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Estimation of Elasticity Price of Electricity with Incomplete Information*

by

Xavier Labandeira**
José M. Labeaga***
Xiral López-Otero****

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** Rede, Universidade de Vigo, Facultade de CC.EE., Campus As Lagoas s/n, 36310 Vigo and FEDEA. (xavier@uvigo.es)

*** Instituto de Estudios Fiscales and UNED. (jlabeaga@cee.uned.es)

**** Rede, Universidade de Vigo. (xiral@uvigo.es)

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Abstract

The sharp increase in energy prices and the growing concern for environmental issues, among other things, are behind the renewed interest in energy demand estimation. However, there is very little academic literature that takes account of the usual situation of energy suppliers: high quality but incomplete data. In this paper, we propose a useful and rather simple instrument for estimating electricity demand with incomplete or/and imperfect data available to suppliers. In particular, using real data of expenditure and consumption of electricity, we employ a model of random effects for panel data in order to estimate residential and industrial electricity demand in Spain.

Keywords: Electricity demand, microeconometrics, panel data.

JEL classification: C13, C14, C23, Q41.

1. Introduction

There are many reasons why the estimation of the price elasticity of the demand for electricity is important. First, the socio-economic importance of the production and consumption of electricity in contemporary societies is obvious. This justifies a detailed analysis of the effects of price changes from multiple perspectives (efficiency, distribution, economic growth, etc.). In addition, there are a number of factors that have increased interest in this matter in recent years: energy deregulation; a large increase in the price of certain primary energy products; policies to correct the environmental damage caused by energy (in particular, those related to global warming); and the growing promotion of energy efficiency.

The analysis of the effects of price changes on the demand for electricity is, moreover, essential for planning and organizing the supply of electricity adequately. However, suppliers of electricity have many problems estimating demand because the information they have is usually incomplete and/or imperfect. This paper presents a relatively simple procedure for estimating demand equations in these circumstances. This is especially pertinent to the case of Spain, where, after a period of government-controlled prices, there are large imbalances between regulated prices and supply costs that can lead to a sudden and sharp increase in the price of electricity.

The economic literature about energy demand dates back to the middle of the last century. Specifically, it began with the work of Houthakker (1951), who analyzed residential electricity consumption in the United Kingdom using cross-sectional data. Afterwards, Fisher and Kaysen (1962) made a study of residential and industrial electricity demand in the United States. They were the first to distinguish explicitly between the short term and the long term in residential demand. For their part, Baxter and Ress (1968) and Anderson (1971) focused on industrial electricity demand, while Houthakker and Taylor (1970), Wilson (1971) and Anderson (1973) addressed residential electricity demand. Noteworthy among the first empirical studies that used panel data in this field are Mount et al. (1973), who applied it to the entire electricity demand, and Houthakker et al. (1974) who used it in the context of residential demand. Afterwards, Lyman (1978) analyzed the residential, commercial and industrial demand for electricity, incorporating the use of data from companies and non-linear demand functions.

However, it was in the 1990s when empirical literature about electricity demand became very extensive and sophisticated (see, for example, Madlener, 1996). Many studies start from singleequation econometric models to estimate electricity demand, residential or industrial, applying different methodologies. A first alternative consists of estimating electricity demand through an aggregate model, using prices, income (or GNP) and climatic conditions as explanatory variables. Filippini (1999), García-Cerruti (2000), Hondroyiannis (2004), Holtedahl and Joutz (2004) and Narayan and Smyth (2005), too, can be classified in this group for the case of residential demand. Beenstock et al. (1999) covers residential and industrial demand. Kamerschen and Porter (2004) analyze industrial, residential and aggregate demand, and Bose and Shukla (1999) estimate residential, industrial, agricultural and commercial demand.

The use of aggregate data results in the loss of much information related to individual behavior. A second option, which is the one this article follows, consists of using microeconomic data to estimate electricity demand. Among the explanatory variables that are normally introduced in this case are stock of durable goods, type of housing or characteristics of the home for the case of residential demand, as well as company size, type of industrial sector and intensity of electricity in production for industrial electricity demand. Examples of this alternative are Baker et al. (1989), Leth-Petersen (2002), Larsen and Nesbakken (2004) and Filippini and Pachauri (2004), too, all of them dealing with residential demand of electricity. For industrial electricity demand, the contributions of Woodland (1993), Doms and Dunne (1995) and Bjørner et al. (2001), too, are noteworthy. In the case of Spain, academic literature about residential electricity demand is scarce, with Labandeira et al. (2006) one of the main contributors. In particular, there is almost nothing about Spanish industrial and commercial demand for electricity. This article tries to fill that void, estimating residential as well as industrial electricity demand in a context of individual demand equations and using panel data.

Likewise, this article provides a methodology that permits electricity suppliers to forecast the short-term evolution of electricity demand on the basis of the incomplete (but high-quality) information that they have. To make the estimations, the article starts from real data about consumption and spending on electricity in Spanish households and companies and obtains the rest of the necessary data from different public sources. The use of real data on consumption and spending is another advantage of the article, as data from public surveys is normally used in most studies of demand for goods and services. In this data, there are a series of errors in the variables (quantities and prices) that are difficult to correct and can cause major biases in the results.

The main results obtained by this research show that electricity demand is inelastic with respect to its price in the short term, although there are differences between residential and industrial demand. In the case of residential demand, consumers react in the short term to increases in the price of electricity (although less than proportionally), while the reaction of companies and large consumers is virtually non-existent. Furthermore, there is a certain relationship between the level of per capita household income and the price elasticity of demand for electricity. Finally, we observe that the price elasticities of electricity demand are, on average, very robust to different values of income elasticity and price elasticity of gas used in the article.

The article is divided into six sections, including this introduction. Section Two presents the theoretical model and the econometric model used for estimation, followed by a description of the data used in Section Three. Section Four gives the main results obtained and Section Five analyzes the relationship between the elasticities obtained and the level of income or production. The article finishes with a summary and conclusions. Also, because of its importance, an Annex describing the information used in more detail is included.

2. Model

2.1 Theoretical framework

When setting adjusting electricity consumption, we distinguish between domestic consumers and companies and large consumers. The theoretical framework for each of these groups is presented below.

a) Households

Households do not demand electricity to consume it directly; they use it to produce a series of final goods and services (light, hot water, prepared food, etc.). As such, electricity can be considered an intermediate good for households, so we can analyze the demand for electricity following the basic framework of the household production theory. According to this theory, households acquire goods that they use as inputs in the production process to obtain goods that are useful for households (see Becker, 1965; Muth, 1966 or Deaton and Muelbauer, 1980, for a more detailed analysis). In the case that concerns us, households combine electricity, natural gas and capital equipment (appliances) to produce a composite energy good.

Adapting Filippini's model (1999), the production function of the final energy good (x) can be defined as a function dependent on the electricity consumed (e) as well as the natural gas consumed (g) and the stock of household appliances (a),

$$x = x(e, g, a) \tag{1}$$

The household has a utility function[1] that depends on the quantity of the composite energy good and the quantity acquired of a composite numerary good (y) that directly provides utility, as well as household characteristics that influence their preferences (z),

$$u = u(x, y; z) \tag{2}$$

Following Deaton and Muellbauer (1980), the household decision process can be modeled in each period as a problem of optimization in two stages. In the first stage, consumers behave like a company, minimizing the costs of producing the energy good, while in the second stage they maximize their utility. The problem for the consumer in the first stage is,

$$\begin{aligned} &Min\ p^e e + p^g g + p^a a \\ &s.t \\ &\quad x = x(e, g, a) \end{aligned} \tag{3}$$

where p^e is the price of electricity, p^g the price of natural gas and p^a the price of the stock of appliances. As a result, the cost function is obtained,

$$c = c(p^e, p^g, p^a, x) \tag{4}$$

Applying Shepard's lemma, we obtain the demand derived from inputs, so, for electricity,

$$e = \frac{\partial c(p^e, p^g, p^a, x)}{\partial p^e} = e(p^e, p^g, p^a, x) \tag{5}$$

[1] We assume that this has the normal properties of differentiability and curvature.

In the second stage, the household maximizes its utility, subject to its budget restrictions,

$$\begin{aligned} &Max\ u(x, y; z) \\ &s.t \\ &\quad c(p^e, p^g, p^a, x) + y = r \end{aligned} \tag{6}$$

where *r* is the household income level. Solving this problem, we obtain the demand functions of the goods *x* and *y*. In the case of the composite energy good, we get

$$x^* = x^*(p^e, p^g, p^a, r; z) \tag{7}$$

Substituting this demand function in the demand function derived from electricity,

$$e = e(p^e, p^g, p^a, x^*(p^e, p^g, p^a, r; z) = e(p^e, p^g, p^a, r; z) \tag{8}$$

In response to variations in the price of electricity, households can modify their stock of appliances or reduce their use. However, given that the temporal scope of this article is the short term, we assume that the stock of appliances remains constant. Also, in the short term, prices of appliances can be considered constant and be excluded from the model without causing biases in the estimation (Halvorsen, 1975).

b) Companies and large consumers

In the case of companies and large consumers, electricity is an input in their production process. Assuming that all companies consider the price of electricity and other factors exogenous and that each minimizes its production costs, the demand for electricity can be expressed as a function of the price of the factors and of the level of production (Bjørner et al., 2001).

As such, the problem for companies is the minimization of their production costs in the short term, subject to their production function,

$$\begin{aligned} & Min\ p^e e + p^g g + p^u u + FC \\ & s.t \\ & \quad m = m(e, g, u, \bar{k}) \end{aligned} \tag{9}$$

where *m* is the company's production level of the final compound good, *u* other inputs that are necessary in the production process, p^u the price of those inputs, and *FC* the company's fixed costs, determined by the stock of capital ($\bar{k}$) that it has. The stock of capital remains constant (and implies only fixed costs) given the short-term analysis.

Solving the problem, we obtain the company's cost function, in which we can distinguish between fixed costs (*FC*) and variable costs (*VC*),

$$c = c(p^e, p^g, p^u, m, \bar{k}) = FC(\bar{k}) + VC(p^e, p^g, p^u, m) \tag{10}$$

Applying Shepard's lemma, we derive the demand for electricity,

$$e = \frac{\partial c(p^e, p^g, p^u, m, \bar{k})}{\partial p^e} = \frac{\partial VC(p^e, p^g, p^u, m)}{\partial p^e} = q(p^e, p^g, p^u, m) \tag{11}$$

Assuming that, in the period under consideration, electricity and gas are separable from other inputs so that the relationships between electricity and gas with other inputs are neutral in terms of price, it is possible to exclude the price of other inputs from the model. Furthermore, supposing that the price of the final composite good remains constant, the fact that the function of electricity demand depends on the production level is equivalent to its dependence on the production value, which we denote *r*.

2.2 Econometric model

Once we obtain the demand function for electricity, it is necessary to specify a functional form in order to estimate it. Although there is no consensus in the literature about the most appropriate functional form, most of the studies that use individual demand equations adopt a linear or logarithmic form. This is why we choose to use a double logarithmic specification, because the estimated coefficients are equivalent to the elasticities and, as such, it is assumed that they are constant. This way we start from the following classical model of random effects for panel data,

$$\log e_{it} = \alpha + \beta \log p_{it}^{e} + \gamma \log p_{it}^{g} + \delta \log r_{it} + \sum_{j=2006}^{2007} \varsigma_j \, duyea_j + \sum_{k=1}^{11} \theta_k \, dumon_k + \sum_{l=1}^{n-1} \iota_l \, duprov_l + \eta_{1i} + \varepsilon_{1it} \qquad (12)$$

where *i* indicates the household (company) and *t* the month. Dummies for year, month and province ($duyea_j$, $dumon_k$ and $duprov_l$, respectively[2]) are incorporated in the consideration of possible spatial and temporal effects on the consumption of electricity. This way, effects that are unobservable due to consumer characteristics or location are controlled. η_{1i} is the unobservable heterogeneity and ε_{1it} is the idiosyncratic error term.

However, the absence of available information with respect to the price of gas and income (the value of production, in the case of companies) requires the initial model to be transformed, using complementary information, to achieve a consistent estimation of the price effects. Therefore, instead of estimating income elasticity (δ) and crossed elasticity with respect to the price of gas (γ), these are considered data (see the next section) and the model is transformed to consider the effect of these two variables on electricity demand. Therefore, in the new specification, we subtract both variables multiplied by their respective elasticities from electricity consumption so that we obtain

$$\log e_{it} - \hat{\gamma} \log p_{it}^{g} - \hat{\delta} \log r_{it} = \alpha + \beta \log p_{it}^{e} + \sum_{j=2006}^{2007} \varsigma_j \, duyea_j + \sum_{k=1}^{11} \theta_k \, dumon_k + \sum_{l=1}^{n-1} \iota_l \, duprov_l + \eta_{2i} + \varepsilon_{2it} \qquad (13)$$

$\hat{\gamma}$ and $\hat{\delta}$ being the data that we introduce for the crossed elasticity of the electricity demand with respect to the price of gas and the income elasticity, respectively. η_{2i} is the unobservable heterogeneity and ε_{2it} the idiosyncratic error term of the new model.

In the case of residential electricity demand, moreover, we introduce climatic variables that can affect the behavior of households in reducing their margin of reaction to a variation in the price of electricity. Therefore, the model for the residential case is specified as,

[2] *n* represents the number of provinces in the sample.

$$\log e_{it} - \hat{\gamma}\log r_{it} - \hat{\delta}\log p_{it}^{g} = \alpha + \beta \log p_{it}^{e} + \sum_{j=2006}^{2007} \varsigma_j \, duyea_j + \sum_{k=1}^{11} \theta_k \, dumon_k + \\ + \sum_{l=1}^{n-1} \iota_l \, duprov_l + \kappa \, HDD_{lt} + \lambda \, CDD_{lt} + \eta_{2i} + \varepsilon_{2it} \qquad (14)$$

HDD_{lt} and CDD_{lt}, being the Heating Degree Days and the Cooling Degree Days, respectively, of the province *l* in the period *t*.

3. Data

This study was made using monthly data for the period from September 2005 to August 2007. The data was provided by one of the main Spanish electric companies, Iberdrola Distribución S.A.[3] We have observations from 422,696 households, 30,499 companies and 688 large consumers.

Natural gas prices were calculated on the basis of rates set by the government in the successive Royal Decrees about rates published during the period. Gross disposable income per household was used as an income variable, while for companies and large consumers, the variable used as a proxy of the production value differs according to the sector to which the companies belong. In particular, for companies that belong to the primary sector, added gross value is used; for the industrial sector, net turnover; for the building sector, exploitation revenue; and for the service sector, the production value. All of this data was obtained from the National Statistics Institute (hereafter referred to as INE, its initials in Spanish) (see Annex).

The parameters used for income and the price of gas in the estimation are shown in Table 1. In the case of households, these values were taken from Labandeira et al. (2006), while in the estimations for companies and large consumers, they are an average of the results provided by academic studies that analyze industrial demand for electricity (income elasticity) and the industrial demand for gas (price elasticity of gas).[4] We also analyze the variation in the values of

[3] The data was provided without being identified or associated with specific consumers, with the goal of respecting the Spanish legislation on data protection.

[4] As no individual data are available for adjusting the demand of electricity, after subtracting from the initial demand the product of the elasticities and the averages of the variables for gas price and income, there is a problem of measurement errors in the quantity of electricity demand. This affects the estimation of the standard errors of the coefficients, so it is corrected in the empirical exercise by using a method that provides standard errors robust to

the price elasticities of electricity in the three samples for different values of the parameters corresponding to income elasticity and gas price elasticity. In particular, we suppose that the crossed elasticity is 0.1, household income elasticity is 0.9 and income elasticity of companies and large consumers is 0.6.

Table 1. Parameters used

Parameters	Households	Companies	Large Consumers
Cross-Price Elasticity of Gas	0.05	0.05	0.05
Income Elasticity	0.7	0.3	0.3

Source: the authors' production

With respect to the climatic variables, we have the *Heating Degree Days* and *Cooling Degree Days*. Both variables were calculated on the basis of information given by the Spanish Meteorology Agency (Ministry of Environmental, Marine and Rural Affairs) about daily maximum and minimum temperatures of the provincial capitals that this study covers. Eighteen degrees Celsius is taken to be the ideal temperature, considering an interval of ±5ºC around this temperature (13ºC-23ºC) within which it is assumed individuals do not need to use heating or cooling equipment.

4. Results

Given that the unobservable heterogeneity is included in the composite error term $\nu_{it} = \eta_{2i} + \varepsilon_{2it}$, the term presents autocorrelation over time for the same sample unit. This is why we estimate the proposed models by general least squares, so that the estimators obtained are consistent and efficient.[5] We make three estimations of the corrected demand for electricity, one for each group of consumers of electricity (Equation 13 for companies and large consumers, and

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heteroskedasticity and autocorrelation (White, 1982). This procedure is indeed equivalent to calculating the elasticities on the average of the relevant variables.

[5] With ordinary least squares, the estimators would be consistent but not efficient. In addition, as has been mentioned, the standard errors are corrected by White's (1982) procedure.

Equation 14 for households) including the prices of electricity and the time and space dummy variables mentioned as explanatory factors. The results obtained are shown in Table 2.

Table 2. Price elasticities of short-term electricity demand

	Households	Companies	Large Consumers
Elasticity	-0.2471 (0.0023)	-0.0241 (0.0024)	-0.0152 (0.0073)

Note: Standard errors between parentheses
Source: The authors' production

As expected, in the three cases, electricity demand is inelastic with respect to its price in the period analyzed. That is, an increase in the price of electricity will give rise, *ceteris paribus*, to a less-than-proportional reduction in electricity demand. The results show a residential demand for electricity that is more rigid than that obtained by Labandeira et al. (2006) on the basis of data on electricity expenses from the INE's *Encuesta Continua de Presupuestos Familiares* (Continuous Survey on Family Budgets), inasmuch as this value strictly corresponds to the short-term estimation while the results of Labandeira et al. (2006) try to include more middle- and long-term effects. In any case, the results obtained are within the normal values obtained by the literature (see, for example, Narayan and Smyth, 2005).

Elasticity is lower in the case of companies and large consumers than it is in the case of households, and the values obtained for both types of non-residential consumers are significant. This is probably explained by the fact that households present a larger capacity to react in the short term, while companies will generally have to make modifications (with positive cost) in their production processes to be able to reduce their consumption of electricity. In fact, it is possible to speculate that the adaptation in companies will occur when the increase in the price of electricity is very pronounced and leads to structural changes that affect their behavior as consumers. In other words, income and activity, too, are important factors in the explanation of the demand for electricity by residential consumers and companies, but while there are other variables like prices and climatic variables that affect residential demand for electricity, activity by itself explains the behavior of large consumers and companies as regards electricity demand (given the current price levels).

Also, a sensitivity analysis has been carried out through additional estimations of the models. In these estimations, the values used for income elasticity and the cross-price elasticity of natural gas are modified, incorporating the variation in the values obtained for these parameters by the academic literature. The results of the new estimations show values for price elasticities of electricity that are very similar to those obtained in the original model, for households as well as for companies and large consumers, which suggests that the estimated elasticities are robust. In fact, the changes in the values corresponding to companies and large consumers are, in the most pronounced case, less than three percent and practically zero in the case of households. This exercise reiterates the fundamental result of the article: the adjustment of demand by companies occurs almost exclusively due to the state of their economic activity, while households are much more flexible in accommodating their demand via prices.

It is also worth noting that the influence of the climatic variables on residential demand is small but significant, such that if in one month the Heating Degree Days/Cooling Degree Days increase one unit, electricity demand would vary on average by 0.019%/0.029%. In terms of degrees, when the average minimum/maximum temperature in a month diminishes/increases by one degree Celsius, electricity demand would increase on average by 0.3347%/0.3903%. It is worth mentioning that the influence on demand is greater on hot days than on cold days, surely because generating cold depends almost exclusively on electricity.

5. Elasticities and level of income or production

Once price elasticities of the demand for electricity are estimated, we present the relationship between them and the level of income by province for the residential case, and between the elasticities and the level of production by provinces and by industrial sectors. To this effect, two non-parametric contrasts are used: Spearman's contrast of correlation by ranges and Kendall's contrast. To make these contrasts, the price elasticity of demand in each province was estimated for each group of consumers, and by sectors for companies and large consumers. Once these estimations are obtained, in each group of data the different provinces (sectors) we have information for are ordered according to their adjusted price elasticity, as well as according to their per-capita GNP/gross disposable household income in 2005.[6]

[6] In the case of activity sectors, we order them according to the added value in each of them in the year 2005.

Table 3 shows Spearman's (r_S) and Kendall's (τ) statistical values for the three groups of consumers along with the critical values for making the contrast with a significance level of 5%. In both contrasts, the null hypothesis is the absence of association between the variables, which cannot be rejected for companies (that is, there is no relationship between the ranges). Contrary to this, in the residential case, the null hypothesis of absence of relationship between ranges is rejected in both contrasts, as it is for large consumers with Kendall's contrast. As such, it is possible to affirm that the elasticity of demand by provinces is related to the per-capita income level of the province in the residential case, with elasticity being lower (in absolute value) the higher the level of per-capita income is. In the case of companies, the relationship between elasticity and per-capita GNP is inexistent, as the elasticity depends on other factors. For their part, in the case of large consumers, there seems to be a certain relationship between the variables, although it is of little importance.

Table 3. Spearman's rank correlation coefficient and Kendall's τ statistic. The case of provinces

	Companies	Large Consumers	Residential
r_S	0.39699	0.52527	0.66231
Critical value r_S	0.447	0.538	0.398
τ	0.28421	0.42857	0.48
Critical value τ	0.326	0.407	0.287
n	20	14	25

Source: The authors' production

For the sectorial case, applicable to companies and large consumers, consumers are grouped according to activity classification codes, and afterwards, the demand elasticity of electricity for each group is estimated. After the data is ordered, the contrasts are made according to the information supplied in Table 4 (statistics and critical values). On this occasion, for companies as well as for large consumers, none of the contrasts allows us to reject the null hypothesis of absence of relationship; that is, price elasticities of demand for electricity by sectors do not depend on the added value in the sector. This does not mean that the level of activity has no bearing on the behavior of the demand; in fact, it is quite the opposite. That is, the level of activity in a certain period conditions companies' and large consumers' demand for electricity, something that is not reflected in the calculated sectorial averages of activity levels.

Table 4. Spearman's rank correlation coefficient and Kendall's τ statistic. The case of sectors

	Companies	Large Consumers
r_S	0.14598	-0.07534
Critical value r_S	0.390	0.472
τ	0.09	-0.16
Critical value τ	0.280	0.346
n	26	18

Source: The authors' production

6. Conclusions

In this article, we have estimated the price elasticity of the demand for electricity in Spain, for the case of households as well as for companies and large consumers, using real data on prices and electricity consumption. We have also analyzed the relationship between these elasticities and the level of per-capita income. Our objective is twofold: to add to the small body of empirical literature in Spain about this matter, useful for the definition and analysis of energy and environmental policies, and provide electricity suppliers with a rigorous but simple tool so that they can carry out demand estimations with incomplete information. Although the method is illustrated with an application for the case of Spain, especially interesting and relevant given the context of prices and policies, we feel that its usefulness transcends any temporal and spatial application.

We have observed how households react to prices in the short term although their demand is inelastic with respect to prices. For their part, electricity demand of companies as well as of large consumers are hardly affected by the variations observed in prices, with demand elasticities very close to zero. All the previous results, especially those related to residential demand, are consistent with the abundant international empirical evidence on the matter, which reinforces and validates the approach followed here. From the results of this article there also emerges the existence of a relationship between the elasticity of electricity demand and the level of per-capita income of provinces for the case of households: elasticity diminishes (in absolute value) as the level of per-capita income increases. This relationship does not exist for the case of companies, although it does to some extent for large consumers. Lastly, we have found no relationship between demand elasticity by sector of activity and the added value in those sectors.

As such, it should be expected that, even in the short term, an increase in the price of electricity leads to households using electricity more efficiently. This means that, in response to the prospect of dramatic increases in the cost of electricity in the coming years, Spanish electricity suppliers should contemplate these reductions in demand when planning their strategies. On the contrary, the foreseeable increases in prices will hardly affect the consumption of electricity by companies and large consumers in the short term due to the high costs entailed in changing their production systems. Given that these groups account for nearly two thirds of electricity consumption in Spain, it is foreseeable that the effects of the price changes will be tempered. This result is reinforced because, in the residential case, as the level of income in a territory increases, electricity demand becomes more elastic.

In any case, we must reiterate that the results of this paper probably indicate the lowest threshold of adaptation by agents to changes in the price of electricity, not only because we are dealing with short-term estimations, but also because the modeling does not include the (related) decision to consume durable goods that are linked to the use of energy products.

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ANNEX

Description of the data used

As explained in Section 3, for the calculation of natural gas prices we use the rates set by the Spanish government (rate 3.1 for households, assuming an average consumption of 2500 kWh/year, and the arithmetic average of rates 3.2, 3.3 and 3.4 for companies and large consumers). To calculate the prices implicit in each of these rates, we assume an average consumption of 27,500 kWh/year, 75,000 kWh/year and 100,000 kWh/year, respectively. Prices are deflated through the Consumer Price Index (CPI), taking September 2005 as the basis. To obtain the Gross Disposable Income per household, we start from gross disposable income of households by provinces for 2004, data obtained from the INE. Given that we are dealing with annual data, the data is broken down into quarters for the purpose of estimation (seasonal analysis). The quarterly weightings used (see Table A1) were calculated on the basis of the information provided by the INE, which includes the temporal variability of income. Once the data was broken down into quarters, it was inflated according to the evolution of the CPI to obtain the data for 2005, 2006 and 2007. Lastly, given that the data on consumption corresponds to households, we divide income by the number of households in each province to get gross disposable income per household.

Table A1. Quarterly weightings of gross disposable income. 2004

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Weighting	0.2569	0.2382	0.2547	0.2501

Source: The authors' production

The variable used as a proxy of the production value for companies and large consumers was obtained in the following procedure:

a) Primary sector: Gross quarterly added value (INE). The available data was deflated using the implicit deflator of the GNP (on the basis of data from *Contabilidad Nacional*) to express it in real terms.

b) Industrial sector: Annual net revenue (INE) for 2005 and 2006. To break down the data into quarters, monthly data from the Industrial Production Index was used, calculating the arithmetic average of the monthly data in each quarter. Once the quarterly data was obtained, the quarterly weighting was calculated by dividing the data of each quarter by the quarterly aggregate for the year. Applying these weightings to the data on annual net revenue, we obtain the quarterly data. For 2007, the data from 2006 was inflated in each quarter by the increase in the industrial production rate in the corresponding quarters of 2007 to preserve the seasonal variability of industrial demand for electricity. Lastly, the data was deflated to the base period of September 2005 using the Industrial Price Index.

c) Building sector: Monthly exploitation revenue. Deflated using the CPI for housing.

d) Service sector: Production value (Annual Services Survey and Annual Trade Survey of the INE). Only the annual data from 2005 is available. This was broken down into quarters according to the quarterly structure of Gross Added Value in the service sector in 2005. To obtain the quarterly data for 2006 and 2007, it was inflated using the implicit GNP deflator. Given that in the data base provided by Iberdrola Distribución S.A. there are data that correspond to services not included in these surveys, we calculate their production value by previously obtaining the weight in the Gross Added Value of the service sector data that was included, assuming that that weight also represents the weight of these services in the total value of the production sector. From this we get the total value of the production of all services for which there is no data.

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