FACTORS DRIVING COOKING FUEL CHOICE AMONGST URBAN POOR: A STUDY OF BHUBANESWAR CITY IN ODISHA, INDIA

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ABSTRACT

This study explores the factors that impact choice of cooking fuel, in our case, Liquefied Petroleum Gas (LPG) among the urban poor in India. In earlier studies multiple socio-economic and market related factors (e.g. distribution and pricing), are discussed as determinants of which ultimately determine the cooking fuel choice of household. However, no clear or integrated models exist. This study focuses on household characteristics that can impact cooking fuel choice. Primary data collection was carried out in 3036 households in three urban-slums of Bhubaneswar, Odisha, India and was used as a sample for the study. The analysis revealed that along with income, the social status and other household characteristics are important in determining the cooking fuel choice. A major finding of the study is that unaffordability is not the single most criteria. The cooking fuel choice of a family is basically a function of external and household specific factors.

1. INTRODUCTION

Usage of traditional biomass fuels for cooking has been an age-old practice in many developing countries. While large scale urbanization, societal awareness and increased per capita income have encouraged the use of cleaner sources of energy (IEA 2004), in many developing countries traditional biomass-based fuels are still predominantly used for domestic cooking (Foell et al., 2011). With time the urban middle-income and the higher income population have moved towards using cleaner sources of energy, however, biomass continues to dominate in the lower-income households. Traditional energy forms such as firewood, charcoal and agricultural residues are easily available and widely used as a cooking fuel in India (Jain et al., 2014). Such use draws a trade-off between the low cost, easily available energy options and the adverse environmental and health impact of these energy sources.

1.1. Literature Review

There have been extensive studies done in the areas of household energy consumption. The traditional view on fuel choice has been the energy ladder approach (e.g. Leach, 1992). Fuel laddering as a concept emphasizes the fact that households move to cleaner and better energy sources as their income level improve (Jain, et. al, 2014). This approach was critiqued partially by Masera et al., (2000) who observed the pattern of Mexican household energy consumption. The authors suggest that data that household energy consumption follows more of a stacking pattern rather than an incremental ladder pattern. Households switched to or include cleaner and more convenient fuels in their fuel mix as their income and socio-economic status rise (Smith & Sagar, 2014). This process is often called fuel switching (Heltberg, 2005) or fuel stacking (Masera et al., 2000), to reflect the fact that several fuels are often used concurrently in the same household. Fuel switching generally occurs faster in urban areas compared to rural areas (Heltberg, 2004, 2005; Hosier and Dowd, 1987; Gundimeda and Köhlin, 2008). Possible explanations for the lower rate of fuel switching in the rural areas include a lack of infrastructure for modern fuels (Leach, 1992), lower or non-monetary sporadic income, a traditional lifestyle and smaller opportunity cost of time in addition to the higher availability of collectible fuels and the

decision-making status in the household. Additionally, the availability of biomass strongly influences the path of urban fuel switching (Barnes et al., 2004). For Indian consumers, Pachauri (2004a) found that income and the location i.e., rural and urban are the most significant factors in determining a household's energy consumption.

There has been extensive research in the areas of household fuel consumption and factors predicting the same. While studies have been focusing around many developing economies such as Ghana, Ethiopia, Mexico, Vietnam, little empirical studies are available on India. This is the major focus on this paper that if the findings from the other countries are in tandem or India has some different factors which determine their energy choices in households. An older study by Alam, Sathaye, Barnes (1998) suggested that underlying fuel transition of India is consistent with the other developing countries. Although Government policies have favored the rich, because of the inequities in fuel and equipment availability among different income groups. The study by Alam et al., (1998) was conducted 20 years before and India has undergone massive transformation in terms of urbanization, change in per capita income and availability of fuel options. The present study will focus on understanding the current day scenario of household energy consumption and whether it is different in any way from the previous studies.

Leach 1992 focused on the traditional view of fuel choice i.e., the energy ladder wherein households move towards cleaner and better energy sources as their income rises. Past studies consistently indicate a strong correlation between household income levels and the types and amounts of fuel used for cooking (Cecelski et al, 1979, Leach 1988, Reddy 1990). However, subsequent studies defy the findings. The findings were presented based on Mexican households by Masera et al., (2002) which focused on fuel stacking which is where households include cleaner energy options in their fuel basket as their income rises.

A study by Mekonnen and Köhlin (2008) proved that fuel choices by households are determined by socio economic factors. This study suggested that economic status, and price of alternative energy sources are important determinants of fuel choice in urban Ethiopia. The study also suggests the use of multiple fuels or "fuel stacking" behaviour by households. Consistent with the above literature review by Mekonnen and Köhlin and in a study on Ghanaian households by Akplau, Dasani and Aglobitse (2011) it was again reiterated that the fuel ladder concept is not robust. From the Ghana living standards survey it was found that the most preferred fuel is LPG, followed by charcoal, and kerosene is the last preferred option. While Kerosene has price-elastic demand the price elasticities of demand for other fuel types examined are inelastic. Households tend to follow the fuel stacking model since it helps them to mitigate potential vulnerability in case of dynamic fuel prices and it ensures energy stability.

The survey of BPL households revealed various reasons for not preferring or preferring LPG as a source of cooking fuel. While the literature review clearly indicates the significance of the economic perspective of the decision-making process, in this study we will try to identify potential psycho social factors which emerge from household characteristics which are also elementary in determining a household's energy choice. The objective of this study is to understand if income continues to dominate the fuel choice of households or are there other characteristics of a household which affect a household's energy choice. There are a set of factors which came out as a part of the survey and can be demarcated as internal and external factors. We will particularly focus on specific household characteristics. We will be testing the hypothesis of usage of LPG versus social status, economic status; type of house they live, approximate time spent on cooking and

analyse the characteristics which are most important in determining the choice of fuel. The hypothesis to be tested would be whether household characteristics have no impact on LPG usage or household characteristics have a significant impact on the LPG usage of a household.

Research Aim 1: Is family size i.e. number of members in a family a factor in determining the fuel choice of a household?

Research Aim 2: Does type of house i.e., pukka (house made of brick and concrete, structurally strong), semi pukka and kuccha (made of bamboo, and earthy materials, generally temporary in nature) impact the choice of fuel by a household?

Research Aim 3: Can the household's using and not using LPG be grouped in homogenous clusters based on social status, economic status, monthly income, and time spent on cooking?

2. METHOD

2.1. Data and Sample

Primary data collection was carried out amongst 3036 households in three urban slums in Bhubaneswar, Odisha. The sample is of the urban poor who were distributed across various socio-economic strata with the average household size being 4. A Majority of the respondents were males (61%). The respondents live in three kinds of house i.e., kuccha (10.3%), semi pucca (73.4%) and pucca (16.3%). Kuccha houses are made of materials such as mud, dry leaves, straw and bamboo. In a semi pucca structure either the roof or walls but not both are made of pucca materials like burnt bricks, stone, cement, concrete or timber while pucca houses both roof and wall are made of such material. The houses may or may not have a separate cooking area.

In terms of occupation, most of the respondents were labourers (43.49%) followed by small business (14.36%), driver (11.39%), mason (5.83%). In terms of Economic status, the sample can be divided into Above Poverty Line (1%), Below Poverty Line (40%), Ration Card Holders (54%) and members of Antyodaya program (5%). Below Poverty Line is an economic concept which is used to demarcate individuals and households who live below a certain income level and require assistance from the state for survival. Internationally 1.90 dollars per day per head of purchasing power parity is the stated benchmark for the poverty line. Ration cards are an official document which entitles the holder to a ration of various goods ranging from food to fuel which is issued by the Government of India. The Indian Government works out the Public Distribution System country by the help of the ration card which helps in establishing the eligibility and entitlement to the goods. Antyodaya Anna Yojana is a Government of India sponsored scheme to provide subsidized food to the poorest of the poor of India. The Government provisions up to 35 kilograms of rice and wheat at a highly subsidized cost of three rupees per kilogram of rice and two rupees per kilogram of wheat.

In terms of social status, the sample is divided into Schedule Caste (20%), Schedule Tribe (12%), Other Backward Classes (31%), General Category (36%) and Minority (1%). The Scheduled Caste and Scheduled Tribe are officially classified by the Government of India and it is specifically for the classes which have been underdeveloped, socially and educationally disadvantage. General class in India are groups who do not have any special status and are not entitled to any reservation benefits and are often referred to as the forward classes. Minority status is for religious communities in India which include Muslims, Sikhs, Christians, Buddhists, Zoroastrians and Jains. In terms of Economic condition of the sample population, 12% of the households have an average income from 2000 to 5000 Indian Rupees, 58% have an income from 5000 to 10000 Indian Rupees and 31% of the households have an income above 10000 Indian Rupees.

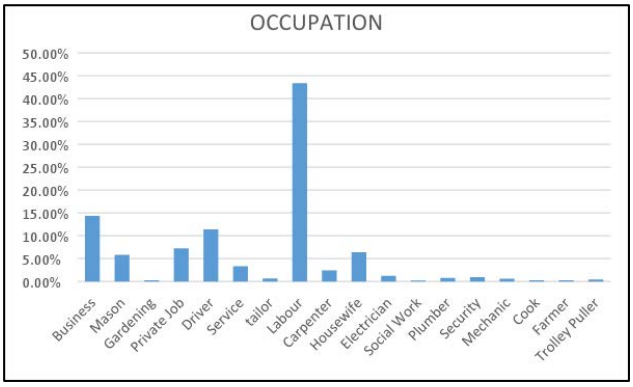

Fig 1: Occupation of the Respondents

2.2. Statistical Techniques Used

In this study our aim is to find if the variables relating to the household characteristics are of utmost importance in determining a household's energy choices and what drives their decision making. We use regression techniques to arrive at the importance of the variables. The data is more on the categorical side hence we use logistic and multinomial logistic regression to arrive at the results. We also used cluster analysis technique to build homogenous clusters of users and non-users of LPG based on the household characteristics.

3. RESULTS AND ANALYSIS

Logistic Regression is used to analyze the data where the independent variable that is whether a family uses or does not use LPG as a cooking fuel. The independent variable used in this regression model is number of members in the family intuitively, larger families would have more cooking requirements and hence traditional forms of cooking fuel would entail more time consumption in cooking. Our aim is to determine the probability of a family using LPG given the number of family members that they have. The average number of members in the family as per the data is 4 while the minimum is 1 and maximum is 20. We will determine the probability of LPG usage given the number of family members. On attempting logistic regression while it is found that it is not highly significant in terms of determining LPG usage or non-usage (Although it does have a slight impact in terms of probabilities), It is however of utmost importance in determining behaviors related to fuel stacking which is consistent with previous research.

The equation of the Logit model is given by:

$$Li = \ln(Pi\,(1-Pi)) = \beta + \beta 1X1 \qquad (1)$$

where P is the Probability of the family using LPG (odd of y being equal to 1). The Probability of the participant is calculated using the following formula:

$$Pi = eLi/\,(1+ eLi) \qquad (2)$$

On examining the probabilities, it is noticed that there is a slight drop in the probability of using LPG as a source of fuel as the number of members in the family increase. The reasons attributed to this are more the number of people, more cooking requirement hence more requirement of fuel ultimately leading to higher cooking costs. Families hence engage in fuel stacking to keep a check on their expenditure in terms of cooking fuel. The below graph highlights indicative probabilities of a household using LPG as a fuel and the decreasing trend in probabilities as the number of family members increase.

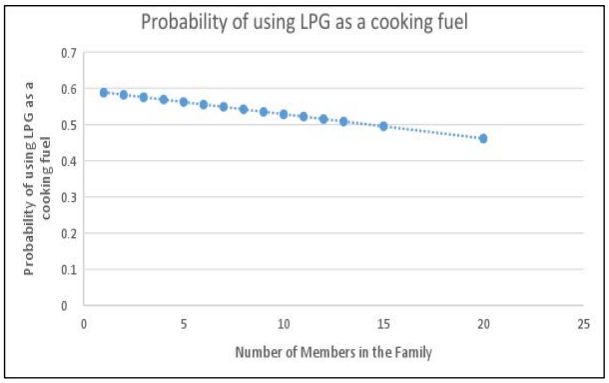

Figure 2: Graphical Representation of The Probability of Using LPG as Cooking Fuel Based on The Household Size

In terms of fuel choice, it is found that LPG, Firewood and Kerosene are highly used with 42%, 29% and 22% households using them as primary fuel while electric heaters, charcoal

are least preferred with negligible percentage of households using those. Past studies on fuel choice highlight the importance of household characteristics in determining the fuel options used. Most studies have hinted towards household size as being an important metric in determining the fuel choice.

Multinomial logistic regression was used to understand how significant types of houses are in determining the usage or non-usage of LPG. There are 3 kinds of houses which the families live in kuccha, pukka and semi pukka houses. A key finding in terms of trends in LPG usage amongst the BPL population revealed that the consumers are concerned about the safety issues which are associated with the usage of LPG. In kuccha and semi pukka households there are cases where there is no separate kitchen facility available and cooking is done inside or outside the house. The fear is that children might have access to such places and hence deemed to be unsafe. By means of logistic regression we will arrive at probabilities of using or not using LPG based on the type of the house. In this case we conduct a multinomial logistic regression where we use the number of members in the family as a continuous independent variable
Dependent Variable: Users and Non-users of LPG coded as 1 and 0 respectively (Categorical) Independent Variable: Number of members in the family (Continuous) Independent Variable: Type of house- Pukka, Semi Pukka and Kuchha (Categorical). Firstly, we test the null hypothesis that there is no difference between the null and the final model versus there is a difference between the null and the final model. The null model contains the intercept only and does not consider the independent variables whilst the final model consists of the intercept and the independent variables. On testing the level of significance, we see that there is a significant difference between the null and the final model and hence we reject the null hypothesis concluding that there is a significant difference between the null and final model.

Table 1. Model Fitting Information Based on Multinomial Logistic Regression

Model	**Model Fitting Criteria**	**Likelihood Ratio Tests**		
	-2 Log Likelihood	**Chi-Square**	**Df**	**Sig**
Intercept	183.313			
Final	109.357	73.955	3	.000

From the Model Fitting Information, we conduct the likelihood ratio test of the final model against the null model. The Chi square statistic value of 73.955 is the difference between -2 log likelihoods of the Null and the final models. In this case the significance level is less than 0.05 hence we can conclude that the final model with all the parameters is better than the null model.

Table 2. Pseudo R Square Values

Cox and Snell	.059
Nagelkerke	.079
McFadden	.044

From the Pseudo r square values, we can understand that these independent variables are not enough to build the predictive model and we need to consider more/other independent variables to build a robust model.

Table 3: Goodness of Fit Results Based on Multinomial Logistic Regression

	Chi-Square	**Df**	**Sig**
Pearson	28.155	25	.30
Deviance	29.567	25	.24

From the likelihood ratio test results, we can determine which variables in logistic regression are highly significant in determining the usage and non-usage of LPG. While as we noticed earlier numbers of members in the household do have a major impact on the LPG usage, the type of house that they stay in does have a major impact on their LPG usage decision because it is also tied to their economic status.

Table 4: Likelihood Ratio Test Results Based on Multinomial Logistic Regression

Likelihood Ratio Tests				
Effect	**Model Fitting Criteria**	**Likelihood Ratio Tests**		
	-2 Log Likelihood	**Chi-Square**	**Df**	**\Sig**
Intercept	109.357[a]	.000	0	.000
Family size	109.582	.225	1	.635
House	182.512	73.155	2	.000
The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.				
a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.				

From the parameter estimates we can determine the regression equation and the probability of LPG usage as it changes with change in type of house and the number of family members. The parameter estimates come up to be -1.932 for Pukka House and -1.830 for Semi Pukka and the significance level of these estimates is 0.00 hence they are highly significant.

Table 5. Parameter Estimates from The Multinomial Logistic Regression

Usage/Non-usage		**B**	**Std. Error**	**Df**	**Sig.**
0.00	Intercept	1.346	.297	1	.000
	Family Size	0.19	.041	1	.636
	Pukka	-1.932	.280	1	.000
	Semi Pukka	-1.830	.247	1	.000
	Kuchha	0[b]	.	0	.

Cluster analysis was done to create homogenous groups of LPG users and non-users. Cluster Analysis is a grouping technique wherein based on a given set of conditions we divide the sample into homogenous sub groups based on a few independent variables. Cluster analysis coupled with discriminant analysis helps us in determining the variables which are keys in determining the composition of the homogenous groups. Such independent variables are called cluster variates. In this study we attempt cluster analysis where we build two clusters using SPSS based on usage and non-usage of LPG. The variables used for clustering are:

(1) Social status i.e. Scheduled Caste, Scheduled Tribe, Other Backward Caste, General and Minority (2) Monthly Income i.e., greater than 2000, greater than 5000 and greater than 10000 (3) Economic Status i.e., Above Poverty Line, Below Poverty Line, Ration Card holders, Antodaya and Others

(4) Approximate Time spent on cooking is as per the data shared by the households

Table 6. Cluster Analysis Results

	Cluster		**Error**		**F**	**Sig**
	Mean Sq.	**Df**	**Mean Sq.**	**Df**		
Social Status	10.077	1	1.337	550	7.536	.006
Monthly Income	762.5	1	1.268	550	601.59	.000
Economic Status	0.228	1	0.358	550	0.636	.425
Time Spent on Cooking	0.004	1	0.383	550	0.012	.915

The final cluster centres after the considering the iterations focus on two clusters the non-users of LPG are the low-income group households from the scheduled tribe social status and the users of LPG are the medium to higher income households from the other backward caste categories. The first cluster is more prone towards using firewood as the primary means of cooking while there is a significant population which uses LPG as well but that is one of the multiple fuel choices that they keep available for themselves. These findings are consistent with the past studies although social status was not used as a metric, the reason attributed to this will also be that most of the studies were conducted in regions other than India where social status is not as profound as in India. Social status in

Indian households determines the ghettos that they stay in and also their tastes and preferences.

3. DISCUSSION

Research Aim 1: Is family size i.e. number of members in a family a factor in determining the fuel choice of a household?

By statistical analysis we arrive at the conclusion that family size is not significant in determining a household's energy choice however the probability of household using LPG as a cooking fuel reduces as the family size increases. The reason attributed to this finding could be that households indulge in fuel stacking especially when the family size is bigger. While households do use LPG as a source of cooking fuel, it is not the only source of cooking fuel. However, the impact of this variable is not highly significant although this variable cannot be rejected outright as a deterministic variable. When the size of household increases they tend to stack different fuel types such as charcoal, kerosene to meet the increasing energy demand (Ngui et al., 2011). A household which is larger and has many females often means that the opportunity cost is low to collect firewood and there is increased potential of fuel stacking. (Van der Kroon et al., 2013 and Narasimha and Reddy, 2007, Heltberg, 2004).

Further examining the data, we also found that amongst the households who use LPG as a cooking source, 40% of the households use 5-kilogram LPG cylinders while 60% use 14.2-kilogram cylinders. The extensive use of the small cylinders is also indicative of households stacking fuel, while they use LPG as one source it may or may not be their primary source of cooking fuel. The findings from this study are consistent with the past surveys and we can safely conclude that household size continues to be a metric which determines the fuel choice options of the households. Households continue stacking fuel options which ensure energy stability and reduce vulnerability towards fluctuating disposable income and the fuel prices

Research Aim 2: Does type of house i.e., pukka, semi pukka and kuccha impact the choice of fuel by a household?

Intuitively we could say that a household's income determines the type of house that they live in; however, this is not completely true in case of this survey and probably in the case of BPL population residing in the slums of the developing countries. The reason attributed to this finding could be that families sometimes tend to stay in the same houses even if their income increases, there is a kind of social inertia and geographical affinity to locality in these cases which prevent them from moving to other areas. Hence, economic status at times cannot be deterministic of the type of house that a family resides in. This variable is important in determining whether the household would use LPG or not since they cited safety as a reason for not using LPG. In semi pukka and kuccha houses there are at times no separate kitchen/ cooking area and cooking is primarily carried outside the house which prevents the household from using LPG. They also believe that it is not safe to cook within the house with children around and hence the results also predicted that the probability of using LPG is highest in pukka houses followed by semi pukka and lastly kuccha. In a study by Pundo and Fraser (2006) in Kisumu District of Kenya the findings were that household fuel choice depends on whether the household dwelling unit is traditional or modern type of house and also whether or not the household dwelling is owned.

Research Aim 3: Can the household's using LPG and not using LPG be grouped in homogenous clusters based on the social status, economic status, monthly income, and time spent on cooking?

Basically, to answer the question, if these variables are significant in determining which subgroup i.e., users or non-users household would fall into. To group households into homogenous clusters we use a set of variables to understand which ones are significant in determining whether the household would or would not use LPG as a cooking fuel. Social

status and monthly income came out as significant variables while approximate time spent on cooking and economic status were not significant in determining the household's energy choice. Social status is important in homogenous grouping because below poverty households tend to live in common ghettos and have similar taste and preferences in cooking hence they could be grouped into categories based on the parameter. Similarly, various income brackets tend to have similar behaviour and hence there is homogeneity in such brackets. Understanding occupation as metric is important because intuitively and by qualitative analysis we can determine that majority of these occupations have a sporadic income flow. We will use this understanding later in our study. Only 3% of the sample is occupied by service and 7% by private job which ensures a stable income. Around 58% of the sample households earn between INR 5000 to 10000 while 12% of the households are earn around 2000 to 5000 Indian Rupees per month. Hence, we can conclude that most of the households are in the low-income bracket and have a low per capita income given the household size of the sample.

However, it could come as a surprise that economic status is not significant while monthly income is significant in determining the household's energy choice, the reason being the economic status i.e., BPL, ration card, Antodaya etc. is not always authentic, people tend to forge documentation to receive the benefits and many a times these statuses are not updated as per the latest economic condition of the families. Hence, they cannot be used as a determining variable in such studies. Lastly approximate time spent on cooking is also not a driving factor because the families may not have reported the right time durations and sometimes cooking is done in phases which make it difficult for any household to report the right time for the survey and they tend to approximate the time.

By performing a K mean cluster analysis, we arrive at a conclusion that along with type of social status and monthly income is significant in determining the fuel choice. While in previous studies it was highlighted that households consider the opportunity cost of time in determining fuel choices, in our study that is highly insignificant, and the approximate time spent on cooking does not influence a household's energy choice in any way. Social status is a key determinant of the household characteristics i.e., taste and preferences in cooking, type of cooking etc. and hence from the level of significance we can clearly conclude that it is of great importance in determining the fuel choice. Economic Status of APL, BPL, Ration Card etc. in the poorer households is sometimes not correctly assessed, the reasons being sporadic income, lack of appropriate data etc. and hence that cannot be used as a metric to arrive at any conclusions. The findings are consistent with the study on urban households in Bauchi Metropolis in Nigeria (Bisu et all, 2016) where the type of dwelling and socio-economic status was key in determining the fuel choice of households.

4. CONCLUSION AND FUTURE IMPLICATIONS

From this study we can safely arrive at a conclusion that household characteristics are of great importance in determining the fuel choice of the households in urban BPL families. Previous studies by (Jain et al., 2014, Lucon et al., 2004, Yadem 2013) reported that in rural household income play a significant role on adoption and use of LPG. The likeliness that a household would start using LPG would increase with an increase in their income but as we have seen in our analysis household characteristics play a major role in determining the fuel choice. Socio economic conditions govern the fuel choice of the households. Size of the households, social status is important in this study since they model the attitude of the households towards cleaner fuels. Fuel stacking came as a strong behaviour given lower income households tend to stack multiple sources of energy to add on to their energy security and reduce their vulnerability towards fluctuations in fuel

prices. Policy makers would have to focus on the socio-economic characteristics to reach the bottom of the issue of probing lower income households to use clean fuel for cooking. The study has also shed light on the awareness aspect of the households where they have cited reasons such as “unsure about safety” in using LPG. Policy makers would have to focus on all these aspects to promote usage of cleaner fuels. To conclude that this is a multi-pronged effect wherein policy makers have.

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