ESTIMATION OF RESIDENTIAL ENERGY DEMAND IN TURKEY AND EXPENDITURE GROUPS: EVIDENCE FROM 2012

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Abstract

Energy demand in Turkey has been growing at a rapid rate in recent years. Especially residential energy demand plays a substantial role in the composition of overall energy demand. In this paper, price and expenditure elasticities of energy demand in the overall residential sector and in different expenditure groups along with the effects of lifestyle related variables and demographic variables. We use the survey data of Turkish Household Budget data and Heckman selection model is used to estimate the elasticities. The empirical results show that the residential energy demand price and expenditure elasticities are -2.41 and 0.28, respectively. However when we examine the income groups we find significant differences among them in particular their price elasticities. Households on high expenditures are more sensitive to price changes. The results have important policy implications and emphasize differentiated policy measures in the residential sector.

Key Words: Residential Energy Demand, Price Elasticity, Expenditure Elasticity, Expenditure Groups

Jel Codes: D12, Q40, Q41

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1. INTRODUCTION

In line with the current increase in population, modernisation and economic growth worlds energy demand has increasing substantially. Turkey with a population of over 70 million also has experienced some of the fastest growth in energy demand of countries in the world. According to the Turkish Ministry of Energy and Natural Resources when Turkey's primary energy consumption is taken into account Turkey ranks 18th in the world in 2014. In addition to its growing energy demand Turkey acts as a regional energy transit hub with domestic and international pipelines.

Turkeys' primary energy production and consumption has reached 31964 tonnes of oil equivalent (toe) and 72342 toe, respectively in 2012. However Turkey is an energy importing country and as the problems such as energy security become more severe than last years. In 2012, 9% of the crude oil demand was met by domestic production, natural gas this rate was 1.6%. Iran is the largest supply source of crude oil and Russia is the largest supplier for natural gas.

In recent years, Turkey has attached increasing importance to the establishment of competitive markets. The first step was the implementation of Electricity Market Law in 2001 in which an independent energy regulator (Energy Markets Regulatory Authority) was created and a licensing regime was implemented. Besides, the gas market was liberalised with the Natural Gas Market Law in 2001. In 2013, a new Electricity Market Law was passed with an auditing mechanism for the electricity market and open market plans for all customers.

Residential energy sector which uses energy for heating, cooling, and lighting is the second consumer in Turkey after the industrial sector. Oil is the leading source with natural gas, electricity and coal as regarded total final energy consumption. According to international energy agency the transport sector accounted for half of total oil consumption and the transformation sector was the largest consumer of natural gas in 2011. Moreover, natural gas accounted more than 40% of total electricity generation.

As residential sector accounts for a considerable share of total energy use it is respectable to investigate energy consumer response to income, price and socio economic characteristics. This paper aims to present the determinants of energy demand involving income groups based on household budget survey. We define household energy demand as a function of household expenditure as a proxy for income, price and socio-economic variables such as household size, household electrical appliance stock and age. Also we have taken account between rural and urban areas.

The rest of the paper is organized as follows. The next section presents a literature review on energy demand studies including micro level data. Section 3 describes the empirical model and data. Estimation results are presented and discussed in section 4 and the last section concludes.

2. LITERATURE REVIEW

Household energy demand has been taken account since 1950s. The very first research was about British urban electricity consumption (Houthakker, 1951). Since then various studies of energy demand estimates were carried with different methods. Most of the studies focus on estimating income and price elasticities as the response to changes in income and prices. However, the changeability of parameter estimates is influenced by the type of data which is used to estimate the model.

Mainly studies for energy demand focuses on electricity and uses log-linear demand model. In this type of models, the dependent and explanatory variables are transformed into natural logarithms and elasticities can be achieved from the estimated coefficients. Besides using time series and cross sectional data there are energy demand estimates using panel data.

For instance, Bermann, et al. (1972) focuses on households in West America and California and shows that in the year 1960-1961 heterogeneous household groups are affected differently in the long run although in the short run, electricity demand price elasticity is founded as -.25.

Dubin and McFadden, (1984) claim that using data at a disaggregated level avoids misspecification error that is caused by aggregation bias. They analyse energy consumption of households considering space heating equipment. In this context, they introduce a two-stage methodology. Nesbakken (2001) used this discrete choice methodology for Norwegian households.

There are also studies which take account seasonality. An important example is Filippini and Pachauri (2004)'s research about India's urban household electricity demand by using double logarithmic model. In this study, with three different estimates for the period for the summer, winter and monsoon resulted as income and price elasticities to be inelastic and demographic, geographic variables were found to be significant.

Joo, et al. (2007) examines the residential electricity demand function in Seoul by using a bivariate model. The study shows that socio-economic characteristics (i.e. size of family, the size of house, dummy for having a plasma display panel television, dummy for having an air conditioner) have positive relationships with the demand and the demand is income and price inelastic. Also, Zhou and Teng, (2013) estimates income and price elasticities of residential energy demand with the effects of socio-economic characteristics. They also showed that such variables like household size and electrical appliances are determinants of residential energy demand.

There are a few studies takes account both for electricity and gas demand. Bernard et al. (2010) used multiyear cross section data for Quebec from 1989 for both electricity and gas demand. Estimates showed that electricity and natural gas are substitutes. Jamasb & Meier, (2010) used a household panel dataset which covers 1991 to 2007 with more than 77000 observations. They analyse household energy spending (i.e. electricity, oil and natural gas) by splitting into several income groups.

There are only a few previous studies of estimating energy demand elasticities in Turkey using household data. Başaran (2011) estimated household electricity demand for 2003 to 2009 using household budget survey data. The emprical results show that price elasticities of the household electricity demand ranges from -.55 to -1.14.

3. DATA

Except for the price data, all data is collected from Household Budget Survey (HBS) of Turkish Statistical Institute (TURKSTAT). Electricity price is collected from Turkish Electricity Distribution Company (TEDAŞ).

HBS is one of the major sources providing information on consumption expenditure patterns by socio-economic groups and urban-rural settlements. In 2012, the survey was applied to 13,248 households, and 9,987 responses were received from households. At the same time the weighted number of household ise 20051454.

In the survey there are household consumption expenditure types and classified under 12 groups:1-Foods and non-alcoholic beverages, 2-Alcoholic beverages, cigarette and tobacco, 3-Clothing and footwear, 4-Housing, water, electricity, gas and other fuels, 5-Furnishings, household equipment and maintenance of the house, 6-Health, 7-Transportation, 8-Communication, 9-Entertainment and culture, 10-Educational services, 11-Restaurants and hotels, 12-Miscellaneous goods and services .

In this study we focused on electricty and natural gas spendings in the fourth group. However, there is a missing data problem in the electricity variable. Many of the missing data are observed in the poor income groups. In 2012, there exists 1,304 missing data in electricity and the main reason behind this problem is illegal use of energy.

Table 1. Missing Data According to Income Groups

Income Groups	Electricity
First Group (Poorest)	25.38%
Second Group	13.81%
Third Group	10.93%
Fourth Group	8.35%
Fifth Group (Richest)	6.31%
Total	12.96%

4. MODEL AND ESTIMATION RESULTS

We assumed that household energy consuming appliance stock is fixed, so we estimate the short run demand. Energy demand covers both electricity and gas demand for the year 2012. We use a log-linear functional form and we take the natural logarithm of energy demand, expenditures (as a proxy for income) and price. Also we use the index variable from the data set in order to adjust all monetary values to price developments. This variables helps us to fit monthly datas to year-end.

Energy using household appliances are controlled by dummies. The set of the appliances include refrigerator, washing machine, dishwasher, air conditioner, lcd tv and computer. Household demographic attributes cover living in urban areas, household size, hot water and natural gas utilization. Also the function includes dwelling size as a housing attribute.

The empirical model is specified as the following equation:

$$lnE = \beta_o + \beta_1 lnY + \beta_2 lnP_E + \beta_3 G + \beta_4 Old + \beta_5 Urban + \beta_6 Com + \beta_7 Ac + \beta_8 Wm + \beta_9 R + \beta_{10} Dw + \beta_{11} Tv + \beta_{12} Hhs + \beta_{13} Water + \beta_{14} Size$$

where:

E: Monthly household's energy demand (sum of electricity and gas spending)

Y: Monthly household's expenditure (as a proxy for income)

P_E: Average annual electricity price (as a proxy for prices)

G: Indicates whether a household has access to gas or not

Old: Dummy variable for retired and old household member (equal to 1 for household member whose older than 65)

Urban: Indicates whether a household lives in urban area or not

Com: Indicates whether a household has a computer or not

Ac: Indicates whether a household has an airconditioner or not

Wm: Indicates whether a household has a washing mashine or not

R: Indicates whether a household has a refrigerator or not

Dw: Indicates whether a household has a dish washer or not

Tv: Indicates whether a household has a lcd tv or not

Hhs: Household size

Water: Indicates whether a household has access to hot water or not

Size: Dwelling size

The emprical results are estimated by Heckman's (1979) Sample Selection Model to fix the undesirable impacts of missing data. The intuition behind Heckman's selection model is estimating a probit model in the first stage and using the estimates from this model unbiased estimates in the second stage can be acquired.

The specification for Heckman's sample selection model is as follows: $y_i = x_i\beta + u_{1j}$ (regression equation) if the dependent variable is not observed then the dependent variable for observation j is observed if $z_i\gamma + u_{2i} > 0$ (selection equation) where

$u_1 \sim N(0,\sigma);\ u_2 \sim N(0,\sigma); corr(u_1, u_2) = \rho$

If $\rho \neq 0$ a sample selection bias in the OLS estimator arises. Hence Heckman's selection model provides consistent, asymptotically efficient estimates for all the parameters. Finally the sample selection model is estimated using maximum likelihood technique.

The estimation results for whole sample and sub samples are presented in Table 2. Note that, in the first stage equation, the dependent variable is equal to one if the household reported information on the residential energy demand and zero otherwise, and in the demand equation, the dependent variable is the natural logarithm of the real residential energy demand. All the monetary values are adjusted to price developments. First stage estimates can be found on Appendix 1.

The estimated income elasticity of energy demand is 0.284 for the whole sample. The results for the income groups display somewhat diverse picture. The income elasticity is lowest for the richest group and statistically insignificant for the middle income group. Thus the inflection point may be observed at the middle income group. As shown in the table income elasticity for low-income groups (i.e. first and second group) is evidently higher than the high income groups (i.e. fourth and fifth group).

The sign of the price elasticity is negative for the whole sample as expected. However the price elasticity for the poorest group is positive and for the other sub samples the price elasticity increases with income. The effect is strongest for the richest group. This suggests that a 1% increase in the price of electricity will (ceteris paribus) result in approximately a 5% decline in the richest household consumption of energy and for the poorest group approximately a 1.8 % increase.

An old household member seems to significantly influence the energy demand of households. The estimated coefficient is statistically significant for the last three group however for the low income groups we can not find a significant impact on energy demand.

Living in urban areas affect energy demand negatively for the whole sample and for the sub samples except the third group. It is possible that energy efficient appliances have a widespread utilization in the urban areas so the sign is negative for the all groups.

Table 2. Regression Results-Energy Demand

	All	1st Group	2nd Group	3rd Group	4th Group	5th Group
Income	0.284	0.359	0.682	0.180	0.327	0.214
	(19.54)**	(6.57)**	(4.99)**	(0.99)	(2.39)*	(4.87)**
Price	-2.414	1.868	-1.220	-2.316	-4.412	-5.042
	(8.60)**	(3.00)**	(2.00)*	(3.40)**	(7.24)**	(8.07)**
Old	0.049	-0.017	0.039	0.070	0.092	0.104
	(2.83)**	(0.50)	(1.10)	(1.80)+	(2.12)*	(2.29)*
Computer	0.091	0.123	0.081	0.061	0.032	0.186
	(5.68)**	(2.78)**	(2.61)**	(1.90)+	(0.90)	(4.59)**
Urban	-0.104	-0.157	-0.122	0.034	-0.067	-0.075
	(5.61)**	(4.29)**	(2.66)**	(0.83)	(1.59)	(1.45)
Air conditioner	0.147	0.162	0.150	0.170	0.197	0.083
	(7.87)**	(2.48)*	(3.43)**	(4.03)**	(5.22)**	(2.43)*
Washing Machine	-0.001	-0.035	0.078	0.205	0.176	-0.374
	(0.03)	(0.66)	(0.79)	(1.15)	(1.11)	(1.58)
Dish Washer	0.100	0.068	0.098	0.180	0.049	0.096
	(5.87)**	(1.57)	(3.06)**	(4.96)**	(1.35)	(1.92)+
Refrigerator	0.259	0.362	0.174	0.335	0.083	0.269
	(2.72)**	(2.45)*	(0.88)	(1.35)	(0.40)	(3.41)**
Lcd TV	0.049	0.055	0.103	-0.002	0.026	0.048
	(3.01)**	(1.12)	(2.71)**	(0.04)	(0.79)	(1.45)
Household Size	0.050	0.049	0.038	0.030	0.057	0.036
	(11.19)**	(4.84)**	(3.56)**	(2.62)**	(5.85)**	(3.85)**
Natural Gas	0.510	0.345	0.558	0.609	0.511	0.458
	(29.80)**	(5.56)**	(14.38)**	(15.88)**	(14.74)**	(13.73)**
Hot Water	0.059	0.090	0.064	0.032	0.111	0.081
	(2.40)*	(2.46)*	(1.45)	(0.49)	(1.39)	(0.62)
Dwelling Size	0.122	-0.005	-0.015	0.115	0.101	0.394
	(4.82)**	(0.11)	(0.27)	(1.90)+	(1.74)+	(7.07)**
Constant	-1.549	2.825	-2.562	-1.045	-3.819	-4.644
	(4.47)**	(3.60)**	(1.98)*	(0.60)	(2.78)**	(5.60)**

+ $p<0.1$; * $p<0.05$; ** $p<0.01$

All the household electrical appliances except washing machine, which is statistically insignificant for the all groups, have positive statistically significant impacts on household energy demand. Compared with the other appliances, refrigerator, which has the highest utilization frequency, has the highest impact on household energy demand.

As expected, bigger households and larger dwelling size increase the residential energy demand for the wole sample. A 1% increase (ceteris paribus) in the dwelling size results in about a 0.122% increase in the household's demand for energy, while this variable is statistically insignificant for the lowest income groups.

The dummy variables natural gas and hot water take a value of one for household if there is an access for them. The estimated coefficients for having natural gas have positive impact on household energy demand for both whole sample and sub samples. However for having hot water in the house has positive impact on whole sampla and for the first two groups. The third income group is the inflection point here as well.

5. CONCLUSION

The paper provides the estimation of household energy (electricity and gas) demand for Turkey using household budget survey for the year 2012. The model examined income and price elasticities but also the effect of socio economic determinants. Demand elasticities for the heterogeneous household groups are also examined.

The estimated model suggests that there is a significant difference among households considering the income groups. We find that income elasticity is lowest for the richest group and inelastic for the all groups. On the contrary, the price effect is strongest for the richest group. For the lowest income group an increase in the prices also increases the demand. In addition, medium income level acts like an inflection point in most cases.

Significant effects are estimated for socio-economic variables and household appliance stock in energy demand. The results also indicate these variables (such as dwelling size, old member, using refrigerator, having access to natural gas etc) have significant effects on energy demand in Turkey.

Our findings show that heterogeneity is evident for households according to their income levels. Thus policy makers should take into account this heterogeneous effect in order to achieve successful policy implications.

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Appendix 1. Heckman's Selection Model First Stage Estimates

	All	1st Group	2nd Group	3rd Group	4th Group	5th Group
Yearly Disposable Income	0.241	0.183	0.048	-0.093	0.162	-0.079
	(7.14)**	(2.94)**	(0.60)	(0.96)	(2.77)**	(0.74)
Refrigerator	0.498	0.678	0.333	0.280	-0.164	0.641
	(4.19)**	(4.31)**	(1.12)	(0.77)	(0.30)	(0.98)
Washing Machine	0.347	0.231	0.611	0.528	0.292	-0.211
	(5.12)**	(2.56)*	(4.20)**	(2.45)*	(1.05)	(0.54)
Dish Washer	0.174	0.111	-0.015	0.184	0.087	0.413
	(3.79)**	(1.03)	(0.17)	(1.99)*	(0.82)	(2.98)**
Lcd TV	-0.110	-0.307	-0.158	-0.231	0.052	-0.100
	(2.43)*	(3.05)**	(1.64)	(2.36)*	(0.50)	(0.85)
Air conditioner	0.038	-0.084	-0.097	0.137	0.188	0.132
	(0.69)	(0.66)	(0.85)	(1.14)	(1.33)	(0.86)
Urban	0.548	0.609	0.594	0.329	0.491	0.600
	(13.17)**	(8.19)**	(6.83)**	(3.51)**	(4.46)**	(4.51)**
Household Size	-0.077	-0.097	-0.101	-0.099	-0.039	-0.040

	(8.47)**	(6.00)**	(4.84)**	(4.40)**	(1.54)	(1.72)+
Natural Gas	0.332	-0.018	0.253	0.638	0.420	0.369
	(5.48)**	(0.12)	(2.06)*	(4.04)**	(3.05)**	(2.58)**
Hot Water	0.291	0.230	0.136	0.266	0.386	0.883
	(6.11)**	(3.19)**	(1.38)	(2.27)*	(2.47)*	(4.16)**
Dwelling Size	0.021	0.062	-0.039	0.011	-0.090	0.002
	(0.34)	(0.65)	(0.27)	(0.07)	(0.50)	(0.01)
Constant	-2.483	-2.206	-0.137	1.210	-0.636	0.635
	(6.69)**	(3.45)**	(0.14)	(1.04)	(0.58)	(0.44)
athrho†	-0.333	-0.250	-0.081	0.839	-0.554	-0.142
	(4.75)**	(1.92)+	(0.28)	(5.83)**	(3.56)**	(0.96)
lnsigma‡	-0.453	-0.548	-0.533	-0.396	-0.446	-0.414
	(45.02)**	(21.70)**	(26.77)**	(16.68)**	(18.67)**	(21.56)**

+ $p<0.1$; * $p<0.05$; ** $p<0.01$

† Stata does not directly estimate rho(ρ), it estimates the inverse hyperbolic tangent of ρ. Stata defines this variable "athrho". The standard error is computed using the delta method.

‡ The standard error of the residual is called "lnsigma(σ)".