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Distributional Impact Analysis of the Energy Price Reform in Turkey

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Abstract

A pricing reform in Turkey increased the residential electricity tariff by more than 50 percent in 2008. The reform, aimed at encouraging energy efficiency and private investment, sparked considerable policy debate about its potential impact on household welfare. This paper estimates a short-run residential electricity demand function for evaluating the distributional consequences of the tariff reform. The model allows heterogeneity in household price sensitivities and is estimated using a national sample of 18,671 Turkish households. The model also addresses the common problem of missing data in survey research. The study reveals a highly skewed distribution of price elasticities in the population, with rich households three times more responsive in adjusting consumption to price changes than the poor. This is most likely because the poor are close to their minimum electricity consumption levels and have fewer coping options. In addition, the welfare loss of the poorest quintile—measured by the consumer surplus change as a percentage of income—is 2.9 times of that of the wealthiest.

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I. Introduction

With growing concerns over energy security and climate change, policy-makers have increasingly come to realize that energy prices will have to rise in order to reflect the full cost of consumption. In developing countries, this involves removing subsidies to bring energy prices closer to market rates; in the developed world, the goal is to internalize environmental costs into energy prices. However, at the same time, there is concern that higher energy prices will create economic distress, particularly for the poor households.

Recent reforms in Turkey illustrate these issues. Turkish residential electricity tariffs remained constant during 2002-07, even though fuel costs increased. In 2008, a cost-based pricing mechanism was approved, raising the retail tariff by about 50 percent over one year. Pricing reform is one of the key measures of the electricity market reform launched in Turkey in 2001. It is considered essential for encouraging energy efficiency, attracting private investment, and improving the financial position of the state owned electric utilities. Nonetheless, the magnitude of the price increase was unprecedented. How it would affect households' consumption and welfare has prompted public dialogue and policy debate.

The purpose of this paper is to present a partial equilibrium analysis of the welfare impact of the tariff reform in Turkey.[2] I estimate a short-run residential demand function for electricity which can be used to quantify the welfare effect of price increases on different income groups. By allowing price elasticities to vary with household income (in the cross section), the model reveals a highly differentiated distribution of demand elasticities in the population, with wealthy households three times more responsive in adjusting consumption to price changes than the poorest, *ceteris paribus*.

This result has noteworthy welfare implications. Because poor households are less adaptable to rising tariffs, they suffer a disproportionately larger welfare loss. Although this issue has received attention in the literature, few studies have addressed it in a systematic way.[3] The model also indicates a smaller aggregate price elasticity of demand than a model ignoring the heterogeneity in households' price elasticities, suggesting that a homogeneous estimator will both neglect the variance and underestimate the aggregate impact on the population.

I estimate the demand model using disaggregated consumption data for a representative sample of 18,671 Turkish households from the 2008 and 2009 Household Budget Survey (HBS) of the Turkish Statistical Institute. The dataset provides rich detail in appliance ownership, dwelling

[2] It should be noted that although electricity reform may result in price increases, it also provides opportunities that would not otherwise exist to improve quality and reliability of power supply, and to re-direct public resources more transparently to the poor. Analyzing the broader impact of electricity pricing reform is beyond the scope of the paper.

[3] Previous studies have noted that poor households devote a larger proportion of income to energy, and therefore, carry a disproportionally higher burden of rising energy prices. However, few (if any) studies have estimated the differences in the welfare loss (measured by changes in consumers' utility) between the poor and non-poor.

characteristics, income and demographic information. The large number of observations combined with substantial rate changes under the price reform help identify both price and non-price segments of the demand function.

A common issue of using survey data for statistical analysis is that we only selectively observe those who choose to report. In the Turkish household budget survey, about 28 percent of households with access to electricity did not report electricity expenditure. To address potential sample selection bias, I apply Heckman's selection model (Heckman, 1979) but do not find evidence of selection on unobservables, which suggests that sample selection bias is not a concern in this study. I then use the model to estimate the distributional impact of the 2008 tariff increase in Turkey. To lend credence to the specification and results, I also conduct out-of-sample tests of the model that show how well it predicts consumption responses to new price changes in 2009.

Overall, I find that a 10 percent increase in electricity price will cause an average household in the bottom income quintile to reduce electricity consumption by 1.8 percent, and an average household in the top income quintile to reduce electricity consumption by 5 percent, *ceteris paribus.* The poor are less flexible in adjusting electricity consumption most likely because they are close to their minimum electricity consumption level and have fewer options for switching to other types of fuel.

Not surprisingly, lower income households experienced a greater welfare loss as a percentage of income. The welfare loss from the 2008 price increases, approximated by consumer surplus change, is about 164 Turkish Lira (TL) for a bottom income quintile household, or 2.16 percent of household disposable income, compared with 330 TL, or 0.75 percent of income for the top quintile. However, because expenditures on electricity have been a moderate component of household budget in Turkey - they represented 3.5 and 4 percent of the household's disposable income in 2008 and 2009 - the impact of the 2008 tariff increase on consumer welfare has been limited. These results are robust to alternative model specifications, modeling techniques and sample data.

The rest of the paper is structured as follows. Section II provides the background of Turkish electricity price reform and a literature review. Section III discusses the empirical strategy. Section IV describes data and descriptive analysis. Section V presents the estimated price elasticities, consumer welfare change, and out-of-sample validation tests. Section VI concludes.

II. Background and Literature Review

Turkish Electricity Market Reform

Since 2001, the Turkish Government has embarked on a comprehensive electricity reform program. The reform aims to establish a competitive electricity market so as to increase private investment, improve the supply- and demand-side efficiency and ultimately strengthen Turkey's energy security. Under the reform, the originally vertically-integrated state owned electricity utility had been split into separate generation, transmission, distribution, and trading companies. It also established an independent regulatory agency which regulates the sector and oversees the price. In 2006, a competitive wholesale electricity market was introduced, and in 2008 the government started to privatize the distribution company.

Despite the progress in the reform, a potentially significant energy supply shortage had been envisaged, partially due to the lack of progress in electricity tariff reform. During 2002 - 07, the retail tariff had remained constant, though the price of inputs in electricity production, notably the natural gas prices, had significantly increased. The disconnect between prices and costs contributed to the declining supply margin because insufficient tariffs limited funding available for the maintenance of existing infrastructure and for new investments; additionally, demand may also have increased at a greater pace without appropriate price signals; finally, a cost reflective tariff is considered necessary for the continued privatization of electricity distribution.

To address these concerns, the government started pushing for full cost recovery in the electricity sector in 2008. In January, the electricity price was increased by 20 percent from the fixed level in previous five years. In March, the government approved a cost-based pricing mechanism, enabling automatic quarterly tariff adjustments to cover changes in costs incurred by electricity supply. The new pricing mechanism became effective in July 2008, resulting in another 24 percent price increase in July, and a 9 percent price increase in October. In October 2009, the government announced another 10- percent price hike from the previous month. Figure 1 illustrates the percentage change in electricity tariff during 2008 – 09. All prices are in 2008 TL.

The price reform is supported by an interest to improve energy security. However, how new pricing mechanisms would affect households' consumption and welfare is less known. This uncertainty has provoked debate in the regulatory policy arena, and has drawn considerable attention in the market reform. The paper seeks to shed light on the issue.[4]

Literature Review

How do higher energy prices affect consumer welfare? The literature has focused on both direct and indirect mechanisms by which consumption may be affected by energy price changes. Directly, higher energy prices are expected to reduce discretionary income, as consumers have less money to spend after paying their energy bills. Consumers may also increase their precautionary savings and delay or forgo purchase of energy-using durables. These effects imply a reduction in aggregate demand in response to an energy price increase. Indirectly, higher energy prices are likely to cause reallocation of capital and labor away from energy intensive industries as consumers switch toward more energy efficient durables. In the presence of

[4] An earlier version of this paper on the poverty and social impact analysis of the Turkish electricity tariff reform has served as an input to the World Bank Development Policy Lending to Turkey, one pillar of which is to support the government's efforts on energy market reform.

frictions in capital and labor markets, these sectoral shifts will cause resources to be unemployed, thus causing further cutbacks in consumption. See Kilian (2008) for a review of the direct and indirect effects.

This paper focuses on a partial equilibrium analysis of the short-term welfare effects of higher energy prices, while ignoring the spillovers to income, employment and demand in other sectors. To measure partial welfare effects of price changes, economists typically estimate demand functions to calculate consumer welfare, a method first introduced by Hausman (1981) and Vartia (1983). In the setting of this paper, the key question, therefore, is to estimate a short-term demand function for electricity.

There are two strands of literature using econometric methods to estimate residential electricity demand. Traditional demand analysis usually assumes homogenous price elasticities (especially those using data aggregated over time and regions) and model electricity consumption as a function of income, price and household characteristics.[5] See Taylor (1975), Hartman (1979) and Bohi and Zimmerman (1984) for reviews of these studies.

A recent strand of literature estimates household electricity demand conditional on appliance ownership and their relations with household characteristics (Parti and Parti, 1980; Hartman and Werth, 1981; Sebold and Parris, 1989; Bauwens et al. 1994). In a conditional demand framework, electricity consumption is disaggregated into consumption associated with different appliances held by the household. This specification measures appliance-specific income and price elasticities and therefore allows price sensitivities to differ among households with different appliance portfolio. Swan and Ugursal (2009) provide a review of this approach.

From the point of view of welfare analysis, it is important to understand the distributional effect of price changes, especially the impact of higher prices on poor and vulnerable households. Previous studies have shown that the poor are likely to experience higher economic distress because they spend a larger share of income on energy (World Bank, 2004 and 2007). In fact, poor households may also be less flexible to adjust electricity consumption facing higher prices because their consumption is used for basic needs and they have fewer options for switching to other types of fuel.

To assess differentiated welfare effects, we can estimate a standard demand model separately for different income groups, such as Nesbakken (1999)[6], although doing so sacrifices sample size. On the other hand, based on conditional demand analyses, we can estimate appliance-specific

[5] An active literature on electricity demand modeling had existed in 1970s and 1980s in response to electric utilities and regulators' needs for electricity demand forecasting and planning.

[6] Nesbakken (1999) estimates the same demand function for two sub-groups of households – those whose income is higher than the average household income and those whose income is lower than the average income. He finds that the energy price elasticity is higher for high-income households than for low-income households.

price elasticities and link the ownership of price elastic (or inelastic) appliances to household income. One example is Reiss and White (2005). [7]

A conditional demand model assumes the difference in households' price sensitivities is purely driven by the difference in households' appliance holdings. In other words, households with the same appliance portfolio will exhibit the same level of price sensitivity.[8] This assumption is somewhat contentious because price sensitivities are also likely to be affected by the existing consumption levels of the appliances. For example, when the electricity price increases, rich households may adjust by restricting space heating or cooling to rooms which are frequently used; while households who already restrict the usage of electricity space heating or cooling to the minimum level may have less room to further cut down its consumption.

Different from previous studies, I develop a model that explicitly estimates the income-based heterogeneity in price elasticities by incorporating interaction terms of price and income. Conditional on appliance ownership, dwelling and household characteristics, the model estimates intra-household differences in price sensitivities that are driven by existing consumption quantities, habits and other psychological forces which may all be related to household income levels. The empirical strategy is discussed in the following section.

III. Model

Electricity Demand

Electricity is not consumed directly. In the residential sector, demand for electricity is derived from the demand for services provided by durable electrical appliances. To summarize this demand behavior, two types of decisions are involved. The first is the decision about whether and when to buy or replace an electricity-consuming appliance, given its technical and economic characteristics; and the second decision is about the frequency and intensity of the use of the appliance. In the short run, consumers adjust the utilization rate of the existing capital-stock in response to new levels of prices. While in the long run, both utilization behavior and the composition of household appliance holdings are variable. Therefore, long-run price elasticities tend to be much larger than short-run elasticities.

The key difference between long-run and short-run demand is whether the appliance stock is held constant. To estimate short-run demand elasticities, I therefore incorporate household-level appliance holdings as fixed variables in the demand function and leave appliance replacement

[7] Reiss and White (2005) find that electric space heating or air conditioning exhibit much higher electricity price elasticity than other appliances. After calculating price elasticity for each household conditional on the appliance stock, they find low-income households have greater price sensitivity than high-income households in California. They suggest that this is because there is a weak correlation between household income and ownership of price sensitive appliances, and that it may be the case that households tend to substitute toward more price-inelastic electricity uses as income rises.

[8] Empirically, a conditional demand model estimates the statistical average price elasticity averaged across households who own the appliance.

decisions for future research when enough time has passed by and when those data become available. Given the stock of electricity-using devices, the demand for electricity is also determined by the utilization rate of those devices, which is in turn a function of household income, electricity prices, the possibility to substitute with other fuels, weather conditions, dwelling attributes, and household demographic characteristics. Assuming a log-linear functional form, the demand for electricity of household *i* is thus defined as:

$$\log Q_i = \beta_0 + \sum_{j=2}^{5}(\gamma_1 + \gamma_j I_{ij}) logP_i + \beta_1 \log Y_i + C_i' \beta_2 + \sum_{n=1}^{15} \omega_n A_{in} + \beta_3 SUM_i + \beta_4 WIN_i + \varepsilon_i \quad (1)$$

where Q_i is monthly electricity consumption, P_i is the electricity price, and Y_i is annual household disposable income. Electricity price P_i is treated as exogenous because electricity is sold under a flat rate schedule in Turkey, therefore, marginal price is not affected by the consumption levels.[9]

Recognizing that household demand response to price changes may vary across income groups, the slope parameter of price (γ_j) is allowed to be different for households in different income quintiles[10]. I interact electricity prices with a categorical income variable I_j (j = 2, 3,..., 5) with I_j equal to 1 if the household is in income quintile (per capita disposable income) j. Coefficients associated with the interaction terms are of special interests as they measure price elasticities across income groups. For example, $\gamma_1 + \gamma_j$ (j = 2, 3, …, 5) measures the effect of one percent increase in electricity price on the percentage change of monthly electricity consumption of a household in income quintile j, all else being equal.

C_i is a vector of observable household characteristics including: $RURAL_i$, a dummy variable equal to 1 if the household resides in a rural location, 0 if in an urban location. As noticed in the literature, differences in the efficiency of the housing stock and climate may result in differences in rural-urban consumption (Petersen, 1982); $HSIZE_i$ is the number of people living in the household; $AREA_i$ measures the floor area of the dwelling; $RENT_i$ takes a value 1 if the household rents the dwelling and 0 otherwise. This dummy variable may pick up unobservable differences related to housing ownership in energy consuming behavior. GAS_i, is a dummy variable equal to 1 if the household has access to natural gas, 0 if not. Because natural gas is likely to be a substitute for electricity, access to natural gas may create another source of variation in electricity demand.

[9] Simultaneity between price and quantity becomes a concern when electricity is sold under multistep block pricing schedule, with price being a function of quantity consumed. As consumers sort along the entire block pricing schedule, electricity price (marginal and average) is endogenously determined by the quantity consumed. In his survey paper, Taylor (1975) noted the specification and estimation difficulties raised by the non-linearity of the pricing structure. Barnes, et al (1981), Hauseman, Kinnucan and McFadden (1979), Henson (1984) and Reiss and White (2005) discussed methods to address the simultaneity issue associated with nonlinear tariff structure.

[10] Ideally, we would also allow cross-section heterogeneity in consumer income elasticities. However, alternative specification incorporating interaction terms of income and categorical variables of income quintile did not reveal meaningful differences in income elasticities across income groups.

A_{in} indicates the number of the *n*th appliance owned by the household. Based on prior empirical research that has studied households' appliance use decisions (Parti and Parti, 1980; Reiss and White, 2005), 15 distinct appliances are modeled in the demand equation, including refrigerators, freezers, televisions, computers, air conditioners, electric space heating, and swimming pools and so on. See Table 6 for a complete list of variables entering the model.

Appliance ownership (A_{in}) is also assumed to be exogenous. This is somewhat contentious because it is possible that factors affecting appliance utilization behavior also affect decisions to acquire appliances. In the short run, however, the appliance stock is fixed, and existing evidence suggests that the bias from ignoring the possible endogeneity is likely to be small. See Reiss and White (2005) and Sebold and Parris (1989) for a discussion.

Previous studies indicate that weather conditions are important predicators of electricity consumption (Reiss and White, 2003). However, HBS 2008 and 2009 do not reveal household geographic locations, making it impossible to match weather data with sample households. As an alternative way to capture the weather effects, I add two dummy variables SUM_i and WIN_i which take value 1 if the household is interviewed during the summer months (June – August) and winter month (December – February), respectively. For completeness, I also include month and year fixed effects that, as it turns out, deplete the explanatory power of price, while changing the coefficients of demand parameters only slightly. See Section V and Table 3 for details. This alternative approach, although capturing the seasonality in electricity demand, does not address regional variation in weather conditions. In Section V, I also take a formal approach to validating the model using out-of-sample testing.

Finally, ϵ_i is the error term; $\beta_0, \beta_1, \dots, \beta_4$, $\gamma_j (j = 2, \dots, 5)$ and $\omega_n (n = 1, 2, \dots, 15)$ are unknown parameters to be estimated.

To test for the robustness of the above demand estimation, I also allow household income to enter the interaction term as a continuous variable:

$$log\, Q_i = \beta_0 + \gamma log Y_i \cdot log P_i + \beta_1\, log\, Y_i + C_i' \beta_2 + \sum_{n=1}^{15} \omega_n A_{in} + \beta_3 SUM_i + \beta_4 WIN_i + \varepsilon_i \qquad (2)$$

Furthermore, households may not have noticed price changes until after receiving the electricity bills. To account for delayed response to tariff increase, I also estimate the model using the electricity prices of the previous month. The results are robust to both alternative specifications. This is discussed in detail in Section V.

Sample Selection

Using disaggregated data to estimate residential electricity demand is desirable as we avoid the confounding effect of misspecification arising from aggregation bias. (Blundell, 1988; Barnes, Gillingham, and Hagemann, 1981; George 1980; McFadden and Dubin 1980). However, using disaggregated micro-survey data often suffers from sample selection bias because electricity expenditures are only selectively observed for those households choosing to report.

Indeed, even though Turkey has near universal access to electricity, 4,051 households (27.7%) in the dataset did not report electricity expenditure. Furthermore, poorer households were more likely to have non-positive electricity expenditures (Table 2), suggesting that the sample selection is not random. Suppose that households are endowed with observable and unobservable characteristics, sample selection bias would arise if unobservable characteristics affecting reporting or non-reporting decisions are correlated with unobservable characteristics affecting consumption behavior. On the other hand, if non-reporting behavior and electricity consumption are correlated purely through the observables, we can control for this by including the appropriate observable variables in the demand equation.

I use the Heckman selection model to test for the selection bias. For the first stage regression, one needs variables that affect the chances of not reporting electricity expenditures but not the level of electricity consumption (variables that are not in the consumption equation). The selection variables used are the education level of the household head, whether the household head had a permanent job during the survey month, and whether the household head had health insurance. Education of the household head is putatively not included in the electricity demand estimation, but may plausibly affect household response to survey questions. Similarly, the job status and the possession of health insurance of the household head may not directly affect electricity consumption, but may affect the reporting decision. [11]

In the results section, I present estimates of Equation (1) using an ordinary least square (OLS) model where I limit the observations to households who reported electricity consumption. I also present estimates from the selection model. I found the two models yield nearly identical results. Furthermore, both Wald and likelihood ratio tests[12] suggest that the unobserved variables influencing the reporting decision are statistically independent of unobserved factors of the electricity demand. Therefore, sample selection can be ignored conditional on observable household characteristics.

IV. Data and Descriptive Analysis

Data

The model is estimated using data from the Turkish HBS in 2008 and 2009. The HBS is conducted annually by the Turkish Statistical Institute to collect information on household socio-economic status, living standards, income, and consumption expenditures. The survey is a

[11] A United Nations Development Programme (UNDP) field study on four provinces (Istanbul in both sides of the Bosporus, Cankiri, Kars and Urfa) (Bagdadiogl etc. 2009) suggests that households who did not pay electricity bills during the survey month due to arrears or illegal connections would not report electricity expenditure to the HBS.

[12] See Yamagata (2004) for a discussion on the performance of different tests for sample selection bias.

nationally representative probability sample of 18,671 households in 2008 and 2009. In 2008, the survey was conducted monthly with 720 and annually with 8,640 sample households between January 1 – December 31. That is, survey data of the first 720 households were collected in January. In February, the survey was carried out on a different set of 720 households. This rotation continued until the end of December. The 2009 HBS followed the same methodology but the size of the survey was expanded to contain monthly 1,050 and annually 12,600 sample households. Because each household appears in the dataset only once, the dataset supports a pure pooled cross-section analysis.

The survey is conducted through in-home interview. Each interviewer recorded the data on consumption expenditures during eight visits to the household throughout the survey month, including one visit prior to the survey month, twice during the 1st and 2nd weeks, once during 3rd and 4th weeks and once following the end of the survey month. Interviewers also inventory the households' appliances, physical characteristics of the residence and collect demographic information. Further details about the HBS data and survey design are available in Turkish Statistical Institute (2007).

The survey data are then combined with the actual monthly rate schedule. The Turkish electricity tariff data have two advantages that are fairly unique to the study. First, in the retail sector, Turkey has applied a price equalization mechanism to maintain a nationwide uniform tariff until 2011. Under such a system, all residential consumers face a uniform flat-rate price schedule. The simplicity of the rate structure avoids specification difficulties in identifying marginal electricity prices – a common challenge for demand studies. Second, the tariff reform in 2008 introduced three price hikes for residential electricity that jointly increased the price by more than 50 percent from the previous year. The price change by virtue of its magnitude and exogeneity to the household provides a unique opportunity to identify the price elasticities of electricity demand.

Descriptive Analysis

Table 1 lists the summary statistics of the variables included in the analysis. I divide the sample into reporting and non-reporting groups based on whether the household has responded to the inquiry on electricity expenditure. Table 2 reports mean value and mean differences in household characteristics between the two groups. Households who did not report electricity expenditure had lower per capita income and are more likely to reside in rural areas. Heads of these households are less educated and are more likely to not have a permanent job or health insurance during the survey month. All these differences are statistically significant at 0.01 level.

A narrower way of assessing the distributional impact of electricity tariff reform is to look at its effect on the affordability of household electricity services. Affordability can be defined as households' ability to purchase an adequate level of utility services without suffering undue financial hardship (World Bank 2009). Affordability is usually measured by the affordability ratio – the share of income or expenditure allocated to a specific good or service. Figure 2 illustrates the affordability ratio of electricity for all income quintiles from 2003 to 2008.

As indicated in Figure 2, electricity is a normal good in the sense that its budget share declines as household income rises. This is consistent with observations on energy consumption patterns in other developing countries (World Bank, 2004 and 2009). Additionally, expenditures on electricity have been a moderate component of the total budget of the Turkish households even after the significant price increase in 2008. For an average income household, they represented 2.9 percent of the household's disposable income in 2007 and increased to 3.5 percent in 2008. For the lowest quintile households, they rose to 6.3 percent in 2008 from 5.4 percent in 2007, which is still below the 10-percent benchmark affordability level (Lee, 2007).

V. Results

Demand Parameters

Table 3 presents two sets of regression results. The first set presents electricity demand regressions based on 2008 HBS data (Columns (1) – (5)). The second set of regressions was performed based on the combined 2008 and 2009 datasets. Comparison of the results suggests that all parameter estimates enjoy a high degree of stability across the two datasets.

In addition, parameter estimates are largely insensitive to the choice of model. Columns (1) and (6) report results from estimating determinants of the log of household monthly electricity consumption identified in Equation (1) via OLS model. Columns (2) and (7) report estimation from the Heckman selection model (maximum likelihood). Both Wald and Likelihood Ratio tests strongly support the contention that the unobserved variables influencing the reporting or non-reporting decision are statistically independent of unobserved factors of the electricity demand. Table 4 reports the first stage regression of the Heckman selection model. The estimated correlation coefficient (ρ) is statistically indistinguishable from zero. Therefore, the selection process can be ignored conditional on observable household characteristics.

Coefficients of the log of price and the log of income measure the price and income elasticities of electricity demand. These elasticity estimates correspond to the percentage change in a household's monthly electricity consumption resulting from a 1-percent increase in electricity price or annual household disposable income, holding all else fixed. As expected, the consumption declines in response to price increases and increases when income rises. Estimates of income elasticity suggest that a 10 percent increase in annual household disposable income will cause electricity consumption to increase by about 1 percent. Overall, electricity is price and income inelastic in the short-run in the residential sector of Turkey. Table 8 summarizes short-run price and income elasticities estimated in other studies and on other countries. The estimates of income and price elasticities of the study are in the range of elasticities suggested in the literature.

The coefficients of other variables are consistent with expectations. All estimates have the expected sign and most are statistically significant. The results suggest that many other factors are important in determining electricity consumption - a doubling of household size leads to consumption rising by 10 percent. A 5-percent increase in the floor area increases electricity usage by 1 percent. Other things being equal, rural households had significantly higher electricity consumption than their urban counterparts, consistent with previous findings (Peterson, 1982). Similarly, renting rather than owning a residence has a well determined small positive effect for electricity. Ownership of fridges, freezers, computers, mobile phones, air conditioners, dishwashers and microwaves all significantly increase electricity consumption.

It is particularly noteworthy that access to natural gas is unimportant. This is not particularly surprising since substitutability between gas and electricity is fairly limited, especially in the short run. Interestingly, gas availability turns out to be a strong predictor of households' reporting electricity consumption in the first stage regression. This may suggest that areas having access to gas are likely to be associated with stricter enforcement of bill collection. Finally, conditional on appliance ownership, price and income, the effect of warmer and colder seasons is not significant.

Heterogeneity in Price Elasticities

Table 3 also reveals considerable and meaningful heterogeneity in households' price elasticities. As noted previously, the model permits households' price elasticities to vary with households' income quintile by including the price and income interaction terms. The set of price elasticity parameters $(\gamma_1, \ldots, \gamma_5)$ is jointly different from zero at the 0.05 level in every demand equation. Figure 3 illustrates the marked differences in price elasticities for households in different income categories, especially those between the top and bottom income quintiles.

The estimated coefficients on the price and income quintile interaction terms also show that price elasticity (in absolute term) is positively correlated with household income - a 10 percent increase in electricity tariff will bring about a 1.8 percent decline in electricity consumption by the bottom quintile households, but 5 percent decline by the top quintile households, *ceteris paribus*, almost three times of that of the lowest quintile. To put these estimates into perspective, a typical household in the top quintile will cut back its electricity consumption by 95 kWh per month after a 50 percent increase in electricity price; while a typical household in the bottom income quintile will only cut back its consumption by 21 kWh.

Figure 4 provides further information about the heterogeneity in households demand elasticities. The vertical axis of the graph records month-to-month change of electricity consumption (%) of households in the bottom and top income quintile during 2008. They are residual values from estimating Equation (1), excluding electricity price and seasonal dummies. The residual values therefore contain the variability that can be explained by temporal price variation and monthly fixed effects. As shown in Figure 4, the percentage change in electricity consumption of the top income quintile is in general much larger than that of the bottom income group, especially during the months of August, October and November.[13]

As discussed earlier, I also allow price elasticities to vary linearly with the logarithm of household income which is specified in Equation (2). The corresponding demand estimates are summarized in Column (5) of Table 3 and Panel A of Table 5. Of particular interest of the results is that the coefficient of the interaction term between price and income is negative and is statistically significant at 0.01 level (shown in Table 5 Panel A). This result is consistent with what is discussed above that the price elasticity of demand (in absolute term) is a positive function of income. Figure 5 visually describes the relationship between income and price elasticity. It plots a price elasticity curve fitted to the 10,099 sample households in 2009 against their corresponding income. As shown in Figure 5, with the increase in income, demand changes from being perfectly inelastic to perfectly elastic.

To compare the magnitude of price and income elasticities estimated with Equations (1) and (2), I calculate average price elasticities for each income group at the group mean of household income based on estimates of Equation (2). In addition, the average income elasticity is calculated at the mean of the 2008 electricity tariff. The resulting price and income elasticities, presented in Panel B of Table 5, closely resemble those estimated from Equation (1).

It is also useful to compare the above results with those assuming homogenous price elasticities. Columns (4) and (9) report the demand determinants if we ignore the differences in households' price sensitivities along the income distribution. The resulting homogenous estimator of price elasticity is -0.5. Using survey sampling weights, the average price elasticity estimated from Equation (1) is -0.3, which is lower than the homogenous estimator. Such a discrepancy suggests that neglecting heterogeneity in households' price sensitivity not only ignores the distributional impact of price increases, but also underestimates the overall impact on the population.

Finally, because Equations (1) and (2) only control for seasonal impacts of weather conditions on electricity consumption, it is worth comparing these results with estimations that also control for monthly and yearly fixed effects. Columns (3) and (8) of Table 3 report demand estimates based on Equation (1) while including monthly and yearly dummies. It is not surprising that the variation in price is partially depleted by monthly dummies, and the price elasticity cannot be separately estimated for households in the bottom quintile. However, the pattern between price elasticity and income persists, and the estimated price elasticities differ systematically along the rest of the income distribution; their values do not change significantly from those estimated in other models.

[13] During January and February, rich households increased electricity consumption, possibly because rich households are more likely to use electricity for space heating.

Distributional Impact of Tariff Increases

In this section, I examine the welfare impact of electricity price changes on consumers in different income quintiles based on the estimated demand function. The welfare loss from price increases can be approximated by the consumer surplus change. For a log linear demand function, $P = A_i {Q_i}^{\gamma_i}$, the consumer surplus change of households in income quintile *i* is given by:

$$\Delta CS_i = \int_{Q_{2i}}^{Q_{1i}} A_i Q_i^{\gamma_i} dQ - (P_1 Q_{1i} - P_2 Q_{2i}) = \frac{A_i}{\gamma_i + 1}\left(Q_{1i}^{\gamma_i+1} - Q_{2i}^{\gamma_i+1}\right) - (P_1 Q_{1i} - P_2 Q_{2i}) \quad (3)$$

where γ_i is the price elasticity; Q_{1i} and P_1 are the initial consumption and price, Q_{2i} and P_2 are the new consumption and price. A_i is a constant and is calculated at the means of the exogenous variables for households in income quintile *i*. Details on the calculation of consumer surplus change of a log linear demand function are provided in the Appendix.

Table 7 summarizes the estimated consumer surplus change by income quintile. The annual welfare loss from 2008 price increases is estimated to be 164 TL for an average bottom income quintile household, or 2.16 percent of household disposable income, compared with 330 TL, or 0.75 percent of disposable income for the top quintile. Notably, the consumer surplus change is greater than the financial loss, because it also captures the welfare loss from the reduced consumption.

The results demonstrate that how price elasticities vary with household income has important welfare implications. The burden on the poorest quintile, measured by the consumer surplus change as a percentage of income, is 2.9 times of that of the wealthiest quintile. The welfare effects of electricity price changes would evidently be disproportionally borne by the low-income segment of the population distribution.

Nonetheless, the overall welfare impact from the price spikes seems to be limited. This is because Turkish households spent a relatively small amount of their budget on electricity. Indeed, according to the World Bank, the share of electricity expenditures in household total expenditures (excluding expenditures on health, durables and rents) in Turkey was still the eighth lowest among the European and Central Asian countries after price hikes in 2008.

Model validation – out-of-sample test

As discussed earlier, the empirical model does not capture the impact of regional variation in weather conditions on electricity demand. To examine the model's validity, I predict household demand in 2009 using Equation (1) estimated with 2008 HBS data. Figure 6 and 7 compare the out-of-sample predictions to actual consumption levels in 2009. In Figure 6, the vertical-axis is the sum of the log of the monthly consumption; while Figure 7 plots the sum of monthly electricity consumption. In general, the actual and predicted series are close. Although, as more clearly shown in Figure 7, the model under-predicts overall consumption but it picks up the trend of change fairly well. Furthermore, the average prediction error is – 37 kWh/month, which is approximately one-fifth of the sample variance of the consumption. The root mean square error (RMSE) for the predicted data is 0.548, which is lower than the standard deviation of the consumption sample. Overall, the model appears to deliver reasonable forecasting performance.

VI. Conclusions

This paper analyzes the distributional impact of the 2008 energy pricing reform in Turkey. To assess the consumer welfare change, I estimate a short-run demand specification that allows income-based heterogeneity in household price sensitivities. The model is also useful for understanding the effects of alternative tariff design on energy efficiency, in predicting future revenue and energy demand, as well as in understanding the potential impact of a carbon tax.

The results confirm that the price elasticity of demand differs systematically along the income distribution. The price elasticity of the bottom quintile is -0.18, about a third of the price elasticity of the top income quintile at -0.54. The results indicate that high-income households, with decreasing marginal utility of electricity, are more sensitive to energy price changes than low-income households.

Using consumer surplus change to approximate the welfare impact, I found that the price spikes in 2008 caused a welfare loss of 164 TL for an average bottom income quintile household, or 2.16 percent of household disposable income, compared with 330 TL, or 0.75 percent of disposable income for the top quintile. The results demonstrate that while poor households are less flexible to adapt to price increases, they also experience a proportionately higher amount of welfare loss.

The results imply that when electricity price elasticity varies across household groups, a uniform increase in the price of electricity can be quite regressive. Furthermore, from the point of view of energy efficiency policy, energy savings from removing subsidies to poor households will be less effective than imposing a tax on high-income households because the latter is more sensitive to price changes. Finally, given the relatively high affordability ratios for the poorest households, there is a strong case for carefully crafting social protection policies to ensure that stringent energy pricing policies do not impose undue hardship on poorest households.

Last, the work presented in this paper illustrates the advantages of using a rich micro dataset to analyze the energy demand of household sector. There are other developing countries experiencing similar energy price reform. From a methodological point of view, the availability of household survey data in other developing countries suggests that similar analyses could be carried out in settings where differentiated price elasticity estimates are needed to evaluate the distributional impacts of price increase on households.

Appendix Consumer Surplus Change Calculations

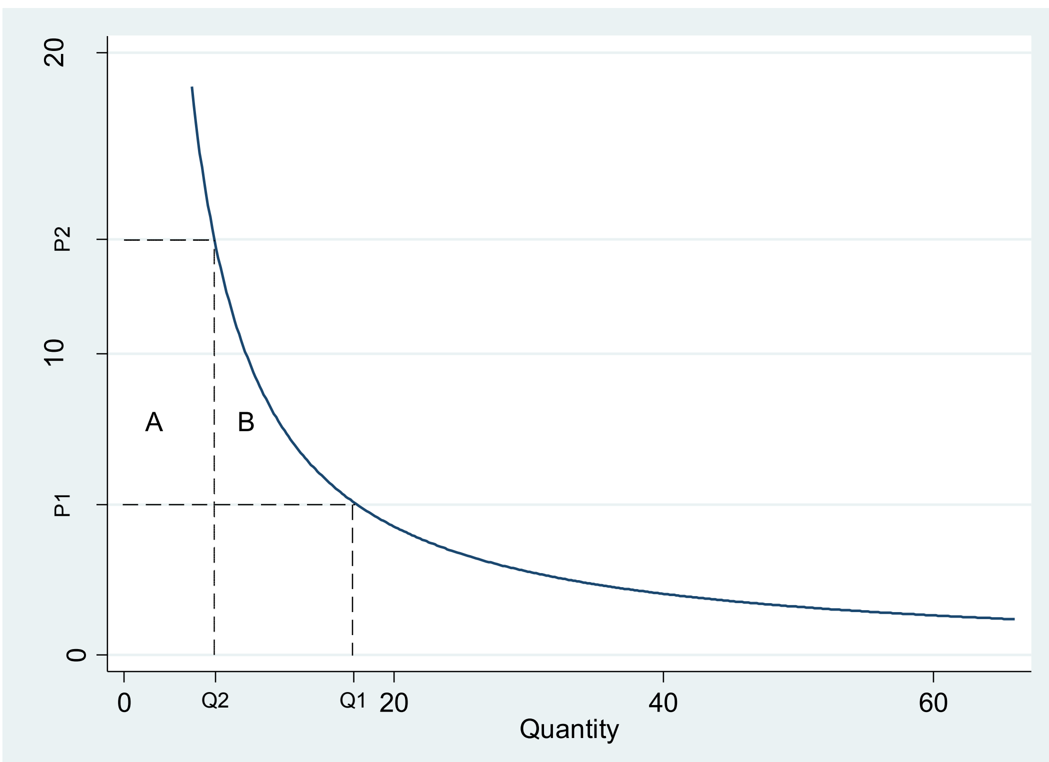
This appendix describes the method used to calculate the consumer surplus change reported in Section V. The equation for a log linear demand function can be written as follows:

$$P = AQ^{\gamma}$$

Where γ is the price elasticity and *A* a constant. Electricity price increases lowers the consumption of electricity, resulting in a decrease in consumer surplus, which is the difference between what the consumers are willing to pay and what they actually do pay. Assume that before the tariff reform, electricity is supplied at price P_1 with consumption of Q_1. Once price is raised to P_2, consumption lowers to Q_2. Consumer surplus is described as the area above the price and below the demand curve. The decrease in consumer surplus as a result of tariff increase is therefore the area of A+B in Figure A. This consumer surplus change can be calculated by the following equation:

$$\Delta CS = CS_1 - CS_2 = \left(\int_0^{Q_1} AQ^{\gamma} dQ - P_1 Q_1\right) - \left(\int_0^{Q_2} AQ^{\gamma} dQ - P_2 Q_2\right)$$
$$= \frac{A}{\gamma+1}\left(Q_1^{\gamma+1} - Q_2^{\gamma+1}\right) - (P_1 Q_1 - P_2 Q_2)$$

Figure A   Consumer Surplus Change



References

Barnes, R, Robert G, and Robert H. 1981. The Short-Run Residential Demand for Electricity. *Review of Economics and Statistics*. 541-551.

Bauwens L. Fiebig, D.G., Steel, M. R. J. 1994. Estimating End-use Demand: A Bayesian Approach. *Journal of Business and Economic Statistics*, 12(2): 221-231.

Bernard, J. T. Bolduc, D. Belanger, D. 1996. Quebec residential electricity demand: a microeconometric approach. *Canadian Journal of Economics*. XXIX(1): 92-113.

Blundell, R. 1988. Theory and Empirical Evidence – A Survey. *The Economic Journal*. 98(389): 16-65.

Bohi D. R. and Zimmerman, M. B. 1984. An Update on Econometric Studies of Energy Demand Behavior. *Annual Review of Energy*. 9: 105-154

Hausman, J.A. 1981. Exact Consumer Surplus and Deadweight Loss. *American Economic Review* 71: 662-676.

Heckman, J. J. 1979. Sample selection bias as a specification error. *Econometrica*. 47: 153-161.

Hartman, R. S. 1979. Frontiers in Energy Demand Modeling. *Annual Review of Energy*. (4): 433-466

Hartman, R. S. and Werth, A. 1981. Short-Run Residential Demand for Fuels: A Disaggregated Approach. *Land Economics*. 57(2): 197-212

Henson, S. E. 1984. Electricity Demand Estimates under Increasing-Block Rates. *Southern Economic Journal*, 51(1): 147-156.

Kilian, L. 2008. The Economic Effects of Energy Price Shocks. *Journal of Economic Literature*. 46 (4): 871-909

Lee, C. 2007. Social policies and private sector participation in water supply – the case of Malaysia. United Nations Research Institute for Social Development.

McFadden, D. Puig, C. and Kirshner, D. 1977. Determinants of the Long-Run Demand for Electricity. *Proceedings of the American Statistical Association*. 109-19.

Nesbakken, R. 1999. Price sensitivity of residential energy consumption in Norway. *Energy Economics.* 21(6): 493-515.

Parti M. and Parti C. 1980. The total and appliance-specific conditional demand for electricity in the household sector. *The Bell Journal of Economics*. 11(1): 309-321.

Petersen, H. C. 1982. Electricity Consumption in Rural vs. Urban Areas. *Western Journal of Agricultural Economics*. 7(1): 1-18.

Reiss, P.C. and White, M. W. 2003 Demand and Pricing in Electricity Markets: Evidence from San Diego During California's Energy Crisis. National Bureau of Economic Research Working Paper 9986. Cambridge, MA.

------- 2005. Household Electricity Demand, Revisited. *Review of Economic Studies*. 72: 853-883

Sebold, F.D., and Parris, K. M. 1989. Residential End-use Energy Consumption: A Survey of Conditional Demand Elasticities. Report CU-6487. Electric Power Research Institute, Palo Alto, CA.

Swan L. G. and Ugursal, V. I. 2009. Modeling of end-use energy consumption in the residential sector: A review of modeling techniques. *Renewable and Sustainable Energy Reviews*. 13: 1819-1835.

Turkish Statistical Institute. 2007. Household Budget Survey Consumption Expenditures. Ankara.

UNDP. Bagdadlioglu, N., Basaran, A., Kalaycioglu, S., and Pinar, A. 2009. Integrating Poverty in Utilities Governance. United Nations Development Programme Report. Ankara Turkey.

Vartia, Y. 1983. Efficient Methods of Measuring Welfare Change and Compensated Income in Terms of Market Demand Functions. *Econometrica* 51: 79-98

World Bank. 2004. Azerbaijan Raising Rates: Short-Term Implications of Residential Electricity Tariff Rebalancing. World Bank Publication Report No. 30749-AZ. Washington DC.

World Bank. 2007. People and Power: Electricity Sector Reforms and the Poor in Europe and Central Asia. World Bank Publication. Washington DC.

World Bank. 2009. Adapting to climate change in Europe and Central Asia. World Bank Publication. Washington DC.

Yamagata. T. 2005. On Testing Sample Selection Bias under the Multicollinearity Problem. University of Cambridge Working Papers in Economics 0522.

Table 1-1 Summary Statistics of Analysis Variables

	Mean	Std. Dev.	Min	Max
PRICE (TL/kWh)	0.180	0.018	0.148	0.201
CONSUMPTION (kWh)	293	222	1.29	4677
INCOME (TL)	20945	20630	800	624,231
HSIZE	3.9	1.9	1	23
Summary Statistics on Dwelling Characteristics				
AREA(Square meters)	103	31	25	600
RURAL (0/1)	0.31	0.46	0	1
RENT (0/1)	0.24	0.42	0	1
GAS ACCESS (0/1)	0.22	0.41	0	1
Summary Statistics on Appliance Ownership				
FRIDGE	1	0.17	0	3
FREEZER	0.08	0.27	0	2
COMPUTER	0.4	0.5	0	5
MPHONE	2.0	1.2	0	9
AIRCONDI	0.16	0.5	0	7
DISHWASHER	0.4	0.5	0	3
MICROWAVE	0.10	0.3	0	2
SAUNA	0.001	0.03	0	1
HEATING	0.02	0.15	0	1
Obs.	18,776			

Note: Prices and household incomes are in 2008 TL.

Table 1-2 Per capita annual disposable household income (TL) and monthly electricity consumption (kWh) by income quintiles

	2008			2009		
Income Quintile	Household Income	Electricity Consumption	Obs.	Household Income	Electricity Consumption	Obs.
Bottom 20%	2,960 (933)	239 (182)	1865	3,068 (1035)	246 (234)	2,205
2	5,504 (670)	279 (233)	1795	5,836 (675)	254 (184)	2,018
3	7,913 (730)	306 (224)	1722	8,267 (760)	280 (199)	2,005
4	11,041 (1165)	326 (241)	1613	11,662 (1292)	291 (203)	1,972
Top 20%	22,302 (12564)	380 (276)	1577	25,280 (18637)	338 (262)	1,899
Total	9,947 (8805)	312 (241)	8572	10,834 (11432)	286 (221)	10,099

Note: Standard deviations are in brackets. Income data are not comparable across year without inflation adjustment. Mean electricity consumption is based on consumption of households who reported electricity expenditures. Income quintiles corresponding to yearly per capita disposable incomes of: less than 4345 TL, 4345 – 6649, 6649-9224, 9224-13,260, and more than 13,260 in 2008, and less than 4646, 4646-6992, 6992-9656, 9656-14,321, and more than 14,321 in 2009.

Table 2 Household Characteristics by Electricity Expenditure Reporting Status

	Mean		Differences in Means
Variable	Non-Reporting	Reporting	Non Report - Report
HOUSEHOLD INCOME (TL)	13,999 (182)	21,957 (174)	-7,958***
RURAL (0/1)	0.57 (0.49)	0.24 (0.43)	0.33***
EDUCATION	3.63 (2.23)	4.80 (2.73)	-1.16***
PERMANENT JOB (0/1)	0.26 (0.44)	0.38 (0.49)	-0.13***
WITH HEALTH INSURANCE (0/1)	0.90 (0.29)	0.95 (0.21)	-0.047***
Obs.	4051	14726	

Note: *EDUCATION* is the educational level of the head of the household and takes the following values: 1 = illiteracy, 2 = literate without diploma, 3 = primary school, 4=primary education, 5=junior high school, 6=vocational school at junior high school level, 7=high school, 8=vocational school at junior high school level, 9=2-year higher educational institution, 10=4-year higher educational institution and faculties, 11=master and doctoral. *** indicates the difference between non-reporting and reporting groups is statistically significant at 1% level. Standard deviations are reported in parentheses.

Table 3 Determinants of Log of Household Electricity Demand (kWh)

Explanatory Variables	1 OLS	2 MLE (Selection Model)	3 OLS (month fixed effects)	4 OLS (homogeneous price elasticity)	5 OLS (Eq. [2] continuous income)	6 OLS	7 MLE (Selection Model)	8 OLS (month-year fixed effects)	9 OLS (homogeneous price elasticity
Income Quintile (Per Capita)	2008 Data					2008 and 2009 Combined Data			
LN(PRICE) Bottom 20%	-0.180** (0.081)	-0.180** (0.081)	-			-0.173* (0.103)	-0.183* (0.099)	-	
LN(PRICE) 2	-0.194* (0.105)	-0.194* (0.105)	-0.203* (0.115)			-0.277*** (0.075)	-0.276*** (0.070)	-0.283*** (0.073)	
LN(PRICE) 3	-0.322 (0.206)	-0.322 (0.207)	-0.334* (0.203)	-0.484*** (0.096)		-0.248 (0.159)	-0.250 (0.162)	-0.247 (0.159)	-0.461*** (0.050)
LN(PRICE) 4	-0.395** (0.187)	-0.395** (0.187)	-0.395** (0.183)			-0.395** (0.152)	-0.397** (0.150)	-0.392** (0.153)	
LN(PRICE) Top 20%	-0.549** (0.231)	-0.547** (0.226)	-0.554** (0.227)			-0.470** (0.180)	-0.480** (0.177)	-0.461** (0.179)	
LN(INCOME)	0.103** (0.043)	0.104** (0.044)	0.102** (0.042)	0.135*** (0.015)	-0.292*** (0.055)	0.105*** (0.018)	0.110*** (0.017)	0.105*** (0.018)	0.132*** (0.009)
HOUSEHOLD SIZE	0.048*** (0.007)	0.048*** (0.007)	0.048*** (0.007)	0.040*** (0.007)	0.040*** (0.007)	0.059*** (0.007)	0.057*** (0.007)	0.059*** (0.007)	0.052*** (0.007)
Ln(AREA)	0.205*** (0.010)	0.205*** (0.010)	0.205*** (0.010)	0.205*** (0.010)	0.205*** (0.010)	0.205*** (0.010)	0.205*** (0.010)	0.205*** (0.010)	0.205*** (0.010)
RURAL	0.136*** (0.015)	0.136*** (0.014)	0.134*** (0.014)	0.135*** (0.014)	0.133*** (0.015)	0.166*** (0.022)	0.164*** (0.021)	0.165*** (0.022)	0.164*** (0.022)
RENT	0.046** (0.016)	0.047** (0.016)	0.046** (0.017)	0.044** (0.018)	0.044** (0.018)	0.023 (0.018)	0.025 (0.018)	0.024 (0.018)	0.020 (0.018)
FRIDGE	0.174** (0.088)	0.172** (0.087)	0.172* (0.090)	0.178** (0.084)	0.177** (0.087)	0.120** (0.044)	0.123** (0.044)	0.119** (0.045)	0.120** (0.044)
FREEZER	0.151** (0.027)	0.151*** (0.026)	0.148*** (0.026)	0.152*** (0.027)	0.153*** (0.027)	0.127*** (0.020)	0.123*** (0.021)	0.124*** (0.019)	0.127*** (0.021)
COMPUTER	0.102*** (0.016)	0.101*** (0.016)	0.102*** (0.016)	0.100*** (0.017)	0.101*** (0.017)	0.091*** (0.012)	0.091*** (0.012)	0.092*** (0.011)	0.090*** (0.012)
MPHONE	0.042***	0.042***	0.041***	0.044***	0.044***	0.035***	0.035***	0.035***	0.037***

	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.008)	(0.008)	(0.008)	(0.008)
AIRCONDI	0.112*** (0.023)	0.112*** (0.024)	0.113*** (0.022)	0.109*** (0.023)	0.109*** (0.023)	0.096*** (0.015)	0.096*** (0.016)	0.096*** (0.016)	0.095*** (0.015)
DISHWASHER	0.114*** (0.009)	0.114*** (0.009)	0.112*** (0.011)	0.113*** (0.010)	0.114*** (0.011)	0.118*** (0.005)	0.117*** (0.006)	0.117*** (0.006)	0.119*** (0.006)
MICROWAVE	0.052** (0.014)	0.052** (0.013)	0.052*** (0.012)	0.047*** (0.015)	0.047** (0.014)	0.065*** (0.014)	0.065*** (0.013)	0.064*** (0.014)	0.061*** (0.013)
SAUNA	0.429* (0.268)	0.429* (0.266)	0.434* (0.253)	0.434* (0.259)	0.412* (0.251)	0.049 (0.165)	-0.045 (0.210)	0.058 (0.162)	0.028 (0.168)
HEATING	0.362 (0.205)	0.362 (0.203)	0.353 (0.224)	0.360* (0.212)	0.353 (0.226)	0.388*** (0.060)	0.390*** (0.059)	0.391*** (0.058)	0.387*** (0.063)
GAS	-0.023 (0.042)	-0.023 (0.041)	-0.024 (0.042)	-0.023 (0.041)	-0.024 (0.042)	-0.042 (0.034)	-0.041 (0.035)	-0.043 (0.034)	-0.041 (0.033)
SUM									
WIN									
CONST	3.177*** (0.358)	3.174*** (0.352)	3.538*** (0.288)	2.388*** (0.135)	6.537*** (0.411)	3.164*** (0.310)	3.102*** (0.289)	3.522*** (0.120)	2.464*** (0.149)
R^2	0.241		0.246	0.238	0.239	0.236		0.240	0.234
Obs.	6924	8571	6924	6924	6924	14620	18776	14620	14620

Note: Columns (1) and (2) report results from estimating determinants of the log of household monthly electricity consumption identified in equation (1) via OLS and Maximum likelihood model using 2008 HBS data. Columns (3) report the results from estimating equation (2) via OLS using 2008 HBS data. Columns (4) report the results from estimating equation (1) via OLS but without permitting heterogeneity in price elasticities across income groups using 2008 HBS data. Columns (5) - (8) report estimation using 2008 and 2009 HBS data. I cannot reject the null hypothesis that coefficients on price elasticities are the same for the OLS and MLE estimation in all cases. Columns (9) report estimation of equation (3) via OLS using 2008 HBS data. Additional estimates of equation (3) are reported in Table 5. Standard errors are reported in parentheses. *** indicates significant at the 1% level; **indicates significant at the 5% level; * indicates significant at the 10% level.

Table 4 First Stage regression for the Heckman Selection Model (ML) - Determinants of household reporting electricity expenditure

	1	2
Variables	2008 and 2009 Data	2008 Data
PERMANENT JOB	0.052 (0.04)	0.002 (0.036)
EDUCATION	0.014** (0.006)	0.008 (0.007)
HEALTH INSURANCE	0.229*** (0.034)	0.257 (0.176)
*Incomequntile2*LN(PRICE)*	-0.254*** (0.080)	0.205 (0.231)
*Incomequntile3*LN(PRICE)*	-0.324** (0.134)	-0.005 (0.156)
*Incomequntile4*LN(PRICE)*	-0.317*** (0.104)	-0.504** (0.177)
*Incomequntile5*LN(PRICE)*	-0.421*** (0.134)	-0.376* (0.227)
LN(INCOME)	0.182*** (0.027)	0.239 (0.042)
HOUSEHOLD SIZE	-0.063*** (0.010)	-0.049*** (0.011)
ln(AREA)	-0.116*** (0.031)	-0.001*** (0.0001)
RURAL	-0.529*** (0.062)	-0.468*** (0.061)
RENT	0.004 (0.036)	0.030 (0.050)
FRIDGE	0.190** (0.067)	0.221 (0.161)
FREEZER	-0.055 (0.046)	-0.093 (0.065)
COMPUTER	0.079** (0.028)	0.071*** (0.019)
MPHONE	0.014 (0.024)	-0.021 (0.036)
AIRCONDI	0.114** (0.041)	0.193*** (0.056)
DISHWASHER	0.082*** (0.016)	0.100*** (0.012)
MICROWAVE	-0.085** (0.040)	-0.158*** (0.055)
SAUNA	5.960*** (0.134)	5.580*** (0.179)
HEATING	0.055 (0.047)	-0.045 (0.065)
GAS	0.228*** (0.056)	0.266** (0.111)

SUMMER	0.0004 (0.022)	0.003 (0.017)
WINTER	0.122*** (0.038)	0.036** (0.015)
CONST	-1.203*** (0.345)	-1.894*** (0.363)
ρ	0.005 (0.017)	0.005 (0.011)
Obs.	18776	8571

Note: This table reports estimates for the first-stage selection model for MLE of household electricity demand using 2008 and 2009 HBS data. The dependent variable is whether a household has chosen to report electricity expenditure during the survey month (1 = reported). The selection criteria for observing household electricity expenditures are (1) educational level of the head of the households, (2) whether she/he had a permanent job during the month, and (3) whether she/he had health insurance. ρ is the heckman estimation of the correlation between the unobservables affecting household electricity consumption and the unobservable affecting the decision to not to report electricity expenditures. Both Wald test and likelihood ratio test cannot reject the null hypothesis that ρ =0. Standard errors are reported in parentheses. *** indicates significant at the 1% level; **indicates significant at the 5% level; * indicates significant at the 10% level.

Table 5 Price and Income Elasticities estimates of Equation (2)

Panel A Income and Price Parameters estimated from Equation (2)		
Variables		
*LN(INCOME)*LN(PRICE)*	-0.228*** (0.024)	
LN(PRICE)	1.735*** (0.224)	
LN(HOUSEHOLDINCOME)	-0.292*** (0.055)	
Panel B Estimated Price and Income Elasticities		
Income Quintile	Price Elasticity	Income Elasticity
Bottom 20%	-0.084	
2	-0.225	
3	-0.308	-0.105
4	-0.383	
Top 20%	-0.543	

Note: Panel A reports estimated coefficients of the following variables - price, income and the interaction of price and income - defined in equation (3). Panel B reports estimated price elasticities of demand for each income quintile at the means of the household income of the corresponding income quintile, and the income elasticity at the means of electricity price.

Table 6 Additional explanatory variables entering demand model

Mnemonic	Variable	Description
TV	Number of TV	Number of TVs at home
DVD_VCD	Number of DVD and VCD	Number of DVD and VCD at home
JACUZZI	Number of Jacuzzis	Number of Jacuzzis at home
LAUNDRY	Number of washing machine	Number of washing machines at home
DRYER	Number of dryers	Number of dryers at home
CARPETW	Number of carpet washing machine	Number of carpet washing machines at home
SECONDD	Second Dwelling	1 if household has a second dwelling

Table 7 Consumer Surplus Change from 2008 Tariff Increase

Income Quintile (per capita)	Financial Loss	Consumer Surplus Change (TL)	Welfare loss as a % of Household Income
Bottom 20%	158	164	2.16
2	161	167	1.32
3	216	231	1.30
4	260	282	1.19
Top 20%	295	330	0.75

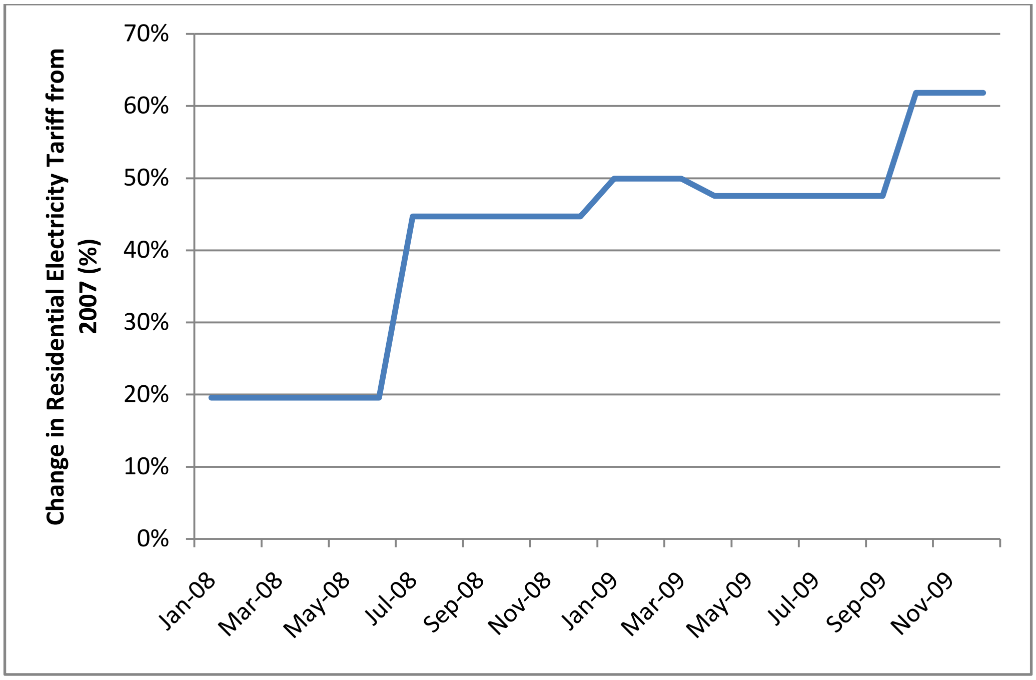
Note: Financial loss and consumer surplus change are estimated results for an average household in the relevant income quintile.

Table 8 Short-run Price and Income Elasticities of Residential Electricity Demand

	Price	Income	Data
Beierlein et al (1981)	-0.107	0.015	US national aggregated data (1967-1977)
Bernard et al. (1996)	-0.67	0.14	Quebec household survey (1986-1989)
Donatos and Mergos (1991)	-0.28 ~ -0.30	0.53	Greece national aggregated consumption data (1961-1986)
Halicioglu (2007)	-0.46	0.40	Turkey national aggregated consumption data (1968-2005)
Nesbakken (1999)	-0.5	0.2	Norway households survey (1993-1995)
Reiss and White (2005)*	-0.39 (Population average) -0.49 (Income less than $18,000) -0.34 ($18,000 to $37,000) -0.37 ($37,000 to $60,000) -0.29 (More than $60,000)		California households survey (1993-1997)

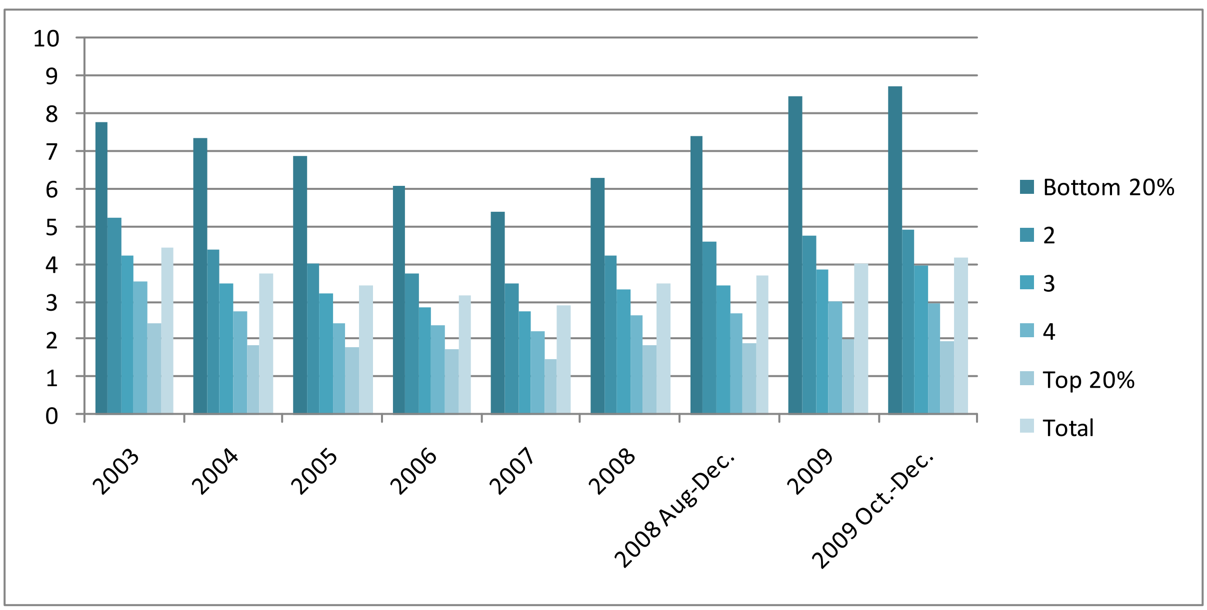
Note: * Reiss and White (2005) did not separately estimate household income elasticities.

Figure 1 Change in Turkish Residential Electricity Tariff Compared to 2007 (%)



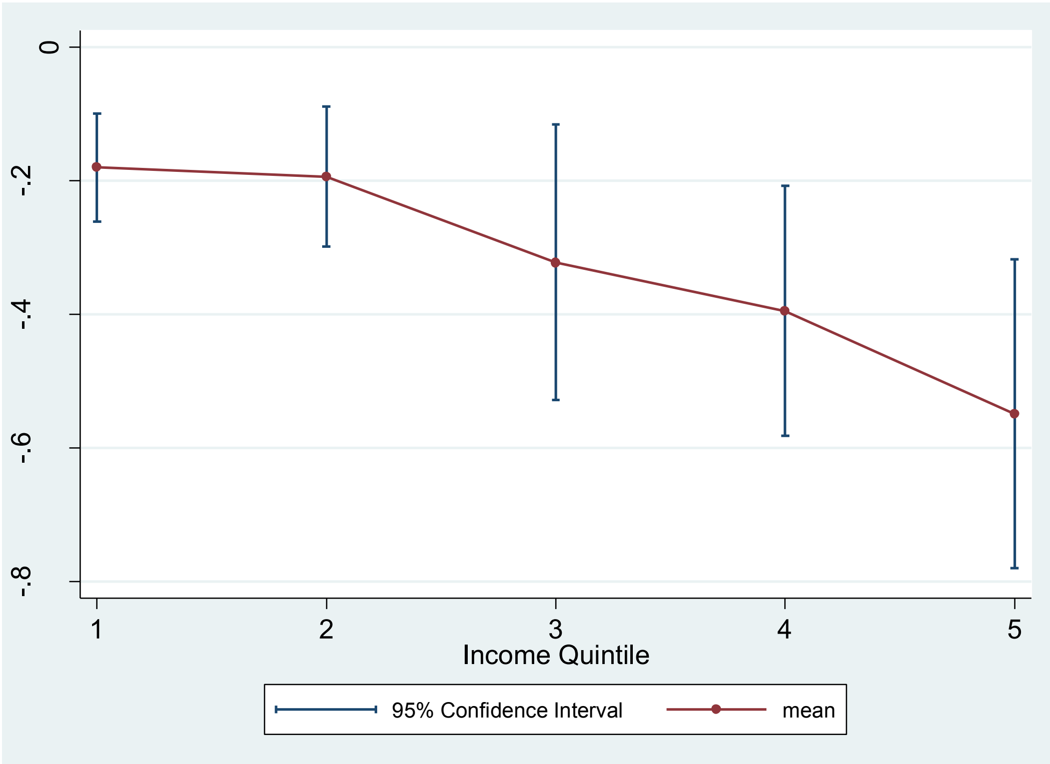
Source: Turkish Electricity Distribution Company

Figure 2 Share of Household Disposable Income on Electricity (%) (2003-2009)



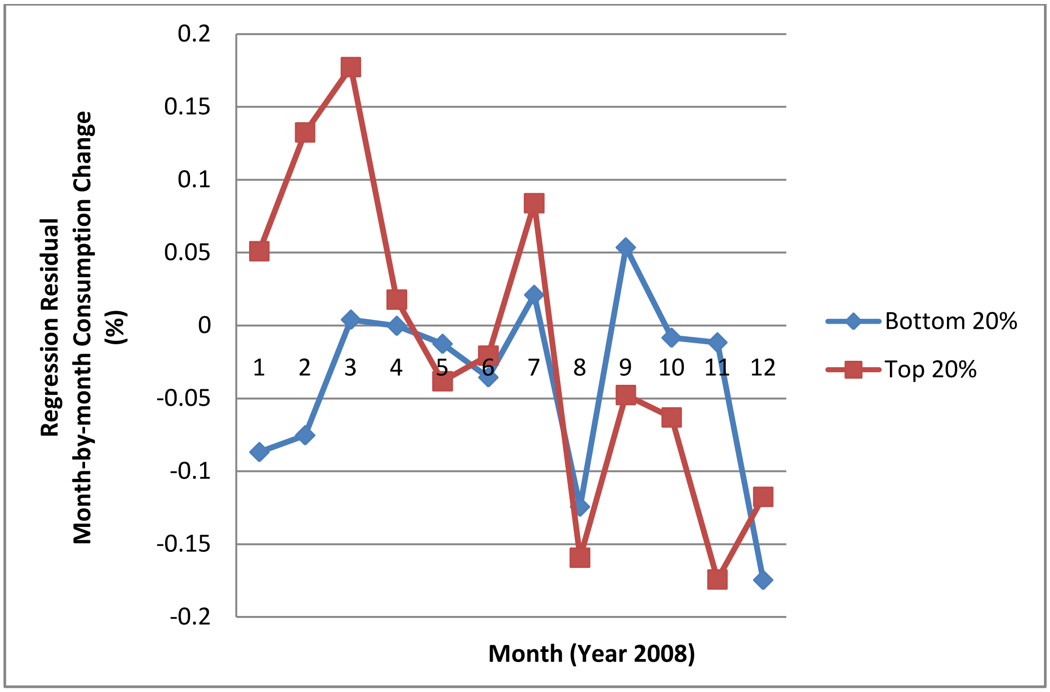
Sources: Calculation based on HBS 2003, 04, 05, 06, 07, 08, 09

Figure 3 Price elasticities estimates by income quintile



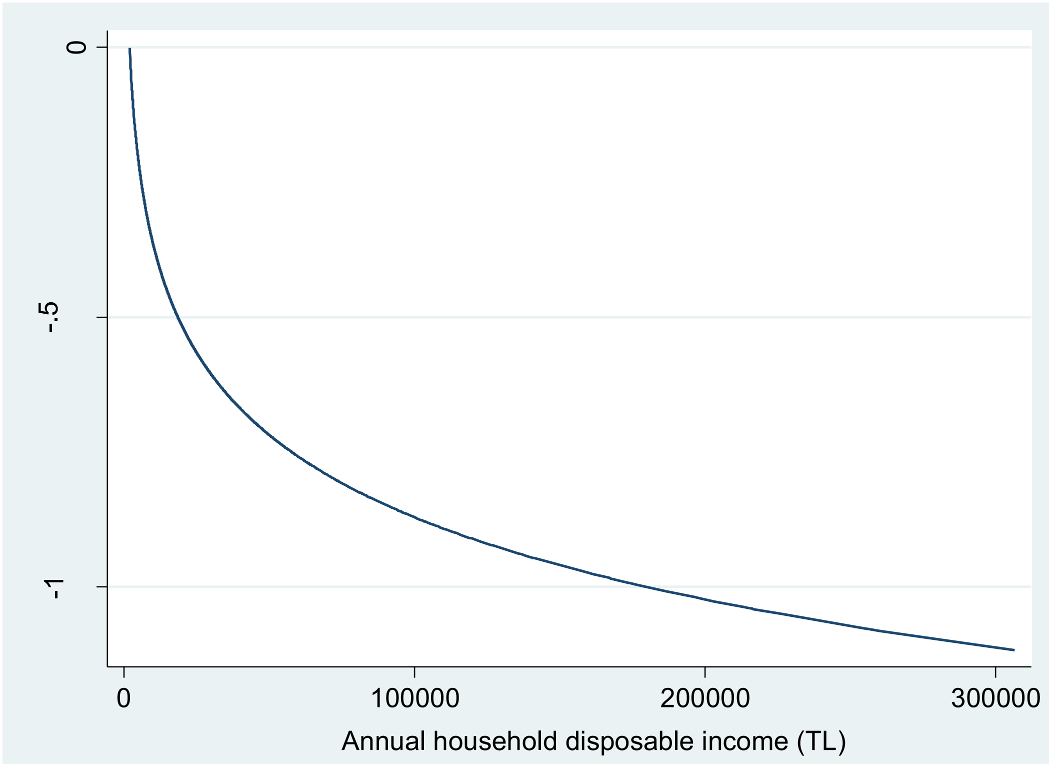
Note: Price elasticities are estimated from Equation (1) via OLS model based on 2008 and 2009 combined HBS datasets.

Figure 4 Monthly Electricity Consumption Change (%) of the Bottom and Top Income Quintiles in 2008



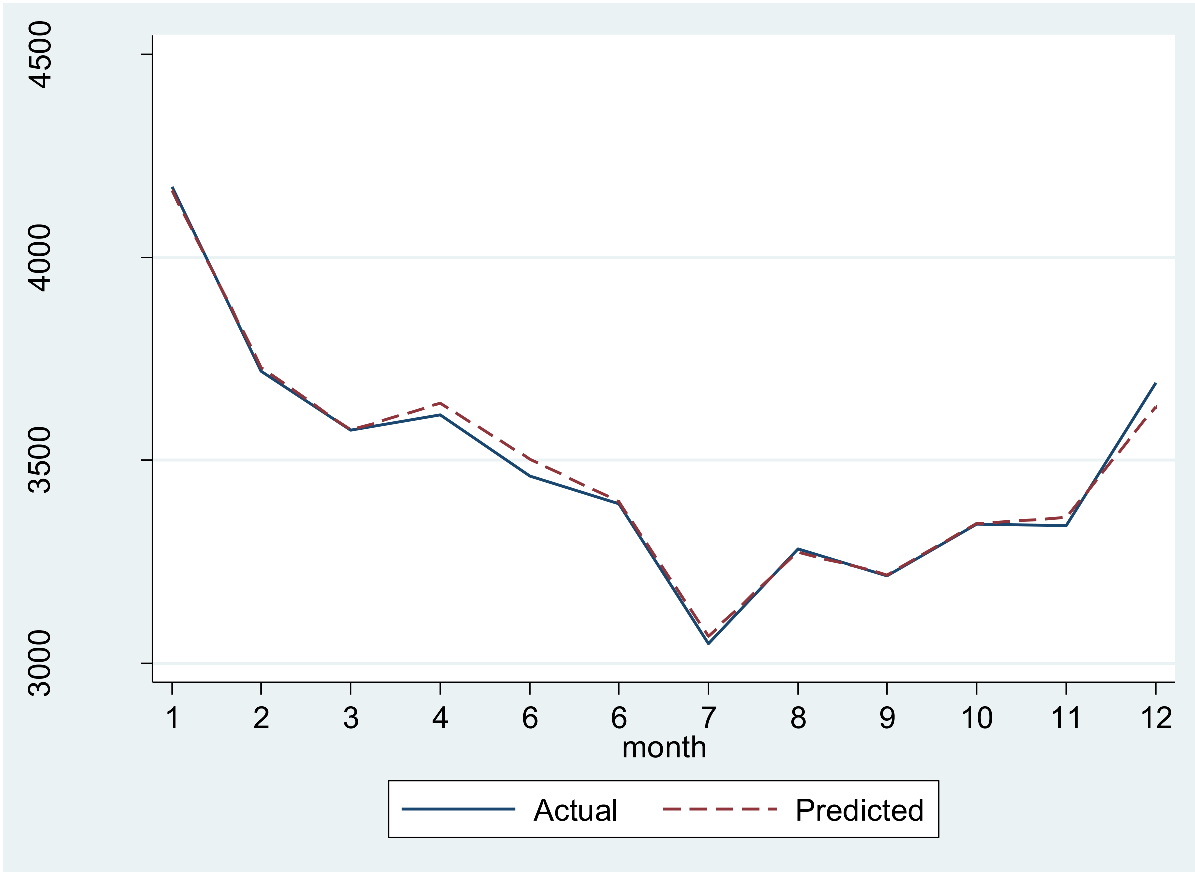
Note: The y-axis represents the estimated month-to-month changes of electricity consumption (%). They are residual values for bottom and top income quintiles from estimating demand functions excluding the electricity price and the month.

Figure 5 Price Elasticity and Annual Household Disposable Income (2008)



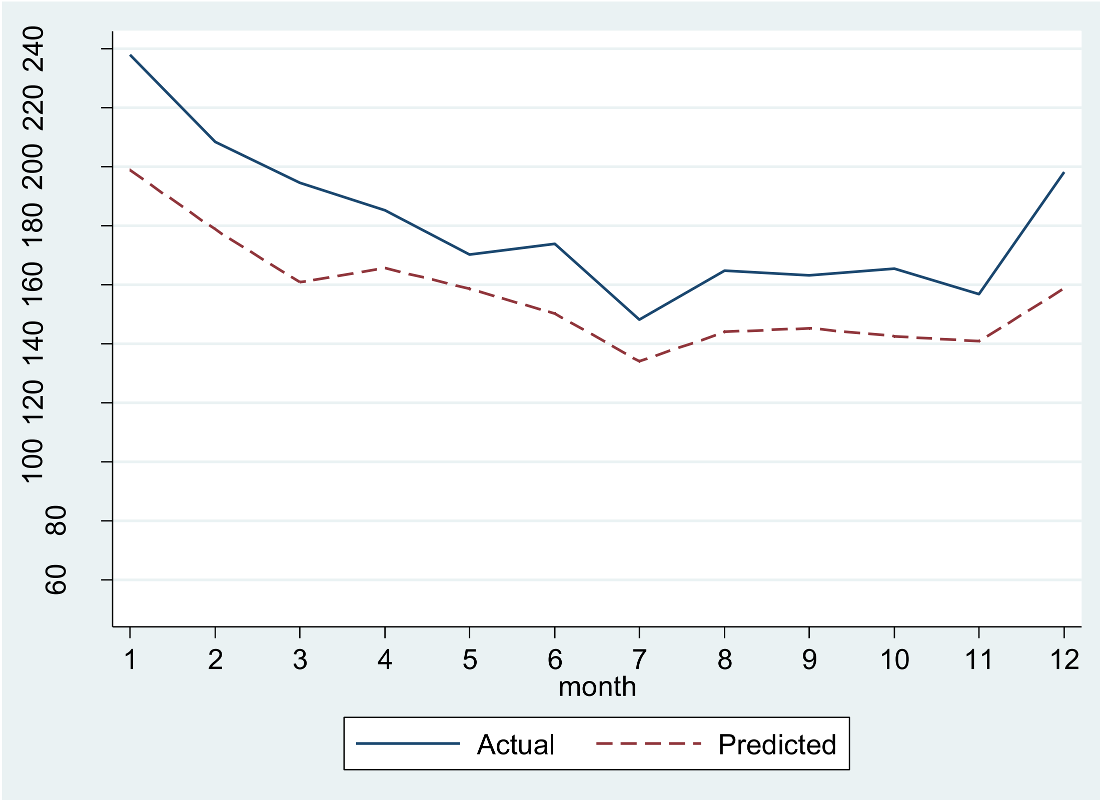
Note: Price elasticities are calculated based on annual household disposable income and demand parameter estimates of Equation (2).

Figure 6 Actual and predicted sum of the log of monthly electricity consumption in 2009



Note: The vertical axis describes the sum of the log of the monthly electricity consumption of sample households in 2009. The solid line corresponds to the actual consumption level. The dashed line depicts the out-of-sample prediction of 2009 consumption based on Equation (1) estimated with 2008 data.

Figure 7 Actual and predicted sum of monthly electricity consumption in 2009



Note: The vertical axis describes the sum of the monthly electricity consumption of sample households in 2009. The solid line corresponds to the actual consumption level. The dashed line depicts the out-of-sample prediction of 2009 consumption based on Equation (1) estimated with 2008 data.