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Determinants of households' choice of energy for lighting in Nepal

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Abstract

The paper identifies the determinants of energy choice for lighting in Nepal by applying a multinomial logit regression to a nationally representative set of household level data. It has been found that the richer households use better quality source of energy, confirming the energy ladder hypothesis. The other significant determinants of energy choice for lighting in Nepal are: gender and education level of the heads of households, family size and proportion of dependent population in families, distance from the market and location of households. The paper suggests the utilisation of the potential of micro hydropower plants for supplying clean energy in the remote areas of Nepal.

Keywords: lighting; energy; determinants; Nepal
JEL Classification Codes: Q40, Q41

1. Introduction

Every day when the sun sets, lighting becomes one of the most important requirements of human beings. Marking of the year 2015 as the "International Year of Light and Light-based Technologies" by the United Nations and the fact that the 2016 global multidimensional poverty index (MPI) considers a household without electricity as deprived, underscores the importance of lighting for human development.

Given the importance of lighting for human development, the question of what determines households' choice of lighting energy becomes pertinent. Following from the theory of consumer demand, the quantity and choice of energy would depend on its own price, prices of the substitutes, income, taste and preferences and so on. The Energy Ladder Hypothesis (ELH) suggests that, *ceteris paribus*, with the rise in income, households switch from inferior to better quality energy (Hosier and Dowd, 1987; Leach, 1992). However, the ELH has been criticized

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for it assigns overwhelming importance to income as a determinant of households' energy choice decision (Masera et al., 2000; Koswari and Zerriffi, 2011). Masera et al. (2000) provided an alternative model, termed as "fuel stacking model (FSM)", suggesting that with the increase in income, households use modern energy but rarely abandon the traditional energy options.

Besides income, factors such as household size; gender, education level and age of the head of the households; family composition in terms of proportions of female, children and old members; urbanization; availability and accessibility can influence the choice of energy use (Masera et al., 2000; Rao and Reddy, 2007; Heltberg, 2005; Nnaji et al., 2012; Rahut et al., 2014). Distance from markets, the existence of road infrastructures and energy distribution channel also have a direct impact on energy choice (Koswari and Zerriffi, 2011). Reliability of energy supply and high installation cost are also important determinants of energy choice (Masera et al., 2000; Koswari and Zerriffi, 2011). Government policy of promoting or discouraging the use of a particular type of energy may also influence the choice of it.

In the context of Nepal, the main sources of energy for lighting are: kerosene, biogas, solar and electricity (Table 1). While electricity is the main source of energy for lighting in both rural and urban Nepal, it is important to note that in rural Nepal, around 17.87 per cent population depends exclusively on kerosene. Thus, there is a need to understand as to what determine households' choice of energy for lighting which will help to design appropriate policy for a transition especially of rural Nepal to cleaner energy and to reduce rural-urban divide in its use. As of now, literature on this area focusing exclusively on entire Nepal is scanty. Consequently, this paper identifies the determinants of households' energy choice for lighting in Nepal, verifies the ELH and endeavours to provide policy-insights for Nepal's energy planning.

2. Data and methodology

The study used the latest round (2010/11) of the nationally representative Nepal Living Standard Survey (NLSS) data.

The present study uses multinomial logit model (MNL) to identify the determinants of households' choice of energy in line with the most common methodology used and applied in the context of diverse countries. Some of such studies are: Adeyemi and Adereleve (2016) [Nigeria]; Heltberg (2004); Hosier and Dowd (1987) [Zimbabwe]; Jumbe and Angelsen (2011) [Malawi]; Lay et al. (2013) [Kenya]; Nlon and Karimov (2015) [Cameroon]; Rahut et al. (2014) [Bhutan]; Reddy (1995) [India], and Rao and Reddy (2007) [India]. In the MNL model, out of j^{th} ($j = 1 \ldots m$) categories of the dependent variable, one category is considered as a reference category and the probability of choosing other categories is compared to the probability of choosing the reference category. If the first category is the reference category, for $j = 2 \ldots m$, the predicted log odds will be given by:

$$\mathrm{Ln}[p(Y_{j=2 \ldots m})/p(Y_{j=1})] = \alpha_j + \sum_{k=1}^{K} \beta_{jk} X_{ik}, \quad (1)$$

where, X_{ik} is a set of explanatory variables, β_{jk} are corresponding unknown population parameters, α is the constant term, and Y_j is the categories of energy options. Exponentiation of predicted log odds for $j = 2 \ldots m$ gives the respective probabilities. By deducting the sum of probabilities for $j = 2 \ldots m$ from one, the probability of the reference category can be obtained. In this paper, the dependent variable is a discrete category of the energy options, viz. electricity, solar, biogas, kerosene and other, as shown in Table 1. Here the base category energy is electricity.

Table 1. Sources of energy for lighting in Nepal (in %)

Energy Options	*Rural (N=3900)*	*Urban (N=2088)*	*Total (N=5988)*
Electricity	61.18	96.46	73.48
Solar	7.77	0.00	5.06
Biogas	0.10	0.00	0.07
Kerosene	17.87	2.83	12.63
Other	13.08	0.72	8.77

Source: Authors' computation using NLSS, 2010-11.

The explanatory variables included in the model are:

- *Household income:* represented by proportion of per capita non-food expenditures to total consumption expenditures.
- *Age:* age of the head of the household.
- *Female headed household:* it is a dummy variable with D =1 for female headed household; D = 0 otherwise.
- *Proportion of dependent members:* proportion of family members below 15 years and above 60 years of age.
- *Family size:* number of members of family.
- *Education:* education level of the head of the household
- *Distance from market:* time to reach market in minutes.
- *Access to electricity:* it is a dummy with D = 1 if the household has access to electricity; D = 0 otherwise
- *Rural households:* it is a dummy with D = 1 for rural household; D = 0 otherwise.
- *Locational dummy:* taking hill region as the benchmark category, two locational dummies have been incorporated, viz. D1=1 if household is in mountain region and D1 = 0 otherwise; D2 =1 if the household is in terai region and D2 = 0 otherwise.

3. Results and discussion

The estimated multinomial logit coefficients are shown in Table 2.

The coefficients of the proxy for household income are negative for kerosene, solar and others implying that with an increase in income, households are less likely to use these sources of energy relative to electricity which is the source of better quality energy given available options. These results are in conformity with the ELH.

Compared to male headed households, female-headed households are likely to prefer electricity to kerosene. In the context of Nepal, since the women usually handle the household chores, a convenient and cleaner energy is chosen when they are in decision making position. However, a female headed household is more likely to prefer biogas over electricity. This might happen due to lack of access to electricity. As far as the family size is concerned, the log of odds of using solar increases and that of using kerosene decreases compared to electricity as size of family increases. However, households with higher proportions of dependent members are more likely to use kerosene than electricity. Level of education of the head of the household is also a significant determinant of energy choice. Education level of the household head is negatively associated with the likelihood of choosing kerosene as compared to electricity. With the increase in level of education, purchasing power and awareness level also improves and preference for cleaner and more efficient energy increases. On the other hand, it has been found that access to electricity makes the use of all other available sources of energy significantly unlikely.

Table 2. Estimation of energy choice for lighting

Explanatory Variables	*Solar*	*Biogas*	*Kerosene*	*Others*
Income proxy	-1.57**	-8.47	-5.61***	-6.46***
	(0.62)	(5.24)	(0.43)	(0.57)
Age of HH head	-0.03	5.94	0.04	-0.03
	(0.03)	(3.90)	(0.02)	(0.03)
Female headed HH	-0.05	3.29*	-0.44***	-0.15
	(0.20)	(1.71)	(0.13)	(0.16)
Dependent population proportion in family	-0.18	-0.02	1.05***	0.77***
	(0.35)	(2.59)	(0.22)	(0.28)
Family size	0.13***	0.37	-0.06***	0.01
	(0.04)	(0.23)	(0.02)	(0.03)
Education level of HH head	-0.02	-0.28	-0.12***	-0.11***
	(0.02)	(0.50)	(0.02)	(0.02)
Distance from market	-0.01**	0.00	0.00	0.00
	(0.01)	(0.04)	(0.00)	(0.00)
Access to electricity	-4.65***	-3.29**	-2.38***	-3.49***
	(0.28)	(1.28)	(0.10)	(0.15)
Rural household	17.00	14.37	0.78***	1.14***
	(900.06)	(2677.83)	(0.16)	(0.29)
Locational dummy				
Mountain region	0.45**	-18.08	-0.34*	-0.17
	(0.22)	(11558.41)	(0.21)	(0.21)
Terai region	-3.00***	-18.11	0.25**	-1.57***
	(0.32)	(3022.44)	(0.11)	(0.16)
Constant	-15.50	-154.13	0.98	2.80***
	(900.06)	(2679.31)	(0.63)	(0.77)

Number of observations = 5979
Log likelihood = -3080.75
LR chi2(48)= 4096.22
Prob> chi2 =0.00
pseudoR^2 = 0.40

Note: The coefficients represent log of odds.* p<.1; ** p<.05; *** p<.01; figures in the parenthesis are standard error.

Meanwhile, compared to urban households, rural households are more likely to use kerosene relative to electricity which may be due to lack of either accessibility or affordability. Further, distance to market makes the choice of solar less likely compared to electricity, the reason for which may be higher costs of transporting solar appliances to distant places. Geography also has a significant effect on the choice of energy for lighting. Compared to the hilly region, while the likelihood of using kerosene is lesser and that of using solar is more than the electricity in the mountain region, the opposite is the case in the terai or plains.

4. Conclusion and policy implications

Using nationally representative NLSS, 2010-11 data, the study has identified the determinants of energy choice for lighting in Nepal. The finding of the study confirms the Energy Ladder Hypothesis. Apart from income, the other important determinants of energy choice for lighting are: gender and education level of the head of households, family size and proportion of dependent population in families, distance from the market, access to electricity and location of households.

The major finding of the econometric analysis is that as the income and access to electricity increase, households tend to use more electricity relative to other sources of energy for lighting. Electricity is in fact the dominant source of lighting energy in rural and urban Nepal. At the same time, it is interesting to note that around 18 per cent of households in rural areas still depend on kerosene. Connecting all households to the national electricity grid system is a challenge in Nepal due to scattered settlement and geographically remote terrain, and thus will require time and sometimes exorbitant cost. Solar is being seen as a long-term cost efficient solution (Bhattacharya, 2006; Bhandari and Stadlere, 2011; KC *et al*., 2011). At present, however, only negligible portion of rural households in Nepal use solar energy. In fact, the households prefer electricity to solar with the rise in their income. The reason may be the diversified end uses of electricity compared to solar. Under such circumstances, pico (electricity generation capacity up to 10 KW) and micro (electricity generation capacity of 10 to 100 KW) hydropower plants can be an immediate viable option, especially in many remote hills and mountains of Nepal which have plentiful fast flowing water bodies suitable for such projects. As of now, about 3300 such hydropower plants have been generating close to 30,000 KW of installed capacity to provide electricity for about 350,000 households in the hills and mountains of the country (NMHDA, 2017). There is, however, still large scope of promoting such hydropower plants in many areas. Government may consider providing financial assistance to communities to set up such micro hydropower plants and take their ownership. Government of Nepal in collaboration with international agencies has indeed taken certain steps to improve the status of electricity generation in the country. However, more administrative efficiency in this regard is warranted, especially for the establishment of medium and large scale power projects as a long –run solution to overcome the current electricity shortage in the country.

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