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ARE TWO-PART TARIFFS EFFICIENT WHEN CONSUMERS PLAN AHEAD?: AN EMPIRICAL STUDY

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Abstract: During the last two decades there has been an increase in using dynamic tariffs for billing household electricity consumption. This has questioned the suitability of traditional pricing schemes, such as two-part tariffs, since they contribute to create marked peak and off-peak demands.

The aim of this paper is to assess if two-part tariffs are an efficient pricing scheme using Spanish household electricity microdata. An ordered probit model with instrumental variables on the determinants of power level choice and non-paramentric spline regressions on the electricity price distribution will allow us to distinguish between the tariff structure choice and the simultaneous demand decisions.

We conclude that electricity consumption and dwellings' and individuals' characteristics are key determinants of the fixed charge paid by Spanish households Finally, the results point to the inefficiency of the two-part tariff as those consumers who consume more electricity pay a lower price than the others.

Keywords: Regulation, electricity, consumer behavior: empirical analysis.
JEL Codes: L94, Q41, D12.

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1. Introduction

Electricity at households is a good demanded under a seasonal pattern, with marked peak and off-peak periods and whose price is set through complex pricing schemes. There are a number of pricing schedules available to utilities or regulators in order to bill electricity consumption. We suggest to classify them into two wide categories, depending on its final aim and structure, named traditional and new tariffs.

The first group includes pricing schedules such as two-part tariffs and decreasing or inverted block tariffs. Under these pricing mechanisms the price is set regardless the moment in which electricity is consumed. Only under block tariffs the marginal price of electricity decreases (increases) as long as consumption of electricity does. However, under two-part tariffs the marginal price of electricity remains the same across all consumption levels. Nowadays, few countries like Spain use a regulated version of this tariff[1] Under this pricing scheme consumers' bill is made of two elements: a fixed charge (or power term), which is the power contracted times its regulated price, and the energy term, which is the kilowatts hour (*kwh*) consumed times the regulated (or marginal) price for this consumption.[2]

Given that the price of the fixed charge and the marginal price are regulated the only choice that the consumer is able to do under a two-part tariff is the level of contracted power. [3] Provided that, the higher the power level contracted, the more the consumer pays.[4]

The second group of tariffs, the new ones, includes those in which the electricity price varies depending on the moment in which electricity is consumed, reflecting the cost of producing the good. It means that the price during the peak hours will be higher than during off-peak hours. In

[1] Although all consumers in the Spanish electricity market are able to choose between a regulated price and a liberalised price from the January 1st of 2003, only 1.3 milion out of 23.3 milion of small consumers (household and small and medium enterprises) were billed using the liberalised price in march of 2005. (CNE, 2005).

[2] The fixed charged must be paid both if there exists consumption of electricity or not.

[3] It must be remarked that power is a measure of capacity, so a higher level of contracted power means the need of higher simultaneous electricity consumption with a number of household electrical appliances. By contrast the energy term is a flow measure and accounts for the value of energy consumption through the time, regardless that this consumption is done with some household electrical appliances simultaneously or along a period of time.

[4] According to Auerbach and Pellechio (1978) the possibility that the fixed charge in a two-part tariff be different among individuals fosters a fairer financing of the fixed costs of generating and supplying electricity.

this group we can find time-of-use tariffs, critical-peak and real-time pricing. These tariffs have been widely used during the last three decades across the electricity markets.[5]

Given these groups above an agreement could be achieved: both of them are tools to discriminate prices, but with different aims depending on the tariff chosen.

On the one hand, under traditional tariffs price discrimination pursues extracting the needed amount of consumer surplus to finance the costs of generating and supplying electricity.

On the other hand, new tariffs discriminate prices to achieve that consumers change their peak / off-peak demand pattern into a more stable one. This is important because in the short-term the installed capacity to generate electricity is fixed.

This fact has led to a debate both in the empirical and theoretical literature. In this sense we can mention the works of Borenstein and Holland (2003); Borenstein (2005) and Faruqui and George (2005). They argue that under tradicional tariff structures consumers do not receive any signal of the degree in which capacity constraints are binding. As a result marked peak and off-peak demands are generated, such that the binding capacity constraint during the peak becomes an excess of capacity during the off-peak periods, which in turn is a source of inefficiency for the system.[6] Moreover, under two-part and block tariffs it is not necessarily true that the more the individuals consume the higher they pay. This fact would be against efficiency and redistributive criteria.

Given this debate, we argue that an adequate financing of generation and supply costs depends on two aspects. First, the payment of a bigger fixed charge by consumers who contract a higher power level. Second, the price distribution resulting from consumption.

In this context the two-part tariff would be inefficient since those consumers who contract more power would like to consume more electricity simultaneously. This fact would lead to peak and off-peak demands and it would make difficult to guarantee the supply of electricity, given an installed capacity of generation. If these peaks in the demand are not discouraged making consumption more expensive it will be difficult to make the load curve stable along the time.

[5] The introduction of new tariff schedules is well documented in the literature. See Taylor and Schwarz (1986, 1990); Hawdon (1992); Aubin *et al* (1995); Filippini (1995) and Matsukawa (2001), among others.

[6] Borenstein, Jaske and Rosenfeld (2002).

Thus, the aim of the paper is to examine the degree of efficiency of the household electricity two-part tariff. In order to tackle this issue, we will identify the determinants in the election of the tariff structure in Spain using household electricity consumption microdata and separating the tariff structure choice from the simultaneous demand decisions.

The methodology used in this paper is organised in two parts: a parametric analysis through an ordered probit model and a non-parametric analysis through spline regressions.

The previous methodology will be undertaken with microdata from the Spanish Household Budget Survey (HBS) in 1999, which is developed by the Spanish Statistics Institute.

The paper concludes that electricity consumption, and dwellings' and households' characteristics are major determinants of the contracted power by each consumer. Moreover, the results point out a degree of inefficiency of the two-part tariff, as those consumers who contract a higher power level are not discouraged to consume higher in particular moments. In other words, in spite of the fact that consumers plan ahead its consumption, contracting an adequate power level at home, the tariff system makes them to behave inefficiently.

The contribution of the paper consists on giving evidence about the fact that a two-part tariff has relevant economic implications over consumers, as it leads to a very similar average price structure across them distinguishing by contracted power. The paper makes also a contribution in methodological fields, combining parametric and non-parametric techniques over microdata in a new fashion with respect to the previous literature.

The structure of the paper is organised as follows. In section 2 we comment on the methodology used in the empirical analysis. Section 3 presents the data and describes the construction of some specific variables. Section 4 is devoted to the discussion of results. Last section summarizes the conclusions of the analysis and discusses its policy implications.

2. Empirical Strategy

The context of the analysis is the short-term. It means that the stock of electrical appliances in a household is fixed. Given this constraint a discrete choice model is used. This model will estimate the determinants of contracted power, as well as the probability to choose a particular power level. This analysis will be a novelty in the sense that discrete choice models in the related literature are focused on the long-term and are concerned with calculating price and income long-term demand elasticities. This methodology, with some variations, was that used in McFadden, Kirshner and Puig (1977); Dubin and McFadden (1984); Baker and Blundell (1991); Nesbakken (1999) and Halvorsen and Larsen (2001).

Once that we have evidence on the decision of contracted power we develop a non-parametric analysis, in which the distribution of average electricity price respect to the consumption of each household is examined depending on the contracted power, in order to obtain evidence on the economic implications of the two-part tariff.

2.1. A discrete choice model on household electricity power

The models of ordered answer take into account the index nature of different answer variables. In this work the levels of contracted power by household are the ordered answers. The underlying element to this indexation in these models is a latent and continuous variable which describes the answer.

In this paper the following specification has been used:

$$P_n^* = \beta' z_n + \varepsilon_n, \quad \text{where} \quad \varepsilon_n \approx N\left(0, \sigma^2\right), \tag{1}$$

where P_n^* is the continuous latent variable which measures the contracted power level by household n, z_n is a vector of explanatory variables which includes dwelling's and consumers' characteristics, β is a set of parameters to be estimated and ε is a random error term, which is supposed to follow a standard normal distribution, with mean zero and known variance.

Given the increasing nature of the ordered variable, the interpretation of the primary set of parameters of the model, β, is as follows: positive signs will show a higher contracted power as long as the value of the associated variables increases, while the negative signs suggest the opposite. These interactions must be compared with ranges among different thresholds which delimit probabilities of choice, in order to determine the most likely power for a particular household.

2.1.1. Econometric issues

In using the ordered probit model we must take into account two issues: the complex survey design and the possibility that some of the explanatory variables may cause an endogeneity bias. In fact, the observations in our sample have not been selected following a random sampling, but a complex survey design, in particular a two-stage stratified selection process. This procedure, in spite of collecting more representative observations from the population, does it at the expense of adding complexity to the econometric analysis.[7]

On the one hand, if the complex survey design is not considered we will incurr in estimation efficiency problems. This is due to the fact that the complex survey design tries to choose households which differs the most among strata, but the less in the same stratum. Thus, there is a correlation of the random error term among observations in the same stratum, since the variance can not be assumed to be constant across the sample.

In order to solve this problem, survey estimation techniques will be used. This procedure considers the way in which sampling process has been undertaken. This fact increases the efficiency and robustness of the estimation results.

On the other hand, the estimation of the ordered probit model could suffer from endogeneity problems due to the use of the household electricity consumption, since there could be a simultaneous relationship between consumption and the contracted power. This could be the case since those households which contract a higher power level want to use a great number of electrical appliances at the same time, consuming more electricity than others. Also, households who consume more electricity are those who own more electrical appliances and therefore those who contract a higher power level.

In order to tackle this problem we have estimated the ordered probit model in two stages. This procedure avoids the obtention of biased and inconsistent estimators. Thus we need to look for suitable instruments for electricity consumption.

One of the instruments used is the household income. This variable is in turn determined simultaneously with consumption as it is likely that those households who earn a higher income are those who consume higher. The opposite may also be true. For instance, if we assume that other goods, like consumption of gas, are good substitutes of electricity, and if gas turns

[7] Skinner, Holt and Smith (1989) make a detailed analysis of the implications of complex survey design.

relatively more expensive than electricity, those households who increase their consumption of electricity could see their available income rising. Given that, we replace income by another variable called non-energetic total expenditures (NETE) and which is constructed from variables in our data set.[8]

2.2. Non-parametric spline on the price distribution

Non-parametric techniques are used to estimate the value of a regression function among two or more variables in a given point, using observations near to this point without introducing constraints about the functional form. In this paper spline regressions are used. Spline regressions are polinomials by segments, in which all segments are connected among each other.

According to Scott (2003), if we have a data set like: $D = \{[x_1, y_1], \ldots, [x_m, y_m]\}$ in $\Re^2$, the spline can be fitted searching the function *f* that solves the following minimization problem:

$$\frac{1}{n}\sum_{i=1}^{n}\left(\left(AP_i - f\left(Q_{e\,i}\right)\right)^2\right) + \lambda\int_{x_1}^{x_m}\left(f^{\,m}\left(Q_e\right)u\right)^2 du\,, \tag{2}$$

where *f(.)* is the fitted function, AP_i is the electricity price by household, Q_{ei} is the amount of electricity consumed by household and *u* is the domain over which every point in the function is fitted. The first term on the equation (2) measures the closeness of the fitted function to the data, while the second term penalizes the curvature in the function. λ establishes the *trade-off* between each other. The choice of this paramater is important to assure that the fitted function is accurate. In this paper this choice has been done through a cross-validation process.

The result of applying the spline above over our data will be six functions between average price and consumption of electricity for six levels of contracted power.

If one of these functions, for the lowest power levels, is the same or over functions with higher power levels, for any level of consumption, the two-part tariff will be inefficient since the average price paid by households with a low contracted power will be equal or higher than that paid by households who contract a higher power.

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[8] This procedure is well documented in the empirical literature. See Dubin and McFadden (1984), Baker and Blundell (1991), Leth-Petersen (2002) and Halvorsen, Larsen and Nesbakken (2003).

2.2.1. Econometric issues

Electricty consumption will be a source of endogeneity bias in the non-parametric estimation. We use it as explanatory variable of the average price and their simultaneous determination is due to the fact that the average price is calculated as the ratio between the electricity expenditure of each household and its consumption. In this case, non-parametric estimation shows a purely arithmetic relationship between both variables.

In order to avoid this problem electricity consumption will be replaced by its prediction, obtained in the first stage of the ordered probit model. This procedure not only avoids the endogeneity problem but establishes an additional link between the two methodological approaches here, since the results of the discrete choice model are an input for the non-parametric estimation.

At the same time, the use of the power variable in the spline regression generates endogeneity too. This is because of the way in which the average price measure has been constructed. To avoid this problem we replace the power variable for its prediction obtained in the second stage of the ordered probit model.

3. Data

In this paper annual cross-section microdata for 1999 in Spain has been used. This data set comes from the Household Budget Survey (HBS), which elaborates the Spanish Statistics Institute. The sample accounts for 9,881 observations or households.

From our original data set it has been considered necessary to construct some additional variables to those included in the survey as follows:

3.1. Variables related to electricity consumption

The need to construct these variables has its roots in the fact that HBS only offers data on annual household electricity expenditure. Thus we construct the following variables: contracted power, consumption in kwh and the average price of electricity.

Contracted power

In order to construct the power variable we have followed the recommendations of the first electric utility in Spain, Endesa and we have created a table which establishes the needs of power depending on the stock of houshold electrical appliances.

Table 1. Power as a function of electrical appliances

ELECTRICAL APPLIANCIES										
Lightning	X	X	X	X	X	X	X	X	X	X
Small appliances	X	X	X	X	X	X	X	X	X	X
Clothes washer		X	X	X	X	X	X	X	X	X
Dishwasher			X			X		X	X	X
Electrical oven					X	X			X	
Electrical cooker							X	X	X	X
Air conditioner				X						X
POWER (KW)	2.2	3.3	4.4	4.4	4.4	5.5	5.5	6.6	7.7	7.7

Source: own elaboration based on the information provided at the Endesa website.

Taking Table 1 as a guideline, we have analysed the stock of electrical appliances in every of 9,881 households in the sample, assigning to each of them a theoretical contracted power, and then transforming it into an ordinal variable. It ranges from 1 to 6.

This way of allocating power involves using rough figures as we suspect of households tending to contract power under its optimal value. However this is the best data that could be used.[9]

Electricity consumption in kilowatts hour

Given the information contained in a household electricity bill in 1999 and in the Royal Decree (RD) 2821/1998, December 23rd, which regulates electricity tariffs in 1999, we have calculated kwh consumed by every household in the sample.

[9] This fact introduces a small measurement error, since assuming a contracted power higher than real, we are considering that the power term in the electricity bill is also higher than the real. Thus the electricity expenditure will be less than the actual and the average price for those consumers who contract power under the optimal level will be higher. In spite of that, this error will be included in the random error term and will not cause any bias in the results.

Table 2. Houshold electricity bills in 1999

	CALCULATION	AMOUNT
TP	$F \times p_F$	X_1
TE	$q_e \times mp$	X_2
Electricity tax	$(X_1 + X_2) \times 1{,}05113 \times 0{,}04864$	X_3
Meter conservation	M	X_4
	Taxable amount	$X_1 + X_2 + X_3 + X_4$
VAT	$(X_1 + X_2 + X_3 + X_4) \times 0{,}16$	X_5
	TOTAL BILL	$X_1 + X_2 + X_3 + X_4 + X_5$

Source: own elaboration based on RD 2821/1998, December 23rd and ENDESA S.A. website.

Note: TP, power term; TE, energy term; p_F, power regulated price by *KW*; q_e, kilovatts hour consumed (kwh); *mp*, kwh regulated pice; VAT, Value Added Tax; *M*, fixed charge for meter conservation. This bill form is established monthly.

HBS offers the "TOTAL BILL" figure, and we are interested in obtaining the number of kwh consumed by each household in the sample. We have regulated prices for each unit of contracted power and consumed kWh (p_F = 1.509 euros/kwh and month and *mp* = 0.086 euros/kwh), as well as the power in every household, calculated as we have described before, and tax rates for electricity tax and VAT.[10] With this information we calculate q_e in every household.

In the previous calculation the cost of meter conservation has been included in the fixed charge. We are aware that this generates a measurement error, because it increases the fixed charge over its actual value, but we argue that our procedure does not introduce a bias in the empirical analysis, since this error is included in the random error term which we assume independent and identically distributed. [11]

Average Price

To the aim of having an individual measure of household electricity price we have constructed a variable which collects the average price paid by consumers as follows:

[10] When taking regulated prices in the two-part household bill we have taken into account the change in tariffs which took place in April of 1999, calculating a weighted average price, where weights are the number of days that every tariff was in force.

[11] We are not able to include this expenditure because depending on the meter that each household has the amount of conservation differs in the bill, and there is not information on the meter owned by each household.

$$AP = \frac{(TP + TE)}{q_e}, \text{ where } TP = X_1*12 \text{ and } TE = q_e \ x \ mp. \quad (3)$$

Given that electricity tariff in Spain is the same for all households, who pay the same marginal price regardless of their consumption, a measure which offers variability among individuals has been obtained.

3.1.2. Variables of households' and dwellings' characteristics

In order to explain the consumers' behaviour, we have constructed six discrete and one continuous variable which have to do with households' and dwellings' characteristics.

Table 3. Variables of households' and dwellings' characteristics

Variable	Description
AGE65	1 if older than 65, 0 in other case
CHILD13	1 if children less than 13 in the household, 0 in other case
HEAT	1 if central heating in the household, 0 in other case
GAS	1 if gas supply in the household, 0 in other case
DWELLING	1 if dwelling owned, 0 if dwelling rented
URBAN	1 in urban areas, 0 in rural areas
NETE	Expenditures in goods and services during the reference year at constant prices, leaving out expenditures in energy supplies

The first two variables, *AGE65* and *CHILD13* explain electricity consumption depending on household age structure, while others like GAS deserves interest in order to test if electricity and gas are substitutes in consumption.

HEAT relates to those households that own central heating. From our survey we are not able to know if this appliance uses electricity or gas, avoiding this fact its use in order to calculate the contracted power.

If a family owns its dwelling it is likely that they contract a suitable power level with respect to their stock of electrical appliances. On the contrary, those families who rent a house may take the power level in the dwelling as exogenous.

URBAN variable distinguishes between urban and rural areas.[12] Finally NETE collects all the expenditures in the household except those related to energy supplies. Main energy supplies in the Spanish households are electricity, natural gas, heating fuel and butane gas.

4. Estimation and results

First of all we estimate the following equation of contracted power by Spanish electricity consumers using an ordered probit with instrumental variables.

$$P = \beta_1 \log q_e + \beta_2 HEAT + \beta_3 REGION + \beta_4 URBAN + \beta_5 YEAR + \beta_6 DENSITY + \beta_7 DWETYPE \quad 9 + \beta_8 GAS + \beta_9 STUDIES + \beta_{10} DWELLING + \varepsilon \qquad (4)$$

Table 4. Description of variables used in the estimation of equation (4)

VARIABLE	DESCRIPTION
q_e	Annual kwh consumed by each household
HEAT	Dummy of ownership of central heating in the household
REGION	Region in which dwelling is located (Autonomous Community)
URBAN	Dummy which distinguishes urban from rural areas
YEAR	Year of dwelling construction
DENSITY	Population density in the dwelling area (low, medium, high)
DWETYPE	Type of dwelling (from big houses to economic accommodations)
GAS	Dummy of gas supply in the household
STUDIES	Education level of the reference person in household (from elementary to university)
DWELLING	Dummy of dwelling ownership or rented

Therefore, our hypothesis is that the contracted power by each household depens on the electricity consumption and on consumers' and dwellings' characteristics.

Given the endogeneity caused by consumption, we instrument it through the following variables.

[12] The work by REE (1998) states that in urban areas households have more electrical appliances than in rural areas.

Table 5. Description of variables used as instruments of consumption

VARIABLE	DESCRIPTION
NETE	Expenditures in goods and services during the reference year at constant prices, leaving out expenditures in energy supplies
AGE	Age of the reference person in the household
AGE65	Dummy, 1 if older than 65, 0 in other case
CHILD13	Dummy, 1 if children less than 13 in the household, 0 in other case
FAMTYPE	Qualitative variable about family structure
FAMSIZE	Number of people in the household
DWSIZE	Dwelling size in square meters
NHOURS	Hours worked by the reference person in the household
SECONDDW	Dummy, owning a secondary dwelling
SEX	Dummy of sex of the reference person in the household

From this specification we have estimated the ordered probit model considering the complex survey design. In this sense we have weighed the variance and covariance matrix by the population stratum which individuals belong to and by the population weight of each of the Autonomous Communities in the Spanish country.

This model is estimated in two stages. In the first stage we have estimated the instruments equation by ordinary least squares (OLS), considering the complex survey design and using the White correction on the variance and covariance matrix to avoid heteroskedasticity. With the same aim, we have taken logarithms on all continuous variables in the the model.

Before the estimations we have dropped 393 observations corresponding to the highest and lowest 1% of the electricity consumption distribution. This task aims to exclude outlier observations in which the meaning of the registered answers could be confusing.[13]

In the same way, we have lost some observations when taking logarithms, in those cases in which a lack of response exists. Finally the second stage estimation of the ordered probit has taken place over 8,659 observations using a maximum likelihood method.

In order to assess the suitability of the instruments chosen we have considered the goodness of fit (R^2) and the joint significance of the regressors. To this aim Bound, Jaeger and Baker (1995) suggested to examine first stage results. They conclude that partial R^2 and F statistics are useful guides in order to assess the quality of estimations.

[13] This procedure has been followed in a number of works in the literature. See for exemple Baker, Blundell and Micklewright (1989) and Buisán (1992).

In this sense, the goodness of fit in the first stage may be considered reasonable, with a value of 29.96 %. Moreover the *F* statistic is significant. These two facts support the strenght of instruments.

Once the first stage is estimated we have predicted the value of consumption variable which has been introduced in equation (4), in turn estimated as an ordered probit.

In order to correct the variance and covariance matrix we have undertaken a bootstrap procedure, which will adjust the standard errors of the estimated coefficients. Our results show that this correction does not make that the estimated parameters be out from their confidence interval at 95%.

Table 6. Results from estimating the ordered probit model with instrumental variables.[14]

Variable	**IV Coefficient**	**s.e (bootstrap)**
$Logq_{eadj}$	0.809337***	0.046
Heat	0.516118***	0.043
Gas	-0.097583**	0.041
URBAN		
Urban-Rural	0.214501***	0.049
YEAR		
1946-1960	-0.077532	0.068
1961-1980	-0.006405	0.043
1981-1995		0.048
1996 and after	0.534696***	0.109
DENSTY		
Medium	-0.134947***	0.043
Low	-0.318430***	0.048
DWTYPE		
Medium house	-0.159447***	0.052
Economic house	-0.426251***	0.063
Accomodation	-2.197474***	0.532
STUDIES		
Elementary education	-0.378909***	0.036
High school	0.089768*	0.047
DWELLING		
Ownership – Rented	0.245617***	0.040
FIXED EFFECTS BY REGION	*Yes*	
	Maximum likelihood R^2	0.334
	McKelvey and Zavoina R^2	0.381
	Loglikelihood	-10552.943
	F(33,8621)	76.93
	Prob > F	0.0000

[14] We have also estimated the model using Ordinary Least Squares. This procedure has not revealed significant differences with results reported in Table 6 except on the magnitude of the instrumented variable, although it remains significant and with the same sign.

To assess the model goodness of fit some measures have been calculated, such as the maximum likelihood R^2, the McKelvey and Zavoina R^2 and the joint significance test.

The R^2s offers values near 40%, showing that the fit is sensible. In the same way, the joint significance test rejects the null hypothesis of lack of significance and is significant at 1%.

Respect to the parameters' values (Table 6) they are, in general, significant and with the expected sign. In particular, the model forecast that a higher consumption of electricity increases the probability of contracting more power.

The estimation also reveals that owning a heating system increases the probability of contracting power. On the contrary those families who use gas diminish that probability. This result agrees with the assumption that gas and electricity are substitutes. On the other hand, fixed effects by region are almost all of them significant at 1%. This result is relevant since it points to the existence of socioeconomical and territorial factors both influencing on household electricity consumption.

The coefficient of URBAN variable is positive and significant at 1%. It shows that households in urban areas are more likely to contract more power, with respect to those located in rural areas.

The variable describing the year of dwelling construction suggests that ancient dwellings, those between fourties and 1980 will tend to contract less power than dwellings constructed from 1980.

Respect to the variable which captures the population density in the household area we can see that as long as the population is more disperse the probability of contracting more power is lower. This variable is significant at 1%.

Parameters associated with dwelling type show that the modest the house the lowest the contracted power. This variable is also significant at 1%.

The parameter associated with the education level points to the fact that more educated consumers contract more power, respect to individuals with elementary studies.

Finally, households who own their dwelling tend to contract more power, respect to the families who rent their houses.

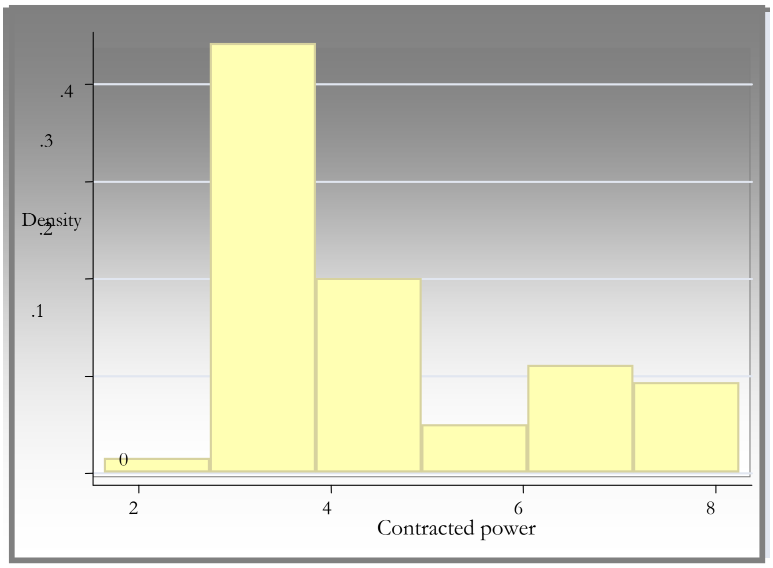
From these results we have predicted the probabilities of contracting power.

Table 7. Probability of contracting every level of power

Variable	Average	s.e.	Minimum	Maximum
P=1	0.164	0.036	$2.98e^{-08}$	0.907
P=2	0.488	0.240	0.003	0.824
P=3	0.226	0.073	0.001	0.306
P=4	0.065	0.034	$5.5e^{-07}$	0.109
P=5	0.090	0.063	$1.65e^{-07}$	0.194
P=6	0.115	0.142	$1.17e^{-08}$	0.877

We can see from Table 7 that the probability of contracting the lowest level of power *P=1* is of 16.4%, for the next level, *P=2*, the probability increases to 48.8%, in *P=3*, we can find 22.6% of the sample, while for the highest levels *P=4*, *P=5* and *P=6* the model predicts that we can find the 6.5, 9 and 11.5% of the households in the sample.

Figure 1. Hystogram of contracted power for households in the sample.



If we compare the model prediction and our data set we can see almost the same scenario, except for the lowest power level, as the model forecasts that 16.4% of the househods would contract this power, while our data show that 2% of the families will do it.

Adding to this fact the high estimated correlation between electricity consumption and power, we can conclude that considering power as a measure of capacity, if households who contract more power are those who consume the most, this consumption may be concentrated in particular moments. This behaviour would favour the existence of peaking demands among households and supports the argument that consumers plan ahead their electricity consumption.

This conclusion is consistent with the idea that two-part tariffs do not offer any signal to consumers neither about the cost of producing electricity nor about the degree in which capacity constraints are binding. Therefore, in spite of the fact that consumers plan ahead their consumtpion, chosing an adequate level of power for it, they do not have any incentive to manage their electricity demand in a rational way. As a consequence marked peak and off-peak demands are created.

We can conclude also, that the ordered probit model above is a good approximation to the contracted levels of power by households. Thus we can see that the electricity consumption and some consumers' and dwellings' characteristics are key determinants of the contracted power.

At this point we are going to assess the influence of the whole two-part tariff on the electricity consumption looking at the average price distribution as a function of the electricity consumption and the contracted power.

In order to tackle this issue we use the average price as endogenous variable because it relates total electricity expenditure with the consumption of this good.

Table 8. Electricity price and consumption distribution by power levels.

POWER[a]		AVERAGE PRICE[b]	CONSUMPTION[c]
2.2	Nº observations	155	
	Mean	0.125342	1278.824
	Median	0.121059	1085.630
	Standard deviation	0.199558	780.286
3.3	Nº observations	4513	
	Mean	0.125103	2151.958
	Median	0.115948	1895.291
	Standard deviation	0.031632	1299.970
4.4	Nº observations	2046	
	Mean	0.142825	2485.389
	Median	0.120598	2199.173
	Standard deviation	0.200598	1462.078
5.5	Nº observations	504	
	Mean	0.133004	2989.819
	Median	0.121570	2676.389
	Standard deviation	0.045009	1646.704
6.6	Nº observations	1130	
	Mean	0.185976	2346.695
	Median	0.142152	2059.931
	Standard deviation	0.333802	1479.767
7.7	Nº observations	951	
	Mean	0.167077	2874.286
	Median	0.139159	2535.489
	Standard deviation	0.139133	1648.382
TOTAL	Nº observations	9299	
	Mean	0.141124	2353.714
	Median	0.121959	2046.788
	Standard deviation	0.159392	1443.257

a. Power expressed in *kW*, b. Average price expressed in euros, c. Consumption expressed in *kwh.*

From descriptive statistics in Table 8 we can see that most of the observations are concentrated in mean and low power levels. In effect, from a total of 9,299 obseravations, 6,714 are in the three lowest segments of power. Moreover we can see that the trend in the average price is practically constant along these three segments in average terms. From the third segment the trend in price is not well defined, since for the power level 5.5 *kW* the price is lower, then increases for the 6.6 *kW* level, and then is lower again for 7.7 *kW*. Therefore, we can not conclude that consumers pay more for their consumption as long as their contracted power increases.

Respect to consumption, the general trend in this variable is increasing by power, although switching from 5.5 *kW* to 6.6 *kW* leads to an important mean decrease. However, if we consider the standard deviation in each power segment we can not conclude that this variable suffers a sustained increase.

The price is under its mean for power levels 2.2; 3.3; and 5.5 *kW*, and over its mean for the rest. Consumption is under its mean for power levels 2.2; 3.3; and 6.6 *kW*, and over its mean for the rest.

Finally, it must be remarked that the dispersion in power distribution is important, both for price and consumption variables. However, this dispersion seems to be higher for the second variable.

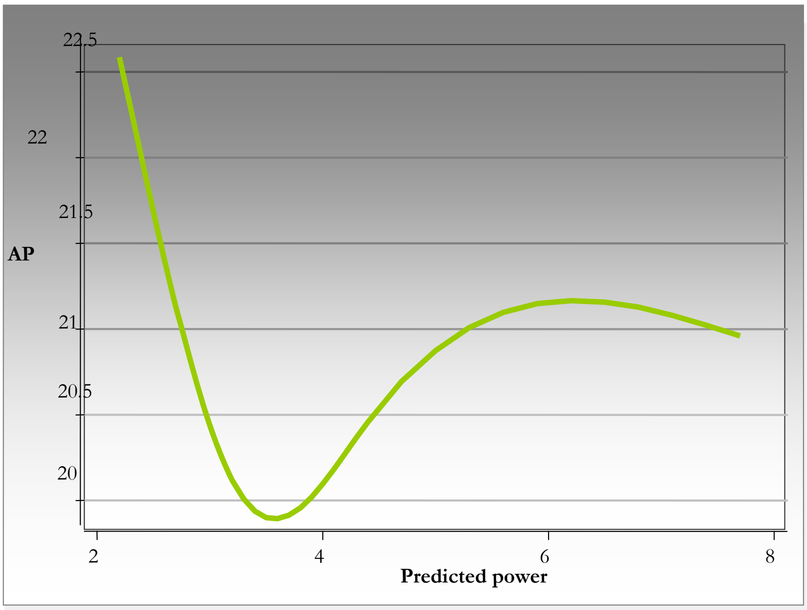
To analyse the relationship among the previous variables we have undertaken a spline regression between the price and the contracted power. Here the bandwith over which every point in the function is calculated is approximated through a cross-validation process. This procedure stablishes that bandwith which minimizes the prediction error out of the sample.[15]

In undertaking this analysis we must take into account endogeneity problems. In particular we must consider that the average price has been calculated as the sum of the power and energy terms over the consumption in kwh. Thus it is not posible to assume that the contracted power will be an exogenous variable to explain the average price distribution.

We solve this problem replacing the value of power by its prediction in the second stage of the ordered probit model. This prediction is individually calculated for all observations in the sample.

[15] See Yatchew (1998)

Figure 2. Nonparametric spline regression between the average electricity price and power. .[16]



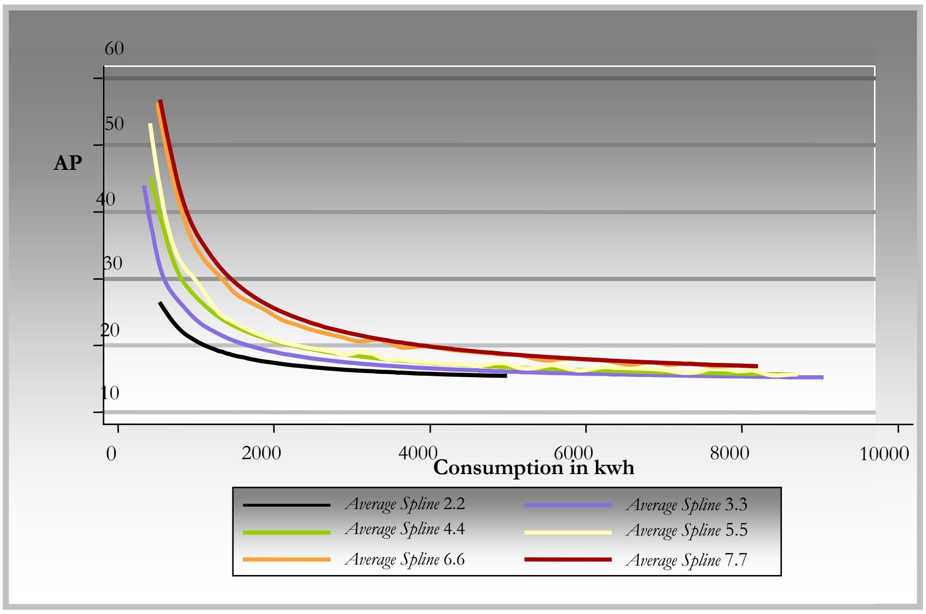
The previous spline regression follows different trends as a function of the contracted power. Thus, we are not able to assure that contracting higher power implies to pay a higher price.

However the spline before is not complete, since if we are interested in the relationship between average price and power, we need to take into account the electricity consumption in the households. The interaction among these three variables will give us the full scenario to assess the effects of a two-part tariff over price and consumption.

In this regression we have considered edogeneity in electricity consumption, so we have replaced this variable by its prediction, obtained in the first stage estimation of the ordered probit model.

[16] Average price is reported in pesetas (the former Spanish currency), both in figures 2 and 3. One Euro is 166.386 pesetas

Figure 3. Non-parametric spline between average price and household electricity consumption by power



From the regression above we can see that while for the lowest consumption levels the average price is higher as long as power is higher too, things change for highest consumption levels. It means that as consumption increases, the average price decreases, and decreases more the higher the power is. Therefore, for highest consumptions, from 6,000 *kwh*, the average price is practically the same regardless the level of contracted power, converging to the marginal price of electricity.

The previous result agrees with our hypothesis that a two-part tariff is inefficient and has economic implications over the sector. This is the case here since it is not true that all consumers pay a higher price when they contract more power, or at least, this is not the case for all consumption levels.

Additionally, if power is a measure of capacity it is likely that consumers who contract more power and consume a high amount of electricity consume the most part of it simultaneously. If this consumption is paid almost at the same price than the consumption of housholds with less power, the two-part tariff is inefficient, since it does not offer any incentive to consumers to flat their demand curve and they are able to continue concentrating their consumption in particular moments without any penalty, and with the consequences that this fact has over the saturation of generation capacity in the system, due to the peaking in demand.

5. Concluding remarks

In this paper the efficiency effects of a two-part tariff over houshold electricity consumers have been examined. Thus, we have estimated an ordered probit model with instrumental variables and non-parametric spline regressions.

The results in these estimations points to the fact that the power contracted by households depends on electricity consumption and on consumers' and dwellings' characteristics. This outcome supports the idea that consumers plan ahead their electricity consumption.

From non-parametric estimations we can see that the two-part tariff introduces inefficiencies on the average price paid by households.

These shortcommings on the pricing scheme are evident from the relationship between the average price and electricity consumption, by power. In effect, as long as the electricity consumption increases the average price decreases in a higher proportion for consumers who contract more power. This price is almost the same for all users in the highest consumption levels, regardless their contracted power.

We conclude that this is inefficient since the power is a measure of capacity, thus consumers who contract more power do this to consume more electricity simultaneously. This fact induces to a peaking demand in particular moments. As long as the average price is almost the same for all consumers, it means that the two-part tariff does not punish the more concentrated consumptions. As a consequence it may occur that at certain times the generation capacity would be insufficient to afford demand during peak time. However in the off-peak time there would be an excess of capacity, with the corresponding cost of maintaining this inactive capital.

Given this scenario it would be suitable to reform the pricing scheme in the Spanish household electricity segment. Indeed, tariff reforms are being discussed in the literature and applied in some electricity markets. In particular it seems that a time-of-use tariff or a real-time pricing would give much better results.

In effect, time-of-use tariffs and dynamic pricing, through the setting of different prices as a function of the moment in which electricity is consumed, are able to switch consumption from peak to off-peak periods, making the demand curve much more stable along the time. As a consequence of the signals received from the market, consumption becomes more rational and the need to set a great amount of generation capacity is reduced in the whole cycle of demand.

In the Spanish case, the use of a tariff which distinguishes prices by periods of time would be an option which would improve notably the efficiency of the system, in spite of the fact that its application would have costs, since it would be necessary to adapt the meters system, in order to be able to distinguish consumption by periods of time during a day. From the evidence here it seems clear that this effort could be worthy.

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