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Analysing electricity consumption: A study of Indian households

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Abstract
Residential electricity consumption is one of the leading areas of research for sustainable development. In India, some studies have examined electricity consumption patterns at state level, district level as well as household level. Our analysis focused on household level consumption pattern of electricity; demographic and economic reasons of affecting these patterns are also considered. Almost Ideal Demand System is employed to study household behavior on eleven categories of good. Income and price elasticities were calculated within the framework of almost ideal demand system to segregate different goods into normal/inferior and substitutes/complements. Logit technique was employed to highlight change in probability of owning different appliances due to different household characteristics. This study found that electricity and firewood are necessity fuels relative to other fuel categories. Equivalence scale was also calculated for income deciles.

Keywords: Residential electricity consumption, sustainable development, almost ideal demand system, household behavior, income elasticity, price elasticity, equivalence scale, consumer expenditure

Introductions

World energy consumption is expected to grow by 55% between 2005 and 2030 and three-fourths of this increase in energy consumption is projected in developing countries with India and China contributing to nearly half the share. According to McKinsey (2008) [15], rising incomes have driven, and will continue to drive, energy demand across consumer classes in rural and urban India. Electricity consumption globally increases at a faster pace than other energy sectors due to electrification of energy uses (Global energy statistical year book 2018) [16]. Much evident significance of electricity sector and its associated policy implication constitute the primary motivation for this paper. Total electricity demand in India can be segregated into 5 major categories namely domestic, industrial, commercial, agriculture and others. Our paper tries to explore the determinants of household consumption of electricity along with its consumption pattern.

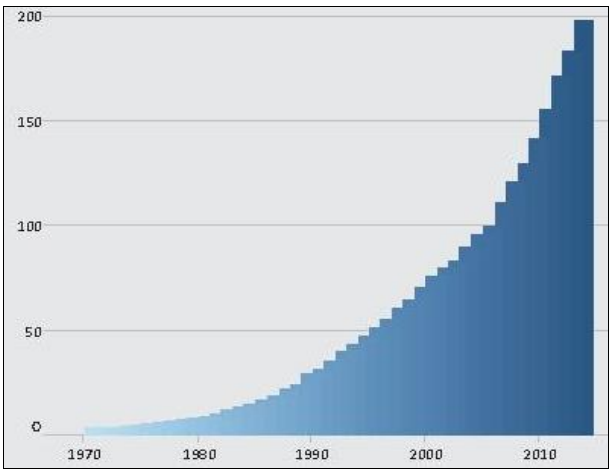
The patterns of residential electricity consumption vary greatly across the world depending upon availability of alternative energy sources, social and demographic factors, level of urbanization and industrialization etc. However macroeconomic variables have indirect impact on consumption of electricity whereas the direct determinants can be found at more disaggregated level, which in our analysis is household level. The percentage of households with access to electricity has increased from 55% in 2001 to more than 80% in 2017 indicating rapid electrification in order to attain the universal goal of electrification (refer Fig. 1). Residential sector of India is a key contributor which consumes 24% of the total electricity in India, making it the second largest next to industry (42%) in terms of electricity consumption in India (Energy Statistics 2017) [17].

Household income can be spent on different categories of commodities comprising of food items which include both essential subsistence food and non-essential food items, consumer durables, energy requirements and other essential services like education, health etc. Households need to choose the respective categories on which they want to spend their income and also the quantities they need to buy within each category. These choice decisions, including choice of electricity consumption, are subjected to budget constraint. Thus, price and income elasticities of demand are important for the formation of policies and programs related to electricity. We aim to estimate own price elasticity and income elasticity of electricity consumption in order to analyze change in electricity consumption due to 1%

change in price of electricity and income of household respectively. Income and own price of elasticity can be used to devise new programs or amend the existing one. Cross price elasticity of electricity consumption is also estimated to address the scope for substitution of electricity consumption by other sources of fuel.

National Sample Survey Organization (NSSO) conducts Consumer Expenditure Survey (CES) to collect information on quantity and expenditure on different aspects of household spending and characteristics across Indian households. Expenditure and quantity of various sources of fuel including electricity, kerosene, natural gas, LPG are also part of the same. We have used 68th round of NSS survey which was carried out during July 2011-June 2012, covering 101651 households in 7469 villages and 5268 urban blocks spread over the entire country. Due to enormous number of observations, we can conclude that our sample is more representative of the population at disaggregated level. Our sample can be further divided into sub samples according to different criteria like income deciles, rural and urban areas etc. to get a more refined analysis.

Electricity Act 2003 requires the Central Government to formulate the National Electricity Policy in consultation with Central Electricity Authority (CEA) and State Governments every five year. Estimation of demand is an important tool to determine plans for capacity addition which includes additional infrastructure as well as transmission and distribution costs. There has been tremendous change in the power sector of India. Current scenario portrays long power cuts and shortages indicating that demand is constantly outstripping supply. Therefore, accurate short-term and long-term demand forecasts for different regions would assist in better planning of policies and the optimal utilization of resources.



Source: (MOSPI, 2015), (CEA, 2011), (CEA, 2014) and older Annual General Reviews by CEA

Fig 1: Trend in India's residential electricity consumption (1971-2014)

Structure of the paper is as follows; section II deals with the literature review of previous studies; section III provides the details of variables and data extraction; section IV summarizes our data from various perspectives; section V explores the methodology which we will be using in our analysis; section VI provides estimation and empirical result from this study and finally, section VII provides conclusion and policy implication.

Literature review

1. The paper "Residential Demand for Electricity in Pakistan" by Muhammad Nasir *et al*. examines the demand side aspect and the effect of higher demand on the shortage of electric power in the country. They estimated the following elasticities:

1. Income elasticity of electricity demand to know whether the rise in the demand is due to increase in household income.
2. Price elasticity of demand to believe that increasing the unit price of electricity will reduce the electricity demand.
3. Household size elasticity of electricity demand by taking population growth as an important factor; using the time series data from 1979 to 2006.

Findings

Electricity demand is price inelastic (-0.63) in short run and the value increases in long run to -0.77, implying electricity to be a strict necessity both in short and long run. Long run elasticity is greater than short run elasticity since in long run the change in the composition of electrical appliances further reduces the demand of electricity. They found a positive sign of income elasticity of demand indicating it to be a normal good.

2. The paper "Elasticities of electricity demand in urban Indian households" written by Massimo Filippini *et al*. used disaggregated level survey data for over 30,000 households using 50th round of NSSO for the year 1993-94 to analyze price and income elasticity of electricity demand in residential sector of all urban areas in India. They estimated three electricity demand functions using monthly data for following seasons: winter, monsoon & summer and postulated the demand of electricity depending upon price of electricity, price of substitute fuels, income, demographic and geographic variables.

Findings

Electricity demand was found to be price and income inelastic in all three seasons and demographic, household and geographical variables were evaluated to be important for determining electricity demand. Results showed significant coefficients for price elasticity with the expected signs. Also the demand during summer months was found to be more price inelastic than during other seasons. Cross price elasticity between fuels showed the complementarity between fuel and electricity. Household size elasticity was found to be significant at 1% level and thus does not help in influencing electricity demand by a larger amount.

3. The paper "Swiss Residential Demand for Electricity by Time-of-Use: An Application of the Almost Ideal Demand System" by Massimo Filippini estimated peak and off-peak periods electricity demands using panel data for 1987, 1988, 1989 & 1990 of 21 cities of Switzerland based on survey on electricity price and electricity consumption. They estimated the same using AIDS Model imposing homogeneity restrictions.

Findings

They found that the allocation of electricity to peak and off-peak periods are not influenced by household size, weather or availability of natural gas. The demand for electricity

during both peak and off-peak periods is responsive to prices. Goods peak and off-peak electricity are substitutes. Hence, pricing policy can be an effective instrument to control electricity consumption and Time-of-use pricing can encourage efficient utilization.

4. The paper "Modelling household energy expenditure using Micro-Data" written by Baker *et al*. analyzed the demand by individual households in Great Britain for gas and electricity with theoretical model using Two-stage budgeting model. Data captures 50000 households for 12 consecutive years using Family Expenditure Survey.

Findings
They found that keeping all the demographic characteristics and other variables constant, income elasticities of both fuels at means of data were small & positive, suggesting that demand increases with income. Income elasticities vary across households. Price elasticities were larger for electricity consumption with some variations across the dataset. They emphasized that these relationships will not be stable over time due to changes in the consumption patterns as consumption pattern varies across households and seasons. They highlighted that welfare cost of subsidizing or taxing fuel prices will differ considerably across households with differing income and other characteristics.

5. The paper "The factors affecting electricity consumption and the consumption characteristics in the residential sector-a case example of Taiwan" by Yi-Tui Chen attempted to examine the factors affecting residential electricity consumption through two approaches, a socioeconomic perspective and direct use perspective. In the socio-economic perspective, the per capita electricity consumption is employed as a dependent variable and the key explanatory variables include GDP, electricity price, employment rate, residential space etc. In direct use perspective, direct use of electricity appliances is intuitively seen as major source of residential consumption by taking various electrical appliances such as lights, AC, refrigerator etc.

Findings
Per capita GDP, employment rate and the residential space influence the per capita electricity consumption in a positive way but the electricity price does not significantly impact the per capita electricity consumption. The results indicate that electricity consumption for lighting ranks first, followed by air conditioning, cooking and living recreation activities. More GDP and bigger residential space may lead to higher living standards and high rate of installation of electric appliances and eventually result in more residential electricity consumption. Implementation of energy labeling schemes provides a significant reduction in electricity consumption.

6. "Residential Demand for electricity and Natural Gas in Pakistan" by Mahmood Iqbal estimated elasticities of residential demand for fuel in Pakistan to verify if they were consistent with a priori economic theory. This paper analyzed the importance of fuel expenditure in the consumer's budget and its sensitivity to changes in income and prices. Demand equation was estimated from the annual data for 1960 to 1981. The data for total residential consumption of natural gas and electricity were taken from the Energy Data Book, 1979 and Energy Year Book, 1981.

Findings
The value of the long-run income elasticity is relatively higher than found in studies for developed countries. The price elasticities of natural gas and electricity show a somewhat heterogeneous pattern. The own price elasticity of natural gas in the OLS estimate was significant for all equations. The availability of substitutes of a good and possibility of reallocation of resources from one good to another are usually greater in the long run than in the short run. Therefore, elasticity of demand of a good would tend to be larger in the long run. There is a slow rate of adjustment of fuel-consuming appliances in the residential sector of Pakistan.

7. The paper "A Residential Energy Demand System for Spain" by Labandeira *et al*. examined the energy demand in Spain using household data from Spanish Household Expenditure survey for simultaneous analysis of energy goods. The article explored consumer choices in electricity, natural gas, LPG, and car fuels for private transport.

Findings
A significant relationship was found between spending on different energy goods and place of residence, household composition and head status. Energy products are rather inelastic in Spain. Electricity is the most elastic good, in contrast to the price independence of natural gas. In case of income elasticities, food, electricity and LPG are normal goods, and natural gas, car fuels and public transport are luxuries, whereas LPG are clearly income inelastic. Income and price elasticities vary with different types of households grouped by their place of residence, which has important implications for efficiency and distribution because some households have limited possibilities to substitute energy goods.

8. The paper "Supply and Demand of Electricity in the Developing World" by Madhu Khanna and Narasimha D. Rao examined the causal relationship between electricity consumption and economic growth, price and income elasticities of demand and the barriers to adoption of energy- efficient equipment. They also examined the performance outcomes of economic policies affecting the electricity sector, including institutional reforms such as privatization and regulations on the supply side.

Findings
Price elasticity of demand for electricity is rather low, ranging between -0.85 and -0.04 with an average value of -0.4 in the short run and between -1.02 and -0.11 with an average value of -0.6 in the long run. Other significant variables which affect the electricity consumption were prices of substitutes like paraffin, candles, LPG, cooking appliance ownership etc. Analysis of supply side indicated demand is constantly higher than the supply of electricity due to lack of investment, infrastructural development, high transmission and distribution losses, low efficiency, and lack of services of major supply controlling authorities. Privatization of electricity is the most sought-after reform in order to increase efficiency of authorities and reduction in transmission and distribution loss.

Data description

The household data in our study has been taken from the 68th Round of National Sample Survey Office (NSSO) conducted from June 2011-July 2012. The NSS data set is one of the primary sources of data for various household variables indicating welfare levels of various households at state/district level. The round considered was the ninth survey to cover various Household Consumption Expenditures. The data set used is cross-sectional and includes 10, 45, 461 observations of households. As one can easily understand that household is the primary sampling unit for recording data, so our analysis is centered on household consumption of electricity. This study restricts its attention to uniform recall period (URP) as data on most of the categories considered are collected on the URP method. The broad categories of goods considered for this study is listed below:

1. Cereals - 129.
2. Pulses and Pulses Products - 159.
3. Milk and Milk products - 169.
4. Edible Oil - 189.
5. Egg, fish and meat - 199.
6. Vegetables - 219.
7. Firewood and chips - 331.
8. Electricity - 332.
9. Kerosene - 334, 335.
10. LPG - 338.
11. Clothing - 379.

Information with respect to the household composition and characteristics (Household size, Size of dwelling, Age of Head of household, Education Level, Land possessed, Ration card possessed, Household Type, Lightning by electricity, Regular Salaried) are used for AIDS demand system analysis. The data also includes economic variables like Monthly per capita expenditure based on URP. For Logit model, the data on possession of the electrical appliances is regressed on demographic as well as economic variables to assess the impact on ownership. This analysis includes AC/cooler, refrigerator, electric fan, inverter and washing machine, as these are the most common durable goods.

We must note that unit values are not same as prices because of 2 reasons. First, unit values also incorporate quality as heterogeneous households consume different type of goods that will have some effect when we will create prices by dividing value by quantities. So, elasticities hence found, might be overestimated. Secondly, unit values are subject to measurement errors. But a theoretical model was developed by Deaton (1998), where consistent estimation of price elasticities was possible because of the variation in unit values. Hence elasticities are proportional to what we would have generated, if we would have used prices.

Preliminary analysis

This section sets out a number of descriptive statistics that provides insights of NSS 68th Round pertaining to electricity and other categories. In order to understand the meaningful features of our cross-section analysis, following tables and graphs are considered.

Table 1: Average monthly household expenditure and average prices for all categories

Category Name	Average Consumption Expenditure	Average Prices
Cereal	814.3133	0.0164773
Pulses & Pulse Products	216.9587	0.0571896
Milk & Milk Products	760.1029	0.1547311
Edible Oil	251.2973	0.0813069
Egg, Fish & Meat	476.1251	0.6276884
Vegetables	341.6940	0.0582921
Firewood and Chips	175.0790	0.0031559
Electricity	224.4912	3.007354
LPG	157.0323	0.0310371
Kerosene	41.0366	0.0192421
Clothing	291.7974	128.745

Table 1 shows Average monthly household consumption expenditure and Average prices for all the categories including food items, electricity, LPG, Kerosene, Clothing and Firewood & Chips. This gives a point estimate to describe mean consumption expenditure as well as mean prices to depict broad patterns at household level. Average consumption expenditure for electricity is ₹224 which is less than most categorical expenditure in food category. Average price for electricity is greater than all the categories except clothing. More refined trends according to income deciles are portrayed in table 2.

Table 2 shows Average monthly household consumption expenditure as per income deciles. As income is increasing, the average Electricity consumption is increasing which makes sense as well-off households can afford appliances like air conditioning, fan, and water heater; these households are most likely to have larger energy needs due to bigger floor areas and a greater number of rooms. We can see the same behavior in case of most of the categories except cereal, firewood and chips and kerosene. As per the theory, share of necessary food items like cereals reduces or stays constant after certain increase in income as the Engel Curve often flattens. This pattern is clearly recognized. Firewood and chips along with kerosene are informal type of fuel. As income increases, people tend to shift to clean sources of fuel like electricity, LPG etc.

Table 2: Average monthly consumption expenditure according to income deciles

Income Deciles	Cereal	Pulses & Pulse Products	Milk & Milk Products	Edible Oil	Egg, Fish & Meat	Vegetables	Firewood and Chips	Electricity	LPG	Kerosene	Clothing
1	779.88	177.22	277.56	210.95	232.27	276.18	235.11	79.19	28.52	54.25	105.94
2	828.66	188.81	348.44	224.56	296.13	296.60	234.50	108.89	56.16	54.63	142.21
3	848.02	197.20	415.19	233.97	345.08	312.17	225.88	128.06	86.08	51.59	163.91
4	877.85	209.03	476.58	247.22	393.88	326.29	214.56	153.97	117.59	50.60	205.28
5	887.66	215.81	518.27	253.32	439.19	339.61	196.80	170.26	152.20	48.29	241.69
6	901.54	218.33	549.27	254.96	490.69	357.31	171.09	188.98	184.19	46.14	277.26
7	893.80	223.82	607.22	260.32	544.70	370.37	145.29	211.69	221.51	40.82	338.01
8	888.37	225.43	664.10	259.47	601.48	391.66	116.41	247.78	258.77	38.46	398.25
9	880.03	233.84	743.21	266.36	693.87	407.37	91.06	306.45	287.82	32.47	519.61
10	862.95	250.35	892.62	282.15	817.32	430.12	67.82	463.71	311.31	21.67	840.25

Table 3: Average monthly electricity consumption expenditure on the basis of household head's gender

Electricity	Sex	Mean
	Male	228.624
	Female	192.821

Table 3 shows Average Monthly electricity consumption Expenditure when household's head is considered. Clearly, female headed households tend to consume less electricity as compared to male headed households. One reason could be that female-headed households are more likely to face tougher economic conditions than their male counterparts. Therefore, they are less likely to afford the up-front cost of electricity bills and appliances. In many places, the cultural constraints on women may also restrict households' expenditure if the earning head is female. One reason to expect that female-headed households may be poorer, controlling for household size, is that their heads are more likely to be responsible both for generating income and for child care and domestic chores while this is surely not the case for male headed households.

Figure 2 shows the ownership of appliances across households. About 70% households don't possess refrigerator while 30% do own it. Around 85% households don't possess washing machine and inverter as the figure given is for aggregate so it includes rural areas also where these products are somewhat luxury. Same reasoning is applicable for Air conditioner and Cooler. However, electric fan is a necessity in all areas so its possession is around 85% which is quite high.

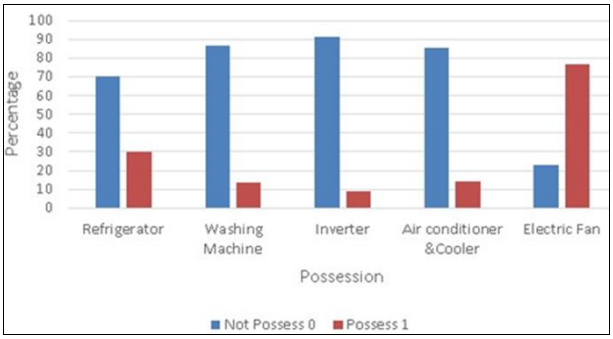


Fig 2: Various Appliances Ownership across all households

Methodology

Almost ideal demand system

In this paper, the model which is considered for estimation is Almost Ideal Demand System (AIDS) proposed by Deaton and Muellbauer (1980) [2] as it has considerable advantages over other demand models. AIDS gives an arbitrary first-order approximation to any demand system. It satisfies the axioms of choice and its functional form is consistent with household budget data. It avoids the need for non-linear estimation. Above all, it can be used to test the restrictions of homogeneity and symmetry. It is being used since it is widely accepted because of its empirical validation. The general specification is given by:

$$\ln e(u,p) = \alpha_0 + \sum_j \alpha_j lnp_j + 1/2(\sum_j \sum_i \gamma_{ij} lnp_i lnp_j) + u\beta_0 \prod_j p_j^{\beta_j}$$

Where e (u, p) is expenditure being function of utility u and price p.

Using Shephard's lemma, we can estimate the demand function using the expenditure function. Since, utility is unobservable, we apply inverse of expenditure function to get the budget share equation as:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ji} lnp_j + \beta_i \ln\left(\frac{m}{P}\right) \qquad i,j = 1, \ldots . n$$

Where,

- w_i is the budget share of good i,
- p_j is the price of good j, and
- (m/P) is the total real expenditure on all n goods in the consumer budget.

Price index P is found as:

$$lnP = \alpha_0 + \sum_j \alpha_j lnp_j + (1/2)\sum_i \sum_j \gamma_{ij} lnp_i lnp_j$$

Restrictions implied by the economic theory are as:

1. $Adding\ up: \quad \sum_i \alpha_i = 1, \ \sum_i \gamma_{ij} = 0, \ \sum_i \beta_i = 0$

Adding up is satisfied within the data where the respective budget shares of the commodities sum to 1.

2. $\text{Homogeneity: } \sum_i \gamma_{ij} = 0$

Homogeneity can be forced in the model during the estimation.

3. $Symmetry: \quad \gamma_{ij} = \gamma_{ji}$

Symmetry can be forced in the model during the estimation.

AIDS revolve around elasticities. With reference to Cecilia Alexandri, Bianca Pauna, Lucian Luca (2014) the approximations to respective elasticities are:-

- Expenditure elasticity of demand is: $\varepsilon_i = 1 + \frac{\beta_i}{w_i}$
- Uncompensated Price Elasticity of demand is: $\varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i}{w_i} w_j$
- Compensated Price Elasticity of demand is: $\varepsilon_{ij}^* = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} + w_j$

Logit model: A logit regression model allows us to establish a relationship between a binary outcome variable and a group of predictor variables. It models the logit-transformed probability as a linear relationship with the predictor variables. More formally, let **y** be the binary outcome variable indicating failure/success with 0/1 and p be the probability of y to be 1, p = prob(y=1). Let x_1,……, *xk* be a set of predictor variables. Then the logistic regression of **y** on x_1,……, *xk* estimates parameter values for $\beta_0, \beta_1, \ldots\ldots, \beta_k$ via maximum likelihood method of the following equation:

$$\text{logit}(p) = \log\{p/(1-p)\} = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k$$

In this paper, logit model is employed to determine appliances ownership of the households and hence, electricity consumption being affected by various factors like household size, education level, dwelling type etc. The dependent variable is discrete variable that takes value 1 if the household owns the appliance otherwise, it takes value 0. Econometrically, the logit model can be defined as the regression to find the parameters β that best fit the following model where ε is an error distributed by the logistic distribution.

$$y = \begin{cases} 1, & \beta_0 + \beta_1 + \varepsilon > 0 \\ 0, & otherwise \end{cases}$$

The interpretations are represented in terms of log-odds which can be defined as

$$OR = \frac{odds(x+1)}{odds(x)} = \frac{\left(\frac{F(x+1)}{1-F(x+1)}\right)}{\left(\frac{F(x)}{1-F(x)}\right)} = \frac{e^{\beta_0+\beta_1(x+1)}}{e^{\beta_0+\beta_1 x}} = e^{\beta_1}$$

$$\log(OR) = \beta_1$$

This exponential relationship provides an interpretation for β: The odds multiply by e^{β} for every single unit increase in the covariates. An odd-ratio greater than 1 represents a positive relationship between the related covariate and the probability of owning the appliance. Whereas, a negative relationship is represented if an odd-ratio is less than 1. Each estimated coefficient is the expected change in the log odds of dependent variable for a unit increase in the corresponding predictor variable holding the other predictor variables constant at certain value.

Equivalence scale

Barten model of equivalence estimates the household consumption behavior assuming substitutability of various goods, namely items for kids being substituted with relatively cheaper commodity basket for adults. In reality, households allocate the resources, caring more for children and hence the commodity basket for kids is treated as subsistence or necessity basket. This household behavior is a serious drawback of Barten equivalence model. Prais-Houthakker model gives unexpected results in analysis of British Data for 1968-73 by Muellbauer (1977b). The rejection of these scales demands more appealing model.

Pollak and Wales have pointed that consumption demand is the function of "physiologically necessary" component and "psychologically necessary" component. Biologically, in the adolescence period, the consumption behavior of individual's changes as growth requirements demand more consumption and when the individual becomes adult, his consumption stabilizes. This is captured through "physiologically necessary" component, while "psychologically necessary" component is captured through households' limitations represented by corresponding income. Amsterdam model improves over these limitations and hence is preferred in the analysis.

The Amsterdam scale is defined as:

$$Scale(male) = \begin{Bmatrix} 0.52 & if\ age < 14 \\ 0.98 & if\ 14 \le age < 18 \\ 1.00 & if\ age \ge 18 \end{Bmatrix} \qquad Scale(female) = \begin{Bmatrix} 0.52 & if\ age < 14 \\ 0.90 & if\ age \ge 14 \end{Bmatrix}$$

This scale is used to calculate the equivalence scales of the households in proportion to the members in the households. The representative household of 2 adults- husband and wife of age above 18 years have a scale of 1.90 equivalent adult males which is taken as 1 household scale. For all the households, the respective scales are calculated assigning the weights to each member as per the Amsterdam scale. Household equivalence is calculated as per the following ratio:

$$\frac{\text{Equivalence scale of the household}}{\text{Equivalence scale of the represntative household}} = \frac{\sum_{i=1}^{n} s}{1.90}$$

Where s represents the weight assigned to each member as per the Amsterdam model.

Price indices

Unit prices for several categories like milk and milk products, egg, fish, meat, clothing etc. were not extractable directly from data. The reason being quantities of these categories were not presented in uniform units. For example; milk was reported in litres whereas as milk products like ghee and butter were in kgs. Quantity of kgs cannot be directly added to litres. Therefore, a uniform quantity cannot be calculated and hence, no unit prices.

In order to solve the problem, different prices of uniform sub-categories were calculated. Then average price of broad category was calculated using weighted mean of sub-category prices where weights were respective budget shares of sub-categories from total consumption expenditure of broad categories.

Extending the milk example, a mathematical depiction of process is given below:

$$p_1 = \frac{\text{Total consumption expenditure on milk}}{\text{Total quantity of milk consumption in litres}}$$

$$p_2 = \frac{\text{Total consumption expenditure on (butter + ghee + curd + ice cream)}}{\text{Total quantity consumed in kgs}}$$

Total consumption expenditure on broad categories = Total consumption expenditure in litres + Total consumption expenditure in kgs.

$$w_1 = \frac{\text{Total Expenditure of Milk in Litres}}{\text{Total Consumption Expenditure on milk}}$$

$$w_2 = \frac{\text{Total consumption expenditure of milk products in kgs}}{\text{total consumption expenditure on milk products}}$$

$$\text{Price Index for milk \& it's products} = \frac{w_1 p_1 + w_2 p_2}{w_1 + w_2}$$

Estimation and Results

Results from AIDS demand system

The estimated model A is AIDS demand system without controlling for demographic controls whereas Model B is AIDS demand system with demographic controls namely, size of the household, possession of land and primary source of lighting. Model A of the table classifies coefficients of real income of categories i.e. cereals, pulses, milk, oil, vegetables, firewood chips, electricity and kerosene as necessities whereas eggs, fish and meat and clothing as luxuries. Model B interprets the same results for the goods other than kerosene and LPG which are classified as luxuries. Model B is preferred specifications as it improves R^2 of the model for all categories. Results are as per expectations since eggs, fish and meat can be excluded or included in diet according to personal discretion and all other categories of food constitute necessary component of food category. Similarly, firewood and electricity constitute necessary part of fuels whereas use of LPG and kerosene can be altered as per discretion. All expenditure elasticities are positive and significant indicating that all categories considered are normal goods. All own price elasticities are negative and significant implying a downward sloping demand curve for all categories satisfying law of demand.

Table 4: Results of AIDS model

Categories↓	Model A				Model B			
	β	ei	eii	R^2	β	ei	eii	R^2
Cereal	-0.0229***	0.920***	-0.355***	0.2008	-0.0613***	0.790***	-0.303***	0.3688
Pulses & Pulse Products	-0.0104***	0.864***	-0.566***	0.2071	-0.0111***	0.855***	-0.550***	0.213
Milk & Milk Products	-0.0251***	0.869***	-0.940***	0.0864	-0.02461***	0.872***	-0.941***	0.0873
Edible Oil	-0.0147***	0.832***	-0.379***	0.2244	-0.01539***	0.825***	-0.378***	0.2274
Egg, Fish & Meat	0.02344***	1.159***	-0.922***	0.1415	0.030029***	1.206***	-0.923***	0.152
Vegetables	-0.0175***	0.856***	-0.872***	0.0856	-0.01119***	0.908***	-0.866***	0.0872
Firewood and Chips	-0.0076***	0.881***	-0.919***	0.1135	-0.00927***	0.856***	-0.901***	0.1243
Electricity	-0.0136***	0.800***	-0.475***	0.2183	-0.00437***	0.935***	-0.372***	0.2396
LPG	-0.009***	0.841***	-1.849***	0.1623	0.000206	1.004***	-1.745***	0.286
Kerosene	0.01458***	0.916***	-1.415***	0.1354	0.017691***	0.899***	-1.385***	0.1812
Clothing	0.08286***	2.130***	-0.627***	0.1854	0.08931***	2.274***	-0.522***	0.1988

In table 5, diagonal coefficients represent own price elasticities. Negative own price elasticity suggests that as price of good increases, its share in the household budget reduces. Prices of kerosene and LPG turned out to be elastic whereas other prices are inelastic. The (i, j)th element of price elasticity matrix represents the cross price elasticity of category i with respect to price j where $i \neq j$. As per theory, negative cross price elasticity indicates that the pair of goods considered is complement and positive cross price elasticity indicates that the pair is substitute. Most of the off-diagonal elements are significant. To reinstate the fact with the help of example, cross price elasticities of electricity and LPG is negative implying these fuels being complements. We expect households with higher electricity consumption to portray high income household for which LPG consumption (formal source of cooking fuel) to be higher. Cross price elasticity of cereals and electricity is positive implying that the goods considered are substitutes. Higher share of electricity consumption in total budget will leave lower proportion dedicated towards food necessities like cereals. Positive cross price elasticity of clothing and electricity indicates that these are substitutes. Other elasticities can be interpreted on the same lines.

Table 5: Results based on elasticities

Categories	Cereal	Pulses & Products	Milk & Products	Edible Oil	Egg, Fish & Meat	Vegetables	Firewood and Chips	Electricity	LPG	Kerosene	Clothing
Cereal	-0.303***	-0.111***	0.157***	-0.005	0.113***	0.047***	0.017***	0.038***	0.209***	-0.086*	0
Pulses	0.041***	-0.550***	0.099***	-0.324***	0.163***	0.144***	0.092***	-0.018***	-0.179***	-0.160*	0.021***
Milk	0.216***	0.206***	-0.941***	-0.02	0.222***	0.131***	0.208***	0.071***	-0.341***	-0.199*	0.010*
Edible Oil	-0.009*	0.170***	0.101***	-0.378***	0.150***	0.110***	0.127***	0.153***	-0.071***	-0.259*	0.005*
Meat	0.291***	0.283***	0.297***	0.301***	-0.923***	0.192***	-0.113***	-0.064***	-0.202***	-0.378*	0.152***
Vegetables	0.054***	0.135***	0.196***	0.239***	0.154***	-0.866***	0.052***	0.022***	0.140***	-0.140*	0.042***
Firewood	-0.663***	-0.130***	0.191***	-0.028	0.094***	0.031***	-0.901***	-0.073***	1.410***	-0.230*	0.015**
Electricity	0.416***	0.272***	0.154***	-0.026	0.190***	0.151***	0.204***	-0.372***	-0.823***	-0.207*	0.044***
LPG	0.768***	0.371***	0.215***	0.137***	0.195***	0.175***	0.350***	-0.044***	-1.745***	-0.293*	0.072***
Kerosene	0.283***	0.228***	0.057***	0.03	0.235***	0.138***	0.230***	0.064***	-0.455***	-1.385*	0.016***
Clothing	0.236***	-0.410***	0.386***	-0.118**	0.368***	0.276***	0.169***	0.186***	0.281***	-0.367*	-0.522***

Tests for homogeneity and symmetry restrictions were conducted and both the restrictions were not satisfied (results in appendix). Failure of homogeneity can be ascribed to a number of possible causes. The introduction of serial correlation through imposition of this condition can be one of the reasons. Expenditure on several items may be relatively inflexible in short run like durable goods. The explanation of such items may require other variables like lagged dependent variable or time trend that can be proxied by price level. Omission of such variables could lead to rejection of homogeneity. In table 6, Demographic controls are added as controls. All the coefficients are highly significant at 1% except for 3 coefficients. It implies that the controls which are added to model significantly capture variation other than relative prices and real expenditure.

Table 6: Results for demographic controls in AIDS Model

	Household Size	Land Possessed	Lighting code
Cereal	0.059112***	0.04072***	-0.03252***
Pulses & Pulse Products	0.008835***	0.001832**	-0.00481***
Milk & Milk Products	0.018458***	-0.00903***	-0.00317***
Edible Oil	0.011664***	-0.00202*	-0.00521***
Egg, Fish & Meat	-0.02467***	0.009989***	0.012044***
Vegetables	0.006164***	0.005091***	-0.00656***
Clothing	0.00189***	0.006271***	0.002127***
Firewood	0.000563***	0.001201***	0.000425***
Electricity	-0.00131***	-0.00128*	0.014855***
LPG	-0.00352***	0.015268***	0.008641***
Kerosene	-0.01447***	0.013614***	-0.00215***

Results from Logit model

Appliance ownership depends on several factors like income of the household, frequency of salary received, household size, ownership of land, possession of ration, level of education of household, age of household head, dwelling type, electricity as primary source of lighting.

Table 7: Results from Logit Model

Variables	Fan	Cooler/AC	Inverter	Washing machine	Refrigerator
(a) Income					
i) MPCE	3.79E-06***	1.00E-06***	8.01E-07***	2.97E-06***	5.91E-06***
ii) Regular salaried-No	-0.09878***	-0.00824	-0.09292***	-0.24405***	-0.34608***
(b) Household Characteristics					
i) Household Size					
ii) Land Possessed- No	0.085105***	0.102807***	0.101266***	0.118503***	0.150001***
iii) Ration Card Possessed - No	-0.04854	-0.34465***	-0.58209***	-0.23162***	-0.29751***
iv) Education level	-0.54611***	-0.06126**	0.247054***	-0.32642***	-0.50687***
Literate without formal schooling					
Through EGS/NFEC/AEC – 02.	0.026166	0.427063*	0.405477	0.212856	0.128065
Through TLC -03.	0.553953*	-1.41131	-0.24578	-0.58427	-0.48754
Others- 04.	-0.01541	0.184633	0.334202	0.142033	0.520714***
Literate with formal schooling					
Below primary -05	0.213588***	0.100205**	0.237487***	0.226729***	0.384049***
Primary -06	0.269672***	0.372461***	0.644958***	0.731268***	0.735479***
Middle -07	0.402288***	0.577668***	1.121671***	1.146879***	1.111555***
Secondary 08	0.703339***	1.099313***	1.77484***	1.734575***	1.624306***
Higher secondary -10	0.594523***	1.352872***	2.116768***	1.93297***	1.696103***
Diploma/certificate course -11	1.482503***	1.407924***	2.284601***	2.438538***	2.14689***
Graduate -12	0.846125***	1.687027***	2.714136***	2.505042***	2.145949***
Postgraduate and above -13	1.27E+00***	2.299318***	3.109552***	2.841666***	2.403828***
Dwelling					
Hired-2	0.27988***	0.105113**	0.53932***	0.04517	0.18239***
No dwelling unit-3	-0.22926	0.277315	0.200003	0.402149	-0.11833
Others-9	-0.26998***	-0.09682	-0.26219**	-0.39925***	-0.28444***
vi) Lighting: Electricity	3.193168***	2.3287***	1.603186***	2.49151***	2.612099***
vii) Household Head Age	0.008937***	0.015972***	0.031503***	0.033495***	0.033041***
Constant	-3.06522***	-6.25186***	-7.42831***	-8.30359***	-7.54506***

As income of the household increases, probability of ownership increases in all the appliance categories; higher income means higher proportion can be devoted towards purchase of durable goods as shown in table 7. If the household member is not regular salaried, the probability of ownership decreases in all the appliance categories; if the income is infrequent then, people postpone purchase of durables. As household size increases, probability of ownership of appliances increases in all categories; more the members, higher would be demand for durable goods. As individuals who do not possess land can be considered less wealthy; probability of appliance ownership decreases in all categories. Similarly, individuals who do not possess ration cards belong to higher distribution of income, probability of

appliance ownership increases. As education level increases, affluence increases and hence the probability of appliance ownership. Most of the coefficients of education are positive whereas negative coefficients are insignificant. If the dwelling type is rented, probability of electricity consumption is more than owned. This result is not as per expectation. If the primary source of lighting of household is electricity, probability of ownership of appliance increases significantly. This variable is the highest contributor to probability of appliance ownership. As age of the household increases; probability of appliance ownership increases.

Equivalence scale

Table 8: Represents average equivalence scale and MPCE for income deciles

Income deciles	Mean household scale	Mean MPCE	Electricity
1	2.11917	61069.19	79.19
2	2.044779	83546.93	108.89
3	2.011799	100112.3	128.06
4	2.0083	116956	153.97
5	1.988265	135820.8	170.26
6	1.960234	158708.9	188.98
7	1.957948	188395.4	211.69
8	1.954803	231340.4	247.78
9	1.933268	305953.2	306.45
10	1.968502	670008.5	463.71

In table 8, Equivalence scale is calculated with reference to 1 couple household that comprises husband and wife. According to Amsterdam model considered above, 1 couple equals to 1.90 adult male equivalents. Equivalence scale for each household is calculated using the methodology mentioned above. Equivalence scales reduce as income deciles increase. Along with equivalence scale, average monthly per capita expenditure is also presented to give point estimates of income in each decile. As one child is added to the family, individuals in lowest income decile spend 21% more than reference household whereas individuals in highest decile spend only 6% more than reference household. Our data presents economies of scale for richer households.

Conclusion and Policy Implication

This paper suggests that electricity is a necessity component of fuel category. It is important for household welfare, public investments and environmental considerations, household welfare. More formal analyses should be carried out to analyze income, own-price and cross-price elasticities of demand for a full set of domestic energy sources, including fuelwood. A more detailed national sample surveys might help to address this gap. In this paper we have analyzed Indian households using National Sample Survey Organization data, that includes quantities and values of fuelwood, electricity, kerosene, LPG etc. Further insights can be sought by disaggregating the data, into relevant sub-samples, case in urban and rural samples, which were sub-divided into expenditure classes.

The investigation of electricity demand and the estimation of elasticity coefficients provide useful information on the consumption behaviour of electricity and different categories in relation to incomes and prices. All uncompensated own-price elasticities are negative which is consistent with the economic theory. The majority of cross-price elasticities are significant which suggests that the groups considered are either substitutes or complements to electricity according to coefficient sign. Accounting for the substitutability within the fuel and energy groups, electricity and LPG are found out to be complements. The table classifies coefficient of real income of categories i.e. cereals, pulses, milk, oil, vegetables, firewood chips, electricity as necessities whereas eggs, fish and meat, clothing, kerosene and LPG as luxuries. Positive income elasticity of demand for electricity estimated in model B confirms that with further economic development of the country, one can expect to see a rise in the electricity consumption of households. Moreover, with the demographic controls included in the model, the model covers the impact of heterogeneity among the households in terms of different household composition and demographic characteristics. Thus, the government and electricity agencies need to be aware of the heterogeneity of electricity demand in India in terms of distinctive household characteristics along with the regional variation.

Logit model is employed to determine how appliances ownership and hence, electricity consumption is affected by various factors like household size, education level, dwelling type etc. Income earning potential clearly increases use of electricity; with projected increase in economic conditions of households of India, electricity consumption is expected to increase many folds. And primary means to increase in electricity consumption is through appliance ownership and use. Also, we can see that as education increases, earning potential also increases and there is increase in electricity consumption. We should create awareness about electricity on each level of education in order to use electricity efficiently and judiciously. It can also be pointed that households where electricity is main lighting fuel, increases ownership of appliances tremendously.

Generally, result of the study as regards to own price elasticity shows that a pricing policy alone will not be effective in curbing future household electricity demand in India. However, given that electricity tends to be consumed disproportionately by wealthier and better off segments in India, the present method of subsidization is not efficient. The current policy of subsidization implies that in fact large proportions of the benefits are realized by the upper middle- and higher-income groups and therefore defeats the purpose of the subsidies. Thus subsidization policy should differ substantially across households with differing income and other characteristics.

Policy makers should take actions such as providing subsidies or lowering taxes to encourage energy-saving

electric appliances. The introduction and improvement of energy efficiency standards for households, thereby promoting the development of energy-saving technology and reducing energy demand for housing, such as from water heating, cooking and electrical appliances, should be undertaken. With increases in income level, it is necessary for every resident to enhance their awareness of energy conservation. A final recommendation is to develop and periodically conduct a Residential Energy Consumption Survey (RECS) in India. The RECS can include surveys of households, appliance manufacturers, and DISCOMs to collect data on energy use patterns of households. This data can play a crucial role in estimating the future energy demand and also in assessing the improvement in appliance efficiency over the years.

The programs like "My Mumbai, Green Mumbai" for exchanges of ceiling fans and air-conditioners with efficient appliances have been successful in reducing electricity consumption. Similar programs run by Delhi Electricity Board with its distributors to reduce upfront costs for efficient air-conditioners gave incentives to consumers to switch to efficient air-conditioners (5-star BEE rated). The UJALA scheme by central government to replace electric bulbs with LEDs (that consumes less than half of energy consumption by fluorescent bulbs) are expected to reduce the electricity consumption of consumer base. The rising electrification will lead to increase in consumer base and rise in electricity consumption. The increasing affluence of the households will increase appliance ownership and hence power demand. Moreover, the Ministry of Power, Government of India has advised manufacturers of air-conditioners to set 24 degrees as default temperature. This will save 20 billion units of electricity in one year alone, according to power industry. This initiative of the government will help in power consumption reduction and controlling greenhouse gases.

Coal is major source of energy conversion for power plants which leads to various environmental challenges and switching to non-conventional sources of energy can be a better option. Various advanced countries like France and Japan have been successful in implementing incentive schemes for consumers, incentivizing them with eco-points, concessions, reduced taxation and cashback coupons for lower level of electricity consumption. India can implement such schemes to reduce the demands as supply is more-constrained. At household level, people could use the minimal appliances as per the household needs. For this, consumers can be offered with real time-based electricity pricing to reduce loads on DISCOMs.

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Appendix

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. *****constrained aids model with demographic controls*****

.
. aidsills w129 w159 w169 w189 w199 w219 w379 w331 w332 w338 wkero, prices ( p129
> totalv) intercept( hh_size wland_owned lightingcode ) homogeneity symmetry

Iteration = 1       Criterion = .34275061
Iteration = 2       Criterion = .64722509
Iteration = 3       Criterion = .64265303
Iteration = 4       Criterion = .12521163
Iteration = 5       Criterion = .25947195
Iteration = 6       Criterion = .0509464
Iteration = 7       Criterion = .12386797
Iteration = 8       Criterion = .0585535
Iteration = 9       Criterion = .03674298
Iteration = 10      Criterion = .04561807
Iteration = 11      Criterion = .00435993
Iteration = 12      Criterion = .02061631
Iteration = 13      Criterion = .00749031
Iteration = 14      Criterion = .00789101
Iteration = 15      Criterion = .00547161
Iteration = 16      Criterion = .00106093
Iteration = 17      Criterion = .00348344
Iteration = 18      Criterion = .00029473
Iteration = 19      Criterion = .00113352
Iteration = 20      Criterion = .00085109
Iteration = 21      Criterion = .00047397
Iteration = 22      Criterion = .00035759
Iteration = 23      Criterion = .00007519
Iteration = 24      Criterion = .00027433
Iteration = 25      Criterion = .0000232
Iteration = 26      Criterion = .00003038
Iteration = 27      Criterion = .00009282
Iteration = 28      Criterion = .00003824
Iteration = 29      Criterion = .00001061
Iteration = 30      Criterion = .00002301
Iteration = 31      Criterion = .0000263
Iteration = 32      Criterion = 3.932e-06

AIDS - PROPER ESTIMATION WITH FIXED ALPHA_0 = 0
HOMOGENEITY AND SYMMETRY CONSTRAINED ESTIMATES
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Equation	Obs	Parms	RMSE	"R-sq"	F(15, 52828)	Prob > F
w129	52844	15	.07921	0.3673	2190.23	0.0000
w159	52844	15	.0349293	0.2006	947.08	0.0000
w169	52844	15	.1485976	0.0855	352.81	0.0000
w189	52844	15	.0335643	0.2268	1107.15	0.0000
w199	52844	15	.0859113	0.1514	673.18	0.0000
w219	52844	15	.0497393	0.0870	359.71	0.0000
w379	52844	15	.1124196	0.1221	524.68	0.0000
w331	52844	15	.0654141	0.2391	1185.71	0.0000
w332	52844	15	.0486626	0.2860	1511.62	0.0000
w338	52844	15	.0549201	0.1809	833.57	0.0000
wkero	52844	15	.0250639	0.1966	923.42	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
w129						
gamma_lnp129	.0267296	.0022951	11.65	0.000	.0222312	.031228
gamma_lnp159	-.0313511	.0023536	-13.32	0.000	-.0359641	-.0267381
gamma_lnp169	-.053392	.0015622	-34.18	0.000	-.056454	-.0503301
gamma_lnp189	-.0445755	.0024159	-18.45	0.000	-.0493105	-.0398404
gamma_lnp199	.0313372	.0013438	23.32	0.000	.0287035	.0339709
gamma_lnp219	-.0419516	.000769	-54.55	0.000	-.0434588	-.0404443
gamma_lnp379	.0972487	.001464	66.42	0.000	.0943793	.1001182
gamma_lnp331	-.0371729	.0012844	-28.94	0.000	-.0396902	-.0346555
gamma_lnp332	-.0113687	.0011451	-9.93	0.000	-.0136129	-.0091244
gamma_lnp338	.026453	.0027702	9.55	0.000	.0210234	.0318826
gamma_lnpkero	.0380432	.002418	15.73	0.000	.0333039	.0427825
beta_lnx	-.0585914	.0006785	-86.35	0.000	-.0599213	-.0572615
alpha_hh_size	.0549693	.0008315	66.11	0.000	.0533396	.056599
alpha_wland_owned	-.0387687	.0023248	-16.68	0.000	-.0433251	-.0342122
alpha_lightingcode	-.0329022	.000772	-42.62	0.000	-.0344153	-.0313892
alpha_cons	.7892675	.0094427	83.59	0.000	.7707602	.8077749

w159						
gamma_lnp129	-.0313511	.0006405	-48.95	0.000	-.0326064	-.0300958
gamma_lnp159	.0276522	.0007968	34.70	0.000	.0260905	.0292139
gamma_lnp169	-.0107733	.0003487	-30.89	0.000	-.0114568	-.0100898
gamma_lnp189	-.0122406	.0008179	-14.97	0.000	-.0138436	-.0106376
gamma_lnp199	.0067565	.0002671	25.30	0.000	.006233	.00728
gamma_lnp219	.0024228	.0002284	10.61	0.000	.0019752	.0028703
gamma_lnp379	.0094385	.0005698	16.57	0.000	.0083218	.0105552
gamma_lnp331	.0045744	.0003491	13.10	0.000	.0038902	.0052586
gamma_lnp332	-.0128823	.0003594	-35.84	0.000	-.0135868	-.0121778
gamma_lnp338	.0093137	.0009259	10.06	0.000	.0074989	.0111284
gamma_lnpkero	.0070892	.0006738	10.52	0.000	.0057686	.0084098
beta_lnx	-.0056701	.0003222	-17.60	0.000	-.0063015	-.0050387
alpha_hh_size	.0045608	.0002508	18.19	0.000	.0040693	.0050523
alpha_wland_owned	.0034404	.0005375	6.40	0.000	.0023869	.0044938
alpha_lightingcode	-.002977	.0001863	-15.98	0.000	-.0033421	-.0026119
alpha_cons	.1522201	.0033917	44.88	0.000	.1455724	.1588678

w169						
gamma_lnp129	-.053392	.0026052	-20.49	0.000	-.0584981	-.0482859
gamma_lnp159	-.0107733	.0032431	-3.32	0.001	-.0171296	-.004417
gamma_lnp169	-.0513011	.0020665	-24.82	0.000	-.0553514	-.0472508
gamma_lnp189	-.0146257	.0033434	-4.37	0.000	-.0211786	-.0080729
gamma_lnp199	.032104	.0011572	27.74	0.000	.029836	.034372
gamma_lnp219	-.0103363	.0009678	-10.68	0.000	-.0122331	-.0084395
gamma_lnp379	.0549737	.002303	23.87	0.000	.0504599	.0594874
gamma_lnp331	.003722	.0014503	2.57	0.010	.0008795	.0065646
gamma_lnp332	-.0066347	.0015065	-4.40	0.000	-.0095873	-.0036821
gamma_lnp338	.0079289	.0037715	2.10	0.036	.0005369	.0153209
gamma_lnpkero	.0483345	.0032025	15.09	0.000	.0420578	.0546113
beta_lnx	-.0331944	.0013839	-23.99	0.000	-.0359069	-.0304819
alpha_hh_size	.0232172	.0009363	24.80	0.000	.0213822	.0250523
alpha_wland_owned	-.0128469	.0020879	-6.15	0.000	-.016939	-.0087547
alpha_lightingcode	-.0043001	.0007338	-5.86	0.000	-.0057384	-.0028618
alpha_cons	.4293617	.0153233	28.02	0.000	.3993286	.4593949

w189						
gamma_lnp129	-.0445755	.0006247	-71.36	0.000	-.0457998	-.0433512
gamma_lnp159	-.0122406	.0007987	-15.33	0.000	-.013806	-.0106752
gamma_lnp169	-.0146257	.0004177	-35.01	0.000	-.0154445	-.013807
gamma_lnp189	.0485496	.0008242	58.91	0.000	.0469343	.050165
gamma_lnp199	.008518	.000313	27.21	0.000	.0079044	.0091315
gamma_lnp219	-.0026163	.0002433	-10.75	0.000	-.0030931	-.0021394
gamma_lnp379	.0166552	.0005581	29.84	0.000	.0155613	.0177491
gamma_lnp331	.0049859	.0003674	13.57	0.000	.0042658	.005706
gamma_lnp332	.0011276	.0003703	3.04	0.002	.0004018	.0018535
gamma_lnp338	-.0056589	.0009313	-6.08	0.000	-.0074841	-.0038337
gamma_lnpkero	-.0001194	.0007219	-0.17	0.869	-.0015344	.0012956
beta_lnx	-.0105405	.0003031	-34.78	0.000	-.0111345	-.0099464
alpha_hh_size	.0076213	.0002497	30.52	0.000	.0071319	.0081107
alpha_wland_owned	.0001676	.0005971	0.28	0.779	-.0010027	.0013378
alpha_lightingcode	-.0032881	.0002025	-16.24	0.000	-.003685	-.0028913
alpha_cons	.0983417	.0034372	28.61	0.000	.091605	.1050784
w199						
gamma_lnp129	.0313372	.0017563	17.84	0.000	.0278948	.0347795
gamma_lnp159	.0067565	.0019496	3.47	0.001	.0029355	.0105776
gamma_lnp169	.032104	.0009986	32.15	0.000	.0301469	.0340611
gamma_lnp189	.008518	.0020055	4.25	0.000	.0045873	.0124487
gamma_lnp199	-.0261878	.0009282	-28.21	0.000	-.028007	-.0243685
gamma_lnp219	.0134838	.0006128	22.00	0.000	.0122827	.0146849
gamma_lnp379	-.0345453	.0013752	-25.12	0.000	-.0372407	-.0318499
gamma_lnp331	-.003418	.0009038	-3.78	0.000	-.0051895	-.0016465
gamma_lnp332	.0041342	.0009037	4.57	0.000	.0023629	.0059055
gamma_lnp338	-.0015253	.002274	-0.67	0.502	-.0059823	.0029317
gamma_lnpkero	-.0306573	.0017436	-17.58	0.000	-.0340747	-.02724
beta_lnx	.022189	.0008622	25.74	0.000	.0204992	.0238789
alpha_hh_size	-.0187262	.0006417	-29.18	0.000	-.0199839	-.0174685
alpha_wland_owned	.0050543	.0013325	3.79	0.000	.0024427	.0076658
alpha_lightingcode	.0123608	.0004628	26.71	0.000	.0114538	.0132679
alpha_cons	-.0417922	.0087261	-4.79	0.000	-.0588951	-.0246893

w219						
gamma_lnp129	-.0419516	.0009211	-45.54	0.000	-.043757	-.0401462
gamma_lnp159	.0024228	.0011917	2.03	0.042	.0000871	.0047584
gamma_lnp169	-.0103363	.0005657	-18.27	0.000	-.0114451	-.0092275
gamma_lnp189	-.0026163	.0012245	-2.14	0.033	-.0050161	-.0002164
gamma_lnp199	.0134838	.0004425	30.47	0.000	.0126165	.014351
gamma_lnp219	-.0028294	.0004293	-6.59	0.000	-.0036709	-.001988
gamma_lnp379	.0271522	.0008303	32.70	0.000	.0255249	.0287794
gamma_lnp331	-.0015666	.0005456	-2.87	0.004	-.0026359	-.0004973
gamma_lnp332	-.0002155	.0005439	-0.40	0.692	-.0012815	.0008505
gamma_lnp338	.0069252	.0013898	4.98	0.000	.0042011	.0096492
gamma_lnpkero	.0095317	.00105	9.08	0.000	.0074739	.0115896
beta_lnx	-.0148698	.0004469	-33.27	0.000	-.0157457	-.0139938
alpha_hh_size	.0083392	.0003809	21.90	0.000	.0075927	.0090856
alpha_wland_owned	.0007061	.0008924	0.79	0.429	-.0010431	.0024552
alpha_lightingcode	-.0083428	.0003066	-27.21	0.000	-.0089438	-.0077418
alpha_cons	.1862041	.0049917	37.30	0.000	.1764205	.1959877

w379						
gamma_lnp129	.0972487	.0023969	40.57	0.000	.0925509	.1019466
gamma_lnp159	.0094385	.0034027	2.77	0.006	.0027693	.0161076
gamma_lnp169	.0549737	.0018701	29.40	0.000	.0513084	.058639
gamma_lnp189	.0166552	.0035023	4.76	0.000	.0097908	.0235197
gamma_lnp199	-.0345453	.001301	-26.55	0.000	-.0370951	-.0319955
gamma_lnp219	.0271522	.0010537	25.77	0.000	.0250869	.0292174
gamma_lnp379	-.1118648	.0021708	-51.53	0.000	-.1161195	-.1076101
gamma_lnp331	-.0033081	.0016994	-1.95	0.052	-.0066388	.0000226
gamma_lnp332	.0077226	.0016355	4.72	0.000	.004517	.0109281
gamma_lnp338	-.0122855	.0039554	-3.11	0.002	-.020038	-.004533
gamma_lnpkero	-.0511871	.0032061	-15.97	0.000	-.057471	-.0449032
beta_lnx	.065277	.0006617	98.65	0.000	.06398	.0665739
alpha_hh_size	-.0458821	.0010739	-42.72	0.000	-.047987	-.0437772
alpha_wland_owned	.0288271	.0031618	9.12	0.000	.0226301	.0350241
alpha_lightingcode	.0194203	.001042	18.64	0.000	.0173781	.0214625
alpha_cons	-.3858061	.0121733	-31.69	0.000	-.4096654	-.3619468
w331						
gamma_lnp129	-.0371729	.0012475	-29.80	0.000	-.0396179	-.0347278
gamma_lnp159	.0045744	.0014864	3.08	0.002	.0016612	.0074876
gamma_lnp169	.003722	.0006117	6.08	0.000	.0025231	.004921
gamma_lnp189	.0049859	.001529	3.26	0.001	.0019891	.0079827
gamma_lnp199	-.003418	.0004526	-7.55	0.000	-.004305	-.002531
gamma_lnp219	-.0015666	.0004353	-3.60	0.000	-.0024198	-.0007134
gamma_lnp379	-.0033081	.0011049	-2.99	0.003	-.0054736	-.0011427
gamma_lnp331	.0072703	.0006295	11.55	0.000	.0060366	.008504
gamma_lnp332	.0043895	.0006703	6.55	0.000	.0030757	.0057033
gamma_lnp338	.0251639	.0017273	14.57	0.000	.0217785	.0285493
gamma_lnpkero	-.0046405	.0012401	-3.74	0.000	-.0070709	-.00221
beta_lnx	.0041361	.0006556	6.31	0.000	.0028511	.0054211
alpha_hh_size	-.0033349	.0004668	-7.14	0.000	-.0042498	-.0024199
alpha_wland_owned	-.0250289	.0009093	-27.53	0.000	-.0268111	-.0232468
alpha_lightingcode	-.0069367	.000322	-21.54	0.000	-.0075679	-.0063055
alpha_cons	.042789	.0067017	6.38	0.000	.029654	.0559241

w332						
gamma_lnp129	-.0113687	.0008898	-12.78	0.000	-.0131126	-.0096247
gamma_lnp159	-.0128823	.0010925	-11.79	0.000	-.0150236	-.0107409
gamma_lnp169	-.0066347	.0004823	-13.76	0.000	-.0075801	-.0056893
gamma_lnp189	.0011276	.0011253	1.00	0.316	-.0010779	.0033332
gamma_lnp199	.0041342	.0003533	11.70	0.000	.0034418	.0048267
gamma_lnp219	-.0002155	.0003138	-0.69	0.492	-.0008306	.0003996
gamma_lnp379	.0077226	.0008077	9.56	0.000	.0061394	.0093057
gamma_lnp331	.0043895	.0004728	9.28	0.000	.0034628	.0053162
gamma_lnp332	.0273592	.0005107	53.57	0.000	.0263582	.0283603
gamma_lnp338	-.0200249	.0012713	-15.75	0.000	-.0225166	-.0175333
gamma_lnpkero	.0063928	.0009338	6.85	0.000	.0045625	.0082231
beta_lnx	-.0059003	.0004729	-12.48	0.000	-.0068271	-.0049735
alpha_hh_size	-.0004869	.0003349	-1.45	0.146	-.0011433	.0001695
alpha_wland_owned	.0012269	.0006834	1.80	0.073	-.0001125	.0025663
alpha_lightingcode	.0158582	.0002379	66.67	0.000	.015392	.0163244
alpha_cons	-.0473469	.0049566	-9.55	0.000	-.0570616	-.0376323

PREDICTED SHARES, BUDGET AND (UN)COMPENSATED OWN-PRICE ELASTICITIES

	shares b/se	budget b/se	u_price b/se	c_price b/se
w129	0.526***	0.889***	-0.770***	-0.303***
	(0.003)	(0.001)	(0.002)	(0.002)
w159	0.099***	0.943***	-0.708***	-0.615***
	(0.001)	(0.002)	(0.009)	(0.008)
w169	0.327***	0.898***	-1.062***	-0.768***
	(0.006)	(0.002)	(0.002)	(0.006)
w189	0.130***	0.919***	-0.599***	-0.480***
	(0.001)	(0.002)	(0.007)	(0.006)
w199	0.058***	1.381***	-1.316***	-1.236***
	(0.004)	(0.038)	(0.023)	(0.026)
w219	0.181***	0.918***	-0.978***	-0.812***
	(0.002)	(0.002)	(0.001)	(0.002)
w379	-0.188***	0.653***	-0.889***	-1.011***
	(0.003)	(0.003)	(0.003)	(0.005)
w331	0.046***	1.090***	-0.840***	-0.789***
	(0.003)	(0.019)	(0.020)	(0.018)
w332	0.091***	0.935***	-0.687***	-0.601***
	(0.002)	(0.004)	(0.009)	(0.008)
w338	0.030***	1.209***	-1.968***	-1.932***
	(0.002)	(0.033)	(0.088)	(0.090)
wkero	-0.300***	0.897***	-1.036***	-1.305***
	(0.007)	(0.003)	(0.009)	(0.011)

* p<0.05, ** p<0.01, *** p<0.001

UNCOMPENSATED CROSS-PRICE ELASTICITIES

	p129 b/se	p159 b/se	p169 b/se	p189 b/se	p199 b/se	p219 b/se	p379 b/se	p331 b/se	p332 b/se	p338 b/se	p
w129	-0.770***	-0.037***	0.003***	-0.049***	0.020***	-0.029***	0.030***	-0.074***	0.001	0.041***	-0
	(0.002)	(0.003)	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)	(0.
w159	-0.225***	-0.708***	-0.055***	-0.105***	0.048***	0.051***	0.016***	0.045***	-0.119***	0.089***	0
	(0.005)	(0.009)	(0.002)	(0.008)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.009)	(0.
w169	-0.000	-0.012	-1.062***	-0.012	0.063***	0.015***	0.027***	0.008	0.000	0.016	0
	(0.005)	(0.010)	(0.002)	(0.010)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.012)	(0.
w189	-0.213***	-0.078***	-0.036***	-0.599***	0.037***	0.017***	0.015***	0.036***	0.025***	-0.051***	-0
	(0.004)	(0.006)	(0.001)	(0.007)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.007)	(0.
w199	-0.074***	0.039	0.194***	0.023	-1.316***	0.058***	-0.063***	-0.047***	-0.005	0.006	-0
	(0.019)	(0.033)	(0.012)	(0.034)	(0.023)	(0.008)	(0.011)	(0.014)	(0.015)	(0.038)	(0.
w219	-0.100***	0.030***	0.020***	0.012	0.046***	-0.978***	0.036***	-0.011***	0.015***	0.031***	-0
	(0.004)	(0.006)	(0.001)	(0.006)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.007)	(0.
w379	0.041***	0.020	0.034***	0.024	0.062***	0.014***	-0.889***	0.007	0.028***	0.036*	-0
	(0.007)	(0.013)	(0.002)	(0.014)	(0.003)	(0.003)	(0.003)	(0.006)	(0.006)	(0.015)	(0.
w331	-0.951***	0.081*	-0.004	0.079*	-0.043***	-0.075***	0.053***	-0.840***	0.077***	0.554***	-0
	(0.060)	(0.033)	(0.005)	(0.034)	(0.008)	(0.008)	(0.007)	(0.020)	(0.015)	(0.046)	(0.
w332	-0.021**	-0.128***	-0.012***	0.033**	0.023***	0.027***	-0.005	0.046***	-0.687***	-0.225***	0
	(0.007)	(0.013)	(0.002)	(0.013)	(0.002)	(0.003)	(0.003)	(0.006)	(0.009)	(0.016)	(0.
w338	0.547***	0.269***	0.068***	-0.257***	0.023**	0.136***	-0.119***	0.847***	-0.711***	-1.968***	-0
	(0.042)	(0.044)	(0.007)	(0.048)	(0.008)	(0.013)	(0.015)	(0.069)	(0.054)	(0.088)	(0.
wkero	0.039***	-0.003	-0.064***	0.034**	0.066***	0.015***	0.027***	0.012*	-0.001	0.014	-1
	(0.006)	(0.012)	(0.003)	(0.012)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.013)	(0.

* p<0.05, ** p<0.01, *** p<0.001

COMPENSATED CROSS-PRICE ELASTICITIES

	p129	p159	p169	p189	p199	p219	p379	p331	p332	p338	p1
> ero	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	t
> /se											
w129	-0.303***	0.051***	0.293***	0.067***	0.072***	0.132***	-0.137***	-0.033***	0.082***	0.067***	-0
> 291***	(0.002)	(0.004)	(0.005)	(0.004)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.004)	(0.
> 07)											
w159	0.271***	-0.615***	0.253***	0.017*	0.103***	0.221***	-0.162***	0.088***	-0.033***	0.118***	-0
> 261***	(0.006)	(0.008)	(0.006)	(0.008)	(0.004)	(0.003)	(0.004)	(0.005)	(0.004)	(0.009)	(0.
> 09)											
w169	0.473***	0.076***	-0.768***	0.105***	0.115***	0.177***	-0.142***	0.050***	0.082***	0.042***	-0
> 210***	(0.006)	(0.010)	(0.006)	(0.011)	(0.004)	(0.003)	(0.004)	(0.005)	(0.005)	(0.012)	(0.
> 10)											
w189	0.271***	0.013*	0.264***	-0.480***	0.091***	0.183***	-0.158***	0.078***	0.109***	-0.023**	-0
> 347***	(0.005)	(0.006)	(0.006)	(0.006)	(0.003)	(0.002)	(0.003)	(0.004)	(0.003)	(0.007)	(0.
> 08)											
w199	0.653***	0.175***	0.645***	0.202***	-1.236***	0.308***	-0.323***	0.016	0.121***	0.048	-0
> 609***	(0.024)	(0.034)	(0.026)	(0.034)	(0.026)	(0.013)	(0.016)	(0.015)	(0.015)	(0.038)	(0.
> 35)											
w219	0.383***	0.121***	0.320***	0.131***	0.099***	-0.812***	-0.137***	0.031***	0.099***	0.059***	-0
> 294***	(0.005)	(0.006)	(0.006)	(0.006)	(0.004)	(0.002)	(0.003)	(0.004)	(0.003)	(0.007)	(0.
> 08)											
w379	0.385***	0.085***	0.247***	0.109***	0.100***	0.132***	-1.011***	0.037***	0.088***	0.055***	-0
> 225***	(0.008)	(0.013)	(0.005)	(0.014)	(0.003)	(0.003)	(0.005)	(0.006)	(0.006)	(0.015)	(0.
> 11)											
w331	-0.377***	0.189***	0.352***	0.220***	0.021*	0.123***	-0.152***	-0.789***	0.177***	0.586***	-0
> 349***	(0.051)	(0.033)	(0.010)	(0.034)	(0.008)	(0.007)	(0.008)	(0.018)	(0.016)	(0.048)	(0.
> 27)											
w332	0.472***	-0.036**	0.294***	0.155***	0.077***	0.197***	-0.181***	0.089***	-0.601***	-0.197***	-0
> 266***	(0.007)	(0.013)	(0.006)	(0.013)	(0.004)	(0.003)	(0.004)	(0.007)	(0.008)	(0.016)	(0.
> 11)											
w338	1.183***	0.388***	0.463***	-0.100*	0.093***	0.355***	-0.346***	0.902***	-0.600***	-1.932***	-0
> 406***	(0.058)	(0.045)	(0.016)	(0.046)	(0.009)	(0.018)	(0.020)	(0.072)	(0.052)	(0.090)	(0.
> 33)											
wkero	0.511***	0.086***	0.229***	0.150***	0.118***	0.178***	-0.142***	0.054***	0.081***	0.041**	-1
> 305***	(0.007)	(0.012)	(0.007)	(0.012)	(0.004)	(0.003)	(0.004)	(0.006)	(0.005)	(0.014)	(0.
> 11)											

* p<0.05, ** p<0.01, *** p<0.001