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Energy Elasticity in India: An Empirical study with Unit level Household Data

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Introduction

Household energy expenditure depends on many factors, from the availability and pricing of goods and services to household income. The level of income of the households ensures the minimum energy requirements in the society. There are differences in the patterns for individual energy items within the group at Household level expenditure. At any given point in time, households rely on a range of fuels that encompasses at least two steps of the energy ladder (Barnes and Qian 1992, Hosier and Kipondya 1993, ESMAP 1994, Eberhard and Van Horen 1995). Most of the households gradually ascend an energy ladder as their household income or expenditure increases (Albouy and Nadifi 1999). The ladder begins with biomass fuels (firewood and charcoal), moves to modern commercial fuels (kerosene and LPG), and culminates with electricity. In many developing countries, fuel switching and ascending on energy ladder in the household level has been also observed (Leach 1992, Sathaye and Tyler 1991, Smith et al 1994, Reddy and Reddy 1994). With increasing income levels and urbanisation in the society, there is an improvement in efficient fuels, and energy end use equipment to more efficient fuels, electricity and equipment. The reasons observed are varied and not only depend on economic factors but also the affordability or cost of the energy services. In some cases, households choose to use more than one fuel because they want to increase the security of supply. In other cases, the choice of energy source depends on cultural, social or taste preferences (Pachauari and Spreng, 2004).

The affordability of the different energy types for households depend on the market prices of the energy sources (Dutt and Ravindranath 1993). In rural areas various types of fuelwood as well as dung, crop residue, and even tree leaves are

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used for cooking (Asaduzzaman, Barnes and Khandker 2010). Some households used firewood chips or dung cake as there is no monetary cost associated with these items but still it involves opportunity cost in terms of the value of the time spent in collection of these fuels and also it can be collected from nearby forests, common lands or private lands individually. Majority of the households in rural India still depend on biofuels and women spend a lot of time on collecting fuel wood. (Laxmi et al 2003). They mostly use a variety of fuels, e.g., in north India, it is fuelwood, animal dung and crop residues to meet their daily cooking fuel requirements. Kerosene is used primarily for lighting and electricity is another important lighting source. The total cost fuel wood remains an attractive option for households as compared to LPG, because of the high capital cost of LPG stoves (Reddy 2003). This has serious economic implications as precious time of household members is wasted in collecting low quality fuels, which reduces their efficiency and ability to engage in economic activity required for improving their livelihoods (Reddy 2004).

At household level fuel for lighting and cooking as a group is a necessity but various types of fuels have been used at household level and households preferred fuel according to their income or expenditure. Also as income increases, the other factors like availability of goods and services and various characteristics of the household e.g. household size, gender and age of the family members, and personal tastes influence household expenditure patterns. Household income and consumption expenditure are monetary measures used in assessing the economic well-being of population. However, energy consumption is preferred to income or expenditure as it reflects long-term economic status of the households. It is important to note that expenditures are not similar with income, which may even be a better indicator of well-being, for various reasons. At the same time all the regions are not equally endowed with different types of energy resources. Some regions in the world are well endowed with different patterns of energy resources. Undoubtedly, the energy mix in any nation or region is impacted by the level of development, environmental consideration, domestic resources, technological advancements and increasing trade in energy resources. Despite the overall increase in energy demand, per capita energy consumption in India is still very low compared to other developing countries. The Government of India in the mid-term review of the Tenth Plan recognized the fact that under-performance of the energy sector can be a major constraint in delivering a growth rate of 8% GDP during the plan period (Planning Commission). Hence, it is of utmost importance to understand the pattern of energy demand at household level in terms of energy use by household in the economy. In the light of above the data and econometric methodology have been

presented in section II. Section III consists of Empirical results and section IV represents conclusion.

II. Data and Econometric Methodology:

There are vast range of studies available for estimating elasticity. Some of them are based on household data for food and non-food items consume in the household. Very limited studies has found on elasticity of energy for cooking and lighting used at household level. By using Engel curves within the context of an additive utility function (Kelin-Rubin) Ross (1976) estimated price response for various commodities in Australia. Williams found that subsistence expenditure rises and the absolute values of the own price elasticity falls for fuel as family size increases. Ali (1985) developed elasticity by applying extended linear expenditure system using 1979 Pakistan household income and expenditure survey. The price elasticities of different fuels are found at very low level. Burney and Akhtar (1990) estimated price and income elasticity of household level in Pakistan by using household income expenditure survey (1984-85) data. Price elasticity and income elasticity have been estimated by using ELES. They found that all fuels are a necessity for both rural and urban households. Gundimeda and Kohlin (2006) used the Linear Approximate Almost Ideal Demand System (LA-AIDS) by using NSSO (1999) data. Price and expenditure elasticities of demand for four main fuels are estimated for different income groups in rural and urban areas. Rising per capita income and higher energy prices have played an important part in the consumption of energy.

In India at household level seven different fuel sources have been considered for the energy for cooking i.e. coal/coke, firewood and chips, LPG, gobar gas, dung cake, kerosene and electricity and also five different types of fuel have been considered for lighting i.e. kerosene, other oil, gas candle and electricity (NSSO 2001, 2005, 2007 and 2008). The present study focuses on the patterns of energy consumption in terms of fuel and light at household level. In the next section data and econometric methodology has been presented

In the present study the elasticity at household level in terms of expenditure on energy is measured on the basis of 66^{th} quinnquenial round. Expenditure in terms of Rs. on Coke, Firewood and chips, Electricity (std. unit), Dung cake, Kerosene – PDS (litre), Kerosene – other sources (litre), Matches (box), Coal, LPG , Charcoal, Candle (no.), Gobar gas, Petrol (litre) , Diesel (litre) , Other fuel, Fuel and light (Total) and total expenditure of households based on uniform reference in rural urban areas has been taken. For the purpose we have used the household consumption expenditure 66^{th} round (quinnquenial round) conducted by

NSSO. In this round of NSSO survey, 59119 households from rural and 41736 households from urban areas have been surveyed.

It is well known that the expenditure elasticity of demand for a commodity is the ratio of the proportionate change in the expenditure on a particular good or service to the proportionate change in total income or expenditure. Given this definition, goods with income or expenditure elasticity of demand below zero, between zero and one, and above one are called 'inferior goods', 'necessities', and 'luxury goods' respectively. Elasticities can themselves vary with income. A good that is a necessity for the rich can be a luxury for the poor. The demand system considered is based on maximisation of the Klien and Rubin (1947-48) utility function (Ross 1976). Based on survey data, Iyenger (1960, 1964 and 1967), Iyengar and Jain (1974), Gupta (1968 and 1973), Jain (1983), Shahabuddin (1989), Burney and Khan (1991), Talukder (1993) and Upender (1999) made an attempt to estimate household consumption pattern and elasticity at household level in India, Pakistan and Bangladesh. The typical cross section data contains no price information and it is necessary to assume all households face the same set of prices. If the income of households replaced by expenditure of household E_h, then,

$$E_{ih} = \alpha_i^* + \beta_i^* E_h + u_{ih} \quad \ldots\ldots (1)$$

u_{ih}, is error term, E_{ih} is expenditure on i[th] commodity of the household. And α_i^* is intercept and $\beta_i^*$is slope coefficient (marginal propensity to consume). Introducing dummy variable d (0 for rural and 1 for urban) in the above regression for measuring rural urban difference in Marginal Budget Share, minimum required expenditure and energy elasticity at household level. The regression model

$$E_{ih} = \alpha_i^* + \vartheta_i d^* + \beta_i^* E_h + \theta_i^* d^* E_h + u_{ih} \quad \ldots\ldots (2)$$

Here for rural region

$$\alpha_i^* = \gamma_i^* - \beta_i^* \sum_{j=1}^{n} \gamma_j^* \ldots\ldots (3)$$

$$\sum_{j=1}^{n} \gamma_j^* = {\sum_{j=1}^{n} \alpha_j}\Big/{(1-\mu)} \ldots\ldots (4)$$

Minimum required expenditure in rural region

$$\gamma_i^* = \alpha_i + \beta_i \sum_{j=1}^{n} \gamma_j^* \ldots\ldots (5)$$

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And for urban region;

$$\alpha_i^* + \vartheta_i{}^* = \gamma_i^* - \beta_i^* \sum_{j=1}^{n} \gamma_j^* \ldots\ldots (6)$$

$$\sum_{j=1}^{n} \gamma_j^* = {\sum_{j=1}^{n}(\alpha_j + \vartheta_j)}\Big/{(1-\mu)} \ldots\ldots (7)$$

Minimum required expenditure in urban region

$$\gamma_i^* = \alpha_i + \vartheta_i + \beta_i \sum_{j=1}^{n} \gamma_j^* \ldots\ldots (8)$$

β_i^* is slope coefficient (marginal propensity to consume) in rural region. Aggregate marginal propensity to consume is as, $\sum_{j=1}^{n} \beta_j^* = \mu$, ($\beta_i^*$, representing the marginal propensity to consume for the i[th] goods.)

Marginal Budget Share for rural region is

$$\beta_i = \frac{\beta_j^*}{\sum_{j=1}^{n} \beta_j^*} \ldots\ldots (9)$$

For urban region $\beta_i^* + \vartheta_i$ is slope coefficient (marginal propensity to consume). Aggregate marginal propensity to consume is as, $\sum_{j=1}^{n} \beta_j^* + \vartheta_j = \mu$, ($\beta_i^*$, representing the marginal propensity to consume for the i[th] goods.)

Marginal Budget Share for urban region is

$$\beta_i = \frac{\beta_j^* + \vartheta_j}{\sum_{j=1}^{n} \beta_j^* + \vartheta_j} \ldots\ldots (10)$$

Expenditure elasticity based on estimated parameter of regression equation;

$$\eta_{ie} = \left(\frac{\beta_i}{\mu}\right) * \left(\frac{E_h}{E_{ih}}\right).$$

Price elasticity of total expenditure; $\eta_{ei} = (1-\mu)\left({\gamma_i^*}/{E}\right)$.

Thus, in the light of above methodology in the preceding section results of the study has been presented.

IV. Findings of the Study

Table 1 represents average expenditure on various energy items used by the households. Average expenditure on fuel recorded in rural and urban areas 87.79

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and 142.76 respectively. Facts reveals that ile average expenditure is low in rural areas than in urban areas. Average expenditure on for electricity and LPG (i.e. for clean fuel) at household level is also higher. The cost of using clean fuel is higher than dirty fuel and also these fuels are not easily available. This is the reasons that in rural areas household still depending on traditional sources of energy.

Table 1: Average Expenditure on various items on Energy consumed at household level.

Items	Average Expenditure	
	Rural	Urban
Coke	0.179	0.415
Firewood and chips	41.104	12.407
Electricity (unit)	19.076	72.69
Dung cake	7.628	1.748
Kerosene – PDS	5.506	3.027
Kerosene – other	2.152	4.300
Matches (box)	1.414	1.208
Coal	0.392	0.881
LPG *	7.490	43.229
Charcoal	0.033	0.160
Candle (no.)	0.522	1.065
Gobar gas	0.104	0.004
Petrol (litre) *	0.091	0.396
Diesel (litre) *	0.117	0.066
Other fuel	1.985	1.165
Fuel and light (Total)	87.792	142.759
All Households	927.704	1785.815

Note: Calculated on the basis of 66th round unit level data and methodology in section III, *excluding conveyance and MPCE at uniform reference period.

Marginal Budget Share, minimum required expenditure of the households in rural and urban areas has been estimated with the help of regression equations (5-12) and presented in the table 3. In this table slope and intercept are also presented which is calculated with the help of dummy variables as presented in the regression equation presented in methodology. Minimum required expenditure in rural and urban areas are 79.23 and 122.24 but average expenditure is 87.79 and 142.76 (Table 2) respectively. The fact revels that there is need of economical uses of energy resources at household level. Government

as well as non-government organization initiate steps for the proper utilisation of these resources. In rural areas, minimum required expenditure on diesel (not included for travel purpose) is negative which shows that these are non-essential energy resources for households. Marginal budget share for rural and urban areas is 0.50 for total fuel and light. Result reveals the fact that minimum required expenditure is higher in rural areas for firewood and chips while in urban areas for electricity.

All India rural and urban expenditure and price elasticity of various items used at household level calculated with the help of models presented in section II and presented in table 3. Expenditure elasticity for fuel and light is higher in urban areas (6.3) while price elasticity is higher in rural areas (0.08). Expenditure elasticity on different energy resources is higher in rural areas than urban areas excluding other fuels. Expenditure elasticity for electricity and LPG in rural areas are 10.5 and 22.9 respectively while in urban areas 9.4 and 6.4 respectively. The elasticity of total household expenditure with respect to prices of fuel and lights indicates that if prices of all products of fuel and light increased by 100 percent, then the total expenditure of the household in rural region will increased by Rs. 8.35 and in urban region the value is Rs. 6.66 based on uniform reference period keeping other factors constant. Price elasticity for firewood and chips is having maximum value (0.0425) in rural areas and for electricity price elasticity is having maximum value (0.0311) in urban areas. Price elasticity of total expenditure with respect to fuels and light indicates that firewood and chips will affect more household expenditure in rural areas and electricity will affect more in urban areas if price increases by 100 percent.

V. Conclusions and Policy Suggestion:

The present paper examined the patterns of household expenditure on all the energy resources for cooking and lighting in rural and urban areas. Household responsiveness to a change in household expenditure and prices of energy resources for cooking and lighting based on 66^{th} quinnquenial round of NSSO unit level data has been calculated. Household level consumption of energy resources for cooking and lighting consists of household expenditure on (in terms of Rs.) on Coke, Firewood and chips, Electricity (std. unit), Dung cake, Kerosene – PDS (litre), Kerosene – other sources (litre), Matches (box), Coal, LPG , Charcoal, Candle (no.), Gobar gas, Petrol (litre) , Diesel (litre) , Other fuel, in the NSSO 66^{th} rounds. For calculating minimum required expenditure and elasticity a dummy variable approach has been used.

Average expenditure recorded on energy for cooking and lighting in urban areas is higher than in rural areas. The expenditure patterns of rural households

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reveal that household spending has been proportionally more on firewood and chips is more in rural areas and LPG in urban areas (for cooking). As far as lighting is concerned electricity becomes primary source of lighting. Also, one important fact has been found that majority of the households are using dirty fuel for cooking in rural areas while in urban areas clean fuel i.e. LPG is used for cooking.

Table 2: Slope (β), Intercept (α), Marginal Budget Share and Minimum Required Expenditure of various energy items used at household level for all India Rural and Urban region.

Items	Slope (β)		Intercept (α)		Marginal Budget Share		Minimum Required Expenditure	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Coke	0.00002	-0.00003	0.162	0.477	0.0008	-0.0013	0.165	0.468
Firewood and chips	0.00104	-0.00083	40.141	13.886	0.0466	-0.0311	40.306	13.684
Electricity (unit)	0.00478	0.01017	14.638	54.537	0.2150	0.3817	15.396	57.022
Dung cake	0.00026	-0.00015	7.382	2.023	0.0119	-0.0058	7.424	1.986
Kerosene – PDS	-0.00003	-0.00019	5.529	3.359	-0.0012	-0.0070	5.525	3.313
Kerosene – other	0.00016	-0.00010	2.001	4.475	0.0073	-0.0037	2.027	4.451
Matches (box)	0.00007	0.00001	1.351	1.192	0.0030	0.0003	1.362	1.194
Coal	0.00003	-0.00007	0.362	1.004	0.0014	-0.0026	0.368	0.988
LPG *	0.00411	0.00411	3.677	35.886	0.1848	0.1544	4.328	36.891
Charcoal	0.00001	-0.000001	0.026	0.162	0.0003	-0.0001	0.027	0.162
Candle (no.)	0.00013	0.00006	0.400	0.955	0.0059	0.0023	0.421	0.970
Gobar gas	0.00005	-0.0000001	0.059	0.004	0.0022	-0.000004	0.067	0.004
Petrol (litre) *	0.00009	0.00021	0.008	0.025	0.0040	0.0078	0.022	0.076
Diesel (litre) *	0.00039	0.00002	-0.241	0.030	0.0174	0.0007	-0.180	0.035
Other fuel	0.00001	0.00011	1.976	0.965	0.0004	0.0042	1.977	0.992
Fuel and light (Total)	0.01113	0.01331	77.471	118.982	0.5000	0.5000	79.234	122.237

Note: Calculated on the basis of 66th unit level data and methodology in section III, *excluding conveyance and MPCE at uniform reference period

For rural and urban households expenditure on energy for cooking and lighting at household level is inelastic. The marginal budget share in rural and urban areas is same (0.5). One rupee increase in the per capita expenditure will increase more consumption of firewood and chips in rural region while for electricity in urban region. Price elasticity of energy for cooking and lighting are found to be extremely low, implying that the consumption of energy for cooking

and lighting is higher price inelastic. Rural household's response to the change in prices is higher compared to their urban counterparts.

This is also concluded that hundred percent increases in energy for cooking and lighting will increase the expenditure of households in rural region more than in urban region. The Government should focus in the rural areas to use clean fuels for cooking and lighting. The Government needs to create a policy framework that provides incentives for the efficient use of energy. Also the traditional sources of energy used for cooking and lighting are increasing pollution in the environment thus the government must promote those resources which are less polluting and renewable like solar and wind energy.

Table 3: Expenditure and Price elasticity of various energy items used at household level for all India Rural and Urban region.

	Expenditure Elasticity		Price Elasticity	
Items	Rural	Urban	Rural	Urban
Coke	4.220	-5.626	0.0002	0.0003
Firewood and chips	1.053	-4.476	0.0425	0.0075
Electricity (unit)	10.456	9.378	0.0162	0.0311
Dung cake	1.447	-5.912	0.0078	0.0011
Kerosene – PDS	-0.195	-4.116	0.0058	0.0018
Kerosene – other	3.152	-1.533	0.0021	0.0024
Matches (box)	1.994	0.511	0.0014	0.0007
Coal	3.423	-5.251	0.0004	0.0005
LPG *	22.882	6.378	0.0046	0.0201
Charcoal	9.570	-0.622	0.0000	0.0001
Candle (no.)	10.535	3.849	0.0004	0.0005
Gobar gas	19.441	-1.688	0.0001	0.0000
Petrol (litre) *	41.136	35.172	0.0000	0.0000
Diesel (litre) *	137.864	20.125	-0.0002	0.0000
Other fuel	0.204	6.462	0.0021	0.0005
Fuel and light (Total)	5.284	6.255	0.0835	0.0666

Note: Calculated on the basis of unit level data and methodology in section III, *excluding conveyance, and MPCE at uniform reference period.

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