of these energy sources rise, their use will be restricted to important ones. However, expenditure elasticity for charcoal is a bit higher. This might be because the commodity is commonly used in the study area in homes to heat pieces of local scent sticks used as room air freshener. Other reasons are cooking, space heating during harmattan season and ironing clothes due to ineffective electricity supply.

The expenditure elasticity of kerosene on the other hand showed that it is a necessity because it is less one. This implies that since it is also a normal good, its demand increases with the increase in income but it increase is less than the proportional rise in income. Hence, the proportion of expenditure on kerosene falls as income rises. The status of kerosene as a necessary good can be justified because it produces fewer fumes compared to firewood. It is safe to keep for a long time without escaping into the air like LPG and it also provides a source of lighting when used in a bush lamps. In addition, it is used as a backup fuel by most household that use LPG in case their gas unexpectedly finishes and in lighting fuel wood.

Own-price Elasticity of Energy Demand: The results reported on table 3.1 show that all the uncompensated price elasticities were negative and ranged from -0.999 to -1.100. Also, all the coefficients revealed that the energy sources are price elastic, this corresponds with the results of (Authur, Bond and Wilson, 2012 & Gundimeda and Kohlin, 2008), this finding agrees with the *a priori* expectation for dirty energy and contrary for clean energy. The *a priori* expectation was that the price elasticities of demand for dirty fuel would be elastic while inelastic for clean energy.

From the results, it can be observed that charcoal is the most responsive to its own price. This can be explained based on its expenditure elasticity; it was the highest (1.003). This satisfies the theoretical assumption that the higher the percentage of a consumer's income used to pay for a product in this case charcoal, the higher the price elasticity tends to be or the higher responsive it is to its own-price. Implying that people will pay more attention charcoal demand because it is being allocated greater share of expenditure, hence, the higher its price the less the demand. The surprising result is that of kerosene which is found to be a necessity but the second most responsive to its own price. The reason for this could be because of the degree of its necessity. It can be observed that its expenditure elasticity coefficient was very close to been a comfort good (0.886). Hence, its degree as necessity is not that high. With regards to the remaining energy sources electricity, petrol and fuel wood have the same degree of responsive to change in demand due to change in price. This is because they are all equal to one in absolute terms. In general, all the energy sources considered are price elastic, a 1% increase in the prices of these energy sources will result to a decrease in charcoal demand by 110%, kerosene 105%, while electricity, petrol and firewood by 99% each respectively.

Cross-price Elasticity of Energy Demand: The findings show that all the compensated price elasticities were negative ranging from -0.639 to -0.810. This implies that complementary exists among all the energy sources, this agrees with the findings of (Gundimeda and Kohlin, 2008). This is contrary to the *a priori* expectation that assumed that the cross-price elasticities between electricity and other energy sources would be positive as substitute commodities.

In addition, all the cross-price coefficients were lower than the own-price elasticities in absolute terms and were more inelastic. This means that a change in price of a commodity with respect to its own price is elastic. The complementarity implies that the quantities of these energy sources are highly correlated. This is due to the fact that these energy sources perform similar functions. Electricity, petrol and kerosene could be used for lighting, cooling or heating homes, electricity, kerosene, charcoal and firewood for cooking while electricity and charcoal for ironing etc. These energy sources serve as fall back options for each other not as substitute. Some households use fuel wood for food categories that take longer hours to cook such as cow tail or cow leg while other easy to cook items are cooked by the other sources. Also, due to the epileptic power supply in Nigeria, most households have resorted to the use of power generating plants, thus, they complement each other. This claim can be justified based on the fact that these energy sources perform multiple functions, for instance apart from using petrol for lighting homes it is also used in vehicles and grinding machines for domestic use etc. This makes it necessary for a household that uses it for this function to have alternative energy sources for other purposes.

The negative signs of the coefficients could be explained by the fact all the energy sources are highly correlated. An increase in crude oil price would increase the rate at which gas is being sold to electricity generating companies thus, making electricity bills high. Moreover, a rise in crude oil price would increase kerosene and petrol prices because they are both produced from the same source. Fuel wood and charcoal on the other hand would be affected by the rise in crude oil price through an increased transportation cost. Therefore, a rise in crude oil price would increase the prices of all the energy items and consequently decrease their demand, because the impact would be more on the final consumers. Also, when fuel wood exploitation is banned or restricted it would affect it price and that of charcoal.

The Slutsky's symmetry was also imposed and tested. The symmetric restriction was under the assumption that ($\gamma ij = \gamma ji$). Thus, implies that compensated cross-price effects between any two goods are equal. Therefore, the empty columns on table 3.1.3 with (1.000) represent the own-price effects or the Slutsky's symmetry. The restriction is implied both within and across the equation restrict parameters (α, β, γ). The symmetric restriction was therefore imposed through the restrict language.

4 CONCLUSION, POLICY IMPLICATION AND RECOMMENDATIONS

In this study, we have found that all the energy sources considered are normal and comfort goods except for kerosene which is found to be a necessity although its degree of necessity is low because its coefficient is close to being a comfort good and also is not an inferior good as portrayed by the energy ladder model. With regards to the own-price elasticity of all the energy sources all the energy sources were found to be elastic with charcoal as the most responsive to its own price. The cross-price elasticities on the other hand reveal that all the energy sources have complementary relation.

The study therefore recommends that the government should encourage the use of LPG and electricity being the cleanest energy sources that have less health implications.This can be done by improving its production as well as making it accessible and affordable to households.

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Table 2.1
Variables measurement

Variables	**Measurement**
CO_2 emission	Is measured by the amount of CO_2 emitted by a particular energy type in kg
Household monthly income	Household Monthly income is proxied by total household monthly expenditure.
Household size	The variable is measured as the total number of individuals dwelling in the same house and sharing meals together.
Age	This variable is measured in years as the total number of years since the person was born.
Sex	Sex of respondent is a binary variable representing a value of 1 for male and 0 for female.
Rural-Urban dichotomy	This is also a dummy variable representing 1 for urban and 2 for rural.

Source: Generated by Stata 13 from the author's data

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Table 3.1: Non Linear AIDS Regression Parameters Estimates of Energy Demand System

Variable	Budget Share	Expenditure Elasticity	Own-price		
Charcoal	-0.031	1.003	-1.100		
Electricity	0.289	0.999	-0.999		
Fuelwood	0.360	0.998	-1.001		
Kerosene	0.070	0.886	-1.052		
Petrol	0.304	0.998	-0.999		
Cross-price	**Charcoal**	**Electricity**	**Fuelwood**	**Kerosene**	**Petrol**
Charcoal	1.000				
Electricity	-0.810	1.000			
Fuelwood	-0.739	-0.639	1.000		
Kerosene	-7.028	-0.741	-0.678	1.000	
Petrol	-0.795	-0.728	-0.638	-0.728	1.000
Parameter					
B	-0.000095(-4.23)	-0.00035 (11.38)	-0.00046 (11.07)	-0.00843 (-60.10)	-0.00039(-11.18)
$\gamma_i 1$	-0.01546(0.29)	0.44329 (13.99)	0.12557 (1.98)	6.44355 (11.04)	-0.01546 (-0.29)
$\gamma_i 2$		-0.29952(10.77)	-0.33057 (-6.01)	-1.99672(-3.60)	-0.02411 (-0.54)
$\gamma_i 3$			-0.06722(-14.66)	-2.23873(-5.91)	0.09919 (3.70)
$\gamma_i 4$				-2.19967(-4.69)	-0.0592 (-15.35)
$\gamma_i 5$					-0.11282 (-4.27)

Source: Generated by Stata 13 from the author's data. Figures in the parentheses denote t-values.