A Microeconomic Analysis of Energy Choice Behaviour in South Lunzu Township, Malawi

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Doi:10.5901/mjss.2013.v4n6p569

Abstract

This paper reports results of a study that aimed at analysing the energy choice behaviour of people in South Lunzu Township in Malawi. A Microeconometric approach was adopted on survey data collected by way of a questionnaire. Results of Multinomial logit model suggest that most socioeconomic variables under study were inelastic in influencing the probability for the outcomes to be used for purposes of cooking at the household level. Statistically, Age, income, and education of head of household together with household size were important factors influencing the choice of outcomes electricity, charcoal, firewood and LP gas for cooking purposes. The major recommendation of this study is that campaigns emphasising on the abilities of Renewable Energy be developed and disseminated. Also, an emphasis on Liquefied Petroleum Gas for purposes of cooking must be encouraged. These policies would ensure sustainable development by reducing reliance on biomass which is depleting at a faster rate than regeneration.

Keywords: *Energy choice, South Lunzu, Multinomial Logit, cooking.*

1. Introduction

This paper analysed energy choice behaviour of South Lunzu Township in Blantyre city, Malawi. The current economic growth and development agenda has recognised the risk of climate change problems emanating from green house gas emission due to, among other things, consumption of inefficient energy facilities (Kambewa & Chiwaula, 2010; Government of Malawi (GOM), 2006). Sustainable development is essential for future generations to benefit from the resource base without making them worse-off. The state of energy deprivation in Malawi is appalling and the rate at which fuel wood is depended upon for household energy needs is a cause for alarm. There is need for strategies to be identified where sustainable energy resources can be made available to people. In this way, green growth will be achievable together with many other Millennium Development Goals.

There are hypotheses generally regarded by government institutions which inform current energy policy. For instance, renewable energy technologies are believed to be specifically designed for rural energy electrification programmes (GOM, 2006); yet the ability to pay for the resources is lower among rural poor compared to urban poor communities. This research is important therefore in that it will identify strategies that if followed will encourage the use of sustainable energy resources in urban societies too leading to reduced emission of green house gases. The theories of consumer behaviour in microeconomics suggest that man as a social animal is rational whenever choices are presented. For energy, rationality implies that resources deemed superior in providing more energy at an affordable price should be preferred. According to Bhattacharya (2011) the microeconomic basis for consumer energy demand relies on consumers' utility maximization principles which assume that; consumers know their preference sets and ordering of the preferences; preference ordering can be represented by some utility function and the consumer is rational in that she will always choose a most preferred bundle from the set of feasible alternatives.

Following consumer theory, it is considered that an incremental increase in consumption of a good, keeping consumption of other goods constant, increases the satisfaction level but this marginal utility (or increment) decreases as the quantity of consumption increases. Moreover, maximum utility achievable given the prices and income requires marginal rate of substitution to be equal to the economic rate of substitution. This in turn requires that the marginal utility per dollar paid for each good be the same. If the marginal utility per dollar is greater for good A than for good B, then transferring a dollar of expenditure from B to A will increase the total utility for the same expenditure. It follows that reduction in the relative price of good A will tend to increase the demand for good A and vice versa (Mills & Toke, 1985;

Batchaya, 2011; Train, 2009; Cameron & Trivedi, 2005). This paper examined consumer behaviour regarding decision making process for choice of energy facilities for cooking. A Multinomial Logit Model (MNL) was employed and interpretation based on statistical inference, marginal effects and elasticities calculated for each one of the seven outcomes available to the respondents.

2. Literature Review and Research Method

2.1 Research Area and Data Collection

Random sampling was used to collect survey data in Blantyre City's high density area of South Lunzu Township (SLT), which lies to the east of Ndirande Mountain. SLT has twelve sectors each with about 500 households. Among the twelve sectors, data was collected in areas Five, Six, Seven, Eight and Ten. Households were chosen at random and, in total, the survey collected data through questionnaires administered to 318 heads of household and their spouses. Stratified random sampling was used to choose households from where respondents were drawn. Each enumerator was assigned a block from where every 5th household was visited. If a head of household was not available, the spouse or partner was requested to respond to the questions. Where neither of them was available, the immediate household was visited instead and the counting resumed. A semi-structured questionnaire was designed and given to the enumerators to be used for information collection. The questionnaire contained questions regarding demographics (age, sex, and household size), socioeconomic aspects (employment, education, knowledge) and energy use.

2.2 Discrete Choice Models

According to Train (2009), discrete choice models describe decision makers' choices among alternatives. The decision makers can be people, households, firms or any other decision-making unit, and the alternatives might represent competing products, courses of action, or any other options or items over which choices must be made. To fit within a discrete choice framework, the set of alternatives, called the choice set, need to exhibit three characteristics. First, the alternatives must be mutually exclusive from the decision maker's perspective. Choosing one alternative necessarily implies not choosing any of the other alternatives (Train, 2009; Cameron & Trivedi, 2005). The decision maker chooses only one alternative from the choice set. Second, the choice set must be exhaustive, in that all possible alternatives are included. The decision maker necessarily chooses one of the alternatives. Third, the number of alternatives must be finite. The researcher can count the alternatives and eventually come to an end of counting. Where the options are not both exhaustive and finite the researcher can find a way of grouping those not observable as 'other' there by creating another alternative.

Discrete choice models are usually derived under an assumption of utility-maximizing behaviour by the decision maker (Train, 2009; Cameron and Trivedi, 2005; Deaton, 1997). Thurstone (1927) originally developed the concepts in terms of psychological stimuli, leading to a binary probit model of whether respondents can differentiate the level of stimulus. Marschak (1960) interpreted the stimuli as utility and provided a derivation from utility maximization. Following Marschak, models that can be derived in this way are called Random Utility Models (RUMs). It is important to note, however, that models derived from utility maximization can also be used to represent decision making that does not entail utility maximization. The derivation assures that the model is consistent with utility maximization; it does not preclude the model from being consistent with certain forms of behaviour. The models can also be seen as simply describing the relation of explanatory variables to the outcome of a choice, without reference to exactly how the choice is made.

RUMs are an alternative of index function models (Green 2003). Following Train (2009:19) and Green (2003) Random utility models (RUMs) are derived as follows. A decision maker, labelled n, faces a choice among J alternatives. The decision maker would obtain a certain level of utility (or profit if it is a firm) from each alternative. The utility that decision maker obtains from alternative j is $U_{nj}, j = 1, \dots, J$. This utility is known to the decision maker but not by the researcher. Implementing the assumption that consumers are rational, the decision maker chooses the alternative that provides the greatest utility. The behavioural model is therefore: choose alternative i if and only if $U_{ni} > U_{nj}\ \forall j \neq i$.

The researcher observes some attributes of the alternatives as faced by the decision maker, labelled $x_{nj}\ \forall j$, and some attributes of the decision maker, labelled s_n, and can specify a function that relates these observed factors to the decision maker's utility. The function is denoted $V_{nj} = V(xnj, sn)\ \forall j$ and is often called representative utility. Usually,

V depends on parameters that are unknown to the researcher and therefore estimated statistically. Since there are aspects of utility that the researcher does not or cannot observe, $V_{nj} = U_{nj}$. Utility is decomposed as $U_{nj} = V_{nj} + \varepsilon_{nj}$; where ε_{nj} captures the factors that affect utility but are not included in V_{nj}. This Decomposition is fully general, since ε_{nj} is defined as simply the difference between true utility U_{nj} and the part of utility that the researcher captures in V_{nj}. Given its definition, the characteristics of ε_{nj}, such as its distribution, depend critically on the researcher's specification of V_{nj}. In particular, ε_{nj} is not defined for a choice situation *per se*. Rather; it is defined relative to a researcher's representation of that choice situation. This distinction becomes relevant when evaluating the appropriateness of various specific discrete choice models.

2.3 Multinomial logit models

A researcher can adopt a particular specification of a discrete choice model depending on the assumptions that are advanced for the relationship. In the present case, there is a consumer basket of energy commodities which households have been observed to use. Using both stated and revealed preference experiments, the study should have adopted the Multinomial Logit (MNL) Model which is very popular in the studies of more than two alternatives from where an economic agent is expected to choose. However, there are challenges with the MNL especially regarding the assumptions that underlie it. Consequently, the Random Parameters Model (Mixed Logit Model) is adopted for its flexibility. The Multinormial logit model is applicable where more than two alternatives are considered from where a decision maker is expected to choose.

As suggested by Luce (1959) the MNL model can be specified as:

$$p_{ij} = \frac{e^{X_i'\beta_j}}{\sum_{l=1}^{m} e^{X_i'\beta_l}}, \qquad (1)$$

Because $\sum_{j=1}^{m} p_{ij} = 1$, a restriction is needed to ensure model identification and the usual restriction is that $\beta_1 = 0$ (Cameron and Trivedi, 2005). The household head as a decision maker has the knowledge of the value of his/her own β_n and ε_{nj}'s for all j and chooses alternative i if and only if

$$U_i > U_{nj} \; \forall \; j \neq i. \qquad (2)$$

The researcher observes x_{nj}'s but not β_n or the ε_{nj}'s.

3. Results of the multinomial logit model

Results of the multinomial logistic model (MNL) are reported as a split table labelled1 through 6 because included in one; the table could have been long and difficult to read.

3.1 MNL results focusing on outcome electricity

Table 1 gives the part of the results for the outcome 'Electricity' compared to the base outcome which was automatically chosen by Stata to be Electricity and charcoal. Outcome 'Electricity and Charcoal' was a preferred option for cooking needs for over 42 percent of the households and therefore it was chosen as the base category to which the other six categories were compared. The coefficients were reported as Relative Risk Ratio rather than simple coefficients for a more meaningful interpretation since discrete choice models are more concerned with predictions and estimations of probabilities that one event occurs on condition of the other (Cameron and Trivedi, 2005). According to Green (2003) and Cameron and Trivedi (2005), the relative risk ratio is the ratio of the probability of choosing one cooking energy outcome category over the probability of choosing the baseline category. The RRR is also known as the Odds ratio in binary models such as logistic or logit. Since the MNL is a series of equations, exponentiating the linear equations which is the same as calculating the exponential of the coefficient gives the relative risk ratio of obtaining a unit change in the independent variable.

Similar studies that employed MNL include Pundo and Fraser (2006) who employed a multinomial logit model to investigate the factors that determine household cooking fuel choice between firewood, charcoal, and kerosene in Kisumu, Kenya. Their empirical results indicated that level of education of wife, the level of education of husband, type of food mostly cooked, whether or not the household owns the dwelling unit, and whether or not the dwelling unit is traditional or modern type are important factors that determine household cooking fuel choice. The present study goes further to include not three but seven possible cooking outcomes and the household characteristics were also increased.

Table 1. Results of the multinomial logit model for outcome 'electricity'

	COOK SOURCE	RRR	Std. Err.	P>|z|
Electricity	Income	1.00007	0.00000612	0.011**
	Hmsize	1.017479	0.0061	0.004***
	Hhsize	1.217355	0.22143	0.28
	Poor	0.264390	0.26213	0.18
	wtp_smoke	1.000612	0.00043	0.155
	wtp_clean	0.999855	0.0003	0.625
	Age	1.074593	0.04124	0.061*
	exp_food	1.00005	0.00002	0.01**
	_cons	0.000034	0.000087	0.00***
Firewood and Charcoal		(base outcome)		

Where , **, and *** imply statistical significance at the 1 percent, 5 percent and 10 percent level.

As table 1 show, the relative risk ratio for one unit increase in the variable *income* was 1.00002 for choosing electricity as a cooking energy facility compared to a combination of firewood and charcoal. This relationship was statistically significant at the 5 percent level to reject the hypothesis that income is not an important factor influencing choice of electricity for cooking in the household. The results also show that the probability of electricity being chosen as a cooking energy facility rises with increases in income levels. In terms of elasticity, a 1 percentage increase in income has the expectation of increasing the probability of household using electricity by 0.3 percent. This is an inelastic relationship although it was statistically significant at the 10 percent level.

A 1 percentage increase in the size of the dwelling unit (home size) also had a potential of increasing the probability of household using electricity for its cooking needs compared to a combination of firewood and charcoal by 0.70. Again the relationship was inelastic but statistically significant at the 5 percent level. The RRR was also in the favour of the use of electricity with increases in dwelling unit. This was expected since *ceteris puribus*, large houses are owned or occupied by relatively higher earning individuals who demand electricity as a normal commodity compared to the inefficient fuel wood. Although statistically insignificant, household size also shows to have a positive relationship with choice of cooking facility as electricity compared to electricity and charcoal together. The probability that a household that was larger would opt for electricity as its cooking energy facility was expected to be higher compared to smaller sized households. The relative risk ratio of choosing electricity over firewood and charcoal combined for cooking needs was 0.264390 for variable poor and it was statistically insignificant to reject the hypothesis that the perception of wellbeing influences the choice of electricity over firewood and charcoal combined in South Lunzu Township. This does not come as a surprise since the supply side of electricity in Malawi is more irregular than normal.

3.2 MNL results focusing on outcome liquefied petroleum gas

Table 8.2 presents results of the multinomial logit model focusing on LP gas. It should be pointed out that this table should be read together with the other tables from 9.1 to 9.6 as they are essentially the same table split to fit in the pages. As table 2 shows all the predictors apart from expenditure on food were statistically not important in influencing the choice for LP Gas over the combination of outcome 'Firewood and Charcoal. The relative risk ratio (RRR) however was in favour of income, household size, home size and WTP for a clean environment.

Table 2. Multinomial logit model focusing on outcome 'LP Gas'

	COOK SOURCE	RRR	Std. Err.	P>|z|
LP_Gas	Income	1.000015	1.3	0.244
	Hmsize	1.010456	0.01589	0.508
	Hhsize	1.274321	0.65506	0.637
	Poor	6.26	0.00041	0.982
	wtp_smoke	0.9985383	0.00335	0.663
	wtp_clean	1.000134	0.00026	0.608
	Age	0.9978311	0.10705	0.984
	exp_food	1.00007	3.3	0.035**
	_cons	0.0002328	0.00118	0.1
Firewood and Charcoal		(base outcome)		

Where *, **, and *** imply statistical significance at the 1 percent, 5 percent and 10 percent level.

Although not statistically significant the above 1 RRR indicates that for an increase in these variables, there is an expectation that LP Gas will be preferred to a combination of firewood and charcoal. These results are in agreement with studies by Onoja and Idoko (2012) and Cayla et al (2011) where the demand for LP Gas was found to respond positively to changes in income.

3.3 MNL results focusing on outcome Solar

For outcome 'solar' as an energy facility for cooking, the results are as shown in table 3. The RRR for variable 'Income' was 0.9999 and it was not statistically significant. The less than 1 RRR however seem to suggest that increases in income have an expected outcome of reducing the probability that a household chooses solar as an energy facility for cooking needs. Solar energy in this case is regarded as a commodity for the poor and uncivilised households. As a matter of prestige, the use of solar power is expected to be associated with those in lower income brackets. It was interesting to note that all the variables were not statistically significant to reject the hypothesis that they were not important in determining the probability that a household chooses solar for its cooking needs over firewood and charcoal combined.

Table 3. Results of the multinomial logit model focusing on Outcome 'Solar'

	COOK_SOURCE	RRR	Std. Err.	P>|z|
Solar	Income	0.999998	0.0000384	0.964
	Hmsize	0.961197	0.0546014	0.486
	Hhsize	1.15339	0.5094732	0.747
	Poor	8.69	1.32	0.99
	wtp_smoke	1.000846	0.0009461	0.371
	wtp_clean	1.00008	0.0006547	0.903
	Age	1.060452	0.0993914	0.531
	exp_food	1.000026	0.0000601	0.671
	_cons	1.02	1.55	0.987
Firewood and Charcoal		(base outcome)		

Source: Where *, **, and *** imply statistical significance at the 1%, 5% and 10%.

3.4 MNL results focusing on outcome Charcoal

The results for outcome charcoal confirm that in South Lunzu Township charcoal is regarded as a higher and better energy commodity compared to a combination of charcoal and firewood. The RRR of greater than 1.0 suggests that an increase in income also increases the probability of a household opting for charcoal only for cooking needs compared to a combination of charcoal and firewood. This relationship however was statistically insignificant to reject the null hypothesis that income does not have any influence on the choice of charcoal as a cooking energy facility.

Table 4. Results of the multinomial logit model for outcome 'charcoal'

	COOK SOURCE	RRR	Std. Err.	P>|z|
Charcoal	Income	1.000004	5.56	0.463
	Hmsize	1.007348	0.0041799	0.078*
	Hhsize	0.842547	0.0703422	0.04**
	Poor	0.8457198	0.2486062	0.569
	wtp_smoke	1.000407	0.0001776	0.022**
	wtp_clean	0.9998144	0.0001322	0.16
	Age	0.9786352	0.0135062	0.118
	exp_food	1.000009	0.0000148	0.543
	_cons	1.391139	0.9205154	0.618
Firewood and Charcoal		(base outcome)		

Source: Where *, **, and *** stand for statistical significance at the 1%, 5% and 10%.

On the other hand, size of dwelling unit was statistically significant at the 5 percent level to reject the null hypothesis that size of house influence consumers to choose charcoal for cooking energy provision over firewood and charcoal combined. An environmentally important result is where willingness-to-pay for a smoke free environment had a strong influence on the choice of charcoal as opposed to firewood and charcoal combined with a RRR of above one but rather weaker. This suggests that those who had a higher WTP for a smoke free environment had the higher probability of using charcoal compared to a combination of charcoal and firewood for cooking purposes. The remaining variables namely age of head of household, expenditure on food, and WTP for a cleaner environment had weaker influence on the choice of charcoal as a cooking facility.

3.5 MNL results focusing on outcome Firewood

Results for outcome 'firewood' are shown in table 8.5. The rest of the variables apart from age of the head of household were statistically insignificant in influencing the probability that firewood was the outcome of choice compared to the base outcome of 'Firewood and Charcoal' combined. Older heads of household were likely to choose firewood as an energy resource for their household compared to younger heads of household. The RRR for variables household size, poor, and age were above 1. For poor, it means that the probability of the head of household choosing firewood as an energy resource was higher the more they considered themselves poor. The weak and statistically insignificant RRR for income suggests that heads of household with higher income levels were less likely to consider firewood as their energy resource compared to the base outcome of Firewood and Charcoal combined.

Table 5. Multinomial logit model focusing on outcome 'firewood'

	COOK_SOURCE	RRR	Std. Err.	Z	P>|z|
Firewood	Income	1.000001	0.0000134	0.05	0.958
	Hmsize	0.9969821	0.0098938	-0.3	0.761
	Hhsize	1.109337	0.1396677	0.82	0.41
	Poor	1.594377	0.9372467	0.79	0.427
	wtp_smoke	0.9996836	0.0005437	-0.58	0.561
	wtp_clean	0.9999887	0.0003316	-0.03	0.973
	Age	1.040055	0.0223444	1.83	0.068*
	exp_food	0.9999836	0.0000367	-0.45	0.654
	_cons	0.0159083	0.0206996	-3.18	0.001
Firewood and Charcoal		(base outcome)			

Where *, **, and *** stand for statistical significance at the 1%, 5% and 10% level.

A RRR of less than 1 for home size also suggest that the larger the size of the dwelling unit the less likely the head of the household could be expected to choose firewood as an energy resource compared to Firewood and Charcoal combined. Higher expenditures on food were also likely to be associated with lower probabilities of choosing firewood for an energy resource by the head of household.

3.6 MNL results focusing on outcome 'Electricity, Charcoal and Wood'

A combination of electricity, charcoal and firewood was considered because as literature suggests, the unreliability of present energy commodities such as increasing load shedding influences economic agents to consider a mixture of efficient and inefficient facilities. This is called fuel stacking in the literature (Rajmohan and Weerahewa, 2007). In table 6, the results suggest that there is a positive expectation that the increase in income increases the probability that the choice of electricity, charcoal and firewood will be opted over the combination of firewood and charcoal only.

Table 6. Multinomial logit focusing on 'electricity, charcoal and wood'

	COOK_SOURCE	RRR	Std. Err.	P>|z|
Elec., Charcoal & Wood	Income	1.000015	4.96	0.003***
	Hmsize	1.015195	0.004214	0.000***
	Hhsize	0.933908	0.079477	0.422
	Poor	0.707232	0.234273	0.296
	wtps_moke	1.000262	0.000182	0.148
	wtp_clean	1.000043	0.000076	0.574
	Age	1.007142	0.0143441	0.617
	exp_food	1.000027	0.0000133	0.041**
	_cons	0.064395	0.048102	0.000***
Firewood and Charcoal		Base outcome		

Where *, **, and *** stand for statistical significance at the 1%, 5% and 10% level of test.

The results show that the higher the level of income the higher this probability. Statistically it shows that this probability was strong at the 1 percent level of significance to reject the null hypothesis that income has no influence in fuel/energy stacking at the household level in South Lunzu Township. Expenditure on food was also statistically significant to suggest that it has a strong influence on the probability that a combination of electricity, charcoal and firewood is chosen for purposes of cooking over a combination of just two facilities namely charcoal and firewood. The size of dwelling unit was also statistically significant to suggest that the probability of a household to opt for a fuel mix of the three facilities was higher with every increase in the size of the house. The RRR was also relatively larger at 1.02.

4. Analysis of elasticities from the multinomial logit

Table 7 is a summary of marginal effects reported both as marginal and elasticities. According to StataCorp LP (2011), the marginal effects and elasticities are calculated at the mean point for each variable for each outcome. The elasticities for each outcome are interpreted in for purposes of this study because they are easier to understand than the marginal and the coefficients. In table 7, dy/dx represents a marginal effect and ey/ex represents point elasticities.

Table 7. Marginal effects and elasticities for the MNL model

		Income	Hmsize	Hhsize	Poor	wtps_moke	wtp_clean	Age	exp_food
Electricity	**dy/dx**	1.29	0.0002	0.005	-0.01	9.3	-2.7	0.001	6.18
	ey/ex	0.29	0.7	1.19	-0.68	0.24	-0.12	2.72	0.72
LP Gas	**dy/dx**	1.96	-5.6	0.001	-0.07	-8.6	7.83	-8.09	2.3
	ey/ex	0.27	0.22	1.42	-7.2	-1.1	0.13	-0.13	1.12

Solar	**dy/dx**	-1.74	-0.0001	0.0006	0.06	2.2	3.62	0.0002	5.9
	ey/ex	-0.42	-3.23	0.92	9.1	0.39	0.08	2.21	0.23
Charcoal	**dy/dx**	-1.44	0.0005	-0.028	-0.02	5.9	-3.43	-0.005	7.6
	ey/ex	-0.18	0.008	-0.65	-0.09	0.11	-0.16	-0.87	-0.10
Firewood	**dy/dx**	-1.3	-0.0003	0.006	0.02	-2.0	1.05	0.002	-1.03
	ey/ex	-0.32	-0.70	0.73	0.22	-0.34	-0.002	1.5	-0.6
EL_CH_WD	**dy/dx**	1.81	0.002	-0.004	-.001	0.00002	1.7	0.001	2.9
	ey/ex	0.27	0.54	-0.13	-0.18	0.02	0.05	0.23	0.26

For outcome ‘electricity’ the variables income, home size, willingness-to-pay for a smoke free environment, Age of the head of household and expenditure on food had a positive elasticity. However, only age of the head of the household was elastic with an elasticity of 2.7 implying that a 1 unit increase in age was expected to increase the probability of electricity being chosen as a cooking facility by more than twice. For the other variables, the expected probability of choosing electricity as a cooking variable due to a change in say income, home size, willingness-to-pay for a smoke free environment, and expenditure on food was expected to increase less than the increase in the variable itself. Willingness-to-pay for a clean environment had a negative elasticity which was also inelastic.

Income was positive but again inelastic for outcome LP Gas implying that a one unit increase in income was expected to increase the probability that a household chooses LP Gas for their cooking needs over the base category of ‘electricity and wood’ combined. A similar result is observed for variable home size and willingness-to-pay-for-clean-environment. An elastic relationship is observed for the perception of well being at the household level. Where a household perceives itself to be poor, the probability that LP Gas will be substituted for ‘electricity and wood’ was expected to rise by 7 fold. Poor the mindset in this case is important to be addressed. People who believe to be poor regard LP gas as a luxury which can be easily substituted by a combination of electricity and wood.

WTP for a smoke free environment was also elastic at -1.1 implying that a one unit increase in the WTP for a smoke free environment was expected to lower the probability of LP Gas being chosen as a cooking energy facility over the base outcome by more than a unit. Further, expenditure on food was positively elastic at 1.1 implying that for every one unit increase in expenditure for food, the probability of choosing LP Gas as a cooking facility was expected to increase by more than a unit. In addition, household size was also elastic with an elasticity of 1.4 suggesting that every additional family member had the chance of increasing the probability of LP Gas being chosen for purposes of cooking by more than a unit.

For some of the variables, outcome ‘solar’ behaved as a luxury commodity considering the high level of elasticity observed for some of the variables. For instance, home size was negatively elastic at -3.22 suggesting that a unit increase in the size of the household could reduce the probability of the household choosing solar as a cooking energy facility by three fold. In addition, the perception of wellbeing was very elastic with an elasticity of 9.1 and so was age of the head of household with an elasticity of 2.2. The other variables namely expenditure on food, willingness to pay for a clean environment, willingness to pay for a smoke free environment, household size and income were inelastic although with a positive sign apart from income. The negative elasticity for income implies that solar is regarded as an inferior commodity whose demand is expected to be lower with increases in income although not significantly.

None of the variables were elastic regarding the outcome ‘charcoal’. Negative elasticities were reported for size of dwelling unit, perception on wellbeing, willingness-to-pay for a clean environment, willingness-to-pay for a smoke free environment, age of household and expenditure on food. A one unit increase in these variables lowers the probability of charcoal being chosen as an energy facility for cooking by less than a unit and therefore increasing the probability that the base outcome facility is opted. Apart from age of the head of household, all the other variables were inelastic for outcome ‘firewood’. The elasticity of variable Age on outcome ‘firewood’ was 1.5 meaning that a one unit increase in the age of the head of household increases the probability of firewood being the preferred source of energy for cooking needs at the household as opposed to outcome ‘electricity and wood’ combined.

The inelastic relationship between the base outcome on the one hand and household size and perception of wellbeing on the other was negative. It was also negative for expenditure on food, willingness-to-pay for smoke free environment, willingness-to-pay for a clean environment, income and home size. All the variables were inelastic for the outcome ‘electricity, charcoal and firewood’ combined compared to the base outcome of ‘electricity and charcoal’. It was also interesting to note that apart from household size and perception on well being, the other variables had a positive elasticity. For instance, a one unit increase in income was expected to lead to a ‚less than unit increase in the probability that outcome ‘electricity-charcoal-wood’ was chosen compared to the base outcome of ‘electricity and charcoal’. The next section is a summary of predicted probabilities of choosing each one of the outcomes based on the MNL model. The model was validated by testing whether the coefficients of the variables were different from zero. The alternative hypothesis therefore is that the coefficients or parameters were not statistically equal to zero. The statistic used in the literature is the Likelihood ratio test which measures the lambda given by a Chi-square of the form:

$$\chi^2 = -2[L(Br) - L(Bu)\},$$

The results show a Chi-Square statistic of 80.81 with 48 degrees of freedom lost. The p-value was 0.0021 which suggests that at the 1 percent level of statistical significance, the null hypothesis is rejected and the alternative hypothesis that the parameters were not statistically equal to zero is accepted.

5. Conclusion

Behavioural economics argues that human beings are social animals that are rational in that more of a good is preferred than less. This principle is limited when the energy sector in developing countries is considered. For Malawi where energy poverty is rampant, quantity of the commodity is not enough. Quality of the commodity that supplies energy matters as well. There are many options from which consumers can choose energy products to use for their household needs. The list includes firewood, charcoal, paraffin, briquettes, agricultural residues, electricity, solar power, wind energy, liquefied Petroleum gas. A combination of the resources was more common in South Lunzu Township compared to a reliance of pone particular energy resource. According to the results of the Multinomial Logit of energy choice behaviour of residents of South Lunzu Township, the income of the head of household, age, home size and expenditure on food were important factors that affected the probability that electricity was chosen as an energy resource for the household. Outcome 'electricity' the variables income, home size, willingness-to-pay for a smoke free environment, Age of the head of household and expenditure on food had a positive elasticity. However, only age of the head of the household was elastic with an elasticity of 2.7 implying that a 1 unit increase in age was expected to increase the probability of electricity being chosen as a cooking facility by more than twice. For the other variables, the expected probability of choosing electricity as a cooking variable due to a change in say income, home size, willingness-to-pay for a smoke free environment, and expenditure on food was expected to increase less than the increase in the variable itself. Willingness-to-pay for a clean environment had a negative elasticity which was also inelastic.

In conclusion, this chapter paid special attention to the analysis of energy demand choices in the face of several options. Multinomial logit model was employed to the cross section data and the results show that in general, there was a greater probability for firewood and charcoal to be used at the household level given the other outcomes of energy. There were other variables which were inelastic to some of the outcomes. The next chapter finalises this report by providing discussion, conclusion and policy recommendations/implications emanating from the results of the study.

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