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Socio-Economic determinants of Cooking Fuel Choice among Households in Rural Sri Lanka

B.W.R. Damayanthi

University of Sri Jayewardenepura, Sri Lanka

Abstract

Assuming a likely order of movement in fuel selection based on efficiency and cleanliness of energy sources, the present study utilize ordered probit model to investigate the determinants of household fuel switching behavior in rural Sri Lanka. The data were collected from a systematic random sample of 420 respondents using a self-reported questionnaire. Empirical findings reveal that education level of household head and spouse, employment status of household head and spouse, extended family type and perceived LPG cost are the major influential factors of cooking fuel choice while the age of the household head, family size, dwelling type, number of meals cook per day, distance to the town and income are significant but minor factors. It was indicated that there is a greater potential for a transition from traditional firewood burning to improved stoves while the switching to cleaner energy will not be immediate due to the strangeness of non-income determinants. Thus, awareness raising and subsidizing for more energy efficient cook stoves are advocated.

Keywords: Bio mass, , Clean fuel; Cooking fuel; Energy ladder; Sri Lanka

1. Introduction

It is well acknowledged that the cleaner fuels (i.e. LPG and electricity) are better fuel options from the perspective of better health, convenience and efficiency at individual or household level while mitigating the negative effects of biomass fuels on the atmosphere and human life as a whole. However, it is recorded that about 2.5 billion of the world's population meet their daily energy requirements from biomass fuel which has been defined as any material derived from plants or animals which are deliberately burnt by humans (de Koning et al., 1985 ; Nandasena et al., 2012). It consists of animal waste, firewood, charcoal and waste from agricultural crops. It is the primary fuel source for daily cooking for majority of rural residents in the developing world. According to Demirbas (2006) biomass fuel contributes for 60% in Africa, 56.3% in South Asia, 25.1% in East Asia, 23.5% in China, 18.2% in LatinAmerica,3.5%inEurope,2.7% in North America and 0.3% in the Middle East in regional energy consumption. Unlike developed countries, fuelwood is the basic source of energy in households of developing countries (Balat and Ayar 2005), which puts great demand on forestry. In the absence of effective interventions the people who depends on solid fuel are expected to be risen up to 2.6 billion by 2030 (International Energy Agency, 2002, 2006).

Once the consequences of biomass burning is concerned, the negative health effects on human being is at the top. Increased particulate matter (PM) produced by biomass burning may cause to acute lower respiratory infections, tuberculosis, cardiovascular conditions, adverse perinatal health outcomes, and acute health problems (Nandasena et al., 2012). Consequently, worsened indoor air pollution has been a cause for an estimated four million premature deaths per year (World Health Organization [WHO] (2014).

When it comes to efficiency and productivity, wood and related biomass fuel such as firewood and animal waste are inefficient, firstly, because they pollute the air. Secondly, the opportunity cost arising from lengthy cooking time and collecting/processing time is high for women and children especially in the developing countries. It has been pointed that the women and children who mostly collect fuelwood may face time constraints for other productive activities such as education which eventually undermine the human capital formation and the economic stability of the household (Kurmi et al, 2012; Phillips et al, 2016).

Though it is a renewable energy, it is not regarded as environmentally friendly (Nlom and Karimove, 2014). Forests are the major source of biomass fuel supply and therefore the production of and over-dependent on them cause to increase deforestation which further creates negative impacts on biodiversity, ecosystem services, land fertility. Thus, the production of biomass fuel harm the environmental sustainability (Akther et al., 2010; Song et al., 2012; Streets and Waldhoff, 1999).

Sri Lanka is a higher middle income country with more than 77 percent of rural population (DCS, 2015). The major sources of energy consumed at the household level in Sri Lanka are firewood. About 68 percent of population consumed firewood for cooking and other domestic purposes. 29.1 percent of the total population use liquid propane gas (LPG) as their major cooking energy while only 2.3 percent utilize other types such as kerosene. Once the Rural sector is considered, these magnitudes varies slightly recording 76.8, 21.7 and 1.6 respectively (DCS, 2018). Regardless of the sound education level, higher human development status, more than 13mn people stay on the bottom rung of the energy ladder.

The scholarship towards the consequences of this heavy dependence on wood fuel is scant, and available literature suggest that Sri Lankan cooks and the children living in their homes may experience respiratory health problems due to exposure to high particulate matter aroused from biomass burning (Phillips et al, 2016). Researchers posited that the health impacts of indoor air pollution coupled with traditional practices in Sri Lanka has not been adequately addressed and discussed. According WHO (2017) Asthma Deaths in Sri Lanka reached 7,160 or 5.65% of total deaths. The age adjusted Death Rate is 32.23 per 100,000 of population and Sri Lanka position is number two in the world. Further, it was shown that the number of deaths due to chronic respiratory diseases has increased for females than males. According to medical information department sources, number of asthma patients has been rising and at least one million people affected by respiratory diseases (Phillips et al., 2016)

Thus, there is vital in paying adequate attention to make an effective intervention to persuade households to shift towards the use of cleaner fuel. There should be an appropriate energy policy which encourage people towards upper runs of the energy ladder or to use improved cook stoves (Nandasens et al, 2012) in order to minimize at least this health risk. However, household's fuel choice is complex. For instance, as "energy ladder hypothesis", explains, fuel choice and transition to cleaner fuel are majorly determined by the level of income Hosier & Dowd, 1987). According to Rahut et al. (2014) there is a strong association among income, education, life expectancy and energy consumption. Masera et al. (2000) posited that households use the modern fuel with the rise in income but rarely abandon the traditional fuel. Further, the scholarship that prove the significance of other factors such as demography of the household head, employment, educational level, household size, family composition, dwelling characteristics are considerable (Nlom et al., 2015; Barnes et al. 2004; Giri and Goswami, 2018). Besides, urbanization has found to be one of the most influential factor in many studies (Giri and Goswami, 2018) while availability of and accessibility to various types of fuel (Nnaji et al., 2012; Rahut et al., 2014; Rao & Reddy, 2007, Giri and Goswami, 2018). This shows that household's cooking fuel choice and also tendency to choose one fuel over the other is an outcome of not only economic but also socio-cultural and environmental factors. Hence, designing an appropriate policy intervention demands a clear cut understanding of the factors that influence household's choice of energy source. Filling the existing research gap in the local context, this study aims at investigating the factors that influence household cooking fuel choice in the rural sector in Sri Lanka.

2. Literature Review

Household's fuel consumption choice is an outcome of its demographic, socio-economic, cultural, and environmental factors (Alam et al, 1998). However, scholarship towards the phenomenon largely based on the prominent view - energy ladder model - demonstrated that income is a key factor in inter-fuel substitution decision. According to this basic theory, households move progressively towards the efficient fuels as income increases (Nlom et al, 2015; Hosier & Dowd, 1987; Leach, 1992). From the three levels of the ladder, there is strong reliance on biomass fuels such as firewood and animal waste at the first level or lowest run. At the second level, income rise gives households more freedom to change the fuel type from far inefficient to less inefficient i.e. kerosene, coal, charcoal. At the third level, households are much more economically independent

with good income level and move to utilize cleaner fuels such as LPG (Nlom et al, 2015; Giri and Goswami, 2018). Consequently, income has been found be the primary driving force of cooking fuel choice for many researchers (Miah et al., 2011; Akter et al., 2010; Nnaji et al., 2012; Song et al., 2012; Rahut et al., 2014).

Though the income plays an important role in the cooking fuel choice for many, it is still in dispute. According to Akpalu et al. (2011) income increase has not shifted households to a higher rung in energy ladder. His findings confirm that Ghanaian households do not progress from the use of biomass energy to transitional fuel as their living conditions improve while Koswari and Zerriffi (2011) explained households use a mix of energy sources rather than one particular source. This is called fuel stacking model (Masera and Navia, 1997; Masera et al. ,2000) that maximize fuel security and gives the advantages of different types of fuel (Giri and Goswami, 2018). Moreover, according to some other researchers, income may have influenced on the quantity of fuel consumption but not on the fuel choice (Tuan and Lefevre, 1996). Koswari and Zerriffi, (2011) argue that income has an explanatory power of explaining the cooking fuel choice of the poor but once the basic energy requirement is fulfilled, energy consumption will focus on convenience, comfort and entertainment (Koswari & Zerriffi, 2011; Tiwari, 2000).

A vast majority of the studies in the literature provide evidences for diverse factors that influence on cooking fuel choice. Among others, Danlami et al (2015) posited that degree days, electric water heater, electric clothes dryer, dish washer, number in house, age of respondents, nature of employment, municipality of residence, expenditure per capita, private water connection, were positively significant related to household energy choice and consumption. According to Nnaji et al., (2012) and Song et al., (2012) other than household income, level of education of the head of the household, household size, the dwelling ownership, occupation of the household head, number of rooms, number of years the house was built, size of the resident, ratio of female in the household are positively associated with cooking fuel choice of wood while Couture et al., (2012) and Laureti and Secondi, (2012) provide evidence of negative relationship for the same relationship. Thus, the heterogeneity aroused from context or the reginal specificity of the relationship has been evidenced.

3. Methods

3.1 Sampling data and the variables

Systematic random sample of 420 respondents were selected from Pasgoda divisional secretariat in Matara district and self-reported questionnaire was administered for the primary data while the final reports of Household Income and Expenditure Surveys (HIES) for 2012/13, 2016/17 utilized for the secondary data.

Dependent variable: According to the energy ladder theory, households follow a simple linear movement from inefficient to efficient fuels or switch from inferior to better or cleaner energy as income increases(Nlom et al., 2015). In the energy ladder, biomass fuels such as firewood and animal waste are at the bottom while coal, charcoal, and kerosene which are labeled as “transitional fuels” are in the middle. At the top level, with higher incomes, households can afford to move to cleaner fuels such as LPG (Giri and Goswami, 2018). Accordingly, household fuel choice can be ordered meaning fully from dirty to cleaner (from fire wood to LPG). Considering this existing theoretical base, but adjusting it to the context, present study construct its dependent variable assigning values 1, 2 and 3 for firewood; transitional fuel or improved cooking stove for bio mass fuel and LPG respectively. Use of kerosene or other types of transitional fuel for cocking purposes are rarely found in Sri Lanka while improved cooking stoves is widely accepted as a means of reducing indoor air pollution aroused from wood burning. Hence, the dependent variable is meaningfully ordered giving lower value (1) for lower status and higher value (3) for higher status.

Independent variables

Household income: the proportion of per capita non-food expenditures to total consumption expenditures. This proportion is more likely to capture the inequality across households (Basole & Basu, 2015; Giri and Goswami, 2018).

Age: Age of household’s head in years.

Gender: Gender of household head Male=1; otherwise 0

Sp_Age: Age of spouse in years

HH_Edu : Level of education of household head (ordered according to the level of education: primary or less to postgraduate level)

Sp_Edu: Level of education of spouse (ordered according to the level of education: primary or less to postgraduate level)

Exp_Month : Monthly expenditure Rs

Emp_HH: Occupation of household head (ordered according to the level of employment: labour to executive)

Emp_Sp: Occupation of Spouse (ordered according to the level of employment: labour to executive)

HH_size: Number of members in the household

Dwel_type: If Modern=1 ; 0 otherwise

Meals: Number of meals cook per day

Distance :Distance from market in Km

Sep_Kitchen: Kitchen outside the main dwelling unit yes =1; otherwise 0

Extd_Family: Whether living in extended family yes =1; otherwise 0

Attitude_HH: Whether household head believes fire wood cooking is tasty and nutritious

LPG_cost: Whether HH perceive that the cost of LPG is much higher than wood fuel

3.2. Empirical model

The dependent variable of the present study, fuel choice, is in a meaningful sequential order where the higher value gives the superiority of the fuel type and has more than two categories. Hence ordinal model was preferred. Ordinal models are usually based on the assumption that the effects of predictor variables are the same for all categories on the logarithmic scale. That is, the model has different intercepts but common slopes (coefficients) among categories. This model is called *parallel regression* or the *proportional odds* model which can be illustrated as follows for k category response variable.

$$ln\left(\frac{P(y \leq c_1)}{P(y > c_1)}\right) = ln\left(\frac{\pi_1}{\pi_2 + \cdots . \pi_k}\right) = \propto_1 + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_P X_p$$

where π_j, j = 1, 2, ..., k, are the category probabilities.

Accordingly three types of fuels that are observed in the data were ordered in terms of efficiency and ordered probit model was estimated. The probit model assumes that the household's choices of fuel types are latent variables which can be expressed as a linear function of vector of independent variables as

$$y_i^* = \beta X_i + \varepsilon_i$$

where where Xi is the vector exogenous variables, β is the parameter vector. The error term ε_i has a standard normal distribution which comprises the unobserved heterogeneity of the model. The relationship between the observed Y and the latent y*,

$$y = c_1 \ if \ \propto_0 < y^* \leq \propto_2$$

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where $\alpha_0 = -\infty$ and $\alpha_k = \infty$. Then, the cumulative probability of y being in category j or one of earlier categories, $P(y \leq c_j)$, is equal to

$$P(y \leq c_j) = P(y^* < \propto_j) = P(\beta X < \propto_J) = P(\varepsilon < \propto_J - \beta X) = \emptyset(\propto_J - \beta X)$$

where $\emptyset$ is standard normal cumulative distribution function. Thus,

$$\emptyset^{-1}\left(P(y < c_j)\right) = \propto_j - \beta X$$

where α_j corresponds to the cut points of the latent variable and the intercept in the regression model. The coefficients indicate the impact of a unit change in the predictor variable on the likelihood of a state. A positive coefficient, β_1, for example, indicates an increase in the underlying latent variable with an increase in the corresponding predictor variable, X_i

4. Results

Table 1 depicts the descriptive statistics of variables used for the analysis. As it shows more than 80 percent of the sampled population is male. Average age of a head of household is 42 years while it is 39 years for spouse. On average, a household has 3 members and the majority cook three meals a day. For the most, the market place is 1.5 km far while 76 percent households have at least a bicycle. More than 1/3 of the households have separate kitchen outside the main dwelling. Almost 90 percent (88%) believe the use of LPG for cooking is very costly compared to biomass.

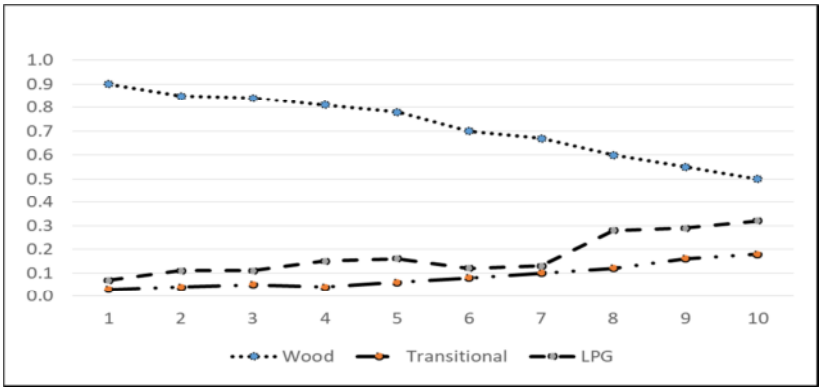
Table 1: Descriptive statistics of the variables

Variable	**Mean**	**HH education**	%
HHH_age	42	Primary less	4.49
HHH_gender	0.82	Below O/L	20.80
Spouse age	39	A/L sat	35.46
HH_size	3	A/L +	22.93
Meals cook	3	Graduate	16.31
Distance to Market	1.5		
Separate kitchen	0.33	**Spouse education**	%
Perceived LPG cost	0.88	Primary less	3.56
Employment category - Spouse	**%**	Below O/L	18.53
Laborer/Casual/Unemployed	28.40	A/L sat	38.48
Clerical	36.40	A/L +	33.25
Teaching	30.20	Graduate	6.18
Executive	5.10		

Source: Author's calculations based on sample data

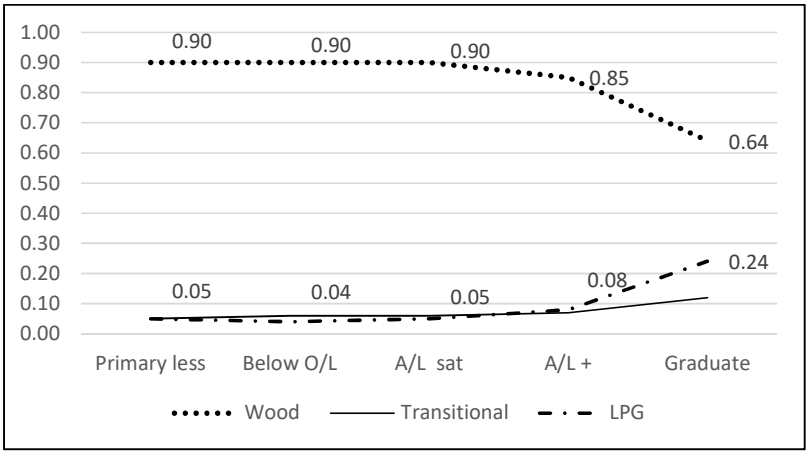
Once the education of household head is considered, only 4 percent of them are primary educators while 58 percent have sat or completed Advance Level. A considerable percentage of household heads are graduates. Spouse's education follows the same pattern except only 6 percent of them are graduates. When employment category of the spouse is considered, 20 percent of them are unemployed and 8 percent is employed as laborers. The majority of the employed spouses are clerical workers while the second largest single trade is teaching.

Figure 1: Cooking fuel type by expenditure decile



Once the association between income and fuel choice is concerned, Figure 1 shows that there is a considerable gap between 1st and 10th deciles in using wood fuel. More than 90 percent of respondents in decile one use wood as their primary cooking fuel while that percentage get reduced to 50 percent in the decile 10. When transitional fuel use is considered, it clearly shows an upward movement with the income level. In contrast, the percentage of respondents who use LPG as the primary cooking fuel does not vary much with income level.

Figure 2: Spouse education and cooking fuel type



As shown in Figure 2, spouse's education level varies slightly negatively with biomass while it shows positive relation with transitional fuel use. As expected, LPG as a primary cooking mode has shown a negligible increase with the level of education. All two graphs suggest that there may be an association between fuel choice and income as well as education level in the uncontrolled setting. Thus it can be expected that with the increased income level people become more economically independent and LPG is affordable for them. Further, positive movement with income and education may be a sign of accepting or knowing of negative effects of biomass fuel on human life. However, Figure 4 indicate that LPG choice is determined mainly by convenience factor. As in Figure 4, almost 90 percent of respondents who use LPG have claimed that they choice of LPG is due to easiness and time saving. Only one percent of them have stated that they concern health effects.

Figure 4: Why use LPG

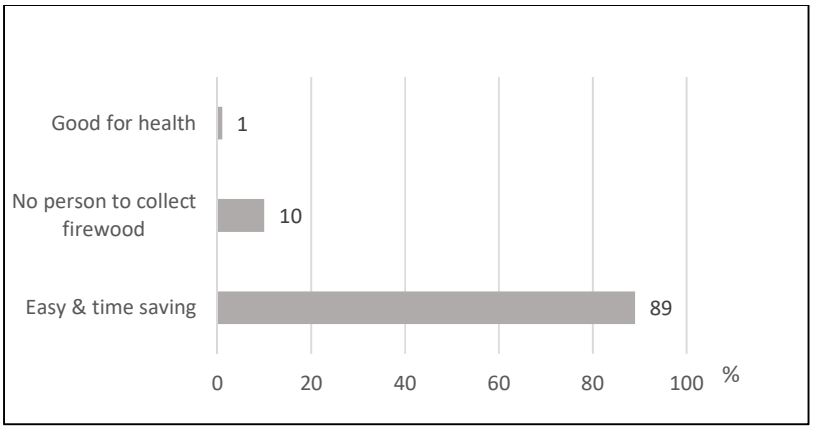
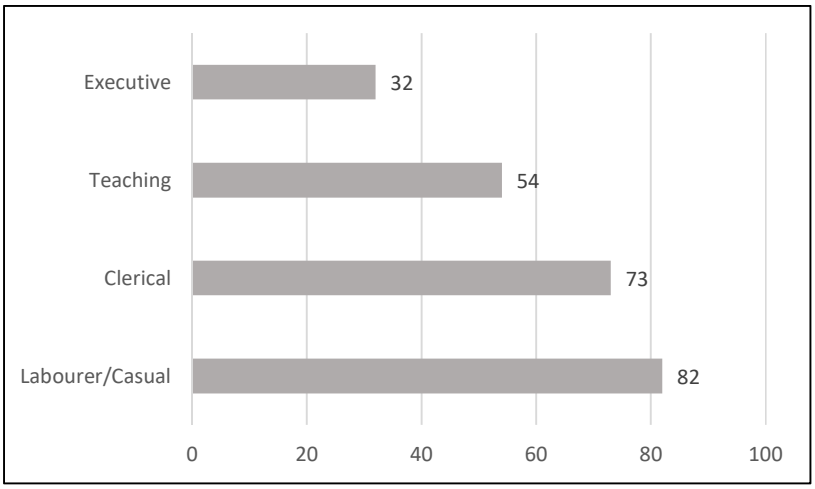


Figure 3: Wood fuel use by spouse's employment category



According to Figure 3, there is a clear pattern in wood fuel choice and employment status of spouse in the rural sector. Causal or labour category mainly use bio mass (82%). There cannot be seen a large difference between labour group and clerical group. A little more than half of the teachers in the sample use wood as their primary cooking fuel. A vast majority of executive level females have shown to be LPG users (68%).

Table 2: Regression results

Variable	Coefficient	Std
Age	-0.372**	0.172
Gender	0.123	0.183
Sp_Age	0.056	0.045
HH_Edu	0.441**	0.176
Sp_Edu	0.310**	0.121
Exp_Month	0.153*	0.080
Emp_HH	0.163*	0.140
Emp_Sp	1.532***	0.202
HH_size	-0.102*	0.060
Dwel_type	-0.053*	0.010
Meals	-0.033*	0.001
Distance	-0.103*	0.053
Sep_Kitchen	-0.105	0.101
Extd_Family	-0.103**	0.030
Attitude_HH	-0.065**	0.009
LPG_cost	-0.362***	0.142

*p<0.01; **p<0.05; ***p<0.001

Household which comprises extended families are less likely to use LPG as main cooking fuel while the household heads who believe that meals cooked on traditional way is healthy and tasty are also less likely to use LPG. Effect size for the variable "perceived LPG cost" is comparatively high and significant at one percent level of significance. Income effect which is estimated through household expenditure is positively significant showing that that households with more income tend to use cleaner fuels. However, it is statistically significant only at 10%.

Calculated marginal effects for the cooking fuel choice are reported in the Table 3. These effects are defined as the unit change impact of independents on cooking fuel choices. The magnitude and direction of impact can be easily compared by using marginal effects. Once the continuous variables are concerned, if the head of household is aged, it increases the probability of using firewood for cooking by 9 nine percent while the households are 18 percent less likely choose LPG. Monthly expenditure as a proxy for income is taken, increase in income decrease firewood use but the rate of change, however, is too small. At the same time it increases transitional fuel 21 percent though the effect on LPG is negligible. Distance to the town shows a positive rate of change towards firewood and as expected, LPG use is negatively affected by this factor. When education level of the household head and also spouse is high the portability to choose LPG is high. It shows that the educated households are more likely to utilize transitional or LPG. Further, increased number of meals cooked a day and the size of the household increase the probability of choosing firewood. Employment status of both household head spouse impacts negatively on firewood use. Households with executive level occupations are 12 percent to 73 percent less likely to use firewood and are 2 percent to 83 percent more likely to use LPG. In this regard, spouse's occupation category has the greatest impact on switching into cleaner fuel. Moreover, a considerable rate of change towards biomass can be seen for the households with elders. It was shown that extended family houses are 78 percent more likely to use fire wood. Once the perceived LPG cost is considered, heads who consider LPG as more expensive are 47 percent more likely to choose firewood and 46 percent more likely to use transitional fuel. All in all, spouse employment level and being an extended family show the greatest effect

on switching rates while higher LPG prices also lead more people to continue using biomass (the switching-rate is 47 percent).

Table 3: Marginal effects of significant variables

Variable	Wood	Transitional	LPG
Age	0.098	-0.017	-0.176
HH_Edu	-0.078	0.450	0.123
Sp_Edu	-0.220	0.670	0.210
Exp_Month	-0.042	0.210	0.056
Emp_HH	-0.120	0.397	0.121
Emp_Sp	-0.735	0.671	0.879
HH_size	0.189	-0.345	-0.021
Dwel_type	0.045	-0.076	-0.067
Meals	0.034	-0.058	-0.007
Distance	0.012	-0.045	-0.024
Extd_Family	0.783	-0.069	-0.021
Attitude_HH	0.046	-0.023	-0.004
LPG_cost	0.468	-0.456	-0.005

5. Discussion

Findings of the presents study suggest that the younger and also wealthier households tend to use cleaner fuels. Though the income seems to be contributory factor in determining cooking fuel type in rural Sri Lanka, the effect is too small to agree with the energy ladder hypothesis. Other things being equal, to feed many people requires generally a large amount of fuel. Hence, it is obvious that larger households will prefer to use firewood more because it is comparatively cheaper and sometimes lower the per-head cost of consumption. On the other side, larger households are comparatively advantageous having extra labor. It can be used to collect firewood from own or public fields. If it is freely available, firewood will be the cheapest cooking fuel compared to other alternatives. Same reasons apply for extended families who have more tendency towards biomass burning.

As expected, the level of education of household head as well as wife have positive effect on using cleaner fuel. Though the rate of change in reducing biomass burning and increasing LPG use are quite similar for educated women, it is very high for transitional fuel. More educated women are more likely to use improved cooking stoves though they hardly move away from firewood as the primary cooking fuel. Main reason behind this factor may be the least or no cost of biomass use. Though they are educated, it was clearly found that the health or environmental hazards of biomass burning were not considered by them.

Other things being equal, employment status of the spouse is found to be the most prominent factor of fuel switching decision. Females who are employed in white collar jobs (office jobs) are more likely to use LPG than their counterpart blue collar job employees (who are mainly labors). In the current context, it was shown that a negligible percentage of respondents concern about health effects and thus the strong significance of employment status is not because of that they are more educated, well aware of the health effects, earning

sufficiently and so on but they prefer for shorter and lighter cooking durations. Further, it takes relatively longer time to set firewood ready for cooking and especially there should be a person to collect. Hence, employed women are very much prefer in using LPG due to time constraints on fire wood processing, cooking and cleaning pots. Furthermore, it is well understood that the better employment position raise and improve women's social status and affordability which lead them into cleaner fuel choice. However, interrelation between education, employment and therefore earning status may have impact on reducing the tendency of using firewood in male context. It was further found that the majority believe that LPG is very expensive and thus it is not affordable for them. However, there was no any respondent who have calculate the average cost of LPG and compare it with the opportunity cost of firewood. Additionally, it was revealed that a considerable proportion of people believe that food that is cooked on biomass fire is healthy and tasty. Taken together, it was clearly found that that non-economic factors are stronger than the economic factors in determining household fuel choice.

6. Conclusions and implications

Assuming a likely order of movement in fuel selection based on efficiency and cleanliness of energy sources, the present study utilize ordered probit model to investigate the determinants of household fuel switching behavior in rural Sri Lanka. The data were collected from a systematic random sample of 420 respondents using a self-reported questionnaire. Empirical findings reveal that education level of household head and spouse, employment status of household head and spouse, extended family type and perceived LPG cost are the major influential factors of cooking fuel choice while the age of the household head, family size, dwelling type, number of meals cook per day, distance to the town and income are significant but minor factors.

Results clearly indicates that there is a greater potential for a transition from firewood burning in traditional cooking stoves to improved stoves. However, the switching to cleaner energy will not be immediate due to the strangeness of non-income determinants. Thus, a mere increase in income will not reduce the biomass burden on the society. But the introduction, awareness raising and subsidizing for more energy efficient cook stoves that involve less firewood consumption, cooking time would be more effective.

This study suggest that better education helps to decrease the firewood choice not because of the health related awareness but because of the time constraints and social status of the spouse (women). Strongness of this matter has strong policy implication on women empowering. In this respect, investing in women education will have a long term impact while the improvements of livelihoods would effect on fuel transition in medium term. Unarguably, the short term policy focus should be awareness raising campaign which accompanied by some form of financial incentives for cleaner fuel alternative.

The possible explanation for the significant proportion of wealthier and also educated household's utilization of biomass as the primary cooking fuel may be the availability and the attitude established about the food taste. Hence, educating them about the benefits of cleaner (and the negative health impacts of using firewood) in order to get away from myths will be very effective in encouraging to reduce biomass tendency.

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