MULTINOMIAL LOGIT ANALYSIS OF HOUSEHOLD COOKING FUEL CHOICE IN RURAL KENYA: A CASE OF KISUMU DISTRICT

by

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1. Introduction

At the centre of Kenya's development dilemma is the question of sustainable household and commercial energy demands against current supplies. Energy scarcity is one of the factors that currently threaten economic growth in Kenya. For instance, in many parts of the country, acute fuel scarcities render meaningful economic growth difficult. Worst affected are the rural communities and urban slums, where many households are unable to grow past their subsistence levels.

Apart from sluggish economic growth, fuel scarcities make household fuel choice a complex economic and social function. For many households, the decision over which fuel to use or how much of the fuel to use, requires a consideration of several important factors. Such factors may include a number of household characteristics and social class, which is a function of wealth and defined by factors such as the type and ownership of the dwelling unit, money income etc. Increasing fuel shortages compels two broad reactions by households: first, some households will switch to other fuel alternatives. Second, the households that are not able to switch (for whatever reasons) may have to adjust their cooking patterns to the prevailing levels of shortages (Cecelski, 1987; Misana, 1988). However, some of the coping techniques may entail dietary and health consequences.

In the light of these facts, this study seeks to investigate the different cooking fuel choices available to households of Kisumu district, and the different factors that affect a household's probability of choosing one cooking fuel against another. The study considers cooking fuel choice between firewood, as a basic fuel, and charcoal or kerosene or gas or electricity. A central thesis of this paper is that cooking fuel choices are affected by a set of household demographic and infrastructure exogenous variables such as gender, age, education, and occupation of the household head and spouse, including household size, types of food commonly cooked, the type of cooking pots commonly used, the ownership of the main dwelling unit, and the materials with which the main dwelling unit is constructed. More specifically, the paper asserts that the wife's characteristics (such as age, level of education, and occupation) affect household fuel choice than similar husband variables.

2. Perspective

Although fuel shortages are common in many regions of the developing world (see, for example, Rijal and Harunori, 2002; Srinivas, 2000; Sharma, 2000; Mahendra, Rai, and Rawat, 1992; Cecelski, 1987; Ekholm, 1975), the nature and magnitude of the factors that affect household cooking fuel choice are not yet clearly understood or reported in household fuel literature.

A household's cooking fuel choice consumption decision can be understood by analysing its decision in a constrained utility maximization framework (Browning and Zupan, 2003; Amacher, *et al.*, 1999), where it maximises fuel utility, subject to a set of economic and non-economic constraints (see, equation 1). Economic factors include market price of fuel, and household money income. Non-economic factors include a set of household demographic and infrastructure factors as mentioned above.

$$U^* = U\left[Q_w(P_w, P_A, I, \Omega) Q_a(P_w, P_A, I, \Omega)\right] \quad [1]$$

Where:

$U^*(P_w, P_A, I, Z)$ is the maximum attainable utility,
Q_w is the units of firewood purchased
P_w is the per unit price of firewood
P_A is the unit price of firewood alternatives,
I is household income,
Ω is a set social factors, and
Q_A indicates the units of firewood alternatives purchased.

However, regional experience suggests that market prices are insufficient indicators of fuel choice in this region since some fuels can be consumed without being bought in the market. Whereas, the cost of using fuels with market prices is equal for all individual households in the same region, the cost of using firewood is determined by the opportunity cost of household member's labour time used to gather firewood from forests or woodlots. This can be considered the private cost of firewood consumption and it differs widely by household. For example, households may collect firewood from their private woodlots, or from the common property forests at no financial cost. However, households that collect from common property forests may incur larger opportunity costs in terms of increased labour as firewood sources become scarcer. This private or opportunity cost is a function of the household's demographic and infrastructure factors. Indeed, fuel choice is affected by the opportunity cost of consuming it. Since, prices of market cooking fuels are to a greater or lesser extent the same for all households in the same region, equation 1 is reduced to exclude price and income exogenous variables. The reduced form is:

$$U^* = U\left[Q_W(\Omega) Q_A(\Omega)\right] \quad [2]$$

which shows that a household's choice of cooking fuel is affected by a set of exogenous social factors (Ω). In this paper, the social factors considered are: age in years of a wife, the level of education of wife, the occupation of wife, the age in years of husband, the occupation of husband, the number of people making up the household, whether or not the household owns the main dwelling unit, whether or not the dwelling unit is modern or traditional type house, and the types of food regularly cooked.

Theoretically, the above social factors are expected to influence household fuel choice in the following manner: First, age of wife is expected to influence fuel choice through developed loyalty for firewood. The older the wife (other things being equal), the more likely the household will continue using firewood. Second, the level of education of wife is expected to have a positive effect on the choice of firewood alternatives. This is because level of education improves knowledge of fuel attributes, taste and preference for better fuels, and income, which then can be used to purchase the fuels which are comparatively expensive. In addition, a highly educated woman is likely to lack time to collect firewood and may prefer to use firewood alternatives.

Third, occupation is supposed to have a positive effect on firewood alternatives. Wives who are employed in white-collar jobs (office jobs) are more likely to use firewood alternatives than their counterpart blue-collar job employees (who are mainly peasant farmers or fishing households). Fourth, if a household does not own the main dwelling unit, the household is more likely to use firewood alternatives. Such houses are likely to be rented and tenants must adhere to landlord occupancy rules. One disadvantage of firewood (which makes it less preferred in rented houses) is that it produces smoke that can stain walls and roofs. Likewise, if the dwelling unit is modern type house, the household is most likely to use firewood alternatives because these fuels are cleaner. In addition, richer households who may afford the firewood alternatives most likely own modern type houses.

Fifth, household size is theoretically expected to negatively affect choice of firewood alternatives. This is because larger household sizes may mean larger labour output, which is needed in firewood collection. It is also assumed to be cheaper to cook for many people using firewood that its alternatives. This is because per unit price of firewood is lower than per unit prices of its alternatives.

Finally, theoretically, the longer the cooking time, the greater is the amount of fuel used up and larger the total cost of the fuel consumed. Charcoal and kerosene burn faster per unit of time compared to firewood making their per unit costs comparatively higher. Because of this, it is expected that if a household cooks foods that take longer to prepare, the household is more likely to use firewood.

3. The Model

The study uses multinomial logit model to estimate the significance of the factors believed to influence a household's choice of cooking fuel in rural Kisumu. Multinomial logit model describes the behaviour of consumers when they are faced with a variety of goods with a common consumption objective. However, the goods must be highly differentiated by their individual attributes. For example, the model examines choice between a set of mutually exclusive and highly differentiated cooking fuels such as firewood, charcoal, kerosene, gas, and electricity. If only two discrete choices have to be analysed, the multinomial logit model reduces to a logit model.

The probability that a household chooses one type of cooking fuel is restricted to lie between zero and one. The model assumes no reallocation in the alternative set and no changes in fuel prices or fuel attributes. The model also assumes that households make fuel choices that maximize their utility (McFadden, 1972). The model can be expressed as follows:

$$\Pr[Yi = j] = \frac{\exp(b_j^{'} X_i)}{\sum_{j=0}^{J} \exp[b_j^{'} X_i} \quad [3]$$

Where:

- $\Pr[Y_i = j]$ is the probability of choosing either charcoal, kerosene, gas or electricity with firewood as the reference cooking fuel category,
- *J* is the number of fuels in the choice set,
- *j = 0* is firewood,
- X_i is a vector of the predictor (exogenous) social factors (variables)
- β_j is a vector of the estimated parameters.

When the logit equation above is rearranged using algebra, the regression equation is as follows:

$$P_i = \frac{e^{(b_0 + b_1 x_1 + ... + b_v x_v)}}{1 + e^{(b_0 + b_1 x_1 + ... + b_v x_v)}} \quad [4]$$

The equation used to estimated the coefficients is

$$\ln[\frac{P_i}{1 - P_i}] = b_0 + b_1 x_1 + ... + b_v x_v \quad [5]$$

From equation 5, the quantity $P_i/(1 - P_i)$ is the odds ratio. In fact, equation 5 has expressed the logit (log odds) as a linear function of the independent factors (Xs). Equation 5 allows for the interpretation of the logit weights for variables in the same way as in linear regressions. For example, the variable weights refer to the degree to which the probability of choosing one firewood alternative would change with a one-year change in age of household head. For example, e^{bv} (in equation 4) is the multiplicative factor by which the odds ratio would change if X changes by one unit.

The model follows from the assumption that the random disturbance terms are independently and identically distributed (McFadden, 1972). In addition, Judge *et al.* (1985) show that even if the number of alternatives is increased (from 2 to 3 to 4 etc) the odds of choosing an alternative fuel remain unaffected. That is, the probability of choosing the fuel remains the same if it is compared to one alternative or if it is compared to two alternative fuels.

The dependent variable is the cooking fuel choice (firewood, charcoal, or kerosene) with firewood as the reference choice. Estimated coefficients measure the estimated change in the logit for a one-unit change in the predictor variable while the other predictor variables are held constant. A positive estimated coefficient implies an increase in the likelihood that a household will choose the alternative fuel. A negative estimated coefficient indicates that there is less likelihood that a household will change to alternative fuel.

P-value indicates whether or not a change in the predictor significantly changes the logit at the acceptance level. That is, does a change in the predictor variable significantly affect the choice of response category compared to the reference category? If p-value is greater than the accepted confidence level, then there is insufficient evidence that a change in the predictor affects the choice of response category from reference category.

4. Empirical Results and Discussion

Empirical analysis uses data from the Kisumu Household Survey (2001), which was funded by the Catholic University of Eastern Africa. A total of 410 households were sampled and interviewed. The survey was stratified according to gender because it was believed that men and women might have different views regarding household cooking fuel issues in this region. Hence, descriptive analyses in this paper emphasize gender differences as central to the understanding of household cooking fuel choice in Kisumu district. In these rural communities fuel procurement and cooking are largely the responsibility of women rather than men. From experience and field observations, to a greater extent, only women and girls collect firewood and do food preparation. For this reason, the research targeted women rather than men. In this respect, about 90 percent of the sampled respondents were women. To be interviewed one had to be either a husband or a wife. The main question of the survey required the respondents to indicate the fuel the household used most for cooking. Gas and electricity were dropped from the analysis because very few households used them. See table 1 for the characteristics of the sample.

Table 2 shows multinomial logit results of charcoal and kerosene as compared to firewood, controlling for the impact of gender. Since social norms discourage men from participating in fuel procurement and cooking, the influence of gender has been removed from analysis in table 2 by excluding the sample of male respondents.

Of the nine examined explanatory variables, only three were statistically significant at the 5% confidence level. They included level of education of wife, whether or not the household owned the dwelling unit, and whether or not the main dwelling unit is traditional or modern type house. Theoretical expectation was that an increase in the level of education of wife has a positive effect on the choice of charcoal and kerosene. Unfortunately, the results show that an increase in the level of education of wife negatively affects a household's choice of charcoal. One possible explanation is that if a household has a female servant (commonly referred to as a house girl), the household is more likely to use firewood since the house girl can collect and use firewood.

The positive estimated coefficients for whether or not the household owns the dwelling unit supports the study's theoretical expectation that if a household does not own the dwelling unit, the household will be more likely to use charcoal or kerosene. The p-value of charcoal is statistically significant indicating that there is enough evidence to believe that a change in ownership of the dwelling unit from owned to not owned is likely to make a household change from using firewood to using charcoal. In fact, the odds ratio shows that the probability of changing from firewood to charcoal with the change in ownership of the dwelling unit is four (4) times greater for charcoal. Unfortunately, the p-value of ownership of the dwelling unit is not significant for kerosene, although, the odds ratio is stronger.

In the conceptual framework, it was argued that if a household dwells in a modern type house, the household is more likely to use charcoal or kerosene. Contrary to this, the results show that if a household resides in a modern type house, the household is less likely to use charcoal or kerosene. In fact, they have statistically significant p-values at the 5% confidence level indicating that there is less evidence to believe that if a household resides in a modern type house, the household is likely to use charcoal or kerosene. One theoretical assumption here was that a modern type house is an indicator of wealth or the availability of money to support purchases of the more expensive better fuels. However, the wealth may be spent in more urgent needs such as school fees. In addition, it was assumed that the household cooks in the main dwelling unit, something that is not always the case. A household may have a separate cooking place built to accommodate the requirements of firewood use so that smoke does not stain the main dwelling unit. If this is the case, the nature of the main dwelling unit may not be a good indicator of fuel choice.

It is unclear why the result of household size has a positive estimated coefficient for charcoal. Other things being equal, to feed many people requires a lot of fuel in aggregate. Hence, the expectation is that larger households will prefer to use firewood since it is comparatively cheaper to use firewood to cook for many people as it has a lower consumption rate per unit of time compared to charcoal or kerosene. However, the probability of this relationship is not statistically significant for both charcoal and kerosene.

Age was expected to be a significant factor in determining household fuel choice. In fact, an increase in age of wife was expected to be less likely to make a household switch from firewood. The results show that both the age of wife and of the husband have negative coefficients for charcoal and kerosene. Their p-values are however not significant at 5% confidence level. The effect of age may become clearer only at older ages. Since the mean ages of the sample were 33,5 and 43,5 for women and men respectively, the sample was made of generally younger households whose desire for better things may be growing.

It was expected that the nature of occupation of wife could have a positive influence on fuel choice away from firewood. Specifically, women who are employed in office jobs (white-collar jobs) were thought to be more likely to use charcoal or kerosene. This was because they are more likely to make more money than their counterpart blue-collar workers (mostly farmers). A possible explanation of the negative relationship between white-collar employment and better fuel choice is that women are generally underpaid regardless of their occupation. Secondly, cultural beliefs may keep working women to a common culture and societal lifestyle of using firewood.

If a household cooks mainly the foods that take long to be ready, the household is expected to be less likely to use charcoal or kerosene. Regression results in table 2 confirm this. However, the results are statistically significant for kerosene only. The fact that the type of food is not statistically significant for charcoal may be explained by the fact that charcoal and firewood are closer substitutes than firewood and kerosene. Since charcoal and kerosene are comparatively expensive, they are less preferred in cooking foods that take more time.

The model seems to fit the data fairly well. Since the p-values of the goodness-of-fit statistics are greater than 0.05 (confidence level), there is insufficient evidence to suggest that the model is not fitting the data adequately. When the analysis was based only on men respondents, none of the variables were statistically significant at the 95% confidence interval. The results were not significantly different when the gender control restriction was removed meaning that women are the ones more involved with cooking fuel choice decisions in their households.

Table 3 shows a binary logit analysis of firewood and charcoal. Firstly, kerosene has been dropped from the analysis because households that chose it as their preferred cooking fuel were comparatively fewer (see table 1). Secondly, it has been dropped to allow for the analysis of choice differences between firewood and charcoal since they are close substitutes: they are produced from trees. The same variables in table 2 have been analysed in table 3.

Age of wife, age of husband, occupation of wife, the level of education of wife, the level of education of husband, and the type of dwelling unit of the household all have positive estimated coefficients. However, only the level of education of wife and the type of dwelling are statistically significant at 5% confidence level. Their odds ratios are similarly strong. These results support the theoretical framework presented earlier, except for age of wife, which was expected to have a negative influence with the use of charcoal. However, a possible argument is that when a woman becomes older, the lack of adequate physical strength needed to gather and use firewood may force the household to switch to charcoal.

Household size, types of foods cooked, and ownership of dwelling unit all have negative estimated coefficients. For household size and the types of food, this relationship was expected as has been explained for the results of table 2. The possible explanation for the negative result for ownership of dwelling unit has also been provided for the results of table 2.

The goodness-of-fit test has p-values ranging from 0.988 to 0.012 indicating that there is insufficient evidence to claim that the model does not fit the data well. In addition, the observed and expected frequencies are not significantly different from one another showing that the model fits the data. In addition, the higher value of the concordant pairs shows that the model fits the data. Similarly, concordant and discordant values in table 3 show that the model fits the data. These values are used as a comparative measure of prediction about the model fit.

5. Conclusions and Recommendations

This study reveals a set of important factors that determine household cooking fuel choice. The study shows that the level of education of wife, whether or not the household owns the dwelling unit, and whether or not the dwelling unit is traditional or modern type are all significant factors in determining the probability of switching from firewood to charcoal or to kerosene. The study also shows that firewood is by far the cooking fuel of choice for a majority of households in Kisumu district.

One important implication of the findings is that as many households continue to use firewood, the increase in firewood harvesting will negatively impact on the economies of these communities, for example, through deforestation, and a declining agricultural productivity. A solution to these environmental consequences requires that modern cooking fuels be made more accessible and affordable, and firewood and charcoal use be made sustainable. Finally, the public should be educated on environmental quality to improve people's understanding of safer and sustainable environmental exploitation as a way of ensuring that use of firewood and charcoal remains environmentally sustainable.

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Table 1: Mean Characteristics of Households in the Survey

Variable Name and Description	N	Distribution		Mean
GENDER (The sex of the respondent)	408	Female: Male:	366 42	-
AGE (Age in years of the respondent)	406	Minimum: Maximum:	15 82	33,52
HOSESIZE (The number of regular members of the dwelling)	406	Minimum: Maximum:	1 20	5,41
SPO_AGE (Age in years of spouse to the respondent)	312	Minimum: Maximum:	19 76	43,5
RES_OCCP (Category of occupation of the respondent)	385	Blue Collar: White Collar:	126 254	-
FOOD_TYP (Category of food cooked by the household)	369	Longer Cooking: Shorter Cooking:	158 211	-
PO_TYPE (Category of pot used for cooking most foods)	404	Traditional Pot: Modern Pot:	288 116	-
RES_EDUC (Category of the level of education of respondent)	406	No Education: Primary & Adult: Secondary & College:	27 89 289	-
SPO_EDUC (Category of the level of education of spouse)	330	No Education: Primary & Adult: Secondary & College:	13 68 249	-
OWN_DWE (Whether or not the household owns the ma in dwelling unit)	397	Owns Main Dwelling Unit: Does Not Own:	286 111	-
NA_DWELL (Type of the main dwelling unit: traditional or modern structure)		Traditional Type Dwelling: Modern Type Dwelling:	152 253	-
PRINCIPAL HOUSEHOLD COOKING FUEL	374	Firewood as Principal: Charcoal as Principal: Kerosene as Principal:	218 129 27	-

Table 2: Multinomial Logit Analysis for Charcoal and Kerosene as compared to Firewood[A] for Female Respondents

No	Variable Name	Charcoal			Kerosene		
		Estimated Coefficient	P-Value	Odds Ratio	Parameter Coefficient	P-Value	Odds Ratio
	Constant	5,785	-	-	5,815	-	-
1	AGE (Age in years of the respondent woman)	-0,029	0,495	0,97	-0,024	0,774	0,98
2	HOSESIZE (The number of regular members of the dwelling)	0,120	0,205	1,13	-0,430	0,148	0,65
3	SPO_AGE (Age in years of husband to the respondent)	-0,045	0,214	0,96	-0,068	0,301	0,93
4	RES_OCCP (Category of occupation of the respondent)	-0,093	0,586	0,91	-0,189	0,822	0,83
5	FOOD_TYP (Category of food cooked by the household)	-0,183	0,684	0,83	-2,851	0,014*	0,06
6	RES_EDUC (Category of the level of education of respondent woman)	-1,005	0,025*	0,37	1,145	0,469	3,14
7	SPO_EDUC (Category of the level of education of husband)	-0,798	0,098	0,45	-1,469	0,149	0,23
8	OWN_DWE (Whether or not the household owns the main dwelling unit)	1,440	0,004*	4,22	1,103	0,315	3,01
9	NA_DWELL (Traditional or Modern structure)	-2,421	0,000*	0,09	-3,090	0,003*	0,05

Test that all slopes are equal to Zero	G 121,948	DF = 18	P-Value = 0,000
Goodness-of-Fit Statistics		Degrees of Freedom	P-Value
Pearson	346,784	412	0,991
Deviance	200,091	412	1,000

A Gas and Electricity have been dropped from the analysis

* Statistically significant at 5% Confidence Level,

Table 3: Binary Logit Analysis for Charcoal as Compared to Firewood[A],

No	Independent Variables	Charcoal		
		Parameter Coefficients	P-Value	Odds Ratio
	Constant	-5,848		
1	AGE (Age in years of the respondent woman)	0,036	0,406	1,04
2	HOSESIZE (The number of regular members of the dwelling)	-0,110	0,239	0,90
3	SPO_AGE (Age in years of husband to the respondent)	0,036	0,325	1,04
4	RES_OCCP (Category of occupation of the respondent woman)	0,095	0,596	1,10
5	FOOD_TYP (Category of food most cooked by the household)	-0,111	0,807	1,12
6	RES_EDUC (Category of the level of education of respondent woman)	0,954	0,034*	2,60
7	SPO_EDUC (Category of the level of education of husband)	0,941	0,044*	2,56
8	OWN_DWE (Whether or not the household owns the main dwelling unit)	-1,430	0,005*	0,24
9	NA_DWELL (Type of the main dwelling unit: traditional or modern structure)	2,431	0,000*	11,37

Test that all slopes are equal to Zero	G 86,810	DF = 9	P-Value = 0,000
Goodness-of-Fit Statistics		Degrees of Freedom	P-Value
Pearson:	243,084	196	0,012
Deviance:	154,245	196	0,988
Measures of Association	Number	Percentage	
Concordant:	7102	84,5%	
Discordant:	1280	15,2%	
Ties:	18	0,2%	

[A] Male respondents are excluded from the analysis

* P-Values are statistically significant at 5% Confidence Level,