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Measuring market power in the Iberian electricity wholesale market through the residual demand curve

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Abstract— **The existence of market power in the electricity market is a recurrent issue. Measuring and understanding market power practices in the Iberian electricity market turn out to be interesting: though a liberalized market, two integrated firms control 80% of total demand and there is a strong - often direct - intervention of government in the market. For various reasons, among which the difficulty in obtaining reliable, extensive data stands out, market power in the Iberian electricity market has rarely been measured. This work aims to contribute to a better knowledge of the way market power occurs. We calculate the elasticity of residual demand to evaluate the two dominant firm's market power, using hourly bides in the Spanish spot market for the period July-August 2004 to 2006. Although our approach was highlighted by Frank Wolak work on the electricity sector, we extend it and discuss its constraints. We discuss the results obtained in the light of the evolution of the electricity sector during that period.**

I. INTRODUCTION

The application of traditional market power indicators, based upon concentration measures, is disputable in the electricity sector. Besides the number and average size of firms, other factors can seriously restrain competition:

- The incentives to production differ according to whether the company is public or private, to market structure and market design.
- Demand elasticity.
- The growing rate of the output.
- Entry and exit barriers.
- Product differentiation.

Each one of these factors can play an important part in the way the Electricity market really works.

Thus, a low concentration level may simply point out that the producers with larger installed capacity have (strategically) chosen to produce less than the amount they were expected to do. This can raise prices and make them to benefit from low demand elasticity.

The electricity market modelling is, most of time, based on the Cournot Model. Competition is driven by quantities (closer to reality than the Bertrand model taking into account the capacity constraints).

Sometimes, it is based on hybrids models (with prices and quantity strategies) which seems to be the most consistent way to determine the existence of market power. In this modelling process, the demand curve cannot be the market aggregated curve because, in the electricity sector, the elasticity of demand is lower than the unity, being close to zero at peak hours.

Then, producers are able to practice high prices and, theoretically, in extreme situations, almost infinite prices. Obviously, this doesn't happen, owing to the fact that each producer faces a residual demand curve, i.e, the total demand deduced by the quantities supplied by his competitors. In this context, the elasticity of demand is higher and the producers bid include finite prices. Even if the elasticity of the aggregated demand was zero, it would be

enough to have a competitor supplying a fringe market to make that residual demand curve to cross the Y axe, therefore, to have a maximum price.

A producer (*i*) residual demand curve $D_i(p)$ is given by:

$$D_i(p) = D(p) - \sum_{k \neq i} S_k(p) \qquad (1),$$

where $S_k(p)$ is the competitor k supply.

Therefore, the residual demand curve of a producer i proceeds from the difference between total demand and total supply deduced by the producer i supply.

II. THE RESIDUAL DEMAND ELASTICITY AS A MARKET POWER INDICATOR

A – A Survey

The model which sustains the application of elasticity of residual demand as a methodology to measure market power has been developed by J. Baker e T. Bresnahan (1988). This methodology has originally been developed to measure market power in product differentiated industries. The authors use a partial equilibrium model. Thus, the residual demand curve of a firm 1 varies according to the quantities supplied by the firm 1, structural demand variables and the competitors' cost curves, as follows:

$$P_1 = R^1(Q_1, Y, W, W^1, \alpha^1, \beta^1, \theta^1) \qquad (2)$$

Where: R^1 is firm 1 inverse residual demand, Q_1 is the amount (quantity) supplied by firm 1, Y are the exogenous variables entering the demand system, W is the vector of industry-wide factor prices, w^1 is the union of all firm-specific factor prices, α^1 represents the aggregation of own-price demand elasticities of all firms except 1, β^1 the variables which determine the costs of each firm and θ^1 is the conduct variable of each firm.

Differentiating equation (2) the residual demand elasticity is obtained. It is given by:

$$\eta_1^R \equiv \frac{\partial \ln R^1}{\partial \ln Q^1} = \eta_{11} + \sum \eta_{1i} \varepsilon_{i1} \qquad (3)$$

Where, η_1^R is the inverse elasticity of residual demand for firm 1, η_{11} is the inverse elasticity of residual demand which results from firm 1 supply, η_{1i} is the inverse elasticity of

residual demand which results from firm 1's competitors' supplies and ε_{i1} is the effect of firm 1supply on the quantities supplied by its competitors.

Based on Stackelberg's model or more complex consistent conjectures equilibrium models the authors find a linear relationship between the elasticity of residual demand and the mark up:

$$-\frac{\partial \ln R^i}{\partial \ln Q^i} = \frac{P_1 - MC_1}{P_1} \qquad (4)$$

In this model there is no distinction between residual demand curve and the demand curve the firm is facing.

However, as Baker and Bresnahan state, this relation occurs since there is no oligopolistic strategic variables which could affect the equilibrium. Unfortunately, this is not the case for most electricity markets.

B – The Electricity sector

As mentioned above, in a context of very low elasticity of residual demand, as it happens in the electricicity sector, the concept of elasticity of residual demand is very useful to enable the determination of market power. Upon this concept, Frank Wolak (2000) built an explanatory model for producers' behaviour in the electriciity sector, which allows, under certain conditions, to measure market power without having to resort to the calculation.of marginal cost.

In power markets, prices are generally defined for each hour. In those cases, the residual demand which is faced by a firm in a certain hour corresponds to the global demand in that hour less the aggregate supply bid curve of all other market participants for the same time. For each hour, a bidding supply curve can be built which, for the conditions which sustain the profit maximization model defined by Wolak, can cross all possible curves of the residual demand.

The firm will determine the pair quantity/price, which maximizes its profit, associated to a residual demand curve and will do this exercise for all possible residual demand curves. This way, whatever the residual demand curve is, i.e., the global demand and competitors bids, a firm *j* can maximize its profit at hour *h*, applying the following equations:

$$\frac{\left(P_h - cmg_{jh}\right)}{P_h} = -\frac{1}{\varepsilon_{jh}} \qquad (5)$$

$$L_{hj} = -\frac{1}{\varepsilon_{jh}} \qquad (6)$$

Equation (6) presents the unilateral market power which owns firm j at hour h, where P_h is the market price in that hour, cmg_{jh} is the marginal cost of firm j at hour h and ε_{jh} is the elasticity of residual demand of firm j at hour h.

Notwithstanding, significant amounts of bilateral contracts, future contracts, in parallel with a spot market can disable the application of this equation (Borestein, Bushnell and Wolak, 2002), as it will be shown.

Finally, it has to be said that the validity of this equation depends on $|\varepsilon| > 1$. From quantities supplied such that $|\varepsilon| < 1$, the firm doesn't maximize its profit, but can define prices its own way. In such price region, profits decrease in quantity and increase in price.

The following figure illustrate maximization revenue strategy of a firm i which, for a determinate residual demand, define the pair price/ quantity, P_M /Q_M, which maximizes its profits. Those are maximized at the point where marginal revenues, obtained by the derivative of the residual demand curve, equal marginal costs, which are equal to the firm's supply curve. At this point, the elasticity of the residual demand is higher than 1.
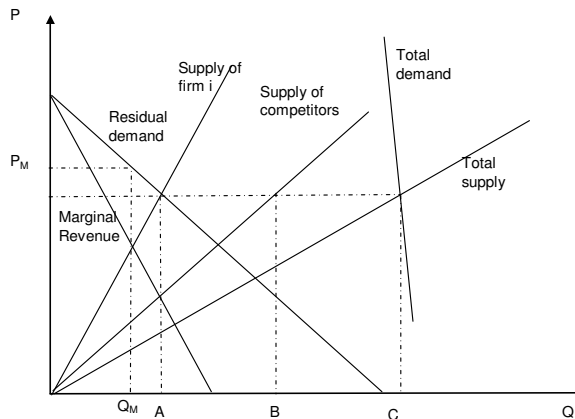

Fig. 1 Profit maximization taking account the residual demand

III - THE MODEL

Wolak's model (Wolak 2000) supposes the firm can sell electricity in the spot market and it can reduce its risk through hedge contracts.

The following optimization problem of strategic biddings occurs:

$$\max_{S(i)} \pi_i \big(S_{(i)}, S(-i) \big),$$

where $S(-i)$ is the vector of strategies of the remaining firms.

Firm A profits at period i of day d are maximized in the following way:

$$\pi_{id}(p) = DR_{id}(p)(p - cmg) - (p - pc_{id})Qc_{id} \tag{7}$$

Where DR_{id} is the residual demand, p is the market price, pc_{id} is the contract' price, $(p - pc_{id})Qc_{id}$ will be the payments made by the contracts purchasers to firm A in case of $p < pc_{id}$. Whether $p > pc_{id}$, the payments will be made in the opposite sense.

The aim of the firm is to find the bid function which leads to a market price corresponding to the highest revenues.

The effect of a residual demand high elasticity is significant on market prices, being amplified when the risk is covered by contracts. Thus, the higher the elasticity of the residual demand, the lower the price will be. Also, the difference between quantities traded with and without hedging contracts will rise. In this situation firms do prefer to cover their risk with hedging contracts. The increasing weight of such contracts makes the quantities sold in the market to decrease. Thus, elasticity goes up.

In such a kind of market, there is a sort of a vicious circle: the more risk adverse the firms are, larger quantities will be sold outside the spot market and more firms will react aggressively in the spot market. Therefore, the higher elasticity will be. In short: a high elasticity leads to a contraction of the demand in the spot market and to the increase of hedging contracts.

IV - THE MODEL STRUCTURE

Our empirical work concerns the measurement - through the calculation of the elasticity of residual demand - of Endesa and Iberdrola market power. Together, they supply 75% of Iberian electricity demand.

Empirical data correspond to hourly bids in the Spanish electricity spot market during the months of July and August between 2004 and 2006. The data (www.omel.es) concerning market agents' purchase and sale bids (price and quantity). Those bids allowed us to rebuild the supply and demand hourly curves. For such period, we had to analyse from 20 000 to 50 000 bids each day.

Firstly, for each one of the firms and for each hour, we calculated total supply, then deducting their bids, in order to obtain the supply curves of their competitors. As, for equal prices, quantities bid and quantities matched are not exactly the same, quantities bid are adjusted to reflect the quantities matched.

Hourly clearing price is defined, where demand and supply cross. As we can't define the elasticity of the residual demand in a particular point, the arc elasticity of the residual demand around the market clearing price is defined.

The market clearing price cannot be defined by the crossing of the firms' (Endesa and Iberdrola) residual demand curves and the supply curve. It is defined by the crossing of total supply and demand.

Therefore, we had to deduce indirectly prices above and under the market clearing price for the residual demand. For this purpose, prices just above and just under the market clearing price were fixed and quantities demanded associated to those prices were calculated. Then, prices of the residual supply (of Endesa's and Iberdrola's competitors) which were closest to those prices - above or under those prices, according to the fact that they were related to the price above or under the market clearing price - were fixed, as well as quantities associated to those calculated prices.

Finally, residual supply quantities above or under the market clearing price were deducted, for those prices, from the demand quantities. After the calculation of the residual demand for those two prices, the determination of firm's i elasticity of the residual demand at hour h was obtained, applying the following equation:

$$\varepsilon_{jh} = \frac{DR_{jh}(P_h(high)) - DR_{jh}(P_h(low))}{P_h(high) - P_h(low)} \frac{P_h(high) + P_h(low)}{DR_{jh}(P_h(high)) + DR_{jh}(P_h(low))} \quad (8)$$

Where $P_h(high)$, is the price just above the market clearing price, $P_h(low)$ is the price just under the market clearing price, $DR_{jh}(P_h(high))$, is the residual demand associated to the price just above the market clearing price, $DR_{jh}(P_h(low))$, $DR_{jh}(P_h(high))$, is the residual demand associated to the price just under the market clearing price.

Firm *j*'s monthly average values of the inverse elasticity of the residual demand at hour *h*, and their respective standard deviations were calculated.

V – EMPIRICAL RESULTS

A. *Inverse Elasticity of the residual demand*

The results are shown for all values, without extreme values (higher than percentile 95).

As it can be observed, the results obtained are not conclusive for 2004 and 2006. In 2006, when extreme values were withdrawn, some values might point out the existence of market power, namely values related to August in Endesa case. However, the values are so high that they cannot be considered relevant.

In July 2005 for those two producers, off-peak hour values and peak and half-peak hour values, in the case of Endesa, present interesting results, although also high. Because of that, they have to be taken into consideration very carefully. In August of that year, values related to Iberdrola at off-peak hours are the only results which can be considered, although they have to be equally taken cautiously.

We also made a complementary econometrical analysis in order to explain such results.

B. *Correlation between price and elasticity*

An econometrical analysis has been done about the correlation between the inverse elasticity of residual demand and the market clearing prices. Parallel to this analysis, the time series stationarity has been studied, as well as the dependent variables endogeneity. Dickey-Fuller's test realized allows to conclude that the serials inverse elasticity of residual demand are stationary.

TABLE I

INVERSE ELASTICITY OF THE RESIDUAL DEMAND

2004

		Iberdrola				Endesa			
		Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme	Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme
July	Average	1,46	**0,75**	1,87	**0,77**	2,50	1,93	4,23	2,29
	Standard deviation	10,00	**0,56**	15,26	**0,54**	3,26	1,54	23,52	1,87

		Iberdrola				Endesa			
		Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme	Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme
August	Average	5,22	**0,89**	4,28	1,12	12,18	1,80	10,28	2,51
	Standard deviation	50,60	**0,79**	37,93	1,25	83,29	1,43	79,80	1,94

2005

		Iberdrola				Endesa			
		Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme	Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme
July	Average	**0,40**	**0,33**	1,21	1,03	**0,71**	**0,64**	**0,85**	**0,77**
	Standard deviation	**0,39**	**0,23**	1,18	0,88	**0,45**	**0,34**	**0,50**	**0,32**

		Iberdrola				Endesa			
		Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme	Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme
August	Average	**0,79**	**0,65**	1,72	1,51	1,03	**0,92**	1,36	1,23
	Standard deviation	**0,85**	**0,55**	1,62	1,35	0,72	**0,54**	0,87	0,65

		2006							
		Iberdrola				Endesa			
		Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme	Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme
July	Average	1,23	1,07	1,73	1,56	2,50	1,84	1,01	0,85
	Standard deviation	1,09	0,77	1,04	0,69	3,54	2,03	0,90	0,55

		Iberdrola				Endesa			
		Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme	Off-peak all	Off-peak without extreme	Peak and half-peak all	Peak and half peak without extreme
August	Average	1,06	**0,87**	1,20	1,05	1,14	**0,91**	0,87	**0,79**
	Standard deviation	1,25	**0,95**	0,93	0,67	1,39	**0,96**	0,78	**0,52**

The endogeneity analysis between the inverse elasticities of residual demand and the market clearing prices, through the Wu-Hausman's test, showed that those variables were endogeneous. Therefore, the linear regression was redefined using instrumental variables. The chosen regressions were validated through the Sargan's statistics.

In July and in August 2004, we observed that there was no correlation between the market clearing price and the inverse elasticity of the residual demand.

TABLE II – REGRESSION OF MARKET CLEARING PRICE ON THE INVERSE ELASTICITY OF

IBERDROLA'S RESIDUAL DEMAND, JULY AND AUGUST 2004

	Coefficient	Standard deviation	t statistic
Coefficient	19,392	40,957	0,4737 [0,636]
Price	-6,6167	16,061	-0,41196 [0,680]

Sargan's statistic (Chi-Square distribution) [Prob.]	0,006 [0,940]

TABLE III

REGRESSION OF MARKET CLEARING PRICE ON THE INVERSE ELASTICITY OF ENDESA'S

RESIDUAL DEMAND, JULY AND AUGUST 2004

	Coefficient	Standard deviation	t statistic
Coefficient	-174,8522	1259,1	-0,13887[0,890]
Price	69,5239	16,061	-0,41196 [0,680]

Sargan's statistic (Chi-Square distribution) [Prob.]	0,0003 [0,985]

In July and August 2005, for a significance level of 5%, the inverse elasticities of residual demand and market prices are correlated, both in both cases: Endesa and Iberdrola. The correlation occurred in the expectable sense: a price increase implies an increase in the inverse elasticity of residual demand and, therefore, a decrease of the elasticity of residual demand.

TABLE IV

REGRESSION OF MARKET CLEARING PRICE ON THE INVERSE ELASTICITY OF ENDESA'S

RESIDUAL DEMAND, JULY AND AUGUST 2005

	Coefficient	Standard deviation	t statistic
Coefficient	-2,3958	0,34269	-6,9912 [0,000]
Price	0,49277	0,04605	10,7007 [0,000]

Sargan's statistic (Chi-Square distribution) [Prob.]	6,1318 [0,190]

TABLE V

REGRESSION OF MARKET CLEARING PRICE ON THE INVERSE ELASTICITY OF IBERDROLA'S

RESIDUAL DEMAND, JULY AND AUGUST 2005

	Coefficient	Standard deviation	t statistic
Coefficient	-2,6298	1,4274	-1,8424 [0,066]
Price	0,53704	0,22304	2,4078 [0,016]

Sargan's statistic (Chi-Square distribution) [Prob.]	1,4430 [0,695]

In July and August 2006, for a 5% significance level, only in the Endesa case the inverse elasticities of residual demand and market clearing prices were correlated.

TABLE VI

REGRESSION OF MARKET CLEARING PRICE ON THE INVERSE ELASTICITY OF IBERDROLA'S

RESIDUAL DEMAND, JULY AND AUGUST 2006

	Coefficient	Standard deviation	t statistic
Coefficient	40,8951	29,0651	1,4070 [0,160]
Price	-8,6375	6,7382	-1,2819 [0,200]

Sargan's statistic (Chi-Square distribution) [Prob.]	0,043759 [0,834]

TABLE VII

REGRESSION OF MARKET CLEARING PRICE ON THE INVERSE ELASTICITY OF ENDESA

RESIDUAL DEMAND, JULY AND AUGUST 2006

	Coefficient	Standard deviation	t statistic
Coefficient	-7,5733	4,2416	-1,7855 [0,075]
Price	1,6866	0,77582	2,1740 [0,030]

Sargan's statistic (Chi-Square distribution) [Prob.]	,0075119 [0,931]

What can we conclude from these regressions?

According to our analysis, they corroborate what was mentioned previously. Let us explain why:

In 2004, the firms' bid strategies were independent from the market prices. On the contrary, in 2005, the firms' bid strategies were influenced by market prices. In 2006, the results were mitigated.

Opposite to Endesa, in the case of Iberdrola, the relationship between market price and the inverse elasticity of residual demand, i.e., the mark-up, was not significant.

In fact, the elasticity of the residual demand of a firm j can be separated into two parts:

$$\frac{\dfrac{d\left(Q_{(p)} - Sc_{(p)}\right)}{dp}}{\dfrac{\left(Q_{(p)} - Sc_{(p)}\right)}{p}} = \frac{\dfrac{dQ_{(p)}}{d_p}}{\dfrac{Q_{(p)}}{P}} + \frac{\dfrac{dSc_{(p)}}{d_p}}{\dfrac{Sc_{(p)}}{P}} \qquad (9)$$

Where $Q_{(p)}$ is the demand function and $S_{c(p)}$ the competitor' supply function.

The first part is the price elasticity of demand, related to the demand. It is independent from firm's strategy, since the behaviour of this variable is known. In higher demand hours, with hourly higher prices, the elasticity is lower. Therefore, the price elasticity of demand is inversely related to the evolution of the prices.

The second part is the price elasticity of quantities supplied by firm's j competitors. This elasticity depends on the strategies of firm j's competitors. Generally, these strategies also lead to a decrease of elasticity with prices. In principle, the relationship between firm's j elasticity of residual demand and the market clearing prices would be decreasing and, therefore, the relation between firm's j residual demand and the market clearing prices would be increasing.

Thus, the results both for Iberdrola and for Endesa, in July and August 2005, show an expected relation between market price and the mark-up. The random relations for Iberdrola in July and August 2006, and for both producers in July and August 2004 are due to the random behavior of those producer's supply functions, taking into account that the demand behavior is stable. Therefore, in those periods the producer's bid didn't follow the known pattern, i. e.:

- at low price hours, the producers bid large amounts, related to base load units, and
- with the increase of prices, the bid reflected the higher variable costs units which have a lower capacity installed, the peak load units. Apparently, price independent bid strategy can suppose that the profit maximization - producers' main objective, - is achieved beyond the spot market. The existence of CTC, whose influence was total in 2004, as well as the existence of legal changes which occur in 2006 – namely, the price cap imposed to the firms belonging to the same group - can explain such strategies.

VI - CONCLUSIONS

The definition of market power through the methodology employed in this paper presents some restrictions. This methodology is based on Wolak's model, but the first reference to the residual demand elasticity as a market power indicator appears in Bresnahan et al paper.

Taking Bresnahan et al model, a direct relationship between the mark-up and the elasticity of the residual demand cannot be assumed when there are oligopoly strategies. Furthermore, Wolak shows (2000) that, when the energy traded is not limited to the spot power market, but it is also traded trough hedging contracts, the elasticity of residual demand may not be able to measure market power.

Those restrictions for applying the elasticity of residual demand are the reasons, jointly or separately, which explain that the application of our methodology did not produce the expected results. Thus, in 2004 the elasticity of residual demand calculated was very low (between 0,5 and 0,1), close to the values presented by Espinosa and Ciarreta (2006), for the period between 2001 and 2004 for the same producers. In 2005, as a result of the increase of pool's prices, the elasticity of the residual demand increased. However, in some

cases, it was lower than the unit, which disabled the utilization of this variable for the market power definition.

Besides the increase of fuel costs, 2005 was marked by a set of legal transformations in Spain which changed the Spanish market power rules. The delay of the payments of debt amounts to be paid through the CTCs mechanism was one of the consequences of those legal changes.

In 2006, prices were close to 2005 prices and the elasticities of residual demand were slightly lower. That year, the Spanish Government established a cap for the energy traded between firms belonging to the same group. Also, the ending of CTC, often announced, finally occurred. The main result of those events was a significant decrease of the energy traded in the pool and the withdrawing of installed capacity by the second major producer, Iberdrola. This capacity was reintroduced in the Spanish electricity market through the emergency technical market, which was much better paid.

What led producers to bid for a production level, in such a situation where their residual demand curves elasticities were lower than 1 and where profits decreased with the amount produced (therefore, producers would not maximize their gains)?

In practice, the majority of Spanish electricity producers was framed by CTCs' mechanism. This mechanism was aimed to make up for eventual losses which could occur with the liberalization of the wholesale market in 1997. CTC led firms to bid on the spot market independently of market clearing price. Thus, profit function is obtained through the following equation:

$$F(\pi_i) = (CTC_{i36} + 36 - C_{i(Qi)})Q_{i(p)} \qquad (10)$$

The resulting profit maximization function defines that firms will produce up to those marginal costs are equal to 36 €/MWh plus the CTC's unitary compensation:

$$C'_{i(Qi)} = CTC_{i36} + 36 \qquad (11),$$

where $C'_{i(Qi)}$ is the marginal cost of firm i.

Profits are maximized independently of price bid and firms are encouraged to produce up to marginal costs equal to 36 €/MWh plus the CTC's unitary compensation. Those are the factors which explain why elasticity of residual demand is lower than the unit. CTC mechanism had the advantage of not encouraging market power strategies, because the bids

of the producers framed by CTCs' mechanism are totally independent from market price variation.

Did the existence of CTCs until June 2006 disabled market power? The answer is negative for two reasons:

- Firstly, not all power plants which bid in the Spanish wholesale market were framed by the CTCs' mechanism. The weight of power plants framed by CTC in the total production decreased since the beginning of this mechanism, namely since 2004 when some new combined cycle natural gas power plant were launched. Those power plants mainly belonged to Iberdrola.
- Secondly, the payments of the amounts due by the CTCs' mechanisms became uncertain, due to: changes in the methodology employed in its determination and also by the fact that the recovering of those amounts were often delayed and included in tariffs deficits[1], which characterize the Spanish electricity sector.

Former works showed that directly, i.e., through the mark-up calculation (Fabra, Toro 2004, see also DG Competition report on energy sector inquiry, 2007) or indirectly, through the producers' behavior analysis (see: Ciarreta, Espinosa, 2004 and Marques, Soares and Fortunato, 2006).

Therefore, the fact that in 2005, for the first time in the analysed period, the elasticity of residual demand was lower than 1 in a certain period of the day, may be due to the decrease of power plants framed by CTCs' mechanism in the set of power plants which bid electricity in the Spanish market, jointly with the payment delay.

2006 stands up as a turning point. Many legal measures were taken to clarify prices' formation in the wholesale market and to limit market power, such as:

- The end of CTCs (Real Decreto 7/2006).
- The end of the obligation to trade the electricity in the pool market (Real Decreto 5/ 2005).

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[1] The income generated by the Spanish tariffs has not been enough to cover the electricity sector firms' cost, creating deficit, which payments to the firms are transferred to the future.

▪ The energy traded in the pool market between firms belonging to the same group is treated as bilateral contracts whose prices are limited to 42,35 €/MWh (Real Decreto 3/2006).

Those factors should led to an increase of the elasticity of the residual demand. However, it didn't happen. In fact, there were many ways to skirt the traditional market rules.

Those restrictions led electricity traded in pool market to significantly decrease its weight in total energy traded. on the contrary Bilateral contracts and the reserve system (emergency system), which are much better paid than the pool market, turned more important, namely in Iberdrola's case.

In what concerns the energy traded, in the market pool, between firms which do not belong to the same group, oligopoly strategies may have been developed in the pool market. Remember that, according to J. Baker e T. Bresnahan, the measurement of market power through the elasticity of residual demand doesn't offer consistent results when there are oligopoly strategies. This may explain the non conclusive results obtained with the elasticity of the residual demand analysis for 2006.

Moreover, the price cap imposed to the wholesale market led, direct and indirectly, to the maintenance of the elasticity of the residual demand of the two major firms, which trade in the Iberian spot market, at a low level.

In this framework, traditional market analyses are invariably affected. A complementary mark-up analysis may confirm those conclusions.

Notwithstanding market power cannot be measured using this methodology, the results obtained, allow highlighting many forms developed by the market agents to skirt the rules imposed by the Spanish State to limit market power. Those results are useful in the Portuguese case, taking account that in Portugal a mechanism similar to the CTCs, the CMEC, were applied, from 2007 for the majority of the Portuguese power plants which are actually operating.

VII - REFERENCES

[1] J. B. Baker, T. F. Bresnahan "Estimating the residual demand curve facing a single firm", International Journal of Industrial Organization 6 pp. 283-200, 1988

[2] Borestein, Severin; Bushnell, James and Wolak, Frank A. "Measuring Market Inefficiencies in California's Restructured Wholesale Electricity Market, "American Economic Review, December 2002, 92(5), pp. 1376-1405

[3] A. Ciarreta e M. Espinosa, "Demand elasticity and market power in the Spanish electricity Markey", Document de Treball núm. 06/6, July 2006

[4] A. Ciarreta, M. Espinosa, *"Market Power in the Spanish Wholesale Electricity Market"* presented at International Industrial Organization Conference Boston, Massachusetts April 4-5, 2003

[5] DG Competition report on energy sector inquiry, SEC(2006)1724, 10 January 2007

[6]   Fabra, N and Toro, J. , Price wars and collusion in the Spanish electricity market, (avalaible online), 2004

[7] F. Wolak "An empirical analysis of the impact of hedge contracts on bidding behaviour in a competitive electricity market", International Economic Journal, Volume 14, Number 2, Summer 2000

[8] A. Fortunato, V. Marques, I. Soares "*Behavior Patterns and the Electricity Market Design: Evidence from the Spanish Daily Market*", presented at the 33th conference of the *European Association for Research in Industrial Economic,* at Amsterdam, Netherlands *in* August 2006