Research & Reviews

ISSN: 2319-9857

Research and Reviews: Journal of Agriculture and Allied Sciences

Economic Analysis of Household Energy Use: A Rural Urban Case Study of Abia State, Nigeria.

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Research Article

Received: 05/09/2012
Revised: 07/02/2013
Accepted: 25/02/2013

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Keywords: Household, Energy use, Rural, Urban, Abia State

ABSTRACT

The study investigated the household energy use between the urban and rural areas of Umuahia North local government area; Abia State Nigeria. Stratified sampling technique was used to select the sample size of 120 respondents (60 from the urban areas and 60 from the rural areas). A set of pretested and structured questionnaire was used in data collection. The result showed that urban households utilized modern domestic energy types (LPG, kerosene and electricity) than rural households. The result of the multiple regression analysis with semi log as the lead equation showed that the critical and significant determinants of urban domestic energy use include household income, occupation of respondents, quantity of energy and cost of substitute energy. The combined effect of all the variables explained 66.67% of the total variation in urban domestic energy use. The result also showed that the critical and significant determinant of rural domestic energy use include household income, household size, occupation of spouse, quantity of energy and cost of substitute energy. The combined effects of all these variables explained 83.3% of the total variation in the rural domestic energy expenditure. The own price elasticity of demand showed mild elastic coefficient for charcoal (-1.2), unitary elastic for fuel wood (1.0), kerosene (1.0), LPG (1.1) and inelastic for electricity (0.2) for urban respondents. The own price elasticities for rural respondents showed inelastic coefficient for charcoal (-0.8), fuelwood (-0.7), kerosene (0.5), LPG (-0.6) and mild elastic coefficient for electricity (-1.2). The result of the cross elasticity of demand showed that the domestic energy types are close substitutes to each other in both rural and urban areas. It was therefore recommended that government should further subsidize the energy prices and provide basic facilities for the supply and distribution chain to make these energy types available and affordable.

INTRODUCTION

Nigeria is an energy rich country blessed with fossil fuel resources such as crude oil, natural gas, coal and renewable energy resources such as solar, wind and biogas [15]. At present, conventional energy resources dominate the nation's energy mix with petroleum, gas and coal being exploited in commercial quantities.

Nigeria's economy has, for over two decades, been plagued by perennial energy crises, which manifest in at least four ways: erratic electric power supply, acute shortages of petroleum products on several occasions, sharp increases in prices of energy commodities, and frequent conflicts between the populace, led by the labour movements, and the Federal Government on what should constitute appropriate prices of petroleum and other energy supplying commodities. These lingering crises have dealt several devastating blows on the nation's fragile economy, slowing down growth and socio-economic development. Perhaps one major pointer to this is a steady decline in the nation's industrial capacity utilizations, which dropped from 78.7% in 1977 to 40.4% in 1987 and 30.4% in 1997 [2]. In the last decades, the Nigerian environment has experienced rapid degradation due to continuous deforestation. A major contributory factor of this is the pattern of socio-economic developments in the country that gave little or no consideration to environmental outcomes

ISSN: 2319-9857

[10]. An aspect of this development is the economic policy of subsidy removal on petroleum products initiated in 1986 as a result of the worsening economic situation in the country. The result is that prices of commercial fuels inclusive of kerosene and liquefied petroleum gas (LPG) (cooking gas) have continued to rise beyond the reach of majority of the Nigerian population. The apparent and relative abundance of petroleum and natural gas in Nigeria call for exploring the full economic benefits desirable from the exploitation.

Nigeria's households have not succeeded in diversifying their energy sources which present a state of disparity in the consumption of commercial energy by both urban and rural dwellers experiencing periods of extended energy crises which has manifested itself in frequent shortage of energy [10]. Fuelwood appears to be a transition good for households that aim at other sources of cooking energy which are more suitable for urban consumption. This implies that a price subsidy policy for liquefied petroleum gas (LPG) and cooking stove could significantly decrease the utilization of wood energy. This has brought about the talk of energy ladder where a progression of fuel wood to modern fuels is expected as income rises [1,9]. The high cost of modern cooking energy, liquefied petroleum gas (LPG), electricity and kerosene are the major constraints for household fuel preferences [8]. According to Chukwuezi [3], a large proportion of the rural people in Nigeria are dependent upon the non- commercial energy sources because the commercial energy requirement for satisfying basic need in the rural areas are modest. Increased use of liquid petroleum gas, natural gas and electricity which could have provided a more reliable alternative to fuelwood in order to reduce deforestation have not been broadly acceptable because of unreliable supply and high cost of associated appliances. However in attempt to satisfy the increase in the demand for the household energy in the country, emphasis should be shifted in the household through the generation of cheaper but affordable energy so as to minimize the use of fuel wood.

So the objectives of the research were to: identify the energy types available in urban and rural areas of Umuahia North LGA of Abia State, Nigeria; determine the factors that influence household energy expenditure in the study area; to determine the level of substitution of one energy source for another in the study area.

MATERIALS AND METHODS

The study was conducted in Abia State Nigeria, precisely Umuahia North Local Government Area (LGA). This area was chosen because it comprises both urban and rural settlements where both the traditional energy sources (Fuelwood and charcoal) and commercial energy sources (LPG, kerosene and electricity) were utilized. The urban area serves as an administrative headquarters to Abia State and Umuahia North Local Government respectively. Umuahia North Local Government lies between latitudes $5^{0}23^{1}$ and $5^{0}45^{1}$ North of the equator and longitudes $7^{0}25^{1}$ and $7^{0}73^{1}$ East of the Greenwich meridian. It is bounded by Bende local Government Area in the north, Umuaha South Local government in the south, Ikwuano Local government in the east and Isuikwuato local Government in the west. The local government area comprises of two extension blocks namely; Ibeku and Ohuhu, with ten autonomous communities and thirty nine villages. The urban areas include Umuahia main town, Ehimiri Housing estate, lowcost housing estate. etc. The population of Umuahia North local Government area is 223,134 with 112,595 males and 110,539 females.

Stratified sampling procedure was adopted for this study. The stratification was based on the level of development rural and urban areas. From each stratum, three autonomous communities from the rural areas and three housing estate from the urban areas were chosen at random. From each of the autonomous communities, two villages were selected at random resulting to a total of six villages. Ten households were selected from each of the selected villages and this resulted to 60 households from the rural area of the study area. From each of the chosen three housing estate in the urban area, 20 households were selected making a total of 60 households which make up a sample size of 120. Instrument of data collection was a well structured and pre-tested set of questionnaires. Descriptive statistics such as mean, percentages and tables was used to analyze socioeconomic variables and the energy types available in the area. Multiple regression analysis was used to draw inferences on the determinants of household energy expenditure while demand elasticity indicators were used to draw conclusion on the level of substitution of one energy source for another.

The implicit model of the ordinary least square (OLS) multiple regression model is stated thus;

$$Q = F(X_1, X_2, X_3, X_4, X_5, X_6, ei) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

Q = Household energy expenditure(₦) / month

X_1 = Household income (₦) / month

X_2 = Household size

X_3 = occupation of the respondents (farmers =1, non farmers = 0)

X_4 = occupation of the spouse of respondent (farmer =1, non farmer = 0)

X_5 = quantity of energy type (kg)

X_6 = cost of substitute energy(₦) / month

The expenditure function was regressed using four different functional forms namely linear, exponential, double log and semi-log and the one with the best fit in terms of its alliance with apriori expectation, the value of its R^2, number of significant coefficients and the value of the F-ratio.

The own price elasticity is stated thus:

$$ep = \frac{\partial Q}{\partial p} \cdot \frac{p}{Q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where: ep = price elasticity

$\frac{\partial Q}{\partial y}$ = slope of the linear demand curve

Q = quantity demanded

P = price of commodity.

The cross price elasticity is stated thus:

$$Exy = \frac{\partial Qx}{\partial py} \cdot \frac{Py}{Qx} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,

Exy = cross elasticity of commodity X with regard to commodity Y
Qx = Quantity demanded of commodity X
Py = price of commodity Y

RESULTS AND DISCUSSION

The distribution of the respondents according to the type of domestic energy used is shown in table 1. The table reveals that majority (87% for the urban and 75% for the rural) households used kerosene as their domestic energy. The table further reveals that 20% of the urban households and 23.3% of the rural households used charcoal/ crop residues for cooking, 7% of the urban and 55% of the rural household used fuel wood while 42% of urban respondents and 5% of the rural respondents used liquefied petroleum gas (LPG) as their domestic energy. However, 48% of the urban respondents and 16.7% of the rural respondents used electricity while 45% of the urban household and 38% of rural household used petrol/diesel (generating set). The implication of the results showed that the consumption of kerosene had dominated all other domestic energy sources in both study areas because of its availability and diversified use as a source of lighting in kerosene lanterns. This is in accordance with Ouedraogo [17], who stated that kerosene is the most popular domestic energy in urban Nigeria. Also, the result showed that though fuel wood is still a veritable source of domestic energy in the rural areas, kerosene usage is currently more popular due to the problem of fuel wood scarcity and the health imperatives of the use of fuel wood. This result is in accordance with Chukwuezi [3], who stated that the utilization of fuel wood has serious health impact because open fires in the home produce unventilated smoke.

The results further imply that the traditional energy sources (charcoal/crop residues and fuel wood) have reduced in importance in the urban areas showing that urbanization had led to the depletion of these sources of energy. The result also showed that the use of electricity in urban and rural areas is dwindling because Nigeria at present still suffers acute and fluctuating electricity supply [10]. For this reason, electric stoves are not used because it is not favourable due to constant power fluctuation. The rural respondents do not utilize liquefied petroleum gas (LPG) because of the deepening nature of poverty in the area and ignorance.

The result of the estimate of factors determining monthly domestic energy expenditures of the urban households in Umuahia North Local Government, Abia State is shown in Table 2. The F-ratio of the four functional forms tried were significant at 1.0% risk level indicating that any of the functional forms could be used for predictive purposes. But the semi-log functional form was chosen as the lead equation for this study based on econometric and statistical reasons such as the number of regression co-efficient that are significant, the values of R^2 and the significant level of F-ratio.

ISSN: 2319-9857

Table 1: Distribution of the Respondents According to Energy type used in both Urban and Rural areas of Umuahia north Local Government area of Abia State, Nigeria.

Energy types	Urban *Frequency	Percentage (%)	Rural *Frequency	Percentage (%)
Charcoal	12	20.0	14	23.3
Kerosene	52	87.0	45	75.0
Fuelwood	4	7.0	33	55.0
LPG	25	42.0	3	5.0
Electricity	29	48.0	10	16.7
Petrol/diesel	27	45.0	23	38.0

Source: field survey data 2010.

* = multiple responses recorded.

For a cross section analysis of these factors that influence the total monthly domestic energy expenditures in the urban areas of Umuahia North LGA, Abia state, Nigeria, the results provided a reasonably good estimates of the socio-economic characteristics that affect total monthly domestic energy expenditure (R^2=0.822).

Examining briefly, the individual characteristics of the aggregate urban household monthly domestic energy expenditure equation, the result showed that four out of six explanatory variables had significant coefficient at given levels. The significant variables include monthly household incomes, occupation of respondents, quantity of energy and cost of substitute energy.

Specifically, the coefficient of household income (902.654) was positive and statistically significant at 95% level confidence level. The sign of the variable is in alignment with aprori expectation and theory. This implies that domestic energy is a normal good whose expenditures increase with increase in income. The result of this study collaborates the finding of Wange and Bessler [20] in which they stated that the income of the consumer were significantly related to the quantity of meat consumed by the people of southern Nigeria.

The relationship between urban household monthly expenditure on domestic energy and the occupation of the respondents was strong, positive(4230.690) and statistically significant at 5.0% risk level. The sign of the variable is in tandem with apriori expectation. Expectedly, urban respondents are involved in formal employment and very much exposed. This by extension reflects the literacy rate of the respondents and their good consumption. Olagoke [16] strongly believed that academics and exposure will affect good consumption pattern and such effect depend more on the values attached to the good rather than on the social values. Consumers with higher level of education, exposure and in formal occupation are expected to evaluate products by their price and specific quality.

The coefficient of the quantity of domestic energy used (3429.988) is positively related to the monthly expenditures in the urban areas at 1.0% probability level. This sign of the variable is in consonance with a prori expectation. It implies that the greater the quantities of domestic energy used in the urban areas, the greater the expenditure component that will be incurred. The reason being that sufficient quantities of domestic energy is critical to normal living in the urban areas. The result is synonymous to Ezeh *et al* [6] and Oji [12].

The coefficient of cost of substitute energy (1725.696) is positive and statistically significant at 1.0% alpha level. The sign of the variable is contrary to normal expectation. Expectedly, domestic energy speculator households may buy the regular and the substitute energy in large quantities in anticipation for a future rise in price thus shoring up the monthly domestic energy expenditure

The results of the estimate of factors determining the monthly domestic energy expenditure of the rural household in Umuahia North LGA of Abia state, Nigeria is shown in Table 3. The F-ratio of the four functional form tried were significant at 1.0% risk level indicating that any of the four could be used for predictive purposes. But the semi-log functional form was chosen based on economic and statistical reason such as the number of significant regression coefficients, the value of R^2 (0.883), and the significant level of the F-ratio ($P < 0.01$)

The coefficient of monthly household income is positive and statistically significant at 10.0% probability level. The sign of the variable is in consonance with a prori expectation. This implies that increase in monthly household income would be associated with a similar increase in the expenditures on domestic household energy requirements in the rural areas. The monthly income status of the respondents has implication on household welfare. This relationship is possible due to the advantages associated with economics of scale, which come about through the expansion of purchases made possible by increased income [6,7,14].

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Household size in the rural areas has positive (613.572) relationship with the monthly expenditure of domestic energy. This implies that the higher the household size, the more likelihood of increased expenditure on domestic energy. The sign of the variable is obvious, expected and conforms with a prori expectation. Generally, the more people in a household, the more mouth to feed and this conventionally would require more energy to cook the food hence increase in cooking energy expenditure. This result is synonymous with Pollark and Wales [18] who opined that the rate of consumption is a function of number.

Table 2: Estimate of the factors Affecting Monthly Domestic Energy Expenditure Level of Urban Household in Umuahia North Local Government Area of Abia State, Nigeria

Variables	Linear	Exponential	Double log	Semi log+
Constant	-225.772	7.424***	3.560***	-3.1485.092***
	(-0.314)	(22.167)	(4.927)	(-7.767)
Monthly household income (X1)	0.018***	3.7527**	0.123**	902.564**
	(5.505)	(2.441)	(2.033)	(25.656)
Household size (X2)	86.564	0.070*	0.328***	669.800
	(1.069)	(1.858)	(2.813)	(1.025)
Occupation of respondent (X3)	444.098	-0.151	0.314	4239.690**
	(0.685)	(-0.499)	(0.915)	(2.202)
Occupation of spouse respondent (X4)	372.313	0.241	0.314	172.252
	(0.636)	(0.883)	(1.062)	(0.104)
Quantity of energy used (X5)	63.614****	0.011***	0.663	3429.988***
	(11.976)	(4.366)	(7.072)	(6.522)
Cost of substitute energy (X6)	0.025	-6.953E-5*	0.071	1725.696***
	(0.336)	(-1.998)	(0.809)	(3.513)
R^2	0.953	0.630	0.795	0.822
Adjusted R^2	0.948	0.588	0.772	0.801
F-ratio	179.100***	15.053***	34.263***	40.702***

Source: Field survey data, 2010

+ = Lead equation

***, **, * indicate variables are statistically significant at 1.0% and 5% and 10% risk levels respectively.

Figures in parentheses are the t-ratio.

The coefficient of spouse occupation (1071.730) is positive and statistically significant at 10.0% alpha level. This implies that the more the respondent spouse are involved in formal employment, the greater the complementarity of these household expenditure. The sign is in tandem with normal expectation.

The coefficient of the quantity of domestic energy used (2590.260) is positive and statistically significant at 1.0% risk level. Its sign implies that increase in the quantities used of domestic energy would trigger simultaneous increase in the expenditure as most of these domestic energies are bought and hence have cost implication. The result corroborates the findings of Ezeh et al[6] and Oji [12].

The coefficient of cost of energy substitutes (866.409) is positive and strongly significant at 95.0% confidence level. The sign of the variable is contrary to normal expectation and theory. The reason for the sign could probably be informed by the high fluctuating and indeterminate nature of prices of all domestic energy sources thus forcing the households to purchase the regular and substitute energy source in greater quantities as a cushion and insurance against spontaneous scarcity and unrelenting rise in price of any of them. This guides against unpalatable emergencies in the home.

The estimate of own price elasticity of domestic energy source (charcoal/crop residues, fuel wood, kerosene, liquefied petroleum gas and electricity) in the urban area of Umuahia North LGA, Abia state Nigeria are displayed in Table 4. The coefficient of charcoal or crop residues (-1.2), fuel wood (1.0), Kerosene (1.0), and liquefied petroleum gas (1.1), show that a proportionate change in price would lead to the same proportional change in quantity demanded of these various domestic sources hence exhibiting a unitary elastic demand. This reinforces existing belief that these goods are necessary. The own price elasticity coefficient of electricity was 0.2, thus shows that a percentage change in price would result in a less than proportionate change in the quantity demanded of it. These results compared favourably with Donelly [4].

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Table 3: Estimate of the Factors Affecting Monthly Domestic Energy Expenditure Level of Rural Household in Umuahia North Local Government Area of Abia State, Nigeria

Variables	Linear	Exponential	Double log	Semi log+
Constant	-226.85	7.285	4.193***	-17010.893***
	(-0.334)	(26.680)	(6.855)	(-5.917)
Monthly household income (X1)	0.046**	9.014E6	0.058	519.345*
	(2.485)	(1.212)	(1.028)	(1.994)
Household size (X2)	179.244***	0.052**	0.242***	613.572**
	(3.376)	(2.425)	(3.363)	(1.813)
Occupation of respondent (X3)	221.610	0.083	0.114	461.864
	(0.640)	(0.596)	(1.295)	(0.731)
Occupation of spouse respondent (X4)	-158.173	-0.118	0.012	1071.750*
	(-0.410)	(-0.760)	(0.084)	(1.567)
Quantity of energy used (X5)	64.697****	0.014***	0.684***	2590.260***
	(9.901)	(5.471)	(9.871)	(7.956)
Cost of substitute energy (X6)	0.179*	2.943	0.096	866.405**
	(1.919)	(0.079)	(1.290)	(2.473)
R^2	0.892	0.682	0.862	0.833
Adjusted R^2	0.880	0.646	0.846	0.894
F-ratio	73.133***	18.912***	55.056***	44.057***

Source: Computation from Field survey data, 2010

+ = Lead equation

***, **, * indicate variables are statistically significant at 1.0% and 5% and 10% risk levels respectively.

Figures in parentheses are the t-ratio.

The estimate of own price elasticities of domestic energy sources in rural areas of Umuahia North Local Government Area, Abia State, Nigeria is shown in Table 4. Since 1.0 % increase in price of charcoal/crop residues, fuel wood and liquefied petroleum gas will cause demand for them to decrease by -0.8%, 0.7% and 0.6% respectively, hence the demand elasticity is said to be perfectly inelastic [11]. However, 1.0% increase in price of kerosene will trigger an increase in demand for the good by 0.5% though the elasticity is positive, since the change (increase) in demand is less than the proportionate cause (price), the elasticity is said to be inelastic [4]. The own price elasticity is perfectly elastic because 1.0% increase in price will result to 1.2% reduction in demand for it.

Table 4: Estimates of own price elasticities of demand of different domestic energy types in urban and rural areas of Umuahia North Local Government Area of Abia state, Nigeria

	URBAN	RURAL
Domestic energy types	Own price elasticity	Own price elasticity
Charcoal/ crop residues	-1.2	-0.8
Fuel wood	1.0	-0.7
Kerosene	1.0	0.5
Liquefied petroleum gas	1.1	-0.6
Electricity	0.2	-1.2

Source: Calculation from field survey data, 2010

The estimate of cross elasticity of demand between various energy sources in urban areas of Umuahia North Local Government Abia State, Nigeria is shown in Table 5. The table posted a cross elasticity coefficient of 6.7 between fuel wood and kerosene. This result shows that 1.0% increase in the price of kerosene would cause 6.7% increase in the demand for fuel wood. This implies that the two goods (fuel wood and kerosene) are perfect substitute [5, 13]. The table also shows the cross elasticity coefficient between fuel wood and charcoal as -4.2. It implies that 1.0% reduction in the demand for fuelwood would cause 4.2% increase in the price of charcoal. This results further consolidates the fact that fuel wood and charcoal are perfect substitutes.

The result (table 5) further posted a cross elasticity of demand coefficient of -0.5 between kerosene and charcoal. It shows that 1.0% increase in the price of charcoal would initiate 0.5% reduction in the quantity demanded of kerosene. Since the values of the coefficient (-0.5) is greater than zero, this implies that the goods are sparingly good substitutes. The coefficient of cross elasticity

ISSN: 2319-9857

between kerosene and liquefied petroleum gas (LPG) is 0.91. This implies that a 1.0% increase in price of LPG would trigger 0.91% increase in the quantity demanded of kerosene. The implication is that kerosene and LPG are increasingly perfect substitutes.

The estimate of cross elasticity of demand between various energy sources in the rural areas of Umuahia North LGA of Abia State, Nigeria is shown in Table 5. The table reveals a cross elasticity coefficient of 11.0 between fuel wood and kerosene. The result shows that 1.0% increase in the price of kerosene would cause 11.0% increase in the demand for fuel wood. This implies that fuel wood and kerosene are perfect substitutes [5,13]. The table also shows the cross elasticity coefficient between fuel wood and charcoal as -3.5 showing that a 1.0% increase in the price of charcoal would cause a 3.5% reduction in the demand for fuel wood. This result further consolidates the fact that fuel wood and charcoal are perfect substitutes. Furthermore, the result posted a cross elasticity of demand coefficient of -0.2 between kerosene and charcoal. It shows that 1.0% increase in the price of charcoal would initiate 0.2% reduction in the quantity demanded of kerosene. This implies that the two goods (kerosene and charcoal) are sparingly good substitute.

The coefficient of cross elasticity of demand between kerosene and liquefied petroleum gas (LPG) is -0.1. This shows that a 1.0% increase in the price of LPG would bring about 0.1% reduction in the quantity of kerosene. This implies that kerosene and LPG are complementary to each others in the rural areas.

Table 5: Estimates of Cross elasticity of demand of domestic energy source in urban and rural areas of Umuahia North Local Government Area of Abia state, Nigeria

	URBAN	RURAL
Domestic energy types	Coefficient of cross elasticity	Coefficient of cross elasticity
Fuel wood vs kerosene	6.7	11.0
Fuel wood vs charcoal	-4.2	-3.5
Kerosene vs charcoal	-0.5	-0.2
Kerosene vs LPG	0.91	-0.1

Source: Calculation from field survey data, 2010

CONCLUSION AND RECOMMENDATIONS

The research found out that the determinants of domestic energy expenditure of urban households in Umuahia North LGA of Abia state, Nigeria with Semi-log as lead equation (R_2= 0.822) were household income, occupation of respondents, quantity of energy and cost of substitute energy while the critical determinants of monthly domestic energy expenditure of rural respondents with semi-log functional form as the lead equation (R_2= 0.883) were household income, household size, occupation of spouse respondents, quantity of energy and cost of substitute energy. It was observed that all domestic energy used in the study area has substitutes. For instance, kerosene can be substituted with charcoal, electricity and LPG during its period of scarcity.

Based on the findings, the following recommendations were made:

Institution of the renewal energy policy should be put in place as a matter of deliberate policy. This policy will make domestic energy not only available but affordable to both urban and rural areas.

It was observed that the prices of theses modern energy types (Kerosene, electricity, LPG) are prohibitively high, this calls for the need of Nigeria government (Federal, state) to subsidize the energy prices and provide basic facilities for the supply and distribution of energy.

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