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Determinants of Household Energy Consumption in Nigeria: Evidence from Ogun State

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Abstract
This study examines household energy consumption in Ogun State. Primary data on socio- economic characteristics of household head, expenditure on energy and non energy sources were collected from 150 respondents using stratified random sampling technique. Descriptive statistics and multinomial logit were used for data analysis. Descriptive statistics was used to analyze socio economic characteristics of household head and to determine the share of each energy source on total expenditure on energy. Multinomial Logit and Tobit regression models were employed for the analysis of the determinants of fuel choice, the determinants of energy consumption. The determinants of fuel choice (solids) are prices of wood and kerosene and family size squared significantly and positively influence the choice of fuels while prices of wood, kerosene and electricity determines the monthly household's expenditure on fuels. The effect of family size on the choice of fuels is negative and non-linear.

Key words: Determinants, fuel choice, energy, consumption
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INTRODUCTION

The household is responsible for about 15 to 25 percent of primary energy use in many developing countries. Average per capital household energy use in developed countries is about nine times higher than in developing countries, even though in developing countries a large share is provided by non commercial fuels that are often not reflected in official statistics. It is estimated that approximately 2.5 billion people in developing countries rely on biomass fuels to meet their cooking needs (Mekonnen and Kohlin 2008) for many of these countries more than 90 percent of total household fuel is biomass. Without new policies, the number of people that rely on biomass fuels is expected to increase to 2.6 billion by 2015, and 2.7 million by 2030(about one third of the world's population) due to population growth (IEA2006). While rural households rely more on biomass fuels than those in urban areas, well over half of all urban households in sub Saharan African rely on fuel wood, charcoal or wood waste to meet their cooking needs (IEA 2006).

In many developing countries, particularly in rural areas, traditional fuels such as fuel woods, charcoal and agricultural waste constitute a major portion of a total household energy consumption (Dzioubinski and Chipman 1999). The efficiency of a traditional fuel wood cooking stove is as low as 10-12 percent, compared with a liquefied petroleum gas (LPG) stove efficiency of more than 40 percent. Potential energy savings from the used of available efficient technologies for cooking, heating, lighting, electrical appliances and building insulation can reach as high as 75 percent(Dzioubinski and Chipman 1999). Unfortunately diffusion of these technologies, especially in developing countries, is slow. One of the main reasons for that is their high initial cost to the consumer, particularly relative to the low cash in many rural areas. Other factors include shortages of particular fuels, lack of a distribution network and failure of the distribution system.

Production and consumption of almost any type of energy have environmental impacts. Harvesting of fuel wood, in particular, contributes to deforestation, soil erosion, and desertification. In Nigeria, harvesting of fuel wood contributes to deforestation at a rate of about 400,000 hectares per year (Oladosu and Adegbulugbe, (1997). If this trend continues the country's forest resources could be

completely depleted by 2020. Use of fuel wood as an energy source can also contribute to the accumulation of CO2, the main greenhouse gas, both because burning fuel wood produces CO2, and because deforestation destroys an important CO2 sink (Oladosu and Adegbulugbe, 1997). In addition, use of biomass fuel for cooking is a major cause of health problems in developing countries due to indoor air pollution. (Bruse *et al.* 2000; Ezzati and Kammen 2001). For example, the world health organization (WHO) estimates that 1.5 million premature death per year are directly attributed to indoor air pollution from the use of solids fuels (IEA 2006).Use of biomass in traditional stoves expose the users, mainly woman and children, to high levels of indoor air pollution (Dzioubinski and Chipman 1999).

Recognizing the adverse effect of use of traditional biomass fuels, the United Nations Millennium Project recommends halving the number of households that depends on traditional biomass for cooking by 2015, which involves about 1.3 billion people switching to other fuels (IEA2006). According to Dzioubinski and Chipman (1999),one set of factors necessary for switching to other fuel particularly in developing countries is better availability of alternative fuels other than traditional biomass fuels. Such alternative fuels are generally available in the major cities of poor countries, but access to such fuels is much more limited in rural areas and smaller cities in these countries. He further opined that household with low level of income rely on biomass fuels, such as wood and dung, while those with higher income consume energy that is cleaner and more expensive, such as electricity. Furthermore, household in transition-between traditional and cleaner (and more efficient) energy sources consume what are called transition fuels, such as kerosene and charcoal.

Apart from concern about the use of foreign exchange earnings and vulnerability to external shocks, increased consumption of energy products has also raised concern with regards to its impact on the environment. This is problematic because of the sharp rise in anthropogenic emission such as carbon monoxide (co), hydrocarbons (HCs), nitrogen oxides (NO), sulphur dioxide (SO_2) and TSP_S (Shrestha&Malla 1996).

METHODOLOGY

The study area of this research was in Egba division of Ogun State which is situated in the tropics and covered a landmass of $16{,}409.26_{sq}$ kilometres. The state shares its boundaries in the west the republic of Benin East with Ondo State in the north with Oyo State and in the South by Lagos State. It is located within the rain forest belt of Nigeria with an annual rainfall of 1500mm-2000mm and a temperature of 300^0c. Administratively, Ogun State comprises 20 Local Government areas with an estimated population of about 3.6 million people (2006 NPC). Egba zone has its headquarters at Abeokuta occupies a geographical area of $6{,}409.29km^2$. Within the zone are six Local Government Areas of Abeokuta North Abeokuta South EwekoroIfoObafemi- Owode and Odeda collectively sharing common boundaries in the West with the Republic of Benin in the East with Ondo State and in the North with Oyo State.

Primary data was collected from 150 household heads using stratified random sampling technique, each local government serving as a stratum. Data collected include socio-economic characteristics of household heads, prices of fuels, preferences of fuel choice etc. Descriptive statistics was used to analyze socio-economic characteristics of household heads and share of each energy source on total expenditure on energy while Multinomial Logit and Tobit regression models were employed to estimate the determinants of fuel choice and the determinants of energy consumption respectively. The analyses were carried out for the three types of fuel, solid fuel, non solid fuels and a mixture of solid and non solid fuels.

The Logit and Tobit models are specified thus:

Model Specification

The Logit model assumes

$$P(Yt=1/x_t) = \frac{\exp(x,\beta)}{1+\exp(x,\beta)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

An equivalent form can be stated thus,

$$\text{Exp}(x,\beta) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$1+\exp(x,\beta) = 1+\exp(x,\beta)$..... (3)

This can be expressed as $q_{it} = \beta x_{it} + e_{it}$.... (4)

Where q_{it} = an observable latent variable for household expenditure

X_{it} = vector of explanatory variables

B = vector of parameters to be estimated

eit = error term

Variables (1) solid fuels (2) non solid fuels (3) mix of solid and non solid

X_1 =price of wood deflated

X_2= price of charcoal deflated

X_3 =price of kerosene deflated

X_4 =price of electricity deflated

X_5 = family size

X_6 = family size squared

X_7 =max. Education of household head (1 if secondary education else 0)

X_8 = max. Education of household head (1 if postsecondary education else 0)

X_9 = sex of household head

X_{10} =age of household head

X_{11} =expenditure per month

Tobit regression model

The Tobit regression model is expressed as follows;

$Yi = x_i \beta + u_i$ if $x \beta + u_i > 0$ (5)

If $x \beta + u_i \leq 0$ $i = 1, 2... N$ (6)

Where N =number of observations

Y = consumption expenditure on energy/ fuels

X_i = vector of explanatory variables (as expressed above)

β = vector of unknown co efficient

U = independent distributed error term assumed to be normally distributed with zero mean and constant variance (Mc Donald and Moffiit 1990).

Mathematically, the empirical model is thus

$Y_i = b_0 + \sum b_{k1+} e_1$ i =1, 2 ... n and

K = 1, 2 ...k

RESULT AND DISCUSSION

Socio-economic characteristics of household heads and the share of each energy source on total expenditure

Table 1 presents the descriptive statistics which include the dependent and independent variables used in this study. The primary fuels used by households are grouped into solid fuels (wood and charcoal), non-solid fuels (kerosene, gas and electricity) and a mixture of these (when households reported both solid and non-solid as their main fuels). The result in the Table shows that on the average, the share of household energy expenditure in household's total expenditure is 23%. Electricity and kerosene are the two most important fuels in terms of their share in total energy expenditure. (36 and 30 percent respectively).Households spent 8-10% per month on electricity, kerosene, charcoal, wood, petrol, diesel, and gas, which are the most important energy sources. We noted from the Table that the proportion of households, that used solid, non solid and a mixture as main fuel are 36%, 97%, and 33% respectively. The survey had a larger percentage (80%) of male headed household with majority (72%) having a maximum of secondary education and average family size of 4.

Table 1: Descriptive Statistics of Socio Economic Characteristics of Household Heads and the Share of Each Energy Source on Total Expenditure

Variable label	Mean	Std.dev.
Share of energy in total expenditure	0.23	0.25
Share of electricity in energy expenditure	0.36	0.38
Share of kerosene in energy expenditure	0.30	0.51
Share of charcoal in energy expenditure	0.03	0.16
Share of wood in energy expenditure	0.08	0.34
Share of petrol in energy expenditure	0.19	0.57
Share of diesel in energy expenditure	0.02	0.28
Share of gas in energy expenditure	0.01	0.07
Expenditure on electricity per month	3.02	1.33
Expenditure on kerosene per month	2.49	1.78
Expenditure on charcoal per month	0.21	0.55
Expenditure on wood per month	0.67	1.18
Expenditure on petrol per month	1.57	2.02
Expenditure on diesel per month	0.20	0.97
Expenditure on gas per month	0.08	0.26
Main fuel solids (yes =1, else =0)	0.36	0.48
Main fuel mixed (yes =1, else =0)	0.33	0.47
Main fuel non solids (yes =1, else =0)	0.97	0.18
Price of wood	0.58	1.02
Price of charcoal	0.21	0.55
Price of kerosene	2.58	1.78
Price of electricity	2.96	1.32
Price of petrol	1.54	2.01
Price of diesel	0.20	0.97
Price of gas	0.08	0.26
Family size	4.36	1.58
Max. education of household head (1 if secondary education, else =0)	0.72	0.45
Max. education of household head (1 if post secondary, else =0)	0.55	0.50
Sex of household head	0.80	0.40
Age of household head	20.45	9.85
Expenditure on energy per month	8.28	3.52
Expenditure on non energy per month	28.05	10.34
Total expenditure per month	36.33	13.86

Determinants of fuel choice (solids)

Multinomial Logit estimate of the determinants of households' choice between solids, non-solids, and a mixture of solids and non solids fuels are presented in Table 2a and 2b. Non solids fuels are the omitted category (base outcome), with which the estimated coefficient are to be compared.*(Note the omitted category does not change the basic results; it only influences the way the results are interpreted)*. Prices of wood, kerosene, electricity and family size squared are explanatory variables that significantly determined the choice of household's main fuel. The results suggest that higher kerosene prices made household choose either solid fuels only, or a mixture of solid and non solid fuels, moving away from solids fuels, households were also more likely to choose a mixture of solids and non solid fuels with higher wood prices. This suggest, perhaps, that one needs to look at other factors in addition to prices to explain fuel choice, such as consumers income, role of equipment cost, preferences and habit.Family size squared made the choice of households more likely, and the positive

significant coefficient for the square of the family size variable suggest that there is non-linearity, whereby as family size increased, the likelihood of household using solid fuels only or a mix of solid and non solid fuels as the main fuel increased but at a decreasing rate. Age, sex and level of education of the household headas well as total expenditure per month have no significant influence on the choice between solid, non-solid and mixture of solid and non-solid fuels. Households with larger expenditure were less likely to choose only solid fuels as their main fuel. These results are in consonance with the findings of Mekonnen and Kohlin (2008).

Table 3: Multinomial Logit regression on the determinant of fuel choice (solids)

Variables	**Coefficient**	**Standard error**	**T - value**
Constant	5.231	3.199	1.635
price of wood	0.968	0.300	3.230***
Price of charcoal	0.496	0.414	1.197
Price of kerosene	-1.130	0.332	-3.402***
Price of electricity	-1.209	0.401	-3.012***
Family size	-1.522	1.121	-1.357
Family size squared	0.2153	0.108	1.993**
Max.edu .of household head(1 if sec. Else 0)	-1.299	1.117	-1.163
Max.edu. Of household head(1 if post sec. else 0)	-0.623	1.122	-0.555
Sex of household head(1 if male else 0)	0.6760	0.967	0.699
Age of household head	0.01846	0.0452	0.408
Expenditure per month	0.01154	0.04795	0.241
Log likelihood function	-27.43318		

Source: computed from field survey

*** =1%, ** =5%, *=10%

Determinants of fuel choice (mixture)

Table 3b Multinomial Logit regression on the determinant of fuel choice (mixture)

Variables	**Coefficient**	**Standard error**	**T - values**
Constant	1.972	2.714	0.727
Price of wood	0.839	0.243	3.453***
Price of charcoal	0.074	0.326	0.227
Price of kerosene	-0.689	0.227	-3.034***
Price of electricity	-0.398	0.2771	-1.438
Family size	-1.231	1.082	-1.138
Family size squared	0.1738	0.104	1.670*
Max.edu. Of household head (1 if sec. else 0	-0.785	0.901	-0.871
Max.edu. of household head(1 if post sec. else 0	-0.632	0.910	-0.694
Sex of household head(1 if male, else 0	1.1139	0.832	1.338
Age of household head	0.01317	0.0370	0.356
Expenditure per month	-0.05800	0.0381	-0.152
Log likelihood function	-39.27561		

Source: computed from field survey

*** =1%, ** =5%, *=10%

Determinants of energy consumption

The result of the Tobit regression showing the determinant of energy consumption is presented in Table 3. Prices of wood, charcoal, kerosene, electricity, maximum education (post secondary) and expenditure per month are significant independent variables that explain the variation household energy consumption.The sign of each significant variable is in line with *apriori* expectation. The

positive coefficients of prices, level of education and total expenditure per month indicate that energy consumption varies directly with these explanatory variables. Households with more members consumed more electricity kerosene, and wood. This could be due to the high price of wood, electricity and kerosene which makes household switch among different fuels. This suggests that apart from prices, other factors such as availability of close substitute, choice among other factors determines the consumption of a particular fuel.

The energy consumption expenditure increases for every household head that have post-secondary education. One would have expected the same trend for household head that have tertiary education, though the coefficient is positive, indicating increasing effect on energy consumption, but it has no significant effect. Households with a more educated member are more likely to consume cleaner and more efficient fuels as their main fuel. This could be due to the fact that these households have the basic knowledge of the health and environmental hazards these fuels have. A comparison of the coefficients for secondary education and post-secondary education shows that while households who had members with either of these two education levels were more likely to use cleaner and efficient fuels, households with members that had postsecondary education were even more likely to use cleaner and more efficient fuels than those with secondary education.

The linear and positive effect of total expenditure vis-à-vis household income signifies that the fuels in totality are necessities and normal goods even though solid fuels, that is wood and charcoal are regarded as inferior goods.

Table 4: Tobit regression on the determinant of energy consumption

Variable	Coefficient	Standard error	T - values
Constant	0.5088	1.231	0.413
Price of wood	0.7353	0.121	6.064***
Price of charcoal	0.3325	0.170	1.946*
Price of kerosene	0.7076	0.115	6.144***
Price of electricity	0.6341	0.146	4.315***
Family size	-0.484	0.497	-0.973
Family size squared	0.5331	0.492	1.084
Max.edu. Of household head (1 if sec. else 0	-0.147	0.535	-0.276
Max.edu. of household head(1 if post sec. else 0	1.15808	0.540	2.143**
Sex of household head(1 if male, else 0	0.10110	0.435	0.232
Age of household head	0.20917	0.195	1.072
Expenditure per month	0.76958	0.183	4.199***
Log likelihood function	-235.66		

Source: computed from field survey, 2010

*** =1%

**=10%

Conclusion

This study examines household energy consumption inOgun State. Primary data on socio- economic characteristics ofhousehold head, expenditure on energy and non energy sources were collected from 150 respondents using stratified random sampling technique. Descriptive statistics and multinomial logit were used for data analysis. Descriptive statistics was used to analyze socio economic characteristics of household head and to determine the share of each energy source on total expenditure on energy. Multinomial Logit and Tobit regression models were employed for the analysis of the determinants of fuel choice, the determinants of energy consumption. The determinants of fuel choice (solids) are prices of wood and kerosene and family size squared significantly and positively influence the choice of fuels while prices of wood, kerosene and electricity determines the monthly household's expenditure on fuels. The effect of family size on the choice of fuels is negative and non-linear. We found that fuel types such as wood are not inferior, as opposed to the energy-ladder hypothesis. Thus, households tend to switch to a multiple fuel-use strategy (fuel stacking) as their

incomes rise, perhaps, because of a number of factors, including family size, irregular supply of more efficient fuels, that is kerosene, gas and electricity.

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