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An Economic Investigation into Fuel-Wood Demand Behaviour in South Lunzu Township in Malawi

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Abstract

This study analysed the effect of household income on demand for fuel-wood in South Lunzu Township of Blantyre city, Malawi. Survey data was collected through a semi-structured questionnaire about household socioeconomic status. Using Engel function analysis employed in ordinary least squares framework, the study found a negative relationship between fuel-wood and income. This shows that fuel-wood is regarded as an inferior commodity. Other factors that explain the behaviour of choice between fuel-wood and electricity included home size, perception on well-being, age of the head of household, education of the head of household, and total expenditure. Campaigns aimed at changing the mindset of people such as those regarding renewable energy as solutions for rural areas only need to be intensified.

Keywords: Energy demand, Engel function, Income, Fuel-wood, South Lunzu, Malawi.

Introduction

The energy ladder theory suggests that the consumption of energy commodities can be modelled as the ascent of an energy ladder (Barnes and Floor, 1996; Rajmohan and Weerahewa; 2007). The climb follows a transition from the utilization of traditional, dirty and depletable energy resources such as biomass to a mix of modern and cleaner energy resources. The transition from and/or to the inferior types of energy depend on a number of factors. Households decision on which energy facilities to use therefore is modelled as a function of income. Cleaner and efficient energy facilities are obtainable only if households have higher levels of income. The concept however seem to suggest that income is the single most important factor that determines the transition through the levels of energy consumption. Generally, it is believed that those energy resources which are cleaner, efficient and effective at the same time are the most superior to those which are not. Choice of energy facility can be a function of many other factors such as age of the population, education level, availability of the resource and culture (Mekonnen and Köhlin, 2008).

Some empirical studies have shown that the theory of the energy ladder is objectionable especially considering the model's disregard of commonly observed multiple fuel uses and the persevering adherence to established, traditional techniques even in the face of modern alternatives (Masera et al, 2000; Jingchao and Kotani 2010; Barnes and Floor, 1996). Nevertheless, the energy ladder approach serves to explain two dominant problems in the energy sectors of less developed countries. Firstly, there is a widespread production and use of traditional energy sources which poses economic, environmental and health problems. In developing countries most people are poor and this limits their access to modern energy resources. They still depend on the traditional non-renewable resources. Secondly, the access to modern energy sources, such as electricity, petroleum or gas products, is very disproportionately strewn. Rural areas sometimes use firewood because they are too far away from the grid and/or their means of getting money is through sale of subsistence agriculture products that is expected once in a year. Cleaner energy facilities therefore are deemed as more of a luxury than a necessity thereby rendering global efforts such as the Kyoto Protocol of less value.

It is therefore imperative that energy projects for developing countries would have to specifically find strategies that would have two objectives; first to make the production and use of traditional fuels more sustainable, and secondly to enhance a social transition to clean, modern fuels (Modi et al, 2006). With 37% of Malawians living below the poverty line defined by $1 a day, access to and use of modern forms of energy remains low. Biomass which comprise of all organic and traditional energy resources such as firewood, charcoal, animal dung and crop residues, account for 97% of Malawi's total primary energy supply; of which 59% is used in its primary form as firewood (52%) and residues (7%), while the remaining 38% are converted into charcoal. In 2008, 43.4% of all households in urban areas used charcoal, 41.8% firewood and only 13.6% used electricity for cooking (Kambewa and Chiwaula, 2010).

The study reported in this article contributes to the understanding of energy usage patterns of households in a township of South Lunzu in Blantyre, Malawi. The main aim was to analyse the behaviour of households as they go about making decisions on which energy facility to choose for home use. Specifically, the study aimed to:

- Report on the demographic characteristics of South Lunzu Township in Blantyre,
- Analyse the effect of income levels on demand for energy resources
- Identify and analyse whether fuel-wood were inferior commodities, and;
- Provide policy recommendations.

The research methodology

To estimate demand elasticities, many studies in the past have adopted a complete demand system approach where the quantity demanded of a particular type of commodity, typically dividing between food and non-food items, are regarded as composite goods. These are called one-step approaches in the literature (Mustapha et al 2001, Radam et al 2005). Consequently this study follows Rajmohan and Weerahewa (2007) where it was assumed that households first make their decision on the allocation of the total budget on composite commodities broadly defined as food and non-food items. The non-food items are divided between energy and non-energy goods. Next is to decide on which energy items to allocate a share of their budget. Among the energy commodities, a decision is also made regarding the total energy expenditure and how much to allocate on individual resources within the energy budget.

In microeconomic theory, Engle curves explain the relationship between the quantity of a commodity demanded and the income of the household holding other factors such as prices at constant levels. However with the developments in multiple regression models, other factors can be estimated at the same time together with the influence of income (Gujarati 2004:202). Budget elasticities calculated using the coefficients estimated in the Engle function are free measures of responsiveness of quantities demanded to a change in the total budget. In this case, the use of Engel functions assisted to categorise the energy facilities as inferior, necessity or luxury based on income levels. The first stage is an estimation of an Engel function which is used to derive income elasticities. Following Yeong-Sheng et al (2008) equation (1) below is specified.

$$S_i = \alpha_0 + \alpha_1 \ln X + \sum_k \gamma_k H_k + \varepsilon \qquad (1)$$

For purposes of the present study, the terms in equation number (1) above are;

Si; Expenditure share of energy commodity for each household i,

X; total expenditure of both energy and non-energy consumer goods and services,

Hk is a set of dummy variables which are household specific capturing both structural and demographic attributes of the respondents in the survey,

ε is an econometric error term which is assumed to be normally distributed with a mean of zero and a constant variance.

Findings

The demographic characteristics of the respondents

The data for this study was collected at the household level in South Lunzu Township in the city of Blantyre, Malawi between December 2011 and January 2012. The questionnaire was pretested in Nkolokoti Township for reliability in gathering the intended information and data. Nkolokoti Township shares many things in common with South Lunzu Township apart from being immediate neighbours. According to the Population Census of 2008 by the National Statistical Office, Blantyre city had a population of 661,256 persons. In particular, South Lunzu Township had 37,864 persons (NSO, 2009).

The Census however could not state how many households were in South Lunzu. However, given an average household size of 5 people according to the findings of this study, the sample represented about 23 percent of households in South Lunzu Township which is a fair coverage for decision making. Using random sampling where one in every five households was visited, a total of 319 questionnaires were administered using face to face interviews to the head of household. The definition of head of household was according to cultural practice in Malawi where a husband is regarded as so. As such, the first person of contact at the household was the male spouse and where the male spouse was not available, the wife was requested to be interviewed. The descriptive statistics for the sampled population are given in table 1.

Table 1: Descriptive Statistics for Continuous Data

Variable	Observations	Mean	Std. Deviation	Minimum	Maximum
Hmsize	318	68.92296	48.90312	8	540
Hhsize	319	5.003135	1.991331	1	14
wtp_clean	319	879.2194	3515.564	0	50000
wtps_moke	319	620.4389	1123.249	0	10000
pit_cost	319	429.7806	689.4695	0	4000
Educ	316	10.81646	3.122552	1	16
Income	317	41629.4	61871.6	0	570000
Age	319	38.36	11.815	14	82
Eexp	318	3570.314	2776.087	0	30000
Texp	316	51537.57	44525.82	5500	269800
Estb	316	0.088991	0.065064	0	0.594059

Source: Survey data collected in South Lunzu, Blantyre.

In table 1, Household size, which was represented by *hhsize*, was used to measure the number of inhabitants in a dwelling unit. The respondents were asked to provide the number of permanent members of the household who were staying at the dwelling unit at the time of the interview. Permanent residence included those members of the household who were temporarily away such as students in boarding schools and patients admitted in hospitals. On average, each household had 5 people with a maximum of 14 and minimum of 1. This compared relatively well with the estimated national household size by the National Statistical Office of about 4.5 persons (NDO-IHS3, 2012). A standard deviation of about 2 indicated that there were little disparities in the number of people in each of the households visited in the survey.

In terms of willingness to pay for a clean environment represented by wtp_clean, a standard deviation of 3516 indicated that there were very large disparities in the amount of money respondents were willing to part with to have their environment clean. This is easily observed from the table where one respondent was willing to pay up to MK50,000 (about US$310 with a foreign currency exchange rate of MK161 = US$1 as of December 2011 and January 2012) and yet others had no willingness to pay at all. On average however, people in South Lunzu Township as represented by the respondents in the sample were willing to pay up to MK880.00 (US$5.5 or ZAR44) in order to have their environment clean. Related to willingness-to-pay for a clean environment, respondents were asked whether they were willing to pay for a smoke free environment. This was in regard to smoke from burning of wood and factories nearby. Willingness-to-pay for a smoke free environment was represented by *wtps_moke* and in table 5.2.1 the minimum was 0 and the maximum was MK10,000 (US$71) with a standard deviation of 1123. The average willingness to pay for a smoke free environment was MK620 (US$3.8).

Taking income earned by the head of household to proxy household earnings, the highest amount was MK570,000 (about US$3519) per month with the lowest making nothing at all. The average income for the sample's households was MK41,630 (about US$257) per month. There were noticed income inequalities among the households as evidenced by a large standard deviation of 61872. Such a disparity in income distribution does not come as a surprise as the affordability of plots and accommodation in general attracts dwellers from all income groups. Generally, South Lunzu is regarded as a descent residential area with every plot facing a feeder road coupled with a relatively good water supply network although it is classified as a high density area (Blantyre City Assembly, 2007:3). These services in themselves attract the emerging middle class and lower class alike to mix hence the large inequalities.

Education was measured by the number of years of formal schooling a head of household completed as of the time of the survey. It was represented by *educ*. Where it was reported that a head of household repeated a school year, it was recorded as one year. Therefore, the respondents were asked to state their level of education from which the number of years of formal schooling was inferred following Malawi's education system. An individual would have spent 8 years of formal schooling if they stated that they had a Primary School Leaving Certificate, 10 years if they had a Junior Certificate of Education and 12 years if they had a Malawi Schools Certificate of Education

(MSCE) which is an equivalent of O-Level in the British system. The most educated head of household had finished 16 years of progressive schooling leading to a first degree while the least educated had only 1 year of school life. On average head of households had 11 years of formal schooling basically implying completion of at least Junior Secondary School level.

Regression results for fuel-wood

The results of the regression model on the factors that affect household energy choice are shown in table 2. To analyse the effects of income on the quantity demanded of each one of the energy facilities considered in the study, Engel functions were adopted. Engel functions as already stated in section 3 are important in two ways. First the analysis of the behaviour of quantity of a commodity demanded as income changes is possible even with commodities that are heterogeneous. In other words, income being an exogenous factor is still analysed as an endogenous factor. Secondly, the behaviour of the quantity demanded due to changes in income help economists to classify commodities as inferior, necessity or superior. Inferior commodities are those whose demand decreases as income of an individual increases. Some energy facilities might be inferior to others and yet others might be superior. The income elasticity of demand is easily calculated using Engel functions analysis.

The reliability of the Engel function for the demand of fuel-wood was tested using coefficient of determination called the Adjusted R-Squared and the F-Statistic which analyses the variability of the dependent model where all the explanatory variables are used to explain the behaviour of the dependent variable collectively. In table 2 the R-Squared was about 32 percent with the adjusted R-Squared necessary for multiple regression analysis of about 30 percent which are acceptable levels considering that the data set used was cross-section. This means that about 30 percent of the variations in the expenditure on fuel wood are explained by the model.

Further, the F-Statistic which tests the null hypothesis that the variables used in the model are collectively of no importance in explaining the behaviour of the dependent variable was statistically significant at the 1 percent level. The value of the F-Statistic was 14.38. Therefore the null hypothesis is rejected in favour of the alternative that collectively, the independent variables namely total expenditure on energy resources, income, employment status, household size, home size, respondent's perception on their well-being, age of the head of household and education level of the head of household are important in explaining the level of expenditure on fuel-wood at the household level in South Lunzu Township. This model can be relied upon to explain consumer behaviour of demand for fuel wood in Blantyre holding other factors constant.

In this studt, *ebs_wood*, the dependent variable, represented the energy budget share of wood which included charcoal as a proportion of the total expenditure of the household; *eexp* was total expenditure on all energy resources; *income* represented income earned by head of household, *hmsize* was the size of the dwelling unit measured in square metres, *poor* was a dummy variable representing the respondents' opinion on whether they believe to be poor or not as a state of well-being or poverty, *Employment* Status represented a situation of employment and marriage represented marital status of the head of the household visited in the survey. As table 2 shows, the slope coefficient of *eexp* was negative and statistically significant even at the 1 percent level of rejection point (99 percent level of confidence) to reject the null hypothesis that there is no relationship between total expenditure on energy commodities and demand for fuel-wood. This implies that there is a negative relationship between household total expenditure on energy on the one hand and fuel wood as an energy facility on the other hand.

The slope coefficient between *eexp* and ebs_wood was -.00003. In elasticity terms, a 1 percentage increase in total expenditure on energy facilities led to 0.17 percent decrease in demand for fuel-wood. In this case the demand for fuel wood is inelastic to changes in income for the people of South Lunzu in Malawi. Demand was responding by less than the amount of expenditure change. Therefore apart from fuel-wood being an inferior commodity, due to the negative relationship between income and its expenditure, there is an element of it being a necessity to the people probably indicating the demanded commodity coming from fuel wood which is energy. Energy is a necessity without which life can be impossible. In addition, the availability and pricing of the commodity favours those that are poor thereby making it more inelastic to any slight changes in income.

The results on *eexp* were confirmed by the negative relationship between *income* and *ebs_wood* with a t-statistic that is statistically significant at the 1 percent probability value of rejecting the null hypothesis that there was no influence and relationship between the two variables. As income of the head of household grows there is a tendency to lower the expenditure on biomass and a higher expenditure on cleaner energy facilities could be observed. There could be an income substitution effect on biomass energy resources such as fuel-wood. Higher income households tend to spend less on fuel wood than lower income households.

Further, the fuel wood income elasticity was -0.08. This entail that a 10 percent increase in income would lead to a 0.8 percent decrease in demand for fuel wood. Fuel wood therefore is indeed an income inelastic commodity. Although an increase in income is expected to lead to a decrease in demand for fuel wood, the decrease was less than the increase in income. Although fuel-wood is an inferior commodity judging by the negative elasticity, the relationship is inelastic to warrant a strict expectation that any slight increase in the level of income of the head of household will be associated with a drop in expenditure for fuel-wood. The implication of this result is that wood is an inferior energy commodity whose demand decreases as income level of a household improve.

This gives hope that in true sense although most people in Blantyre use fire wood and charcoal for their cooking needs, it is not by choice but rather their level of income is low that they simply use biomass for purposes of survival. Given more income or indeed as microeconomic theory of price predicts, by putting in place a mechanism that will ensure that the price of other more superior energy facilities is lower enough through subsidies for instance, will influence a migration from biomass to cleaner fuels.

The other variables of interest were home size and employment status. At the 10 percent level of significance, home size was statistically significant to reject the null hypothesis that there was no influence and relationship between the size of dwelling unit and expenditure on wood fuel. The slope coefficient for home size was -0.00052 with an elasticity of -0.058 meaning that for every 10 percentage increase in the size of the dwelling unit there was almost a 0.6 percent drop in demand for fuel-wood.

As in income and expenditure on energy resources, the relationship between expenditure on fuel-wood and size of dwelling unit was also inelastic meaning that the percentage change in the dwelling unit was higher than the percentage change in the expenditure for fuel-wood. The perception of the head of household on whether he/she was poor or not was also important in explaining the expenditure on firewood. At 10 percent level of significance, the results reject the null hypothesis that there was no influence and relationship between the belief that a household is poor and expenditure on fuel-wood. The slope coefficient was positive at about 0.0537. However the relationship was also inelastic with an elasticity of 0.04. Fuel-wood was believed to be an energy commodity for those who believed to be poor although the relationship was inelastic.

Table 2 Engel function analysis of demand for fuel-wood

ebs_wood	Coefficient	elasticity	t-statistic	P>|t|
Eexp	-.00003	-0.172	-5.79	0.000***
Income	-0.000000826	-0.0755	-3.24	0.001***
Employment	0.0305	0.0396	0.7	0.483
Hhsize	-0.0034	-0.0258	-0.48	0.631
Hmsize	-0.0005	-0.058	-1.65	0.100*
Poor	0.0537	0.04	1.91	0.057*
Age	-0.0037	-0.217	-3.03	0.003***
Educ	-0.0127	-0.214	-2.67	0.008***
Gender	-0.0430	-0.043	-1.38	0.169
marriage	0.064	0.0717	1.96	0.05**
_cons	1.1137		13.02	0.000***
R-Squared	0.32	Adj R-Squared	0.30	
F(10, 304)	14.38		0.000	

Source: Survey data collected in South Lunzu, Blantyre.

Age of the head of household was found to be negatively related to the expenditure on fuel-wood. The slope coefficient was -0.00371 with an elasticity of -0.217. The relationship was also inelastic although statistically significant at the 1 percent level of significance to reject the null hypothesis that there was no influence and relationship between expenditure on fuel-wood and age of head of household. The negative indicated the transformation respondents could have been going through as time progressed in that the older a head of household was the lower the desire to use inefficient energy resources holding other factors constant. Education level of the head of household was also tested as to how it related to expenditure on fuel-wood. At the 1 percent level of significance, the results reject the null hypothesis that there was no influence and relationship between the

two variables. The slope coefficient of -0.0127 with an elasticity of -0.214 meaning that increasing education level by 10 percent, expenditure on fuel-wood was expected to drop by 2 percent.

Marriage which represented marital status of the head of household was statistically significant at the 5 percent level to reject the null hypothesis that there was no relationship and any influence between marital status of the respondent and his or her expenditure on electricity as an energy resource. The slope coefficient was 0.064 with an elasticity value of 0.0717. This means that male headed households were more likely to demand electricity for their household needs compared to female heads of household. Three variables namely employment status; gender of the head of household and household size were not statistically significant to reject the null hypothesis that they do not affect expenditure on fuel-wood.

Discussion of Results

As the results in section 3 above shows the slope coefficient between lneexp and ebs_wood was -0.15535 meaning that increasing the total expenditure on energy facilities by 1 percent would lower demand on all wood energy commodities by MK0.0016. In elasticity terms, a 1 percentage increase in total expenditure on energy facilities will lead to 0.22 percent decrease in demand for fuel wood. In this case the demand for fuel wood is inelastic to changes in income for the people of South Lunzu in Malawi. Demand was responding by less than the amount of expenditure change. This means that although there is a negative relationship between energy expenditure and demand for fuel wood, it cannot be concluded outright that fuel wood is an inferior commodity. There is an element of it being a necessity to the people probably indicating the demanded commodity coming from fuel-wood which is energy. Energy is a necessity without which life can be impossible. In addition, the availability and pricing of the commodity favours those that are poor thereby making it more inelastic to any small changes in income.

However, there was a negative relationship between household total expenditure on energy on the one hand and fuel wood as an energy facility on the other hand. The implication of this result is that wood is an inferior energy commodity whose demand decreases as income level of a household improve. This gives hope that in true sense although most people in Blantyre use fire wood and charcoal for their cooking needs, it is not by choice but rather their level of income is low that they simply use biomass for purposes of survival. Given more income or indeed as microeconomic theory of price predicts, by putting in place a mechanism that will ensure that the price of other more superior energy facilities is lower enough through subsidies for instance, will influence a migration from biomass to cleaner fuels. The model is generally reliable as an explanation in the variability of the demand for energy facilities. The F-statistic and the adjusted R-squared were all relatively good. Therefore the null hypothesis is rejected in favour of the alternative that collectively, the independent variables namely total expenditure on energy facilities, home size, employment status of head of household and income are important. This model can be relied upon to explain consumer behaviour of demand for fuel wood in Blantyre holding other factors constant.

Conclusion

The major objective of this paper was to analyse the effect of income on the demand for wood and electricity facilities in Blantyre, Malawi. A cross section data set from a sample of 319 households was analysed using ordinary least squares. The results in this study indicate that contrally to other hypothesis, respondents were willing to substitute cleaner energy facilities such as electricity and solar with higher levels of income. Firewood was found to be an inferior commodity in the sense that higher levels of income led to less of these commodities being opted. For sustainable development to be achieved, the study recommends three main policy issues. First is the civic education programmes to be enhanced especially regarding the benefits of renewable energy and that it is not for the rural areas only but also for the urban communities. Secondly, deliberate trade and tax policies aimed at reducing the price of renewable energy are recommended. For instance, zero import duties on all renewable energy facilities must be adopted. Research must understand that rural people do not require modern energy for cooking, television, communication purpose, but rather for the basic social amenities first such as agriculture, water, and health facilities. The other uses are secondary and more of luxuries. Consequently, energy's impact to development should be assessed in the capacity of a contributing factor. The implied yardstick of such assessment is the extent to which interventions contribute to meeting local needs.

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