

Shifting Patterns of Household Fuel Choices in Urban India

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Research so far

- Research & publications
 - Determinants of energy intensity
 - Decomposition of energy consumption
 - Energy intensity and productivity
 - Energy use and CO₂ emissions
 - Environmental certification and energy intensity
- In the context of Indian industries

Introduction

- For a number of developing countries, including India, issues relating to energy choices and household energy transitions are important from a policy standpoint.
- Efforts at encouraging and facilitating households to make substitutions that will result in more efficient energy use and less adverse environmental, social and health impacts are advocated in many of these countries, especially with the adoption of SDG.
- But the effective design of public policy in this area requires, as a first step, research and analysis of the factors that affect energy choices and consumption patterns in rural and urban areas of such countries.

Specifically,

- Urban households often have a wider choice and greater availability and accessibility to modern commercial fuels, electricity, and energy using end-use equipment and appliances, and therefore, greater potential for fuel switching.
- The rapid growth of urban areas in developing countries has been accompanied by a huge surge in the demand for household fuels and electricity.
- In India, the share of urban population increased from 17.3% in 1951 to about 28% in 2001 and is projected to rise to about 41% by 2030 (UN, 2003).
- Changing urban lifestyles have important implications for the quantum and pattern of energy use in households residing in these areas and suggest various avenues for policy relevant research.

The paradox

- Despite a major shift away from the use of biomass fuels towards commercial fossil fuels and electricity over the last two decades in urban areas,
 - there are still many poor Indian households who rely on firewood as their primary source of cooking energy.
- As income increases households tend to switch from firewood to kerosene and then LPG (liquid petroleum gas).
 - However, all households do not necessarily switch completely or, in other words, terminate the use of one fuel when taking up the use of another.

Literature Review

- The traditional view on fuel switching in the household sector of developing countries has been that households gradually ascend an “*energy ladder*” from relatively inefficient fuels more efficient fuels, with increasing income levels and urbanization (Reddy and Reddy, 1994).
 - In general, much of the literature points to income being an important factor influencing energy choice.
- However, while income is important, in as far as it increases the options available to a household, what in fact actually motivates households to switch between different fuels and triggers energy transitions is a much more complex interplay of factors.

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- Recent literature on household energy use in developing countries also supports the view that in fact the picture drawn by the *energy ladder* theory is too simplistic and that there are many factors that determine fuel choice (Davis, 1998; Masera *et al.*, 2000; Barnett, 2000).
- Other recent work in this field include a study for Bolivia (Israel, 2002) that examines whether fixed costs associated with switching to LPG act as a barrier.
 - The study concludes that reducing the fixed costs associated with a switch to cleaner fuels like LPG and increasing income earning opportunities for women can go a long way in encouraging households to shift away from the use of fuel wood.

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- Evidence from empirical studies on the patterns of household energy use in India includes WB, 1999; WB, 2002; Alam *et al.*, 1998.
- Viswanathan and Kumar, (2005) analyzes fuel consumption patterns across rural and urban households in India by examining data on the share of expenditures for different fuels.
- More recently, Gangopadhyay *et al.*, (2003) employ a multinomial logit framework to represent household fuel choice separately for rural and urban Indian households.

Understanding Urban Energy Use

Sectors to intervene	Physical Drivers	Ways to Intervene	Tools to Intervene	Consensus of Stakeholders
Planning	<ol style="list-style-type: none"> 1. Population density 2. Urban Functions 3. Urban Land-use 4. Buildings 	<ol style="list-style-type: none"> 1. Technologies options 2. Management options 	<ol style="list-style-type: none"> 1. Economic tools 2. Regulatory tools 3. Institutional arrangements 	<ol style="list-style-type: none"> 1. Who are these stakeholders 2. Identification of stakeholders
Transport	<ol style="list-style-type: none"> 1. Travel Activities 2. Travel Modes 3. Energy intensity and fuel choices 			
Households	<ol style="list-style-type: none"> 1. No. of households 2. Appliances use 3. Fuel choice 			

Data and methods

- In this study, we analyze cooking fuel choices in urban households of India.
- For this purpose we use a microeconomic data set, which is derived from the Indian Household Consumer Expenditure Survey conducted by the National Sample Survey Organisation (68th round, 2011-12).
- Fuel choice is modeled empirically using a discrete choice framework and the substitution relationships between fuels are examined.
- Further, the impact of income and prices on fuel choice are examined.
- The analysis also aims to identify whether and to what extent other socio-demographic variables determine fuel choices.

Data Source and Descriptive Statistics

- The household micro budget data used in this study is from the household expenditure survey Round 68 covering the period July 2011 to June 2012 conducted by the National Sample Survey Organization (NSSO), a part of the department of statistics of the Indian government (NSSO, 2002).
- The survey collects information on quantity consumed and value of household consumption for a wide variety of consumer goods and services.
 - In addition, data on a host of other socioeconomic and infrastructural variables are collected via the survey.
- The data is collected from a large nation-wide sample of households living in both rural and urban areas using the interview method.
- For the analysis presented in this study, we make use of data only from the urban sample and the quantity and expenditure data for fuels/ energy on a 30-day recall basis.
- The official definition of urban areas is based on number of criteria including “(1) the population of the place should be greater than 5000; (2) a density of not less than 400 persons per square km.; (3) three-fourths of the male workers are engaged in non-agricultural pursuits” (Gol, 2001).

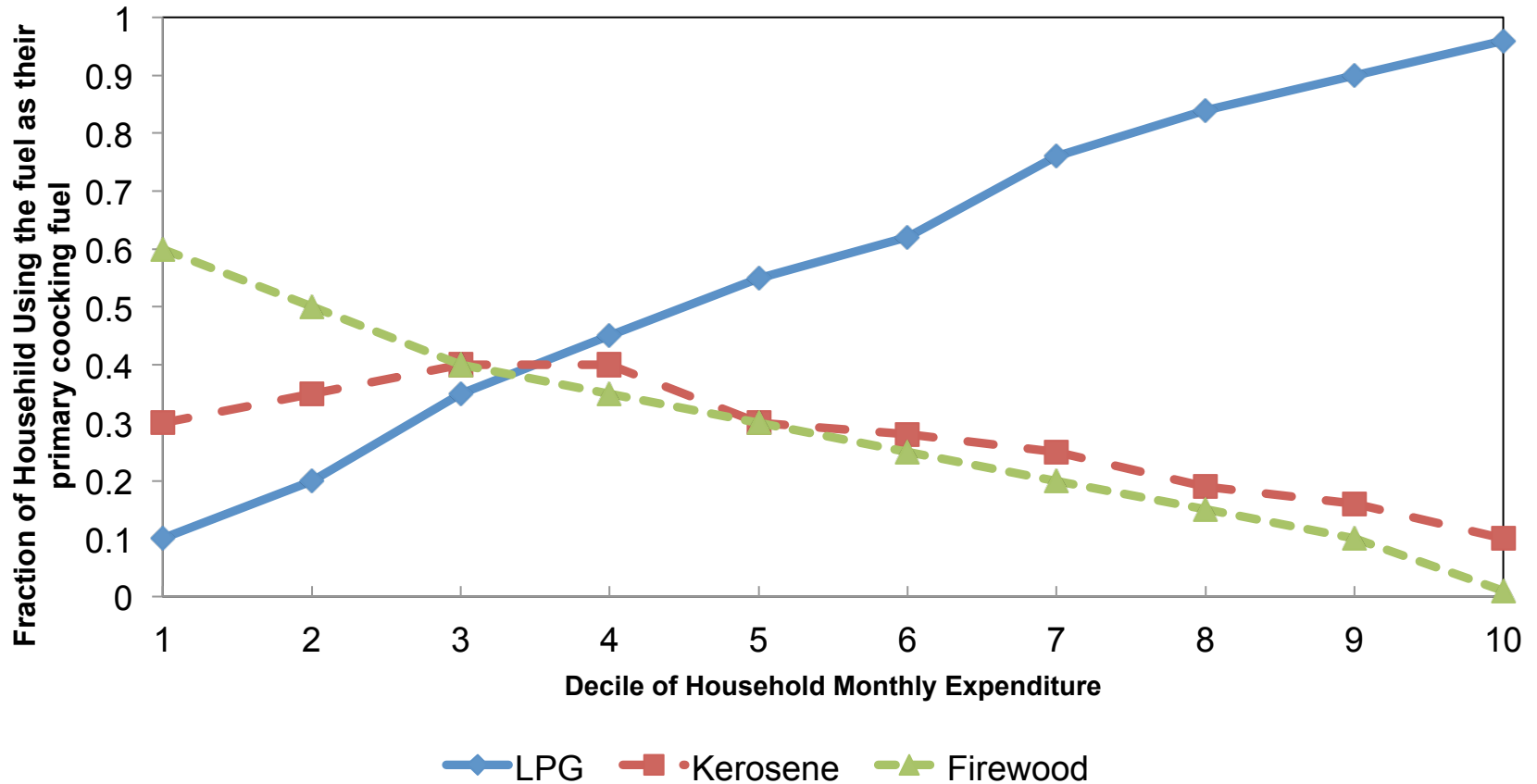
Fuel Choice

- Amongst urban households in India, the main cooking fuels in use are firewood (often commercially bought), kerosene and LPG.
- The data indicate that 22% of urban households still used firewood as a cooking fuel, while the percentage using kerosene was about 52% and about 68% used LPG.
- As different fuels vary in their efficiency, the main cooking fuel is defined as the fuel that provides the highest share of total useful cooking energy used by the household.
- The rates for converting to useful energy for LPG, kerosene and wood are calculated by assuming specific average levels of efficiency in the use of these fuels for cooking.
- The reason for using useful energy as the basis for the analysis is that households in fact do not demand energy in itself, but in fact demand services such as a hot cooked meal that energy helps provide.
- While ideally, one would like to capture demand at the level of energy services, this is not possible and thus useful energy proves to be the best approximation to the level of energy services.

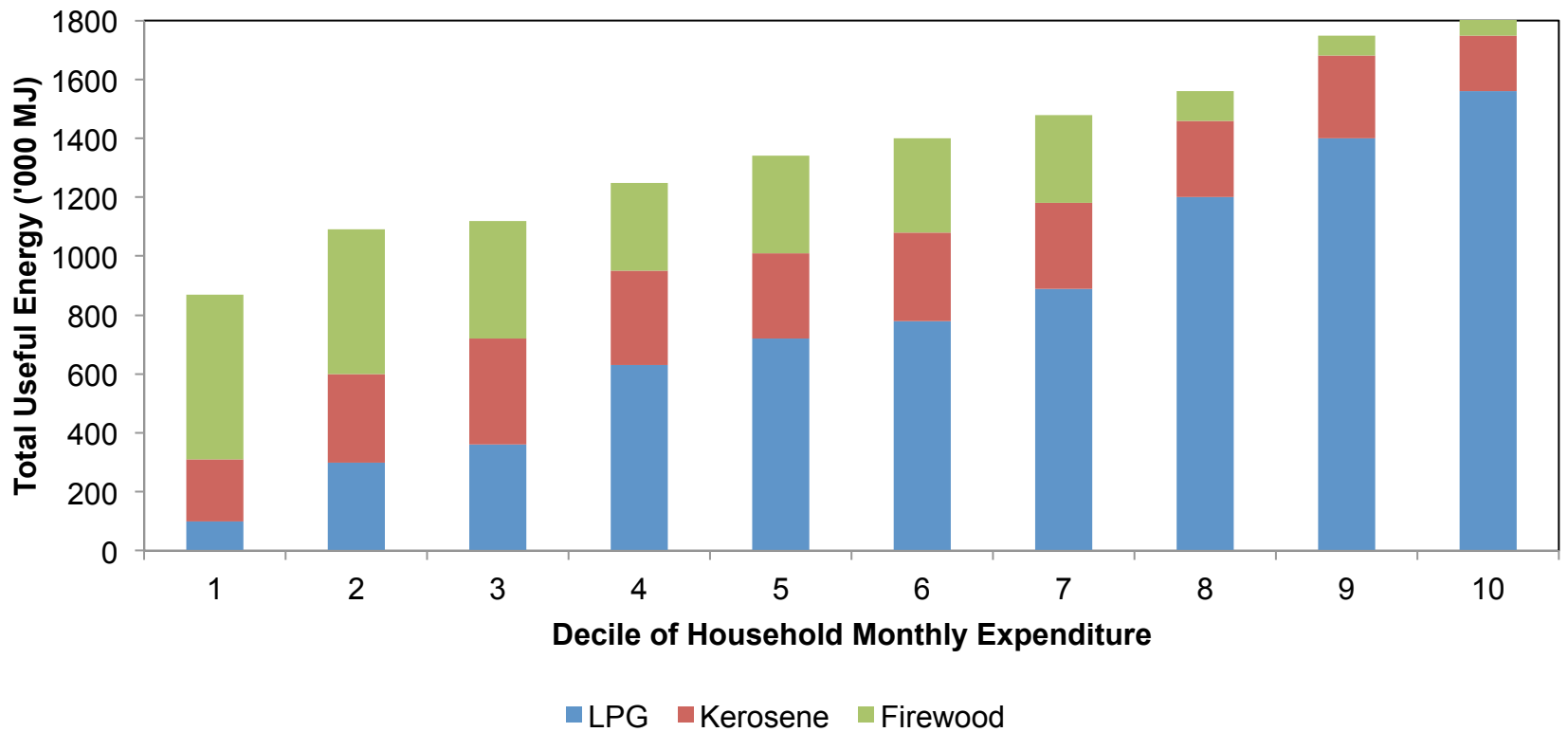
Cooking Fuel Choices

- The data show that about 54% of households use more than two types of fuels.
- The incidence of single-fuel use is about 50% among LPG users and as high as 74% among households using kerosene.
- However, this is not the case for firewood users, most of whom use kerosene as well.
- Finally, there are few households that use a combination all three fuels.
- Thus, we see that multiple fuel use is more frequent in poorer households that are more dependent on less efficient biomass fuels (Pachauri *et al.*, 2004)

Main Cooking Fuel by Income



Total cooking energy by Income



Average share of household's useful cooking energy by primary cooking fuel (%)

Primary fuel used for Cooking	Average Share of Cooking Energy			Fraction of Households	Average share of kerosene purchased in the market
	Firewood	Kerosene	LPG		
Firewood	66.80	16.90	0.70	20.09	31.20
Kerosene	17.50	87.90	3.20	25.50	55.20
LPG	3.20	10.10	92.60	56.60	28.60
Total	17.90	31.30	50.80	100.00	38.90

Discussion

- The descriptive analysis suggests that the observed patterns in the data are consistent in part with the “*energy ladder*” theory.
- In other words, there is a clear order in the distribution of energy shares by the primary fuel.
- Firewood and LPG at the two extremes are more likely to be used with kerosene in the middle, than with each other.
- Moreover, at the bottom of the ladder, households are more likely to use two fuels.
- In contrast, at the top of the ladder (LPG), single fuel choices are more likely.
- The econometric model used in this paper is in line with the ordered preferences observed in the data.

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- As seen in the previous discussion, household income (proxy by the household's monthly expenditure) has a considerable effect on the fuel choice.
- Dummy variables for the level of education of the head of the household, occupation, female headed households, season, and geographic location (state dummies and a dummy for households residing in metropolitan areas) are included in the model in addition to variables relating to household size, fuel prices, and age of the head of the household.
- While the dataset includes a wide variety of information on household level characteristics, expenditure and consumption information, one area where the data are lacking is regarding independent and reliable information on fuel prices.
- For this reason, fuel prices are calculated as the median value of individual prices for each one of the 78 regions (sub-states) in the sample.
- Unit or average values calculated by dividing expenditures on each fuel type by the corresponding quantities for each household are used as a proxy for individual prices.
- Finally, the table also includes descriptive statistics relating to the number of LPG dealers per 100,000 households.
 - This variable is included in the model so as to capture differences on account of LPG availability and accessibility at the state level.

Descriptive statistics (56,983 households)

Variables	Mean	Std. Dev.
LPG Price (Rs/L)*	52.35	0.768
Kerosene Market Price (Rs/L)	26.07	3.42
Kerosene Price in PDS (Rs/L)	14.08	0.87
Firewood Market Price (Rs/kg)	10.45	9.23
No. of LPG distributors per 100,000 HHS**	6.13	7.56
Household Monthly Income (Rs)	4603.08	3456.09
HH Monthly Expenditure Per Person (Rs)	1500.05	904.6
Age of HH Head	45.67	14.71
Family Size	4.89	2.45

*Median prices at the district level (78 districts)

**Calculated at the state level (32 states).

Model and Estimation Methods

- As discussed in the previous sections, the observed patterns in the data suggest that the fuel choice in urban households is consistent with an ordered discrete choice framework.
 - In many of these response variables, the ordering is not obvious at first sight.
 - We contend that the cooking fuel type in an Indian household can be considered as an ordered variable, in that the three fuel types can be clearly ordered in terms of efficiency, comfort and ease of use.
- In this paper we report results of the estimation of an ordered Probit model (Wooldridge, 2002)

Table 3. Regression results

Alternatives in ascending order: Firewood, Kerosene, LPG	Coeff.	Std. Error
ln (LPG price)	-1.780 **	0.228
ln (Kerosene market price)	-0.203 **	0.050
ln (Kero. price in public system)	-0.201 *	0.087
ln (Firewood market price)	0.010	0.045
ln (# of LPG distributors per 100,000 HHs)	0.071	0.036
ln (HH monthly expenditure per person)	1.182 **	0.017
ln (Age of the HH head)	0.519 **	0.023
ln (Number of persons in the HH)	0.424 **	0.018
HHs with a single member	-0.388 **	0.034
HHs with a female head	0.302 **	0.022
Main HH income from casual labor	-0.438 **	0.020
HH head illiterate	-0.899 **	0.019
HH head's education primary school or less	-0.537 **	0.016
HH head has a university education	0.622 **	0.024
HH residence in a metropolitan area	0.187 **	0.018
Interview was held in Monsoon	-0.006	0.016
Interview was held in Winter	-0.025	0.016
Log Likelihood	-29721.2	
Pseudo R-squared	0.2923	
Percentage of correct prediction of chosen fuels:		
Primary fuel for all the sample (41,593 households):	67.07%	
Both 1st and 2nd fuels for multiple-fuel users (22,264 households):	62.57%	

* significant at .05; ** significant at .01;

State dummies (18 groups) are included in the model (see Table A1).

Table 4. Marginal effects at the sample mean

	Wood	Kero.	LPG
ln (LPG price)	0.310	0.391	-0.701
ln (Kerosene market price)	0.035	0.045	-0.080
ln (Kero. price in public system)	0.035	0.044	-0.079
ln (HH monthly expenditure per person)	-0.206	-0.260	0.466
ln (Age of the HH head)	-0.090	-0.114	0.204
ln (Number of persons in the HH)	-0.074	-0.093	0.167
HHs with a single member	0.083	0.071	-0.154
HHs with a female head	-0.045	-0.070	0.115
Main HH income from casual labor	0.093	0.080	-0.173
HH head illiterate	0.218	0.127	-0.344
HH head's education primary school or less	0.113	0.099	-0.212
HH head has a university education	-0.084	-0.145	0.230
HH residence in a metropolitan area	-0.030	-0.042	0.073

Only the statistically significant effects are listed.

For dummy variables the effects are obtained from probability differences.

Table 5. Marginal price and income effects at the sample median by income category

Alternative:		Wood	Kero.	LPG
ln (HH monthly expenditure per person)				
HH expenditure per person:	10 percentile	-0.394	-0.015	0.410
	25 percentile	-0.295	-0.171	0.466
	Median	-0.168	-0.282	0.450
	75 percentile	-0.072	-0.267	0.339
	90 percentile	-0.027	-0.185	0.211
ln (LPG price)				
HH expenditure per person:	10 percentile	0.594	0.023	-0.617
	25 percentile	0.444	0.257	-0.701
	Median	0.253	0.424	-0.677
	75 percentile	0.108	0.402	-0.510
	90 percentile	0.040	0.278	-0.318

To Sum up

- Overall, fuel choice decisions in urban Indian households appear to be flexible and dynamic with many households maintaining the ability to use two or more different fuels for cooking at any given point in time.
- The results seem to suggest several reasons why households shift to the use of modern fuels.
- In urban areas, where firewood is often bought and opportunity costs for collecting wood are high, economic considerations and availability are crucially important in determining fuel choices.
- Higher incomes increase the ability of households to afford both the equipment and fuel costs of modern fuels like LPG, which are also more widely available in urban areas.

Sum up - Cont...

- Better education increases the awareness of households of the negative health impacts associated with the use of firewood and also the advantages of modern fuel use, in terms of efficiency and convenience.
- In larger cities and areas where modern fuel supplies are more regularly and reliably distributed, households are more likely to choose modern fuels and less likely to require back-up or supplemental use of other fuels.
- In addition, households where women are more empowered are less likely to use less efficient wood. Other reasons, such as tastes, customs and status, may also influence fuel choice and require further investigation

Implications

- From a policy point of view, the results suggest that in order to encourage households to make fuel substitutions that will result in more efficient energy use and less adverse environmental, social and health impacts, a subsidization of LPG gas provision, a promotion of higher levels of education, greater empowerment of women and a promotion of general economic development could be effective instruments.
- Given the high fiscal costs associated with LPG fuel price subsidies, it may be more sustainable to promote rebates on the purchase of LPG stoves and easier access to credit or purchase on installment plans for the equipment needed to use cleaner fuels.

Implications – cont..

- In addition, since multiple fuels are more likely to be used by the poor and the share of secondary fuels in total cooking fuel consumption is higher for households in lower income decile groups, a LPG fuel subsidy policy is likely to benefit richer rather than poorer households and may not result in a complete transition away from the use of inferior fuels like wood and kerosene.
- As the results of the analysis presented in this paper highlight, several other variables in addition to fuel price are affecting fuel choice, thus implying the need to explore other policy options, rather than pricing.

Thank You

For your kind attention